märklin digital

# Model Railroading digitally controlled

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The Märklin Digital system is a universal form of model railroad control which is easy to use. This system has introduced modern microprocessor technology to the control of model railroads.

The purpose of this book is to give detailed insight into the possibilities and operation of the system. References to playing with a model railroad are intended to serve as a guide in the explanations.

All components of the Digital system are introduced. In addition, the book contains extensive instructions on setup and operation. Moreover, tips are given on simplifying operation further or opening up additional operating possibilities.

To help explain how the Digital system functions, a block wiring diagram of each component is given along with a description of the manner in which data are processed within the component and in cooperation with the other components in the Digital system.

Wiring diagrams for all gauges and track systems in the appendix give the hookup for turnouts (track switches), signals, circuit and contact tracks as well as working models.

Another section of the appendix explains the solution to control problems frequently encountered on a model railroad, for example: block operation, partial or fully automatic staging yard control and control of a turntable with track indexing.

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Georg Fuhs

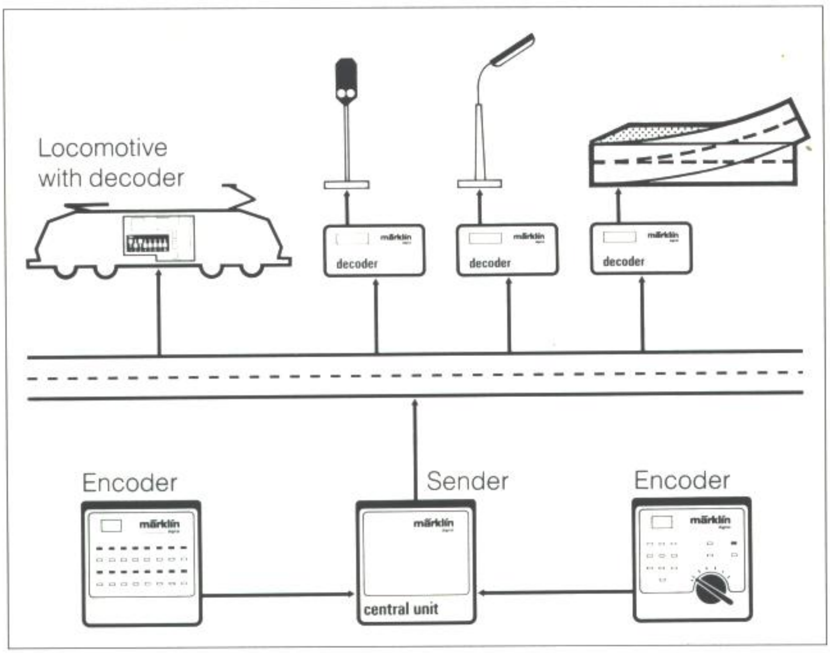
## Contents

## Digital and analog – two possibilities for controlling a model railroad

A "conventional" model railroad is controlled by varying the amount of voltage powering the locomotives to make them go faster or slower. To stop the locomotive, the voltage is shut off completely. The locomotives therefore always operate according to the voltage present in the track. All locomotives on the same track, i. e. in the same track circuit, do exactly the same thing: they all operate fast or they all operate slowly. Independent control of an individual locomotive is not possible in this instance without dividing the layout into different track circuits. The technical expression for model train control through variations in voltage is "analog". Since this is the most common form of model train control, it can also be termed "conventional".

With the conventional form of control for turnouts and signals, a voltage is likewise turned on and off from the control panel. All turnouts would simultaneously change position with this type of control, if each unit did not have its own set of wiring from the control panel.

*Control of a model railroad with the Märklin Digital system (diagram)*




ill. 1

With the Märklin Digital system, model train control makes use of a totally different principle.

Locomotives, turnouts, signals, etc. are not controlled or set directly using voltage. With the Märklin Digital system control takes place exclusively through a transfer of information. The control commands are entered into the control system with a device called a "encoder". In this encoder the setting for the speed control knob or for a push button, for example, is transformed into electrical signals. These signals represent the control information and are transmitted to the Central Unit. It coordinates the flow of information for the entire Digital control system. The Central Unit sends this information along with sufficient power through only two wires to the layout. Here the arriving information is decoded again by receiving components called "decoders". They transform the information back into operating current for locomotive motors, turnouts and signals.

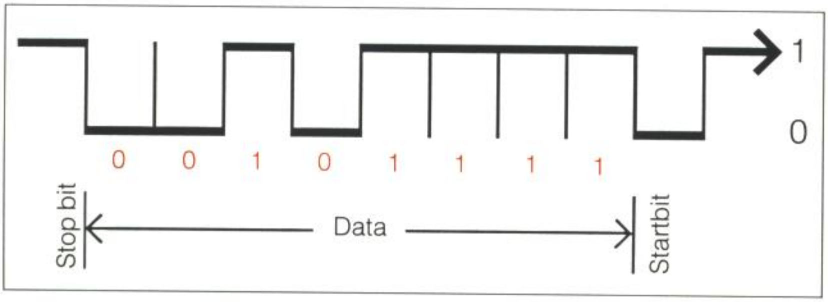
In order that the proper decoder reacts to the commands, it must "know" whether or not the information is intended for it. The transmitted information must therefore contain an address in addition to the control command. Therefore, a complete unit of information always contains two sets of data:

- the address (who is the command for?)
- the command (what is to be done?)

If this information transfer is to be successful, the sender and the receiver must be in tune with each other, i.e. they must "speak the same language". Otherwise, communication is not possible.

Not only is the same language important, there must also be a reliable transmission of the information. The fewer characteristics there are to differentiate, the more reliable this transmission is. For example, five

*Diagram of a byte (8 bits)*




*ill. 2*

different levels of voltage are more difficult to differentiate than the two extremes "current on" and "current off".

For this reason, it was decided during the design phase of the Märklin Digital system to limit it to only two "conditions", namely "positive voltage" (approx. +20 volts) and "negative voltage" (approx. −20 volts). In technical terms the expressions "1" or "high" are used for the positive voltage and "0" or "low" for the negative, i. e. no voltage. The terms "1" and "0" will be used from here on in the text.

## The question immediately arises:

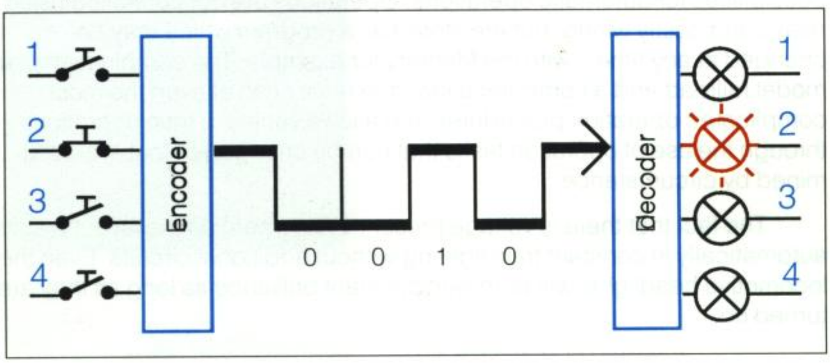
## How can a model railroad be controlled with only "0" and "1"?

The two conditions "0" and "1" are the smallest units of information. They are called a "bit". A series of eight bits makes up the next larger unit of information, the "byte". Several bytes together make up a complete set of information (see illustration 2).

Of course, all of these signals (bits) cannot be sent or received simultaneously on a conductor. For simultaneous transmission, a separate wire is required for each bit. The technical term for this type of transmission is "parallel". With the Märklin Digital system, only two conductors are available as information carriers, namely the running rails and the center studs. Therefore, the "bits" must be sent one after the other. This form of transmission is known as "serial".

Each position or place in this series of bits has a specific meaning, a place value so to speak, and is responsible for a particular function.

*Principle of parallel-serial change (for 4 bits of information)*




*ill. 3*

Suppose, for example, that the sender wants to transmit information for the control of a locomotive. It must also transform the setting of the speed control knob on the Control 80 (which closes and/or opens contacts using a slider in the interior of the unit) and the entered locomotive address into a series of "bits". This transformation makes it possible to do additional processing in the Digital system. This is called encoding. This "parallel-serial" change is depicted in illustration 3. It is one of the tasks of the microprocessor in each control component.

On the other side, at the decoder/receiver, the serial information is changed back into parallel switch settings and analog voltages for locomotive and turnout control. This is called decoding. The "Märklin-chip" in the decoder takes care of this conversion. It also compares the address part of the information with the address set on the coding switches of the decoder and transmits commands to be carried out only if the two addresses agree.

## What are the advantages of digital model railroad control?

The advantage of this form of control is that in principle "everything" is on a single circuit. Every locomotive receives the same information through the rails and center stud contacts as the decoders for the solenoid accessories. The amount of wiring required decreases considerably as a result. Wiring is done over short distances – even for turnouts and signals. The wiring is thus easier to keep track of. Voltage drop due to long wires is no longer a problem. Isolated sections of tracks are no longer needed on densely operated sections of a layout, at locomotive maintenance facilities with a turntable, locomotive sheds and servicing tracks or in a freight yard, for example. This results in a savings in feeder tracks and relays and/or switches.

The microprocessor technology of the Digital system offers new possibilities for automatic operations. Operations are not controlled using relays and costly wiring, but are stored as a program which may be changed at any time – with the Memory for example. The combination of a model railroad and a computer allows the realization of even the most complicated operation procedures and allows variety in train operations through the use of operation tasks that can be changed or that are determined by circumstance.

The fact that there is voltage present everywhere on the layout results automatically in constant train lighting without additional circuits. Even the locomotive headlights will burn with constant brilliance as long as they are turned on.

## The components of the Digital system

The Märklin Digital system is a form of model railroad control built on a modular approach, i. e. there are special components for different functions which can be connected together in a row. The Digital system can thereby grow with the model railroad. This means control components can be set up to suit individual wishes and requirements. Functions which are not needed do not have to be purchased with the modular approach to the system.

The Central Unit, Central Control and the digital control components will be introduced individually in the following sections.

## The Central Unit

The Central Unit (see illustration 4) is the heart of the Märklin Digital layout. The CPU (CPU = **C**-entral **P**-rocessor **U**-nit) is housed in it. Its task is to receive information from all of the control units, coordinate this information and send it out to the layout as control commands.

The manner in which the CPU functions is not determined by relays, switches or wiring (hardware) but by the program (software) in the program memory. This program is permanently stored and can not be forgotten when the Digital layout is turned off. It contains processing instructions for all of the Central Unit's control and coordination tasks.


*ill. 4* *The Central Unit no. 6020*

## Hookup

The control and switching requirements for all control units come together and are coordinated at the Central Unit. The control units are:

- Control 80
- Keyboard
- Switchboard
- Memory
- Computer (using the Interface).

The control units can only be connected to the Central Unit in a particular fashion:

- Control 80 and the Interface on the right side
- Keyboard, Switchboard and Memory on the left side.

The system is protected by the configuration of the multi-pin connections against connecting control units on the wrong side of the Central Unit. This allows the components to be connected up only on the correct side.

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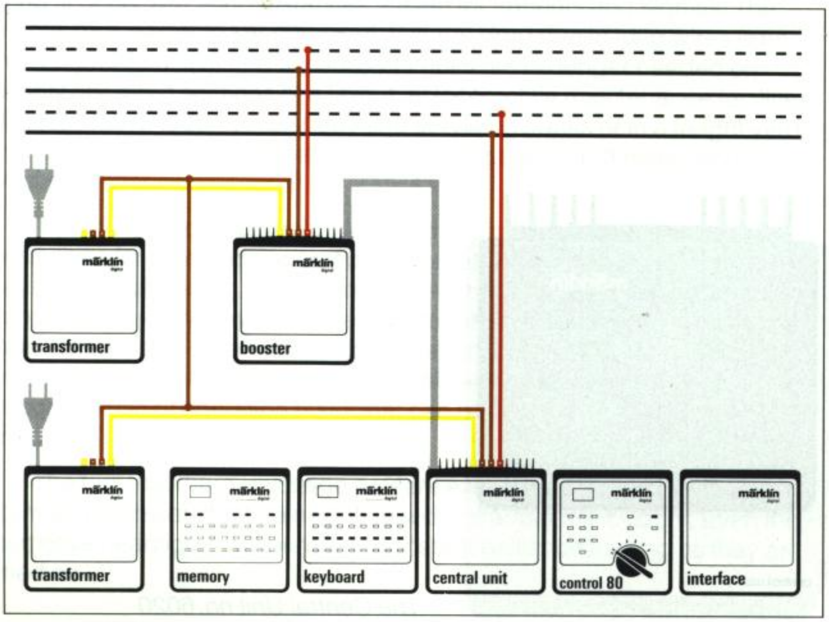
*Hooking up the Central Unit*
*– Connection to the Control Units*
*– Connection to the Transformer and Booster*




*ill. 5*

It is a fundamental rule that the main house current be turned off (pull the transformer plugs) when connecting or hooking up a control unit or decoder. Failure to do so may cause damage or malfunctions in the components.

The Central Unit is linked to the control components by means of the "Digital bus" (this is the collective term for the electrical conductors which pass through the Digital control units). This digital bus contains conductors for providing power to the control units and it contains the IIC bus over which the data and addresses are transmitted serially as well as conductors for the parallel transmission of "emergency stop" and "release" commands. When the control units are plugged together, these conductors are automatically connected by means of the multi-pin side connections located on each unit.

The Central Unit receives the energy it needs to supply power from the transformer by means of a yellow and a brown wire which are connected to terminal clips of the same colors on the back of each unit.

The output provided by the Central Unit to the layout is approximately 45 VA note: 1 VA = 1 watt) and is available at the red and second brown terminal clip on the rear of this unit. Power and control information are sent from here through a feeder track or through separate wires to locomotives, car lighting, turnouts, signals etc.

If the output of the Central Unit is insufficient for the layout, a Booster can be used to provide an additional 45 VA (35 VA in the USA). It receives control signals from the Central Unit by means of a special 5-conductor cable which is connected on the rear of the two units. The Booster receives its power from a second transformer. In the event that the layout needs still more output, additional Boosters can be hooked up.

## Calculating the power requirements of a model railroad layout

The Digital system will function reliably only when there is sufficient power for the layout. The output of the Central Unit is limited to a maximum of 2,5 amps by a protective electronic circuit. This corresponds to an output of approximately 45 VA at 18 volts.

The protective circuit will shut off power to the layout as in the case of a short circuit if the users connected to the Central Unit consume more power.

The power requirements of a model railroad layout consist of the following:

- locomotives in operation (5 to 10 VA according to the size of the unit and the length of the train it is pulling)

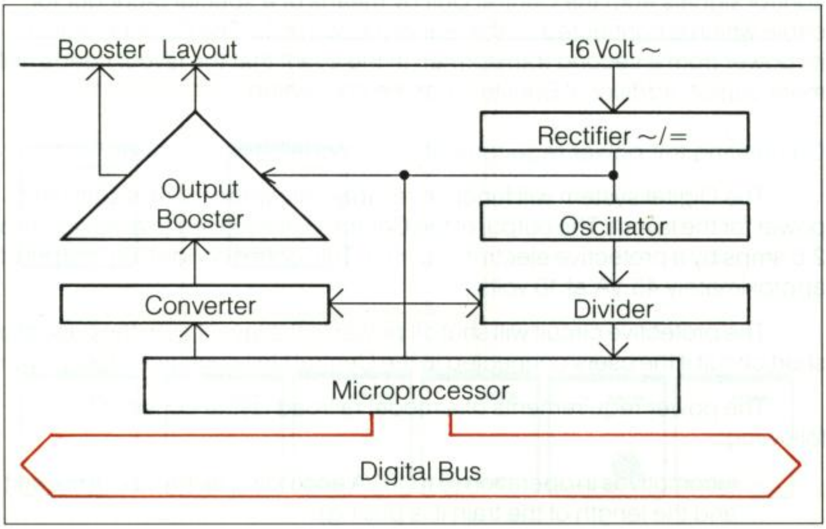
- locomotives standing still (non-illuminated, 0 VA; illuminated, approximately 3 VA; with smoke or TELEX function switched on, approximately 8 VA)
- illuminated cars (approximately 1,5 VA per bulb)
- signal and turnout lanterns (approximately 1,5 VA per bulb)
- switching current for solenoid accessories (approx. 6 VA at the moment of activation, up to 9 VA with older turnouts and signals)
- current for working models (example: approx. 10 VA for the turnable, approx. 5 VA for the crane)

When a large number of control components are connected to the Central Unit, this reduces the amount of output from the latter accordingly. Each control component consumes approximately 2 VA for data processing and illuminated indicators.

## Operation

The Central Unit has no operating elements. After the layout is turned on, a red LED on the Central Unit indicates that it is ready for operation. This LED will go out in case of a short circuit or emergency stop and current to the layout is interrupted. Power to the control components remains on during this time, so that the indicators remain illuminated and the locomotive's addresses that have been entered are not lost.

*Block wiring diagram of the Central Unit*




*ill. 6*

Operation can be restored with the "go" button after the disturbance has been corrected. Keyboards do not have this button and if they are the only control components connected to the Central Unit, operation can be restored by turning power to the Central Unit off and on.

## How the Central Unit functions

A description of the Central Unit's functions encompasses, practically speaking, the entire procedure for data processing in the Digital system. For this reason it is explained in a separate chapter "Function of the Digital system" (page 92) and only a block wiring diagram of the Central Unit is reproduced here (see illustration 6).

## Tips

On large layouts with a large number of control components and Boosters, the Central Unit should only be used for data processing and to provide power to the control components. Otherwise, there may be interruptions in the data processing during peak use periods (example: switching a balky turnout or a momentary short circuit).

If the first user, a feeder track or decoder panel, is relatively far from the Central Unit or Booster, it is recommended that a larger diameter of wire should be used. Voltage losses due to longer wires are avoided to a large extent in this way.

## The Control 80


*The Control 80 no. 6035* *ill. 7*

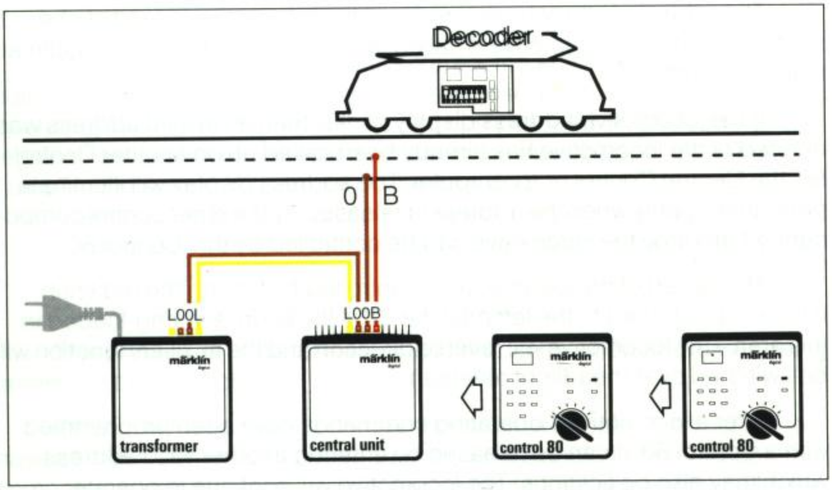
The Control 80 is the control component for locomotives. Up to 80 locomotives can be called up and controlled independently of each other with it.

### Hookup

With the layout turned off (pull the plug on the transformers!) the Control 80 is plugged in on the side of the Central Unit using the former's multi-pin connector (see illustration 8). On the right side of the Control 80 is a socket connection into which additional Control 80's or the Interface may be plugged. Up to ten Control 80's can be connected to the Central Unit in this manner or up to nine may be connected to the Central Control (see page 49).

The plug and socket connection creates all of the necessary electrical connections to the other components of the Digital system. In contrast to the transformers with speed controls in the conventional model railroad control system, a Control 80 has no direct connection to the track.

The plastic clips included with the Control 80 are used to prevent the unit from accidentally becoming disconnected from neighboring components. The clips fit into the slots on the bottom of the housing. The open plug connection on the right side of the Control 80 should be covered with the plastic cap included with the Central Unit to protect against disturbances when no additonal Control 80's or the Interface are to be hooked up.




ill. 8

*Plugging the Control 80 into the Central Unit*

## Operation

When the Digital layout is turned on, the number "99" flashes briefly on the indicator display of the Control 80. That is the signal that the Control 80 has received its internal address from the Central Unit or Central Control. It therefore does not need to have an address set using a row of coding switches. This procedure is repeated automatically each time the layout is turned on or reset.

The address of the locomotive to be controlled is entered using the ten-digit keyboard on the control panel of the Control 80. The locomotive is called up in this way. 01 to 80 are valid addresses. All locomotives addressed must be entered as two-digit numbers.

### Calling up the locomotive with the address "07" occurs as follows:

- press button "0"
- the number "0" now appears in the ten's position on the address display (a locomotive address that was already on the display is erased)
- press button "7"
- the number "7" now appears in the one's position on the address display

The address is thereby entered and the locomotive is ready to be controlled. When a locomotive is called up, the auxiliary function is automatically shut "off".

If the locomotive address display blinks, then an invalid address was entered or the locomotive has already been called up on another Control 80, the Central Control or a computer. The address display will illuminate permanently only when the address is released by the other control component. At this time the locomotive can be controlled by this Control 80.

The speed of the locomotive is controlled by turning the red knob. If the knob is turned to the left past the "0" – the knob is spring-loaded in this area – the locomotive will reverse direction and the auxiliary function will be switched over (headlight reversal).

After a locomotive's operating commands have been programmed with a Control 80, it can be released by entering another valid address which may also be fictitious. The locomotive will continue to operate according to its programming until it is called up again (ignoring the control functions exercised by signals). Now the next locomotive can be directly controlled or can be released after its programming has been entered.

With this sort of Digital system design, you only need as many locomotive controllers as the number of locomotives you want to control independently of each other at the same time. The number of locomotives that can be run simultaneously is not crucial in determining the number of locomotive controllers to be used.

In addition to direction and speed, the locomotive decoders can also control an auxiliary function. For most locomotives this function is controlling headlights. TELEX couplers, smoke generators, interior lighting, locomotive horns, etc. are also possible. This function is switched on and off with the "function" and "off" buttons on the control panel of the Control 80.

During operation on a model railroad it is possible to have a collision occur. This can be avoided at the last minute with an emergency stop of the locomotives/trains. The "stop" button is used to accomplish this. When it is pressed, power to the layout is shut off, so that all locomotives/trains come to an immediate halt. Turnout lanterns and lights which are hooked up to the Digital layout are also shut off. The internal data processing in the entire Digital system and all indicator displays continue to function. In this operating condition the address called up with the Control 80 can be changed. The "go" button restores power to the layout. Operation on the layout is continued. In the event of an overload or short circuit, the Central Unit or Central Control shuts off all power to the layout. After the problem is corrected, power is restored with the "go" button.

## Tips

When a locomotive address is entered, the auxiliary function is automatically set at "off". For example, suppose locomotive "03" has been operating at a certain speed with its function switched on and you want to regain direct control of it without the function being turned off and without a "jump" in the speed. You should do the following:

- enter "0" in the first position of the locomotive address
- press the "function" button and set the speed control knob for the locomotive's speed
- enter the second position of the address ("3").

This procedure is useful most of the time, when a new address is being entered at the Control 80.

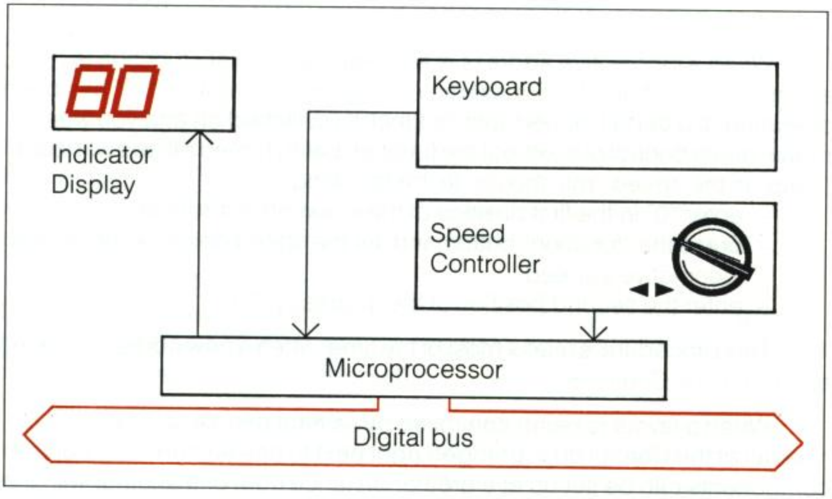
When a layout is being controlled by several people, it is best not to have all of the Control 80's arranged right next to one another. The control components can be set up at a greater distance from one another with the help of the Adapter 60 and Adapter 180. The following should be observed:

- the total length of all adapter cables should not exceed 6 meters (approx. 19½ feet) due to a capacitor effect that takes place in the cables at lengths greater than this.
- if the adapter cable is longer than needed, it should never be rolled or coiled up, but rather laid in a loop.
- due to the possible disruptive effect of foreign electrical impulses, the adapter cable should not be laid next to the house current wiring in the room or directly under 7072 control boxes. Wrapping the adapter cable in aluminum foil and grounding the foil can help prevent this problem.

## How the Control 80 functions

When the Digital layout is turned on, each Control 80 receives its software address from the Central Unit or Central Control in a series from left to right.

The locomotive address, speed and auxiliary function are encoded by the microprocessor in the Control 80 in the data format of the IIC bus. When an address is entered, it is checked by the microprocessor to determine if it is a usable address. If so, it is transmitted serially together with the data for speed and auxiliary function and the individual software address to the Central Unit or Central Control. If the Central Unit/Central Control reports this address as already in use, then the locomotive address indicator display is switched to "blink". Approximately every second the address is checked to determine whether it is still in use and, if so, the display will




ill. 9

*Block wiring diagram of the Control 80*

continue to blink. The display will be illuminated constantly only when the address is reported as "free"; at this time the Central Unit/Central Control will accept operating commands and the address from this Control 80.

The control information is placed in intermediate memory in the microprocessor of the Control 80 and a new data transfer to the Central Unit or Central Control takes place only when there has been a change in the setting of the speed control knob or a change in the status of the auxiliary function.

The commands "stop" and "go" are transmitted in parallel, i. e. over their own data lines, so that these functions can be used at any time.

## The Keyboard

ill. 10


*The Keyboard no. 6040*

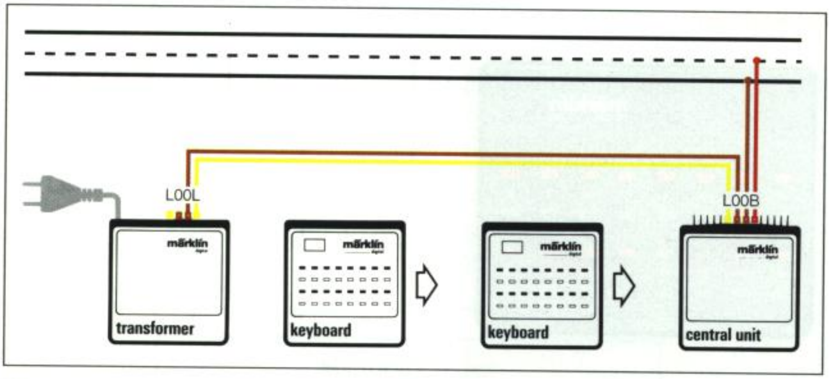
The Keyboard (see illustration 10) can control 16 turnouts, signals or switching functions which are activated using 16 pairs of red and green buttons. Decoders for the control commands of the Keyboard are the Decoder k 83 (for momentary impulse controls such as double solenoid mechanisms) and the Decoder k 84 (for continuous contacts such as lighting and operating models).

### Hookup

With the Digital layout turned off, the Keyboard is plugged into the left side of the Central Unit, Central Control, another Keyboard or the Memory (see illustration 11). All of the necessary electrical connections are automatically made by means of the multi-pin plug connections on the sides of the units. The Keyboard cannot be connected directly to the layout.

The Digital system allows up to 256 switching functions. All total, 16 Keyboards are required for this. The four coding switches on the rear of the Keyboard are used to give it an address from 1 to 16. This procedure is called "coding" and it establishes which function addresses (turnout, signal, etc.) a Keyboard is responsible for. So, for example,

Keyboard no. 1 switches the addresses 1 through 16,
Keyboard no. 2 switches the addresses 17 through 32,
Keyboard no. 3 switches the addresses 33 through 48, etc.



ill. 11

*Plugging the Keyboard into the Central Unit*

The switch settings for the Keyboard addresses can be found in the"Code Table for Keyboards and Switchboards" (see page 168). All Keyboards are set at the factory with the address for "1". Each Keyboard has a set of numbered stick-on labels to identify the address which has been given to the unit. They can be mounted in the rectangular depression on the upper left corner of the unit.

When several Keyboards are connected to a Central Unit or Central Control, it is not necessary to have them arranged in numerical sequence according to the Keyboard addresses. For example, the address "3" could be left out. A Memory unit for route control can also be placed at any desired position in the row of Keyboards.

## Operation

When the Digital layout is turned on, the Keyboard is ready for operation. Switching functions are activated by pressing the appropriate "red" and "green" buttons. The switching impulse lasts as long as the button is pressed.

The setting of turnouts and signals is indicated by a red LED. It is illuminated when the setting is "red" and is extinguished when the setting is "green". Uncoupler tracks and signals making use of a circuit track to return to the "red" need only one button. In cases such as these, two of these types of functions can be handled by a single pair of buttons.

A Keyboard's indicator display is changed when a switching command for a turnout or signal under the Keyboard's authority is issued by another Keyboard with the same coding, a Switchboard, a Memory or a computer.

All solenoid mechanisms requiring a short voltage impulse can be activated when used with the Decoder k 83. Examples are:

- turnouts (double solenoid)
- signals (double solenoid, sometimes also a third solenoid for green/yellow "HP2" [proceed with caution] indications)
- uncoupler tracks (single solenoid)
- operating models controlled by hand at a control panel (example: crane motors)

It must be remembered that only one switching function can be carried out at any single time on the Digital system due to the serial form of the information transmission.

The Decoder k84 is used for functions which must be switched on for longer periods of time. The following can be used with this decoder:

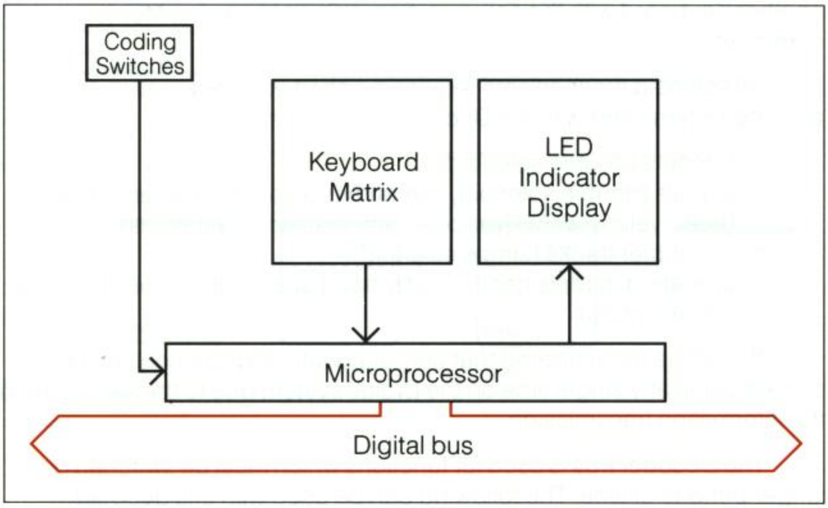
- turntable (motor and switching magnet)
- transfer table (motor and starting contact)
- crane magnet
- operating models needing continuous contact (examples: crossing gates, wind-mills, lighting, motorized switch machines, etc. See sections on applications)
- insulated blocks at signals (chiefly blocks out of view)
- color light signals without their own solenoid mechanisms
- reverse loop circuits for 2-rail systems

The section on applications in this book contains examples of the above with hookup and wiring plans.

## Tips

If a layout is being operated by several people, the Keyboards can be spaced further apart from each other so that the layout can be seen clearly from several control areas. Keyboards arranged in this way are connected to the other Digital components using the Adapter 60 or Adapter 180. Do not forget that Keyboards are connected to the left of the Central Unit/Central Control.

With larger layouts and more than one person operating them, it may be useful to have two Keyboards coded for the same addresses. They are then responsible for the same control functions. For example, turnouts and signals in blocks commonly used by more than one train can be controlled by both individuals operating the two Keyboards.




ill. 12

*Block wiring diagram of the Keyboard*

When the Digital system is in the "emergency halt"condition, a turnout can still be set. The switching command that has been entered is stored in the Central Unit or Central Control and is carried out immediately after the "go" command has been given.

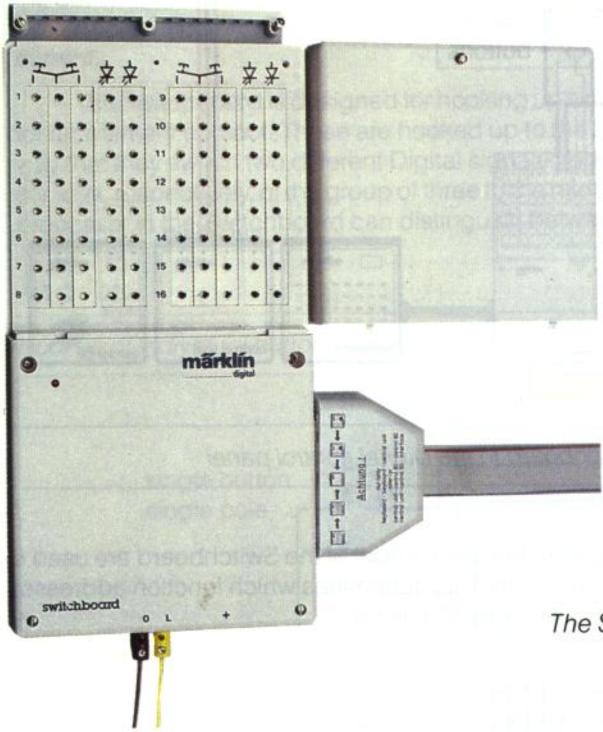
## How the Keyboard functions

When a switching request is made by pressing a button, the information, example: "red button for turnout 6 pressed", is encoded by the microprocessor of the Keyboard into the data format of the Digital system. It is then transmitted serially together with the address set on the coding switches of the Keyboard to the Central Unit or Central Control.

After this switching request is carried out, the Keyboard receives an acknowledgement signal (example: turnout 6 set to red) from the Central Unit. Only then is the corresponding LED display indicator switched over to the new setting.

A built-in buffer battery insures that the settings for turnouts and signals are stored even when the Digital layout is turned off. When the layout is turned on, you can see at a glance what their settings are on the Keyboard.

## The Switchboard

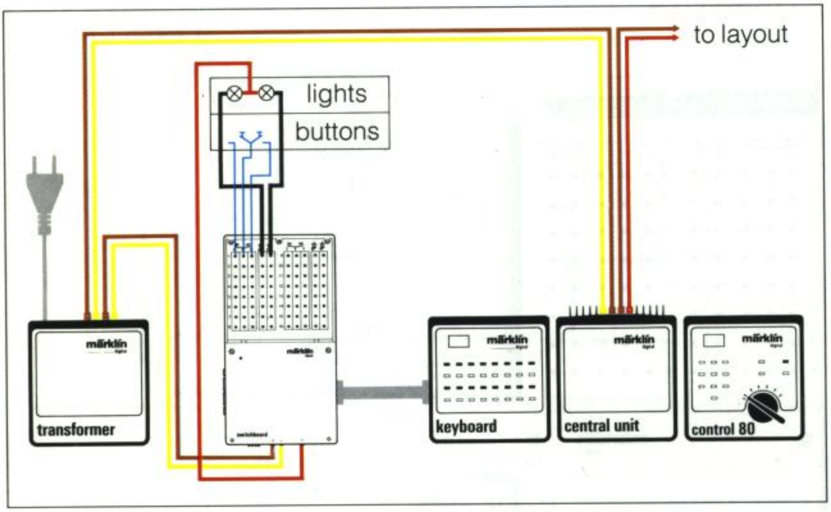



ill. 13 *The Switchboard no. 6041*

Like the Keyboard, the Switchboard can control 32 switching functions. This corresponds to 16 turnouts or signals with their two settings. The Switchboard has no operating or indicator display elements of its own, as it is conceived of as a link to track diagram control boards.

### Hookup

The Switchboard can replace a Keyboard. It has been designed extremely flat for possible installation in a track diagram control board and therefore cannot be directly connected to other Digital components. The adapter cables no. 6038 (180 cm or 71 inches) and no. 6039 (60 cm or 23½ inches) are used to make the connection with the Central Unit or with other Keyboards. When hooking up the Switchboard, do not forget to turn off the power (pull the plug(s) on the transformers!). The Switchboard is connected to the left of the Central Unit or Keyboards (see illustration 14).



ill. 14

*Hooking up the Switchboard to the Digital control panel*

The four coding switches on the front of the Switchboard are used to give it an address from 1 to 16. This determines which function addresses (turnouts, signals, etc.) it is responsible for.

Switchboard
- No. 1 switches addresses 1 to 16
- No. 2 switches addresses 17 to 32
- No. 3 switches addresses 33 to 48, etc.

The Switchboard has five sockets for each switching function (turnout, signal, etc.) and they accept Märklin-plugs. Three of the sockets are for hooking up pushbuttons and two are for connecting indicator displays using light bulbs or LED's. A combination of both types of displays is possible.

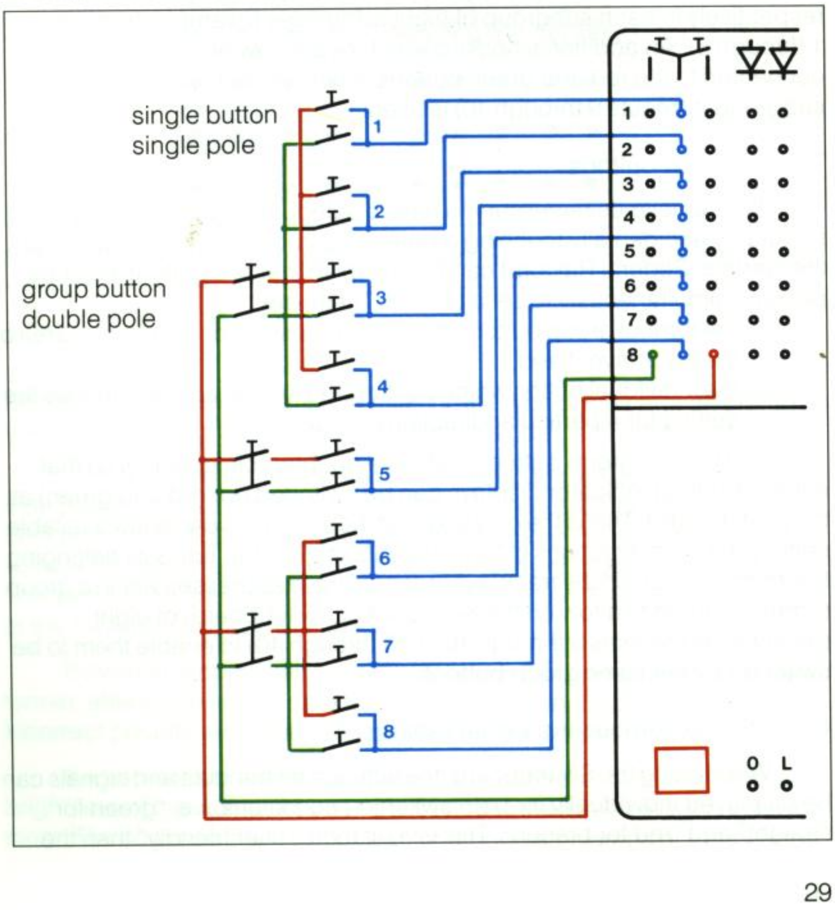
## Hooking up the push-buttons

With a conventional system the solenoid mechanisms of turnouts and signals are usually connected to the ground side of the accessory circuit (brown wire) by means of the buttons. This is done either with a 7072 control box, the buttons on a track diagram control board or by a train passing over a circuit track. With a conventional system all buttons are powered by a single line. Even the 7072 control boxes can be connected to each other, one after the other, without additional wires.

Hooking the buttons up to the Switchboard takes a somewhat different approach. In this instance the turnouts are no longer switched directly by the buttons, rather, the button merely produces a switching request to the Switchboard. For this situation the buttons need only the smallest amount of current.

The Switchboard is designed for hooking up single-pole push buttons for momentary contact. These are hooked up to the Switchboard in such a way that they switch two different Digital signals from the right and left sockets, respectively, of the group of three to the middle socket. The micro-processor in the Switchboard can distinguish between these different

*Hookup of individual buttons to the Switchboard*




*ill. 15*

signals and switch the turnout for the desired setting. The buttons on the Switchboard must be powered by <u>different</u> wires when they are connected to the Switchboard.

### What does this mean for the wiring of the track diagram control board?

Actually, a pair of buttons for each turnout would have to have their own three wires connected to the Switchboard. This wiring plan is the most reliable (see illustration 15).

If a logical order is maintained in wiring a track diagram control board, fewer wires can be used. That is to say, it is not necessary to have a separate set of wires from the Switchboard to receive the control voltage for each turnout. The outer sockets of the set of three for each turnout or signal are connected in perpendicular rows to each other and it is therefore sufficient to have one hookup wire per row of sockets for the red and green buttons respectively in each subgroup of eight addresses (example: turnouts 1 through 8). An additional hookup wire for each row of outer sockets connected to the red and green buttons is not needed until the next subgroup (turnouts 9 through 16) is used.

### Turnout group buttons

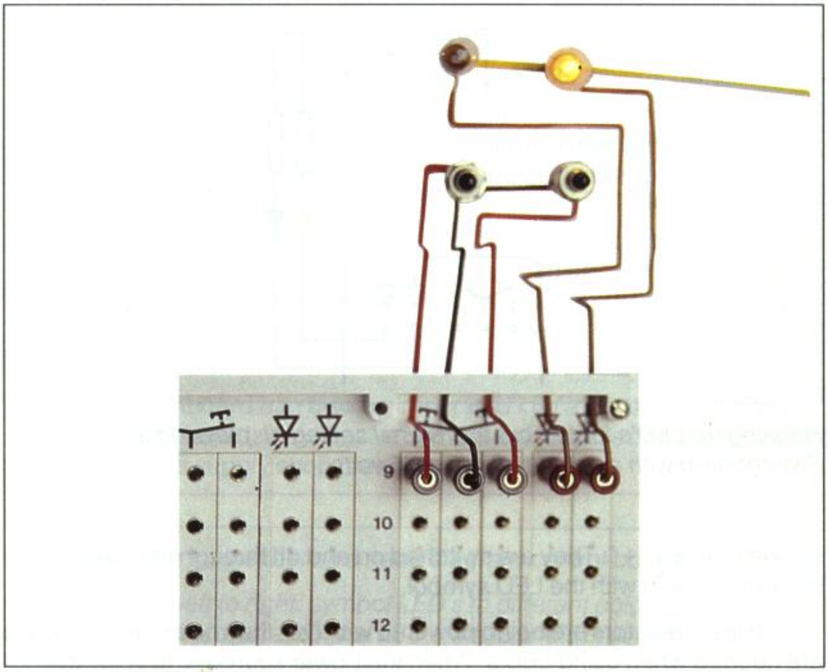
It is sometimes necessary to have a safeguard against setting a turnout by accidentally touching a button. Push-button control panels on the German Federal Railroad can be set up so that two buttons must be pressed simultaneously to set a turnout. These are:

- the turnout group button which is responsible for a particular area of the track layout and,
- the individual button which controls the turnout and determines the setting for a particular direction of travel.

The turnout group button must have double-pole contacts so that different setting indicator displays can be switched (for red and green) at the Switchboard. This is the only way that the indicators can show available settings for both directions of travel (see illustration 15). Turnouts belonging to a related group on the track layout should have addresses within a group (corresponding to a row on the Keyboard or Switchboard) of eight (example: addresses 9 through 16 or 33 through 40) to enable them to be switched by the same group buttons.

### Indicators for turnout and signal settings

When using the Switchboard, the settings for turnouts and signals can be displayed individually for both switching conditions, i. e. "green for straight" and "red for branch". This is a bit more "user friendly" than the




ill. 16

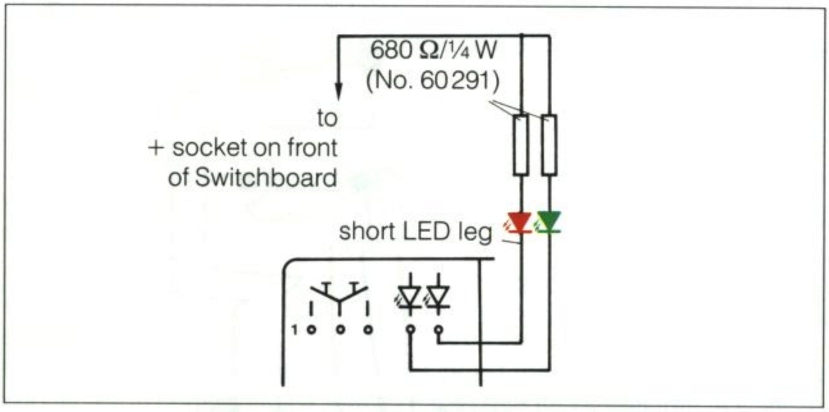
*Basic wiring diagram with light bulbs which is similar to the switching plan*

Keyboard. Likewise, you are not limited in the type of indicator display to be used; miniature light bulbs or light emitting diodes (LED's) can be used.

The indicator display elements hooked up to the Switchboard receive their power from an external source. The existing 6631/6627, 6671/6667 or 6611 (substitute 6001 in the USA) transformers can be used for them. The voltage for this external power source can be as high as 16 volts AC or DC. The transformer is connected to the sockets marked "0" and "L" on the front of the Switchboard (see illustration 17).

If the indicator display on the Switchboard is connected to a DC transformer, attention must be paid to correct polarity in the connections. Incorrect polarity will result in no power from the socket market "+".

If a transformer with a rheostat voltage controller is used, then the brightness of the indicators can be adjusted to the available lighting for the room. The common source of power for all indicator lamps or LED's is the




ill. 17

*Hooking up LED's for turnout and signal setting displays on a Switchboard with a power source of 16 volts.*

socket marked "+". They are switched on and off through the pair of sockets marked with the LED symbol.

If the indicators are being powered with DC, than no protector diodes are needed when using LED's. When the power source is 16 volts, the barrier resistor (680 ohms) is absolutely necessary.

## How the Switchboard, Keyboard and Memory function together

The Switchboard's connection to the central IIC bus enables it to "listen in" on what commands are being sent by other control components and what acknowledgement signals the Central Unit or Central Control is sending back. As a result of this, the Switchboard changes the position indicator display for a turnout or signal, when the switching command is sent out by a Memory or Keyboard. The change in the indicator display takes place only when the Central Unit sends out a signal confirming that it has carried out the switching request of the Keyboard, Switchboard or Memory.

When a Memory is integrated into a track diagram control board (using the s88 track detection module and external buttons), the Switchboard serves as a control device for individual turnouts. The LED's hooked up to the Switchboard can be used as an illuminated display of the routes set by the Memory.

Like the Keyboard, the Switchboard, in conjunction with the track diagram control board, can be used to program the Memory.

## Tips

On larger layouts operated by several people, several Switchboards can also be coded for the same addresses in order to allow areas of track used by more than one train to be jointly controlled and overseen. In this instance the indicator displays on the track diagram control boards will likewise cause all Switchboards to report the current condition of the layout.

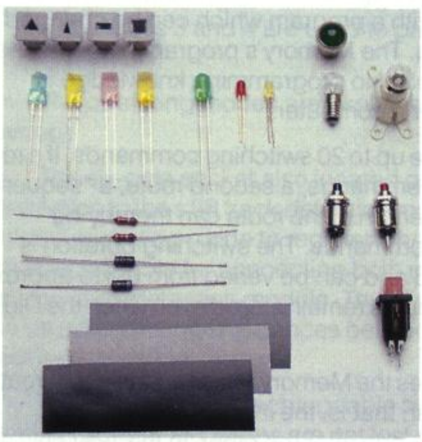
If the adapter cable used to connect the Switchboard to the Digital system is too long, it should not be coiled or rolled up. It should be laid in loops. The distance between these cables and control buttons (example: 7072) connected to conventionally operated users should be as great as possible to prevent electrical interference from the latter.

The Switchboard can also be integrated into a scratch-built track diagram control board. Inexpensive components for this can be purchased at an electronics supply shop (see illustration 18).

---

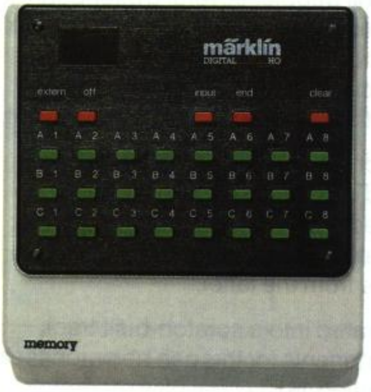
*Components for an inexpensive track diagram control board:*

*upper row from left to right: symbol LED's in different colors and versions with installation hardware, normal LED's with 5 and 3 millimeter diameters, light bulbs with base and glass lens.*
*middle row: protector diodes (1N4001 or other values) and barrier resistors (680 ohms, 0.25 watts), single-pole buttons.*
*lower row: self-adhesive sheets in different shades of gray (to differentiate between main and branch lines) and a double-pole button with built-in LED as an indicator.*



*ill. 18*

## The Memory




*The Memory no. 6043* *ill. 19*

The Memory is a route controller. It stores combinations of turnouts and signals in the form of a program which can be changed at any time. The routes can be called up in two ways: manually using the buttons on the Memory or automatically using train-controlled contacts on the layout.

### What can the Memory do?

Using the most modern microprocessor technology, the Memory can switch and store 24 routes. Assembling the turnout and signal settings into a "route" is done on the Memory with a program which can be changed at any time without changes in wiring. The Memory's programming, i. e. the storing of commands, is very simple. No programming knowledge is needed for it such as is needed for a computer.

Each separate route can have up to 20 switching commands. If a route requires more than 20 switching commands, a second route, a "sequential route", can be attached to it. The length of the route can thereby be expanded beyond 20 switching commands. The switching duration is individually set for each command and can be varied from 0.3 to approximately 3 seconds. Programmed routes remain stored even when the Digital layout is shut off.

Pressing a route button causes the Memory to call up the entire route. This occurs in a sequential manner; that is, the individual switching commands are carried out quickly, one after the other. In this way only a single impulse draws current from the layout's power supply at time. An overload caused by switching many turnouts simultaneously is thereby avoided.

A route can contain all of the switching processes that can be integrated into the Digital system (and that can accordingly be connected to a k 83 or k 84 decoder, i.e. turnouts, signals, uncoupler tracks, relays, crossing gates, etc.). This allows elaborate programs for railroad control with the Memory. Direct control of locomotives is not possible with the Memory.

The routes stored in the Memory can be activated or requested by trains in operation for partially or fully automatic operations. The impulses from circuit or contact tracks are registered by the track detection module and passed on to the Memory.

Activating routes from the layout is designated "extern". On the Memory this external activation of the switching functions can be turned on with the button marked "extern" and off with the button marked "off". It is a very simple and elegant solution for switching the layout from manual to automatic operation.

## Hookup

The Memory is plugged in to the left of the Central Unit, Central Control or a Keyboard as shown in illustration 20. The Memory and Keyboard units can be set up in any order desired.

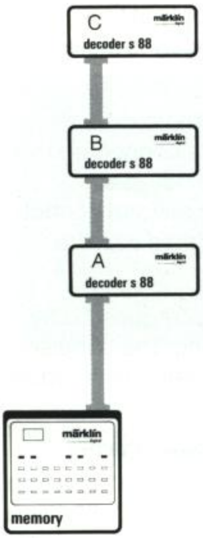
On the back of the Memory is a set of four micro switches. They have two functions in the Memory:

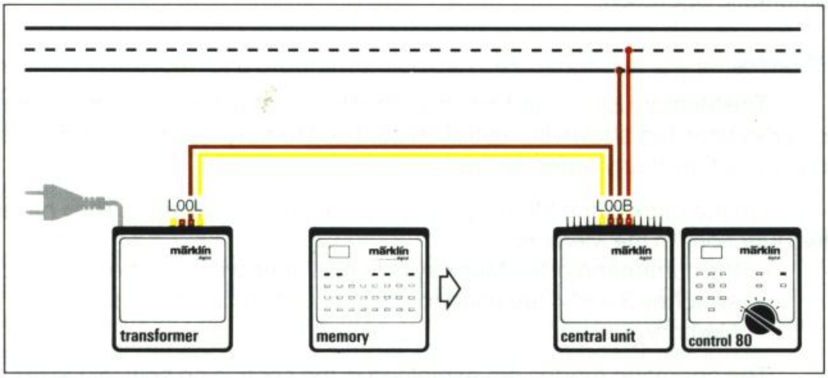
- the numbering of the Memory (1 to 4) is done with switches 1 and 2.
- switches 3 and 4 are used to preselect operating modes on the Memory.

The operating modes are explained in the section on how to use the Memory.

The six-pole socket also located on the rear of the Memory is for connection to the s 88 track detection module. It enables the Memory in the "extern" operating mode to register when a route is requested by a train. The special cable for connecting both units (Memory and s 88) is included with the track detection module. The 200 cm (78¾ inches) no. 6089 cable can be used for longer distances between the memory and track detection modules.

The Memory has a rechargeable battery for its program storage circuit so that programmed routes are not lost during long breaks in operation.




ill. 20

*Hooking up the Memory to the Digital layout*
*Hooking up the s 88 track detection module to the Memory*

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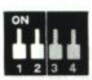
*The set of four micro-switches on the back of the Memory*




ill. 21

When the layout is in operation, this battery is constantly being charged. When the Memory is used for the first time, the battery should be charged for approximately 48 hours.

## Operating the Memory

When the Digital layout is turned on, all of the LED's on the Memory flash briefly. After that only the LED's for "extern" and "end" will still be illuminated. If there are routes already stored in the Memory, they can now be called up with buttons "A1" through "C8". When the Memory has switched on a route, the red LED for the corresponding route button will be illuminated, indicating this condition. The route is now "valid".

## Programming a route

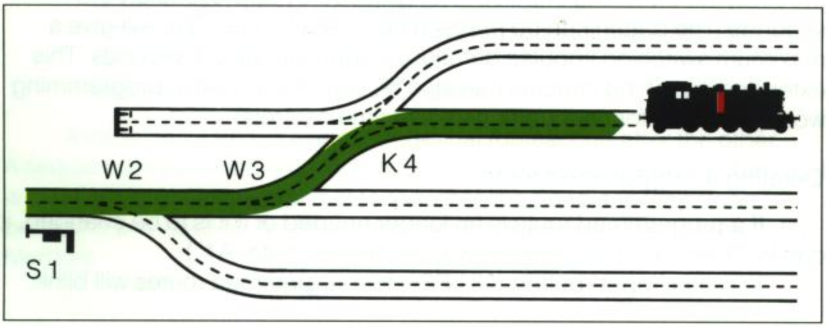
The programming of a route, i. e. the entering of those settings and switching commands that make up a route, is done with the aid of the Digital control panel:

- Keyboard
- track diagram control board through the Switchboard
- computer through the Interface

The following example shows how easy it is to program the Memory:

In the diagram (illustration 22) of a section from a model railroad, route "A1" is supposed to switch the entry into track 3 of the station. To do this, turnout 2 must be set for the straight, turnout 3 for the branch and double slip switch 4 for the branch. Then signal 1 can permit entry into the station.

*A section of a sample station layout*




*ill. 22*

The following steps make up the programming for route "A1":

- press the button marked "input" on the Memory. The LED's for all the previously programmed routes will now blink.
- press the button marked "A1" on the Memory for the desired route "A1". The LED's for "input" and "A1" will now be illuminated constantly.
- press the following buttons on the Keyboard:
  turnout 1 green
  turnout 3 red
  double slip switch 4 red
  signal 1 green
- press the button marked "end" on the Memory and the entry is ended. The LED's for "off" and "end" are now illuminated.

After route "A1" has been programmed, it can be called up by pressing button A1 once. The switching processes for the route are carried out rapidly one after the other.

If a turnout or signal does not switch completely to the corresponding setting, the switching impulse for this solenoid accessory can be lengthened in duration. In our example double slip switch 4 of route "A1" will serve for the demonstration. The programming takes place as follows:

- press the "input" button on the Memory. The LED's for all previously programmed routes will blink again.
- press the "A1" button on the Memory. The LED's for "A1" and "input" will be illuminated.
- press the red button for double slip switch 4 on the Keyboard several times. The extended switching impulse will be transmitted automatically to the right spot in the route.
- press the "end" button on the Memory and thereby complete the entry/change.

Each time the red button for double slip switch 4 is pressed during this process, the switching impulse is lengthened by approximately 0.3 seconds. The button can be pressed up to eight times. This will give a maximum switching impulse duration of approximately 3 seconds. This extended switching impulse can also be used for the initial programming work (example: for uncoupler tracks or time controls).

### Deleting a programmed route

If a programmed route is no longer needed or if it is to be changed, it can be deleted in the following way (example: route "A1"):

- press "input" button. All LED's for programmed routes will blink.

- press "clear" button
- press "A1" button. The indicator display will jump to "end". The LED's for the programmed routes will stop blinking.

  Route "A1" is now completely deleted.

A second method can be used to delete a route in steps:

- press "input" button. All programmed routes' LED's will blink.
- press "A1" button. The LED for route "A1" is now illuminated constantly.
- press "clear" button. Each time this button is pressed, one step in the program (a switching command) is deleted starting from the end and working forward. If all of the steps are deleted, the indicator display jumps from "input" to "end".

If only some of the commands are to be deleted, then the deletion procedure can be broken off at any desired spot by pressing the "end" button. It is thus possible to delete only the last commands in a route in order to make changes. In this instance new commands are entered after deleting the old program steps.

## Programming a sequential route

Each route stored in the Memory can be called up as a sequential route of any other route in the same Memory. A route cannot be called up by itself.

A route can be programmed as a sequential route, if it still has one or more switching commands available in its programming. As an example route C5 shall be programmed as a sequential route of B2:

- press "input" button on the Memory. The LED's for all previously programmed routes will blink.
- enter switching commands for route B2.
- press the button for C5 on the Memory and thereby integrate route C5 at this position into route B2.
- enter other possible switching commands for route B2. These can be additional sequential routes.
- end the entry with the "end" button.

A route can call up several sequential routes, one after the other. A sequential route can be called up by several routes in the same Memory. It is possible to chain several routes together in an endless loop (loop program) and have an automatic operating sequence controlled with the Memory.

### The modes of operation

The Memory's different modes of operation can be preselected with switches "3" and "4" on the back of the unit. The settings for the switches are automatically read in when the Digital layout is turned on. They can also be changed during ongoing operation of the layout. In this instance the buttons "input" and "end" must be pressed causing the Memory to read in the new switch settings.

The "extern" and "off" buttons on the face of the Memory (see illustration 19) are used to set the Memory for manual operation or for external call-up of routes.

The following sections will explain the meaning and logical use of the different modes of operation for controlling a model railroad.

### Manual operation "without interlocking"

Switches "3" and "4" on the back of the Memory are set in the "off" position. The Memory is then in the direct, i. e. manually controlled mode of operation. In this mode routes called up are always switched on immediately by pressing a button. There is no way to check in the direct mode if another route has been destroyed or intersected by calling up a route.

This mode of operation is useful for switchyards, blocks controlled by circuit tracks, and for layouts operated manually. The various possibilities offered by the Memory for safeguarding operation of trains are not used in this mode.

### Manual operation "with interlocking"

If switch "3" on the back of the Memory is set in the "on" position, then the mode of operation "with interlocking" is switched on. Now the Memory checks before activating a route, whether this new route intersects an existing, valid route. If this is not the case, then the switching request is carried out. If it does intersect an existing route, then the switching request is not carried out. LED's of both routes blink, the existing and the requested route. If the button for the newly requested route is pressed a second time within approximately 10 seconds, the first route is set aside and the requested route can now be activated. If the button is not pressed a second time within this period, the request is deleted and the original route remains valid.

If the sequential routes are also to be included in this checking procedure, then switch "4" must also be turned on. The setting for this switch is read in the same manner as for switch "3". Sequential routes will now be activated only when they do not intersect other, valid routes. Sequential routes can also be used in this mode of operation to release previously activated routes, return all turnouts to their normal settings and return the signals to the stop aspect after the train has passed them.

## External operation of the Memory

With s 88 track detection modules the Memory can be controlled from the layout, i. e. using circuit or contact tracks. In this manner trains request or release routes.

Up to 3 track detection modules can be connected to each Memory. They enable the Memory to "learn" whether and when circuit tracks, contact areas, etc. have been activated by trains, and whether and when they are occupied (see illustration 20 "Hooking up the track detection modules to the Memory").

The track detection modules are continuously evaluated only in the "extern" mode of operation. This mode is switched on with the "extern" button and off with the "off" button. In the "extern" mode of operation the routes can also be set manually with the Memory buttons as well as be requested by the track detection modules.

The track detection modules are assigned to the routes in the Memory as follows:

- Track detection module A → Routes A1 to A8
- Track detection module B → Routes B1 to B8
- Track detection module C → Routes C1 to C8

A module's contacts are further divided by function (see illustration 23). The numbers 1 through 8 are the "request contacts"; routes are called up at the Memory using them.

Example:

A train passes over a circuit track connected to contact "5" of module "B". The contact is triggered thus causing route "B5" to be requested.

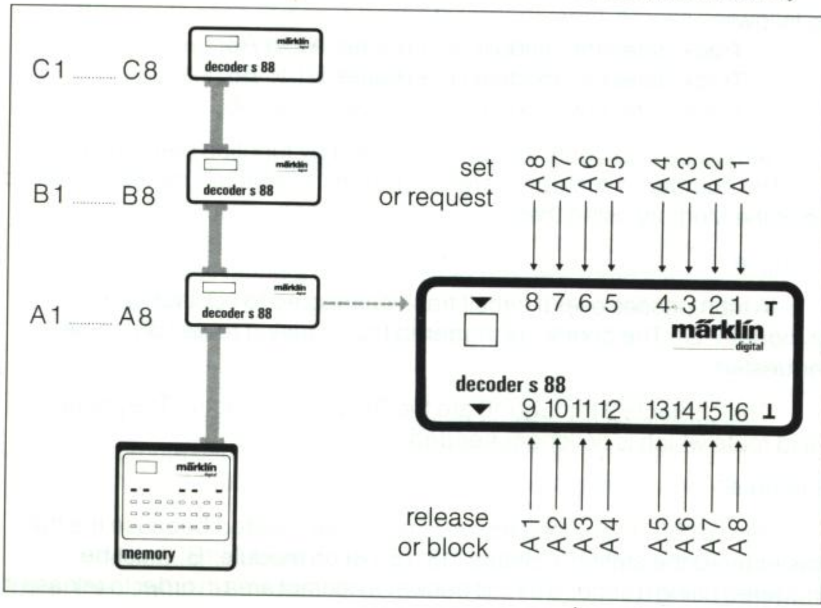
The contacts 9 through 16 are the "release contacts". They release a valid route which is no longer needed.

Example:

Route "B5" requested above is no longer needed because the train has entered the station. Contact "13" (5+8) on module "B" must be triggered using a second circuit track or a contact area in order to release it.

When the release contact for a route is already occupied by a continuous contact (ex. a train at a halt on a contact area connected to that contact) and a request is made for this route, the release contact blocks this request as long as it (the release contact) is activated. In this instance the request is not stored in the Memory. To be effective, the request must be repeated until the release contact is no longer occupied.

*Assignment of the track detection modules to the routes in the Memory*

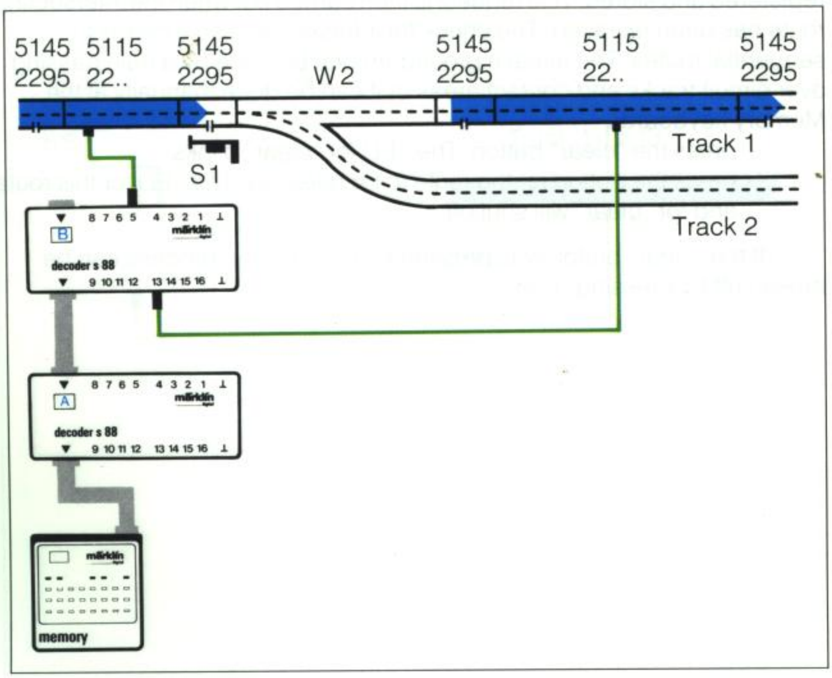



*ill. 23*

## Example:

A train is standing before the entrance signal to the station (illustration 24) and requests route "B5" by using contact area "B5" which is connected to contact "5" on module "B". Route "B5" leads into track 1. A second train is standing on this track in the station and it occupies contact area "B13" which is connected to contact "13" on module "B". This blocks the request for route "B5" and prevents entry onto the occupied track. Only after the second train has left the station and contact "B13" is no longer occupied, can route "B5" be set and the first train receives entry onto the now available track.

*A sample station layout*




*ill. 24*

### External operation "without interlocking"

Switch "4" on the back of the Memory is turned "off". Switch "3" is not needed for external operation, but it does influence operation in the "extern" mode when entries are made using the Memory keyboard panel (see above). All routes requested through the track detection modules are switched on in the order of the requests without regard to whether an existing route is destroyed or intersected.

Only a continuous contact at sockets "9" through "16" on the track detection modules can block the setting of a route. Sequential routes are always set in this mode of operation.

This mode of operation is especially suitable for block operation when it is controlled by circuit tracks (see example in the section on applications in this book, page 149).

### External operation "with interlocking"

The fourth switch on the back of the Memory is set in the "on" position. A request for a route is now carried out only if a valid route is not intersected or destroyed. In cases where there would be intersection, the request is registered and stored. This request is then carried out when the intersecting route has been released. The check for intersection also extends to sequential routes. The release procedure can be done by a train passing over circuit tracks and contact areas or it can be done manually at the Memory keyboard:

- press the "clear" button. The LED for "clear" blinks.
- press the button for the route to be released. The LED for this route and for "clear" will shut off.

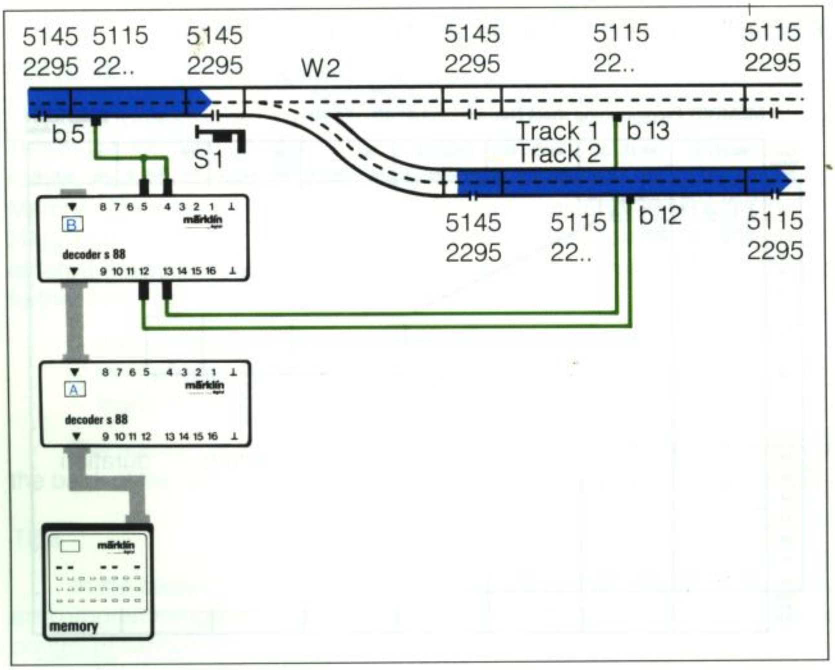
If the "clear" button was pressed by mistake, the process can be broken off by pressing "end".

Example:

Route "B5" from the example above calls up route "B6" as a sequential route; "B6" resets the entry signal to the "stop" aspect and the entry turnout to the "straight". The arriving train has requested route "B5" at the entry signal. Since track 1 was free, it was set. Route "B5" now requests "B6" as a sequential route. "B6" cannot be set, because the commands in route "B5" contradict it. Only after the train has entered the station and reached contact area "B13", "B5" is released, thus allowing "B6" to be switched.

Several routes can also be requested with one circuit track or contact area (see illustration 25). The Memory checks in the order from "A1" to "C8" which routes can be set. Requests that can be honored are carried out in the order given. This aspect of the Memory's design can be used to have it automatically select the entry to a free track from several possible tracks.

*Requesting several routes with one circuit track or contact area*



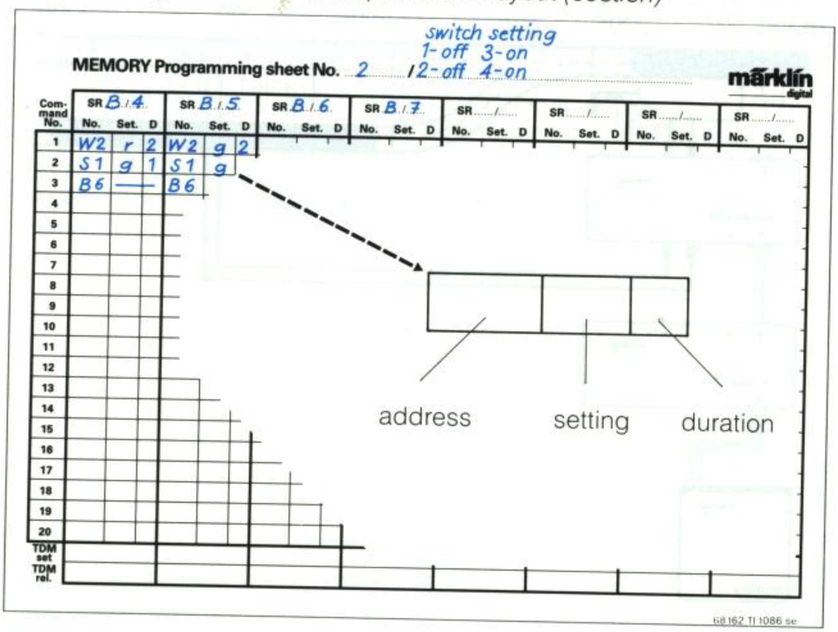

*ill. 25*

Example:

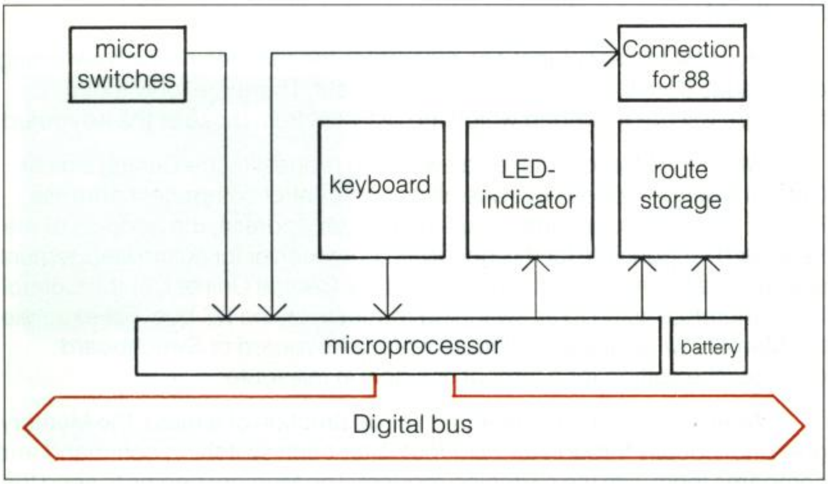
Contact area "B5" in the example of the sample of a station layout is linked with contact "4" in addition to contact "5" on module "B". An arriving train requests routes "B4" and "B5" at the entry signal. The memory checks in the order "B4" and "B5" which route may be set. Since a train is standing on track "2", thereby occupying contact area "B12", route "B4" cannot be set. Track "1" is free and thus entry to this track with route "B5" can be given. Both routes call up sequential route "B6" to reset the entry signal to the stop aspect and to set the entry turnout to the normal position.

With this system the Memory can be used to control staging yards having up to 22 tracks with entries and exits.

*Programming sheet for the sample station layout (section)*




ill. 26




ill. 27

*Block wiring diagram of the Memory*

## The programming sheet

The routes stored in the Memory should be documented in all cases. This helps when tracking down errors and with subsequent changes in routes. As a handy aid, programming sheets for this are included with the Memory. They are divided into 8 columns for routes and 20 lines for the 20 possible switching commands. Request and release contacts can be entered in 2 additional lines. The fields for switching commands are divided further into 3 boxes for:

- the address of the turnout or signal
- the switching position (r = red and g = green)
- the duration of the switching impulse (1 to 8).

The number of the Memory and the setting for the micro-switches on the back of the unit are entered at the top of the sheet (see illustration 26).

## Tips

In the section on applications on page 149 of this book are assembly and programming examples for using the Memory in manual and automatic control of various areas of a model railroad.

## How the Memory functions

How the Memory functions resembles the manner in which switching commands from the Keyboard are carried out. Therefore, only those functions will be described which are different from those of the Keyboard.

When the Memory makes a switching request to the Central Unit or Central Control, it does not transmit its own control component address. Rather, it transmits, in addition to the decoder address, the address of the Keyboard responsible for this decoder. As a receiver for acknowledgement signals, the Memory has the address of the Central Unit or Central Control. It can therefore listen to all switching requests on the IIC bus. For example, the Memory will erase a valid route when a Keyboard or Switchboard changes the setting for a turnout or signal in this route.

When checking for intersection or destruction of a route, the Memory goes individually through all valid routes for each switching command and compares them with the switching request. The Memory begins to send the switching requests to the Central Unit or Central Control only if no conflict with an existing route can be established.

The rechargeable battery built into the Memory guarantees the storage of programmed routes over several months. This battery is recharged each time that the model railroad layout is operated.

## The Central Control


ill. 28 *The Central Control*

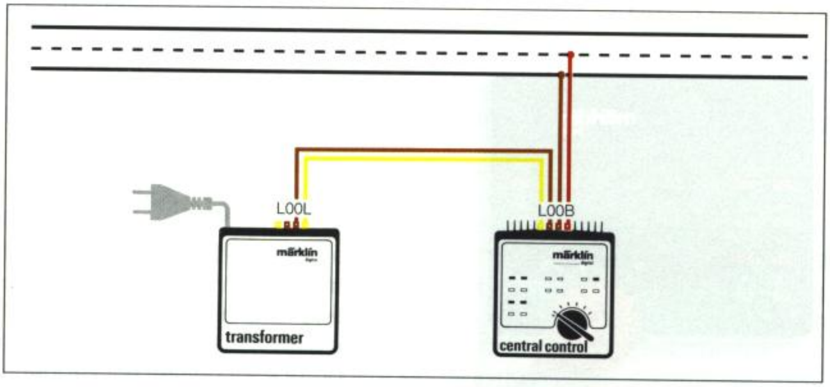
The Central Control is the compact control component of the Digital system. It combines the functions of the Central Unit with the potential to control 4 locomotive addresses and 4 turnouts. The Central Control can be combined with all Digital control components. It is offered only in the Digital starter set.

### Hookup

The output needed by the Central Control for data processing and for providing power to the model railroad layout is received from the transformer. The Central Control is connected to the transformer by a yellow and a brown wire which are connected to the terminal clips of the same colors on the back of both components.

The layout is connected to the red and the second brown terminal clip on the back of the Central Control. Locomotives, car lighting, decoders, turnouts, signals, etc. get their power and control information from here.

If the Central Control's output of 45 VA is not sufficient by itself, a Booster together with a transformer can be added for an additional 45 VA. The Booster receives control information from the Central Control over a special five-pole cable that is plugged in on the back of both units. Additional Boosters can be hooked up for larger layouts with a greater demand for power.




ill. 29

*Hooking up the Central Control to the transformer and the layout*

Other control components can be connected to the Central Control just as in the case of the Central Unit:

- Control 80
- Keyboard
- Switchboard
- Memory
- Interface as the link to a computer.

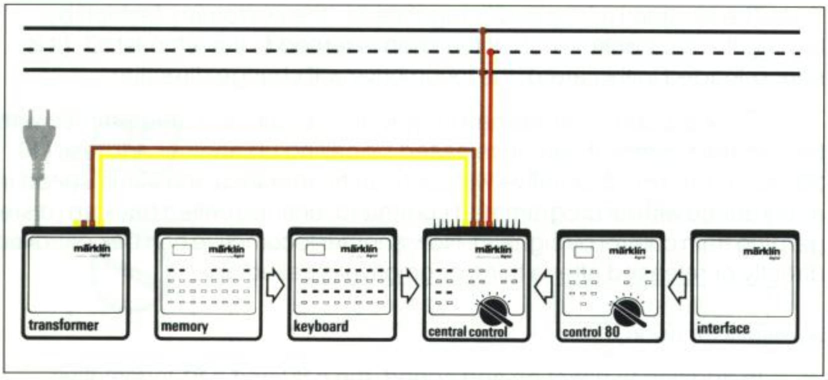
The plug and socket connectors on the sides of these components in the Digital system are arranged in such a way that various components can be plugged in only on the side of Central Control intended for them:

- Control 80 and Interface on the right side
- Keyboard, Switchboard and Memory on the left side.

The house current must always be shut off when connecting or disconnecting control components. Otherwise, damage to the system and malfunctions may occur.

The Central Control, like the Central Unit, is linked to the control components by the central "Digital bus". This Digital bus contains the lines for power supply to the control components, the IIC bus which transmits data and addresses serially, as well as the lines for parallel transmission of the "emergency halt" and "release" commands. When control components are plugged together, these lines are automatically connected through the plug and socket connectors on the sides of each component.

The Digital system functions reliably only if there is sufficient power. As with the Central Unit, the current from the Central Control is limited by a




ill. 30

*Connecting control components to the Central Control*

protective electronic circuit to a maximum of 2.5 amps. At 18 volts this corresponds to an output of approximately 45 VA.

If the users connected to the Central Control require a greater amount of power, the protective circuit will shut off power to the layout as if there were a short circuit.

The calculation of power consumption on a model railroad has been described in the section on the Central Unit (page 15) and applies here too.

## Operation

### Controlling locomotives

Up to four locomotives can be called up and controlled with the Central Control alone. The addresses "10", "20", "30" and "40" can be used for this. If one or more Control 80's are hooked up to the Central Control, all 80 locomotive addresses can be controlled directly.

The locomotive to be controlled is selected by pressing the corresponding button. A red LED will illuminate by this button to indicate which address has been called up. The locomotive can now be controlled.

If the LED blinks when the locomotive address is called, it means that this address has already been called up by a Control 80 or a computer. The indicator will illuminate continuously and the locomotive with the selected address can be operated from the Central Control only after the address has been released by the other control component.

The locomotive's speed is regulated in the customary fashion by turning the red control knob. If the knob is turned to the left past "0" (it is spring-loaded in this area), the locomotive will change direction.

Once a locomotive has had its operating command programmed with the Central Control, it can be released by calling up another address (10, 20, 30 or 40). The locomotive will continue to operate at the same speed in accordance with its programmed command, until it is called back up (disregarding train control by signals). Now another locomotive can be controlled directly or released after a third locomotive is called up.

### Auxiliary function

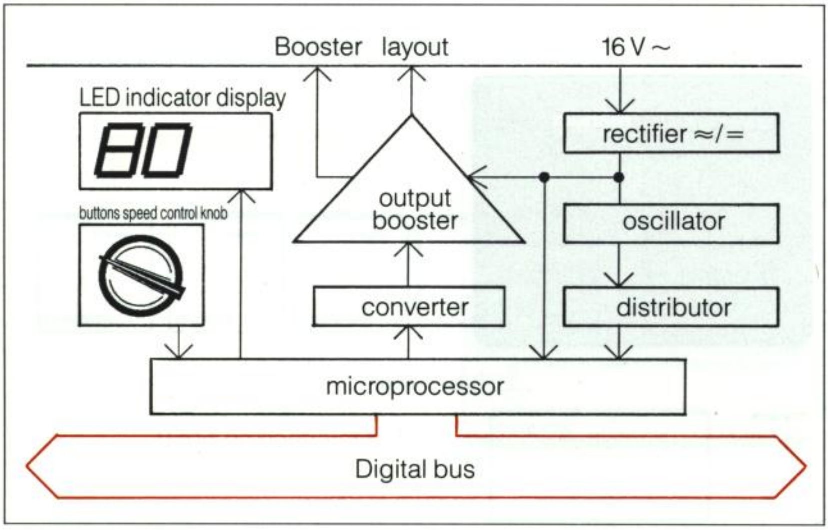
In addition to direction and speed, the c 80 and c 81 locomotive decoders can also control a switching function (headlights, TELEX, smoke, etc.). This function is turned on with the "function" button and off with the "off" button. The auxiliary function can be activated momentarily by pressing the "off" button. It remains activated as long as the button is pressed.

### Switching turnouts

The Central Control can control four turnouts or signals using the solenoid accessory addresses 253 through 256. If the Central Control is expanded to the maximum limits of the Digital system through the addition of Keyboards, Switchboards or the Memory, then all 256 solenoid accessories can be switched. The "red" and "green" buttons determine how the turnouts and signals are set. The switching impulse lasts as long as the button is pressed. The setting for the turnouts and signals is indicated by a red LED. The LED illuminates for the "red" setting and is shut off for the "green". If a solenoid accessory needs only a two-plug connection (yellow and red or yellow and green) at the k 83 decoder (example: uncoupler tracks) and thereby only one button on the Central Control, then two of these accessories can be switched by a single pair of buttons.

### "stop" and "go"

A red LED pilot light illuminates indicating that the Central Control is ready for operation after the unit is turned on. It shuts off if there is a short circuit or if the "stop" button is pressed; the power to the layout is also interrupted. The power supply to the indicators on the Central Control and to any other control components hooked up to it remains on, so that the indicator displays remain illuminated and the locomotive addresses entered remain valid. After the problem has been corrected, operation can be resumed by pressing the "go" button.




ill. 31

*Block wiring diagram of the Central Control*

When the "stop" and "go" buttons are pressed simultaneously, the Digital control components are "reset"; that is, they are returned to their original operating condition when the layout was turned on. The information stored in the locomotive decoders is not erased during this procedure. Since there is only negative voltage in the track during this period when the layout is being turned on, the locomotives come to a stop during the "reset". They resume operation according to the operating information stored in them when a locomotive address, it does not matter which one, is called up.

## Tips

When a layout is being controlled by several people, it is best to have the control components separated from each other. The Adapter 60 and Adapter 180 cables can be used to space the Control 80's and Keyboards from the Central Control.

## How the Central Control functions

As described above, the Central Control has many complex functions, namely those of the Central Unit, Control 80 and Keyboard. To avoid extensive repetition, a description of these functions will not be given here. They can be found in the sections for the individual components.

## The Interface


*The Interface no. 6050* *ill. 32*

The Interface is the link between a Märklin Digital layout and a computer. This opens up new and different possibilities in direct and program-controlled operation of the model railroad. A computer and the Digital control components can be used alongside each other together to operate the layout.

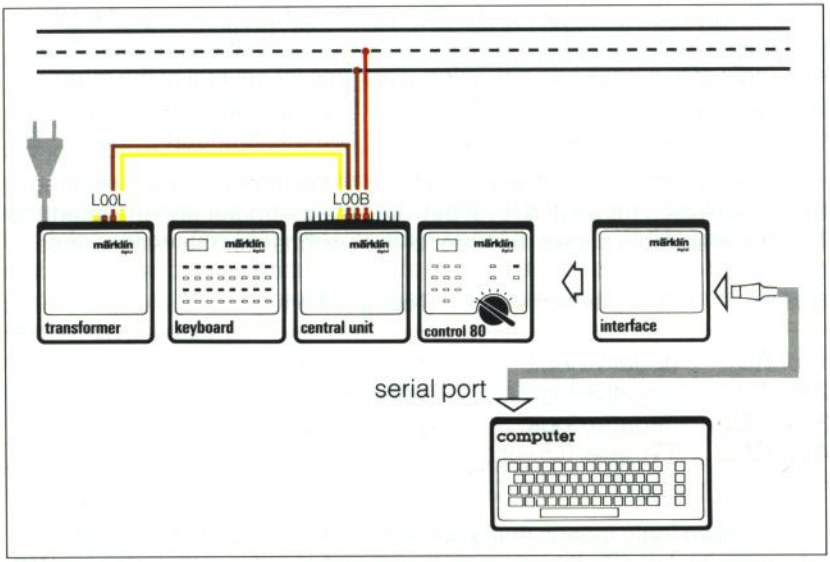
### Hookup

The Interface is plugged in on the right side of the Central Unit or Central Control. Control 80's can be connected between these components. As with all Digital control components, the power supply from the house current must be shut off when hooking up the Interface.

On the right side of the Interface is a socket for the connecting cable to the computer. You can make up this cable yourself (the 6-pin DIN plug for it is included with the Interface) or cables for the more popular computers can be ordered from Märklin. Illustration 34 shows the pin wiring sequence for the socket on the Interface. The designations in the illustration are as follows:

- TD T-ransmit D-ata line to send data
- RD R-eceive D-ata line to read data
- CTS C-lear T-o S-end line to indicate the Interface is ready to receive data
- GND G-rou-ND common ground line

The first two pin connections can be either TD or RD, depending on the component under discussion.




ill. 33

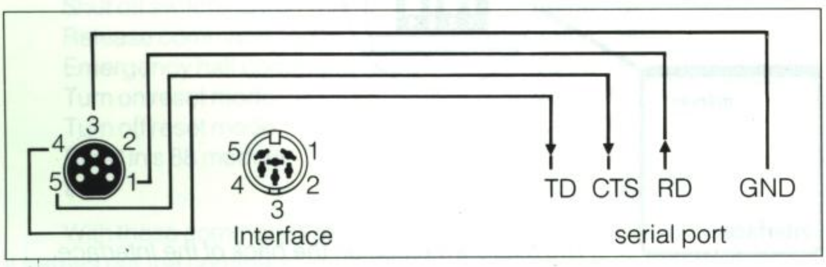
*Plugging in the Interface*

The signals sent by the computer on the TD line are accepted by the Interface, as the receiver, at the RD pin. The data lines must therefore be crossed:

- TD from the computer is connected to RD at the Interface.
- RD from the computer is connected to TD at the Interface.

The CTS and GND lines are connected directly to the same pins on the computer.

*Pin wiring sequence for the DIN socket on the Interface*




ill. 34

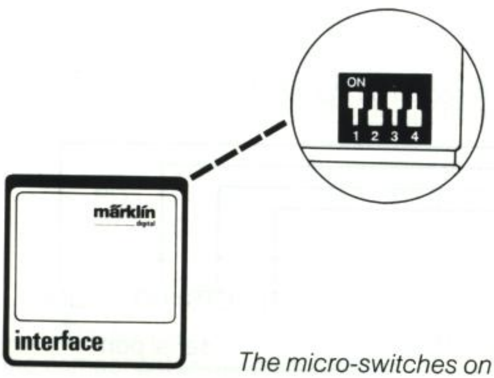
The pin wiring sequence for the serial interface or user port on the computer can be found in the instruction manual for the computer. The appendix of this book has pin wiring diagrams for several of the more popular brands of computers. A shielded four-conductor cable should be used for the cable between the computer and the Interface.

The four micro switches on the back of the Interface are for setting the transmission mode and level between the computer and the Interface. The following table shows the order of the switches for the various lines:

| Switch | "on" position | "off" position |
|---|---|---|
| 1 for RD | negative logic | positive logic |
| 2 for TD | negative logic | positive logic |
| 3 for CTS | negative logic | positive logic |
| 4 for GND | TTL level 0/5 volts | RS 232 level +/− 12 volts |

Positive logic means that a set bit (the smallest unit of information) is transmitted relative to the ground as an impulse with positive charge. With negative logic this signal has a negative charge relative to the ground.

The Digital control system and the model railroad layout connected to it are a peripheral device for the computer in the same manner as a printer. Communication with this sort of device takes place either over an input and output channel (example: "# 2" on Commodore computers) or with special commands which also contain the code for the destination address (serial interface) (example: "out" and "inp" on Schneider computers).




*The micro-switches on the back of the Interface* *ill. 35*

Before transmitting data, this transmission channel must be programmed for the correct data format of 8 data bits and 2 stop bits as well as for the transmission rate of 2400 baud (bits/sec). This process of adjustment is called initialization and is done on a short program. The commands or program steps necessary for this can be found in the description of the serial interface in the computer's instruction manual. The computer manufacturer, its agents or dealers can help with any ambiguity in this information. The Märklin telephone service is also glad to give information and help. In addition, there are demonstration programs for the most popular makes of computers and these programs can be ordered from Märklin on a diskette.

## Controlling a layout with a computer and the Interface

The information transmitted from the computer through the Interface to the Central Unit or Central Control consists mostly of two bytes (one byte = 8 bits). The two bytes make up a command and have these functions:

1st byte → speed, auxiliary function or switching command
2nd byte → address for the locomotive or turnout.

For this reason the first byte is called the "data byte" and the second is called the "address byte".

When the Interface has received the first byte, it checks whether a second byte is following so that the control information is complete. If a second byte is coming, it waits until it arrives. There is no time limit programmed for the waiting period, so the Interface's waiting is not automatically broken off. For this reason it is important when the program is being written and particularly important when it is being entered at the computer terminal, that the "data byte + address byte" unit is preserved. Otherwise, the Interface will "lose its rhythm".

Some commands are not related to any special address or can be transmitted with the address in the first byte. They do not need a separate "address byte":

| | |
|---|---|
| Shut off switching command | Value 32 |
| Release command "go" | Value 96 |
| Emergency halt command "stop" | Value 97 |
| Turn on reset mode | Value 128 |
| Turn off reset mode | Value 192 |
| Read in s 88 module | Value 129–159 |
| and | Value 193–223 |

With these commands the Interface does not wait for an address byte; it carries out the command immediately. An address byte can be sent with the command to turn off "32". It is accepted without the Interface "losing its rhythm".

The Interface indicates with the CTS signal that it is ready to operate. After a command is received, this signal is not sent until the command has been processed. During this time the Interface cannot accept new data.

In the direct control mode, i. e. entries made at the computer terminal, the commands are processed by the Interface faster than they can be entered. With program-controlled operations it is possible that they will arrive faster than the Digital controls can carry them out. For this reason it is necessary in such programs to query the status of the CTS signal each time before sending a command. This also prevents the computer program from "running off without the layout" if the "stop" command is activated due to a short circuit and no further commands can be carried out.

## Controlling locomotives

A two-byte command must be sent to the Interface to control a locomotive. The first byte determines the speed, auxiliary function and reversing direction of travel. The second byte is the locomotive address.

15 operating levels can be called up in the Digital system. "0" signifies halt and "1 to 14" are values for operating levels with increasing speed. Reversing direction is called up with "15".

Values for controlling locomotives 1st byte

| function | off | on | function | off | on |
|---|---|---|---|---|---|
| halt | 0 | 16 | operating level 8 | 8 | 24 |
| operating level 1 | 1 | 17 | operating level 9 | 9 | 25 |
| operating level 2 | 2 | 18 | operating level 10 | 10 | 26 |
| operating level 3 | 3 | 19 | operating level 11 | 11 | 27 |
| operating level 4 | 4 | 20 | operating level 12 | 12 | 28 |
| operating level 5 | 5 | 21 | operating level 13 | 13 | 29 |
| operating level 6 | 6 | 22 | operating level 14 | 14 | 30 |
| operating level 7 | 7 | 23 | reversing direction | 15 | 31 |

If the auxiliary function is to be turned on, the operating level 16 must be added to the value. This addition must be performed for each operating level as long as the function is to remain on. This addition must also be carried out when the direction of travel is reversed. The function changes with the direction of travel even when the former is not turned on.

Values over "31" are not accepted as data bytes for controlling locomotives but are interpreted as switching commands for turnouts.

The second byte contains the locomotive address (01 to 80). The address does not need to be entered into the computer as a two-digit number if it is less than "10", as the computer skips over a preceding "zero". If addresses are sent to the Interface which are greater than "80", the command is accepted as complete, but no data are transmitted to the Central Unit.

## Controlling turnouts

Controlling turnouts will be described here and this description is representative of all functions that can be handled by the k 83 and k 84 decoder panels.

A two-byte command must be sent to the Interface to set a turnout. The first byte contains the control command:

| | |
|---|---|
| "green"/"straight" setting | value 33 |
| "red" /"branch" setting | value 34 |

The setting voltage is turned on with these values and the turnout address in the second byte (addresses 0 to 256/see also pages 110 and 164). It remains on until the command to turn it off is sent from the computer:

| | |
|---|---|
| voltage off | value 32 |

This command to turn off the switching voltage is not directed to any particular turnout but is sent out to all solenoid accessories. An address byte does not need to be sent with the command to turn off the switching voltage. If an address byte does come after the command anyway, it is accepted by the Interface.

---

Important:

The command to shut off the switching voltage must never be left out of the programming. Otherwise, the turnout would receive constant voltage which would cause damage to the turnout solenoids.

---

## Reading in and evaluating track detection modules

If the computer is to control train operation on the layout reliably, it must be able to recognize where trains are and when it should carry out a particular switching procedure. The track detection modules are used for these purposes. The data evaluation procedure for track detection modules takes place as follows:

- send read command to the Interface
- receive data from the Interface
- evaluate data and register if necessary

The Digital system offers two different types of read commands, the reading in of several modules up to the module number indicated (value 128 + module number) and the reading in of a single track detection module (value 192 + module number). The read-in command is a one-byte command and therefore the module number is added to the value.

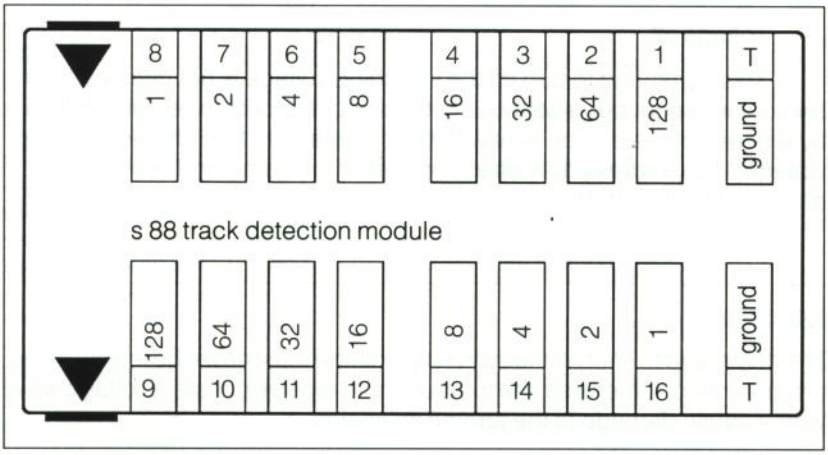
- Example: modules up to number 3 are to be read in:

  Value 128 + module number 3 = 131

- Example: only module number 6 is to be read in:
  Value 192 + module number 6 = 198

After the read-in command is sent, the computer can receive the data from the Interface after a specific processing time (approx. 13 milliseconds

*Relationship of the values to the contacts of the track detection module*




*ill. 36*

+ 10 milliseconds for each module). The Interface transmits two bytes for each track detection module read in. The first byte contains the data for contacts 1 through 8 and the second contains data for contacts 9 through 16 of the specific module. When a contact has been activated, a "1" will be transmitted in the corresponding position in the byte. "0" is transmitted when the contact is open.

As already described, eight contacts are always assembled into a byte when they are transmitted to the Interface and on to the computer. The computer receives this byte at its input buffer where it can be retrieved for evaluation. It can now be used as letters, special symbols or as a decimal value. In addition, each "1" received is multiplied in the computer by its place value (exponent to base 2) and then the values for all activated contacts are added (see illustration 36).

Example:

Contacts 1, 4 and 7 are activated on the track detection module. The first byte transmitted shows a "1" at positions 1, 4 and 7. This "1" is transformed into a power of 2 at the input buffer of the computer. The following table results from this:

| | | | |
|---|---|---|---|
| Contact 1 = | 1× | 128 = | 128 |
| Contact 2 = | 0× | 64 = | 0 |
| Contact 3 = | 0× | 32 = | 0 |
| Contact 4 = | 1× | 16 = | 16 |
| Contact 5 = | 0× | 8 = | 0 |
| Contact 6 = | 0× | 4 = | 0 |
| Contact 7 = | 1× | 2 = | 2 |
| Contact 8 = | 0× | 1 = | 0 |
| Sum of the values | | | 146 |

The computer must now filter out from the sum of the individual powers of two to evaluate the data, i. e. evaluate the data and show the result if necessary on the terminal screen (additional tips and instructions are given along with small sample programs in the chapter on "Computer Controls").

When the track detection module is being read in, you can choose whether the information stored in the input buffer of the module should be preserved or erased. When the unit is in the read-in mode "erase", the input buffer in the track detection module is set to "0" after each read-in. When the unit is reading in without erasing, the activated contacts are sent on as "1", even if they have not been activated again since the last read-in procedure.

Switching between the two read-in modes occurs with these 1-byte commands:

- erase after read-in    Value 128
- do not reset module    Value 192

The commands need to be given only when the read-in mode is to be changed. When the system is turned on, the "erase" mode is activated.

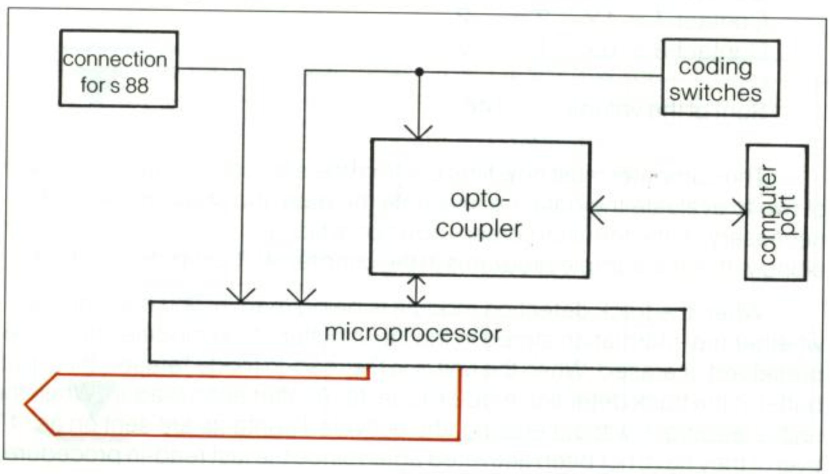
## Tips

Additional tips, hints and especially stimulating information about operation with a computer can be found in the chapter "Märklin Digital and Computers" beginning on page 110.

## How the Interface functions

The Interface is an intermediate unit which can change logic and signal levels. A total galvanic separation of input and the Interface's own data processing prevents to a large extent mutual disturbances of the Interface and the computer.

*Block wiring diagram of the Interface*



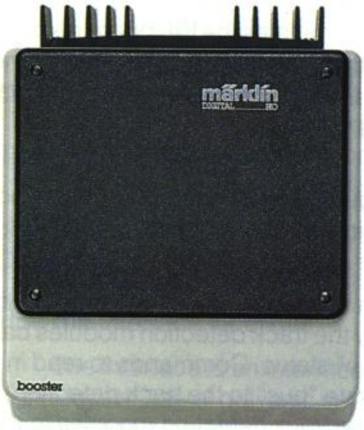

*ill. 37*

When the Digital control components are initialized, the Interface is given a software address like a Control 80 which it transmits along with commands for controlling locomotives to the Central Unit or Central Control. For turnout and signal control the Interface simulates the Keyboard responsible for the address in question. With both types of control commands the Interface receives the acknowledgement signals of the Central Unit/Central Control in the same fashion as the corresponding control components. An "echo" (acknowledgement signal) is not sent to the computer.

A locomotive called up by the computer through the Interface cannot be taken by a Control 80 until another valid address is called up by the computer.

Track detection modules are read in directly by the Interface without using the central "Digital bus". In this way the track detection modules can be read in and evaluated even in the "stop" status. Commands to read in and receive data take place over a separate "bus" to the track detection modules. The transmission of data from the track detection modules to the Interface is done on an Interface signal sent at consistent intervals via the sliding register of the module.

## The Booster




*The Booster no. 6015* *ill. 38*

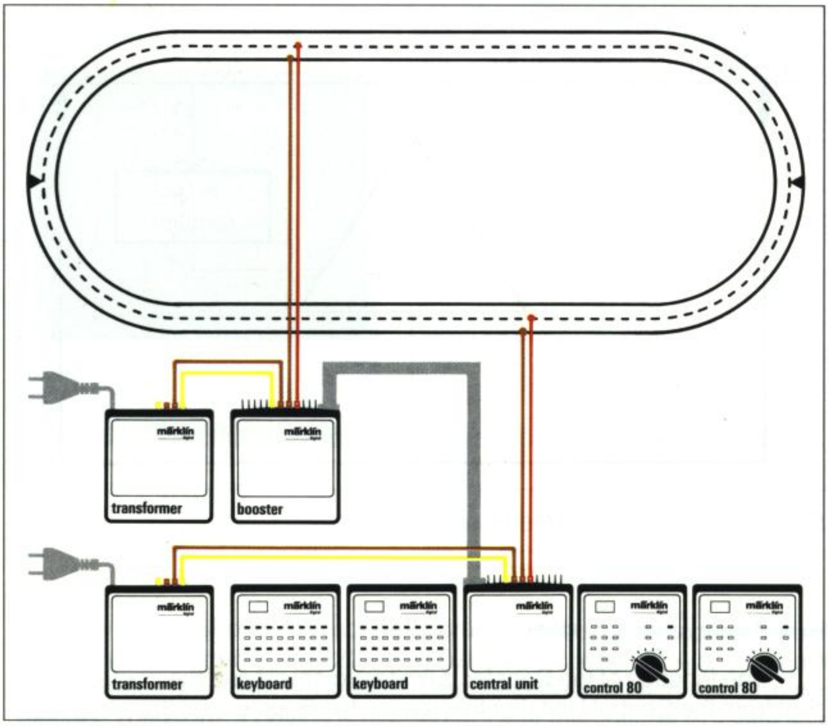
The Booster is used when the output from the Central Unit or Central Control by themselves is insufficient to run the model railroad layout.

### Hookup

The Digital layout must always be turned off when connecting the Booster. The Booster receives the energy it needs from its own transformer. It is connected to the transformer by a yellow and a brown wire which are connected to the terminal clips of the same colors on both units.

The Booster "boosts" the control signals from the Central Unit or Central Control and it receives these signals over a special five-pole cable. This cable is plugged into the special five-pole sockets on the back of both units; the Booster has two such sockets, the Central Unit and Central Control each have one. A second Booster can be hooked up to the second socket on the first unit, a third to the second unit, etc. The use of additional Boosters can satisfy the power requirements of larger layouts.

The circuit or part of the layout powered by the Booster is connected to the red and the second brown terminal clips on the back of the unit. The circuit (i. e. part of the layout) governed by the Central Unit must be insulated at the third rail from the circuits governed by Boosters; otherwise, there would be a short circuit from the joining of both circuits with possible



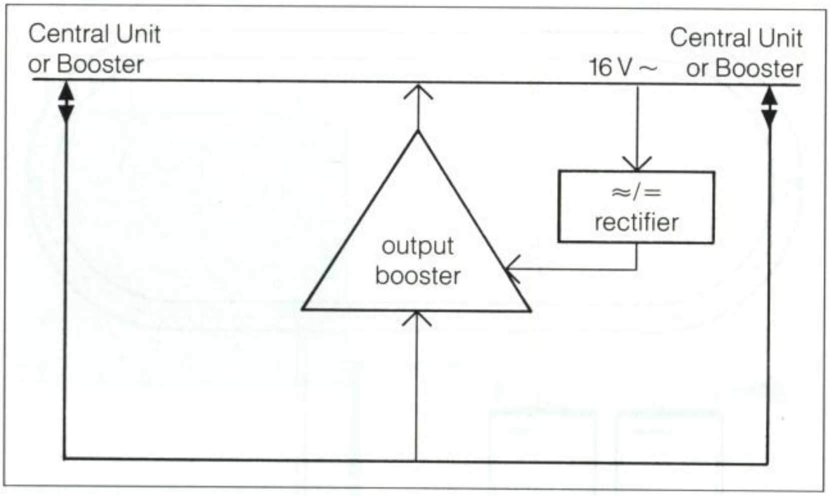

ill. 39

*Hooking up the Booster*

damage to locomotives, tracks or relays. The same situation holds true for the circuits of Boosters; they must be insulated from each other.

A red LED pilot light illuminates to indicate that the Booster is ready for operation.

Like the Central Unit, the current of the Booster is limited to a maximum of 2.5 amps by a protective electronic circuit. At 18 volts this corresponds to an output of approximately 45 VA. If this current consumption is exceeded or if the output voltage drops below a specific value (approximately 12 volts), this circuit shuts off power to the circuit on the layout supplied by the Booster. The red LED pilot light will shut off at this point and at the same time the Central Unit and all other Boosters shut off power to their respective areas of the layout.




ill. 40

*Block wiring diagram of the Booster*

## How the Booster functions

The function of the Booster is limited to amplifying the control signal sent from the Central Unit. For this reason the Booster has the same end level as the Central Unit. The Booster can supply its full output on the layout, as it has no control components to power, these being powered by the Central Unit.

## Tips

If less than 45 VA is needed from the Booster, a 6611/6667 or 6631/6627 transformer can be used to supply it with current.

The voltage to the Booster does not have to be exactly the same as that to the Central Unit. It can vary between 12 and 18 volts. Different power supply voltages result in different voltages from the Booster(s) and Central Unit. In this way areas of the layout with ascending or descending grades can be given their own separate voltage. The trains can be kept at a constant speed over these stretches of track without the necessity for constant attention to the speed control knob on the Control 80.

When there is a short circuit on the layout, its cause can usually be found on that portion of the layout governed by the Booster whose LED pilot light goes out first.

## The Transformer


ill. 41 *The transformer no. 6002/6001*

Electric model railroads cannot be operated on the house current from the wall outlets. The maximum 220 volts (Europe)/110 volts (USA and Canada) is dangerous and there are laws and regulations forbidding its use in this manner. Therefore, a device is needed to lower this voltage to a safe level. This process is called "transforming" in the technical vocabulary and this electrical device is called a transformer.

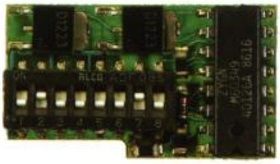
The maximum degree of safety is guaranteed by totally separating the house current circuit from the electrical circuit for the trains. All Märklin transformers have a thermal circuit breaker which shuts off power to the trains and accessories when necessary, so that neither the layout nor the transformer is damaged in case of short circuits or overloads. After a short time the transformer automatically turns back on and remains on, if the cause of the short circuit or overload has been corrected.

The red LED pilot light on the upper left corner of the transformer indicates that it is ready for operation. This light shuts off when the transformer is turned off.

On the back of the transformer are two sets of yellow and brown terminal clips to connect up the Central Unit, Central Control, Booster, lighting circuits, etc. These clips are spring loaded and the wires (with a short amount of their insulation stripped off the ends) are slipped into these clips. The yellow terminals and brown terminals are interconnected respectively inside the transformer, so that it does not matter, for example, which terminal of the two yellow ones a wire is hooked up to. Larger diameter wire should be used when connecting the transformer to components that require a larger amount of current, such as the Central Unit or Booster, to prevent voltage loss from long wires.

The output of the transformer is 52 VA (42 VA in the USA) at 16 volts which is rather higher than the output of the other Märklin transformers.

## The c 80 decoder

ill. 42 

*The c 80 decoder no. 6080*

The c 80 decoder is a digital component for receiving control signals and is used in all locomotives with Märklin universal AC/DC motors.
It controls the locomotive's speed and direction. The decoder can also turn on and off or switch an auxiliary function dependent on the direction of travel such as headlights.

Locomotives equipped with the c 80 decoder can also be operated on conventional layouts.

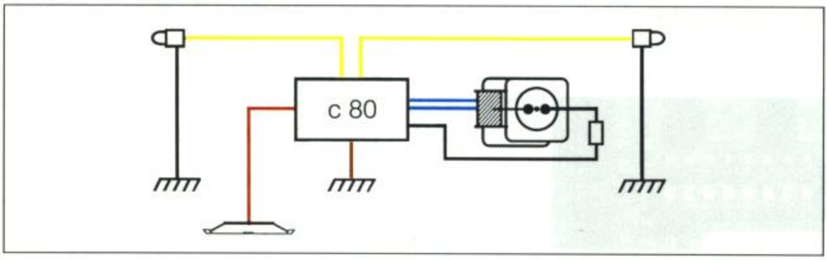
### Hookup

The c 80 locomotive decoder is installed in Digital locomotives at the factory. It can also be "retrofitted" in conventional Märklin locomotives. For these units the reverse unit and any circuit panel (example: the panel used in 3300 series locomotives for electronic reversing) are removed.
The decoder panel is installed in the space left by these parts. It takes over the functions of both of these parts.

The c 80 decoder has seven wires of which two are primary leads. The brown wire is connected to the locomotive's ground (the potential from the locomotive wheels and frame). The red wire is connected of the pickup shoe or, in the case of electric locomotives, to the selector switch for catenary and track operation (see illustration 43). The decoder receives energy and control information over these two wires.

The locomotive motor receives current from two blue wires connected to the two field windings and a black wire leading to the motor's brush plate through the noise suppression choke.

The auxiliary function, a switching function, is connected to both yellow wires. They are usually soldered to the contacts on the headlight bulb sockets. Bulb sockets that are insulated (example: 3300 series locomotives) and other functions which are not directly connected to the locomotive frame must be grounded for Digital operation (see illustration 43).




ill. 43

*Hookup for the c 80 decoder*

The yellow wires for the auxiliary function can be connected together, if there is only a single set of headlights at the front of the locomotive which is to be illuminated in both directions of travel, or if the TELEX couplers at both ends of the locomotive are to be activated at the same time.

The section of this book on applications (see page 138) gives additional tips – especially on converting conventional Märklin locomotives.

## Setting the decoder's address (coding)

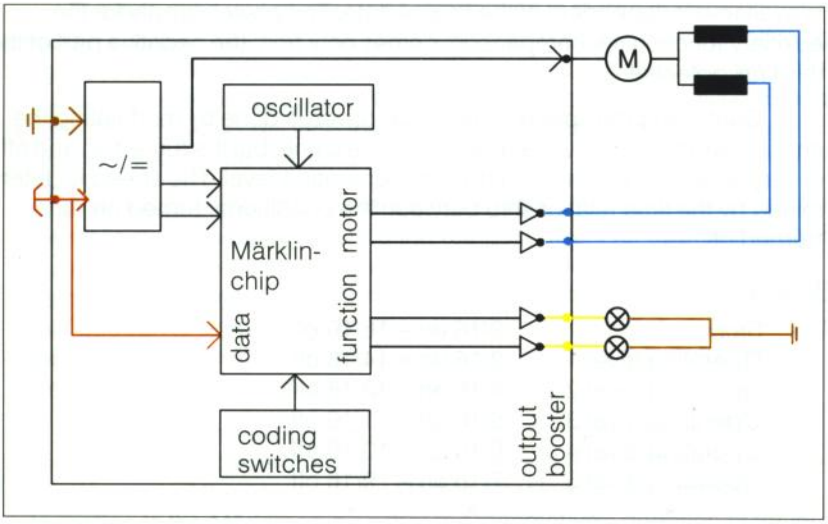
Locomotives equipped with a c 80 decoder at the factory already have an address set on the decoder which corresponds as a rule to the first two digits of the road or class number. Locomotive 120 001-1 is set for an address of "12", for example. The instructions included with each locomotive has the line in the code table underlined in red to show the coding switch setting for this address.

The eight coding switches on the c 80 decoder can be used to change this address at any time. Directions for coding a new address for a locomotive are given in the appendix with the code tables (see page 164).

## Load tolerance

The c 80 decoder can be operated with a continuous load of 700 milliamps and a short term load of 1.0 amps for the motor. The two circuits for the auxiliary function can each have a maximum load of 700 milliamps. This output is sufficient for two Telex couplers or a smoke generator along with the locomotive's headlights. If two smoke generators are to be used at the same time, such as with the 3102 locomotive, a relay must be included in the circuit (see illustration 97, page 142).

ill. 44




*Block wiring diagram of the c 80 decoder*

## How the c 80 decoder functions

The c 80 locomotive decoder receives information sent by the Central Unit or Central Control. This information is first checked for frequency. The decoder is able to differentiate conventional operation (50 Hz), information for solenoid accessories (approx. 10 kHz) and information for locomotives (approx. 5 kHz).

Information intended for locomotives is first checked to determine whether the address part – 4 pulses which are evaluated in a trinary way – is identical to the address set on the eight coding switches. If both addresses are the same, the data part of the information – 5 pulses which are evaluated in a binary fashion – is placed in intermediate memory. Trinary means that three conditions can be transmitted in a unit of information (see also the chapter "Data transmission", page 97). If the exact same information is received twice in succession, then the data part is also evaluated and the commands are carried out. The Digital signals are transformed into analog control voltages (decoded) and amplified by output transistors.

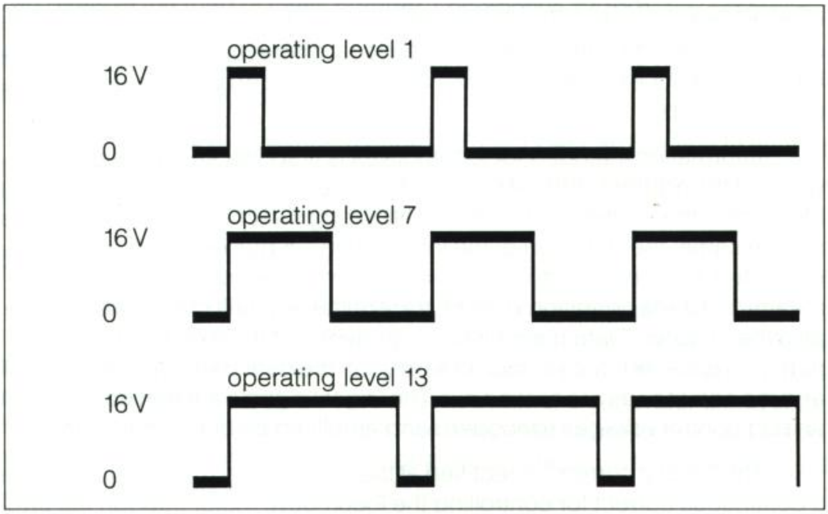
The "digital current" is rectified at the entry point to the decoder so that a continuous current for controlling the locomotive motor through the track is available independent of the flow of data. The power supply for the auxiliary function, by comparison, comes only from the negative part of the third rail potential.

Controlling the speed of the locomotives is done by modulating the impulse width; i. e. the voltage is always the same, but it is turned on and off in very short intervals according to the operating level. The speed is determined by the time relationship between the conditions "turned on" and "turned off".

Example:

| | | |
|---|---|---|
| Stop | 0/16 on – | 16/16 off |
| Operating level 1 | 2/16 on – | 14/16 off |
| Operating level 2 | 4/16 on – | 12/16 off |
| Operating level 3 | 5/16 on – | 11/16 off |
| Operating level 4 | 6/16 on – | 10/16 off |
| Operating level 5 | 7/16 on – | 9/16 off |
| * | * | * |
| * | * | * |
| Operating level 14 | 16/16 on – | 0/16 off |

*Controlling locomotive speed with impulse width modulation (schematic)*




*ill. 45*

The last, valid unit of operating information is stored in the locomotive decoder until new, valid information is received. Therefore, a locomotive no longer called up by a Control 80 will continue to operate at a constant speed because no new operating commands are being sent and received. Blocks (example: at signals) still stop the locomotive, since there is no voltage present here to power the motor.

A very slight amount of current is required by the c 80 decoder and this allows it to store operating information without current for approximately 2 minutes. For this reason insulated blocks should be bridged to the "live" area of the layout by a 1.5 kiloohm resistor which allows enough current to "leak" through to keep the information stored in the decoder, but not enough to power the locomotive's motor. There is no chance of the motor being damaged by this slight amount of current.

With conventional operation the rectified AC current is switched directly through to the motor. An additional circuit recognizes the voltage surge impulse of the conventional Märklin transformer and transfers this information to the Märklin chip so that the locomotive's direction of travel is reversed. With conventional operation the auxiliary function cannot be turned on.

When the locomotive moves from the digitally controlled part of the layout to the conventionally controlled part, the decoder switches over automatically to conventional operation within the space of a few milliseconds. The last units of digital operating information received remain stored in the decoder despite this transfer. The moment the locomotives reenter the digital area of the layout, they will regain their effectiveness, i. e. the locomotives will carry out the commands again. A change in the direction of travel in the conventionally operated part of the layout using the voltage surge impulse remains in effect when the locomotive reenters the digital part of the layout.

If DC current is present in the track, the locomotive will function only when there is a positive potential in the third rail. If the potential is negative, this corresponds to the condition "turn on" in the Digital control and results in a quasi "stand by"; the locomotive remains at a halt and the auxiliary function is shut off. The information for speed and auxiliary function remain stored, however. As soon as the third rail potential becomes positive again, these stored commands are carried out.

In the Digital system all information transmitted over the track generates a portion of the positive potential in the third rail. An address set at the Control 80 (it can also be a fictitious locomotive address if necessary) generates this positive portion of the potential continuously because it is being transmitted again and again in very short intervals (i. e. faster than the decoder switches over to stand by). At the same time, switching commands for turnouts and signals are only sent out a few times (as long as the button is being pressed) and therefore generate only temporary positive impulses in the third rail. This can cause locomotives standing on the track to move slightly when the layout is first turned on and before any locomotive addresses are called up. For this reason a locomotive address should be called up first on the Control 80 or Central Control before beginning operation.

## The c 81 decoder

*ill. 46* 
*The c 81 decoder no. 6081*

The c 81 decoder is the Digital receiving component for all locomotives with DC motors which are to be used on the Märklin three-rail/center stud Digital system. The decoder controls the speed and direction of travel for the locomotives. In addition, it can control an auxiliary function which is dependent on the locomotive's direction of travel (example: locomotive headlights).

Locomotives equipped with the c 81 decoder can be operated on conventional Märklin layouts also.

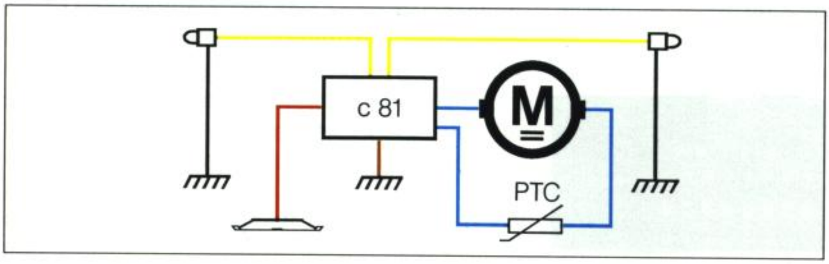
### Requirements for installation

It is absolutely necessary that there are potential-free connections to the motor for the installation of the c 81 decoder. Otherwise, any short circuits that occur will destroy the decoder. Before installation of the decoder, it is necessary to be sure that there are no electrical connections between the motor and the locomotive's wheels and pickup shoe.

With most DC-powered locomotives, space must first be made inside the locomotive body for the decoder panel. It must not be forgotten here that the decoder generates a certain amount of heat depending on its load. It should therefore not be installed directly adjacent to heat-sensitive plastic parts. This is particularly important to remember if the c 81 decoder is to be installed without its housing for space reasons.

### Hookup

The c 81 decoder has two primary leads. The brown wire is connected to the locomotive's ground (the potential of all the unit's wheels). If the contact pickup springs which receive voltage from the wheels are still insulated from each other, they should be bridged by soldering a wire between them to create as much of a ground as possible.




ill. 47

*Hookup for the c 81 decoder*

A number of powered units from other manufacturers are designed in such a way that the locomotive frame on the AC version is the conductor for the potential from the pickup shoe. On these units solder points for the ground must be insulated when they are mounted on the frame.

The red wire is connected to the pickup shoe or, in the case of electric locomotives, to the selector switch for catenary and track operation. The decoder receives energy and control information over these two wires (red and brown).

The locomotive motor receives its power over two blue wires which are soldered to the brush contacts on the brush plate. The noise suppression choke and capacitors on the brush plate or circuit plate should be left in place so that they will continue to function.

The PTC (resistor with **P-**ositive **T-**emperture **C-**oefficient) included with the decoder is installed in one of the blue wires leading to the motor. As the load increases, this unit becomes warmer and thereby increases its electrical resistance thus limiting the amount of voltage to reach the motor. In this way the decoder is protected against destruction from an overload. When converting locomotives with a higher voltage requirement, care must be taken in the installation of the PTC so that it does not come into contact with heat-sensitive plastic parts. The best solution is to mount the PTC directly on the brush plate.

The auxiliary function is a switching function which is dependent on the locomotive's direction of travel, and it receives energy through the two yellow wires. An example of this function is the locomotive's headlights. The auxiliary function must have a ground connection. If the headlight bulb sockets are electrically connected to the locomotive frame and the latter has no ground potential, the socket must be insulated if necessary and provided with its own wire soldered to the ground connection.

The yellow wires for the auxiliary function can be connected together, if there is only a single set of headlights at the front of the locomotive to be illuminated in both directions of travel, or if there is another function, such as a smoke generator, which is to function in both directions.

The applications section of this book (see page 144) gives additional tips on converting DC-powered locomotives.

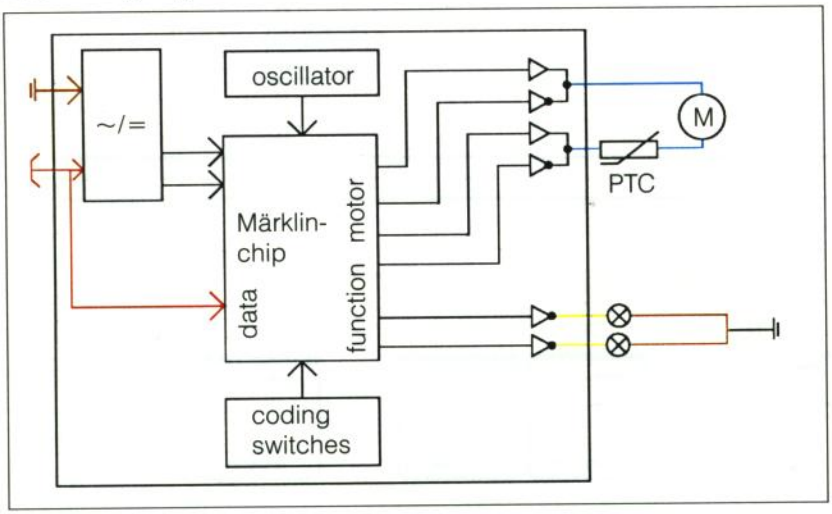
## Setting the locomotive's address

The c 81 decoder is set at the factory for a locomotive address of "25". This address can be changed at any time. The eight coding switches on the decoder are used to set a new address. Directions for address coding are given in the appendix with the code tables.

## Load tolerance

The c 81 decoder can be operated with a continuous load of 1.0 amps and a short term load of 2.0 amps for the motor circuit. This is sufficient for the largest H0 models. The two circuits for the auxiliary function can each have a maximum load of 700 milliamps. This output is sufficient for a smoke generator together with the locomotive's headlights. If the interior lighting

*Block wiring diagram of the c 81 decoder*




ill. 48

for an entire train is to be controlled through the auxiliary function, a relay must be included in the circuit (see illustration 103, page 148).

## How the c 81 decoder functions

The manner in which the c 81 decoder functions is much the same as that of the c 80 decoder. For that reason only the differences between the two units will be covered here to avoid unnecessary repetition.

Märklin universal AC/DC motors change direction by means of two different field windings, whereas DC motors with permanent magnets change direction through a reversal of polarity of the voltage source. For this reason the c 81 decoder has two additional end levels (see illustration 48). Hence, either the positive or the negative potential can be boosted at each exit point according to the direction of travel.

## The k 83 decoder

ill. 49 


*The k 83 decoder no. 6083*

The k 83 decoder is the receiving component for turnouts and signals. It has four sets of triple sockets for connecting four double-solenoid accessories, such as turnouts and signals, or eight single-solenoid units, such as uncoupler tracks. Turnouts and signals connected to the k 83 decoder can also be operated by circuit tracks.

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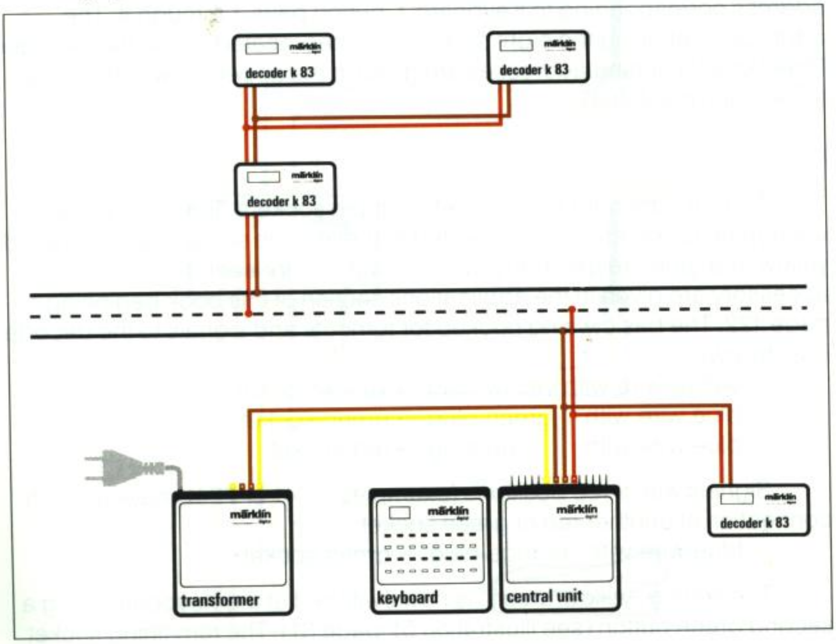
*Hooking up the k 83 decoder*




ill. 50

## Hooking up the k 83 decoder

The k 83 decoder receives its energy and control information through wires connected to the brown and red sockets. Additional decoders can be connected to a second pair of sockets of the same colors. The wires for this can also be branched (i. e. using a 7209 distribution plate for other k 83 units), but there can be no closed circuits. The red and brown wires for the decoder can be connected either directly to the Central Unit or to any spot on the track (i. e. a feeder track).

---

Important!

If the k 83 decoder is receiving its power through the track, on no account may trains be operated over this area of the layout with a conventional transformer. The conventional transformer's voltage surge impulse (for locomotive reversing) can destroy the condensers in the decoder!

---

## Coding

Before being installed, the k 83 decoder must have an address set linking it to a specific Keyboard. The decoders are set at the factory with an address corresponding to Keyboard 1, button pairs 1 through 4. The address is set using the eight coding switches located inside the decoder. Directions for setting addresses are given in the appendix with the code tables (see page 164).

## Hooking up turnouts and signals

The k 83 decoder has four sets of triple sockets. Turnouts, signals, uncoupler tracks, etc. are connected to these triple sockets which are red, yellow and green respectively. Wiring diagrams for each solenoid accessory are given in the applications section of this book beginning on page 122. The basic wiring hookup for turnouts and signals to the decoder is as follows:

- yellow wire with yellow plug → yellow socket
- blue wire with green plug → green socket
- blue wire with red plug → red socket

Signals with three positions (examples: 7041 or 7241) have a fourth connection at another red or green socket:

- blue wire with orange plug → green socket

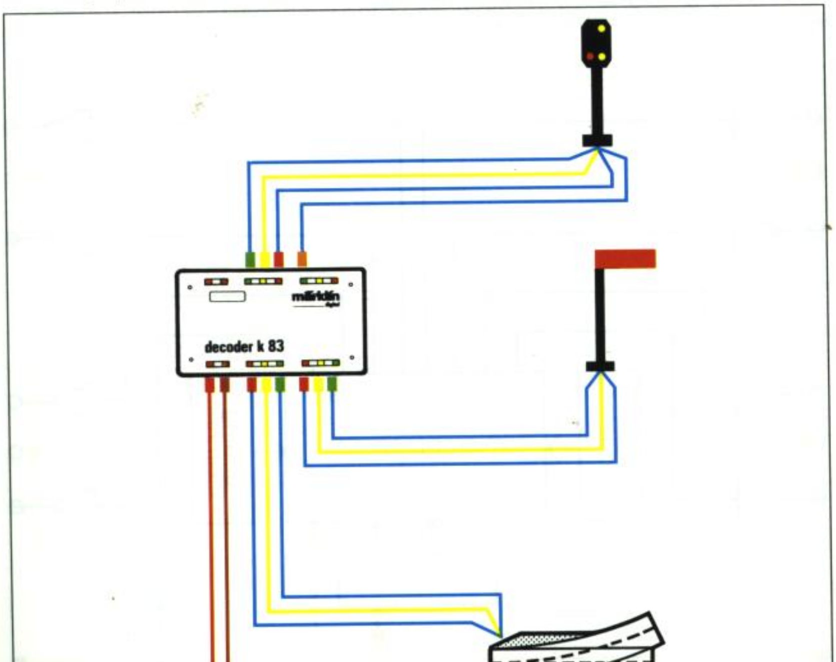
The setting "yellow/green" is now switched at the Keyboard using a second green button (see illustration 51, page 81). The remaining socket (red in this instance) on the k 83 decoder can be used for an uncoupler track or a second signal with three settings.

With color light signals advance and home signals can be connected together at the same set of decoder panel sockets. With semaphore signals they must be connected to their own sets of sockets.

## Tips

On larger layouts with long stretches of track, decoders should be powered over their own feeder wires (red and brown), because there is a certain voltage loss in the track due to the electrical resistance at the rail joints. In this sort of situation less voltage is available to activate turnouts, etc.

*Hooking up turnouts and signals to the k 83 decoder*

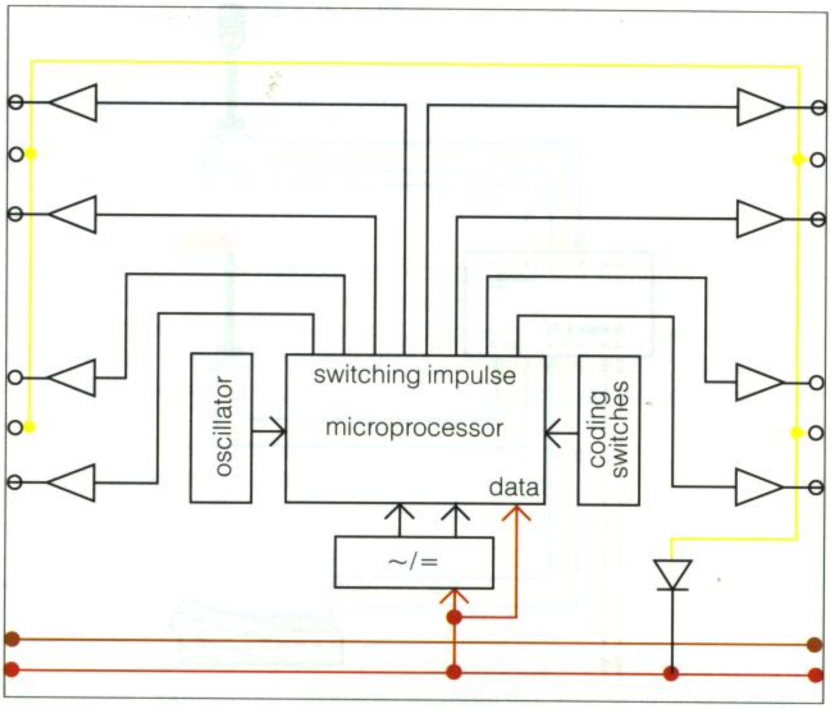



*ill. 51*

If turnouts and signals are to be illuminated only at night in a prototypical fashion, then the "hot" or power lead for the built-in lamps on the signals or turnouts must be separated from the power circuit for the solenoid mechanism and connected to its own wire for a separate power supply. A k 84 decoder or a universal relay can be used to turn the illumination on and off by remote control. The 6631/6627, 6671/6667 or 6611 (substitute the 6001 in the USA) transformers can be used to power the lighting.

When several solenoid accessories are connected to the same set of triple sockets on a decoder, the decoder's output transistors may be overloaded which could destroy the unit. In this situation two decoders should be set for the same address. They operate simultaneously then, when a button is pressed on the Keyboard. It would be even better to have the accessories in question incorporated in a route on the Memory where

*Block wiring diagram of the k 83 decoder*




*ill. 52*

they would be set in succession, one after the other. In this way only one solenoid accessory at a time draws power from the layout. The turnouts and signals function more reliably and an overload of the power supply is avoided.

## How the k 83 decoder functions

The k 83 decoder receives the Digital control signals for solenoid accessories and these signals are transmitted with a frequency of approximately 10 kHz. The address part of the information comes in 5 pulses which are evaluated in a trinary way and the decoder checks whether this address agrees with the address set on its eight coding switches. If so, the data part, 4 pulses which are evaluated in a binary fashion, is processed.
It contains the value for the internal address in the decoder related to the specific triple socket set of a solenoid accessory, the switching direction and the command to turn the process on or off. These signals are amplified to a usable level by output transistors.

The switching current consists of pulsing DC current. The switching sockets (green and red) have positive potential relative to the yellow socket.

## The k 84 decoder


*The k 84 decoder no. 6084* *ill. 53*

The k 84 decoder is the "universal relay" of the Digital system. It is controlled using the Keyboard, Switchboard or Memory and has 4 independent, potential-free relay switches.

All switching functions requiring or able to use a continuous contact can be carried out using the k 84 decoder. The following can be controlled with this decoder:

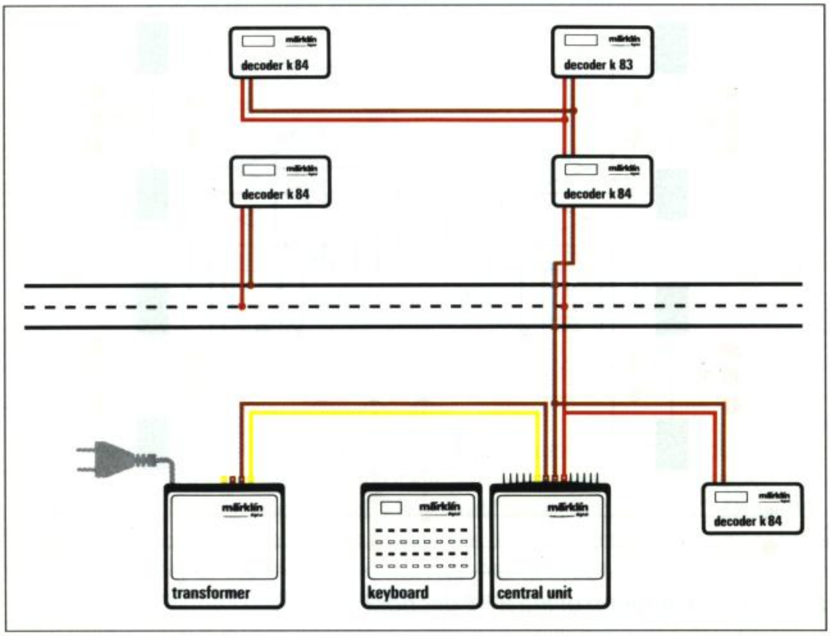
- turntable and transfer table
- color light signals without their own mechanism
- lighting circuits and operating models
- reverse loop controls for two-rail systems
- block sections without signals

### Hooking up the k 84 decoder

The k 84 decoder receives its energy and control information over wires connected to the brown and red sockets. Additional k 84 decoders or k 83 decoders can be connected to the second pair of sockets of the same colors. The wires can also be branched (example: using 7209 distribution strips), but there can be no closed circuits. The power leads for the decoder are connected either directly to the Central Unit or to any place on the track (i. e. feeder track) when the trains are also being operated digitally.

### Setting the decoder's address

Before being used for the first time, the k 84 decoder must have an address set linking it to a specific Keyboard. This address can be changed. The decoders are set at the factory with an address corresponding to Keyboard 1, button pairs 1 through 4. The address is set using the eight coding switches located inside the decoder. Directions for setting addresses are given in the appendix with the code tables (see page 164).




ill. 54

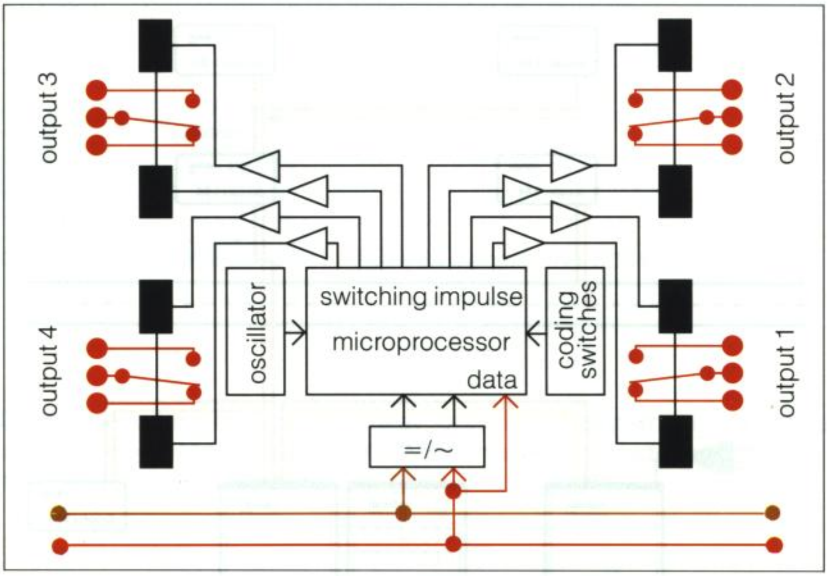
*Hooking up the k 84 decoder*

## Hooking up users

The k 84 decoder has four sets of connections which are set up as single-pole switches, each activated by a relay. Each set of connections has three sockets, green, gray and red. The gray, middle socket normally serves as a "hot" or power lead and is electrically linked to the green or red socket according to the switching command given. A set of connections can serve both as an on/off switch and as a reversing switch.

When two sets of connections are used together, a circuit for changing polarity can be created such as is needed for reverse loops in two-rail systems (mini-club, N gauge, 2-rail H0 and 1 gauge).

Each set of connections can be operated with a continuous load of 3.0 amps. The activating current (example: for switching a balky turnout) can be as high as 8 amps. The switched output for a set of connections can be as great as 125 VA.




ill. 55

*Block wiring diagram of the k 84 decoder*

The applications section of this book has examples with wiring diagrams for the use of the k 84 decoder beginning on page 122. Additional possible uses are staging yard and push/pull commuter train control. They are described in the chapter "Examples Using the Memory".

### How the k 84 decoder functions

The k 84 decoder resembles the k 83 in the way it functions. Only the differences between the two units will be described here to avoid repetition.

The k 84 differs from the k 83 in that the former has four single-pole reversing relays which are controlled by the output transistors. Since these relays require only a slight amount of current for operation, the output transistors in the k 84 are smaller in size.

## The s 88 track detection module

ill. 56


*The s 88 track detection module*

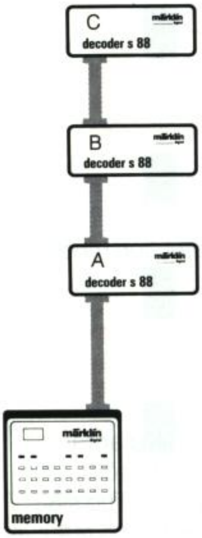
The information sent from the model railroad layout to a track diagram control board or the Digital control system (example: "circuit track activated" or "track 5 occupied") is called "detection signals". The s 88 track detection module makes it possible to have this information retrieved for the Memory or the Interface. The manner in which the track detection module is evaluated differs from the Memory to the Interface.

### Hookup

The s 88 track detection module is connected either to the Interface or the Memory using the special, six-pole cable included with the module. Care must always be taken that the arrow at the connecting sockets on the module must always point to the Memory or Interface (see illustration 57). Additional track detection modules can be connected to the six-pole socket on the unit. A maximum of 3 track detection modules can be hooked up to the Memory and 31 may be hooked up to the Interface.

The track detection modules do not need to be coded. Information reaches the appropriate contacts on the track detection modules automatically as a result of the order in which the modules are hooked up and because the data are transmitted to the Memory and the Interface over a sliding register (i. e. always in the same order according to the order in which the modules are hooked up).

The track detection module is able to evaluate all impulses and continuous contacts which have a ground component (the potential of the outer rails or the ⊥ socket on the s 88 module). Positive voltage is not evaluated by the track detection module. The unit can also be used on layouts where the trains are operated conventionally with AC or DC power, but where turnouts and signals are operated digitally.




*Hooking up the track detection module to a Memory or Interface* *ill. 57*

The following switching elements can be used to send detection signals from the model railroad layout:

HO circuit tracks –

They are activated only by locomotives and cars with center rail pickup shoes and they send an impulse to the track detection module that is dependent on the train's direction of travel. The circuit tracks always carry the (ground) potential of the running rails and therefore do not need to be hooked up to the ground socket (⊥ socket) on the module.

Z circuit tracks –

They are activated by all locomotives or cars with frames or bottoms set close to the rails (example: all powered units) and they send an impulse to the track detection module that is dependent on the train's direction of travel. Z circuit tracks are potential-free and their middle contact (terminal clip) is therefore connected to the ground socket (⊥ socket) on the module.

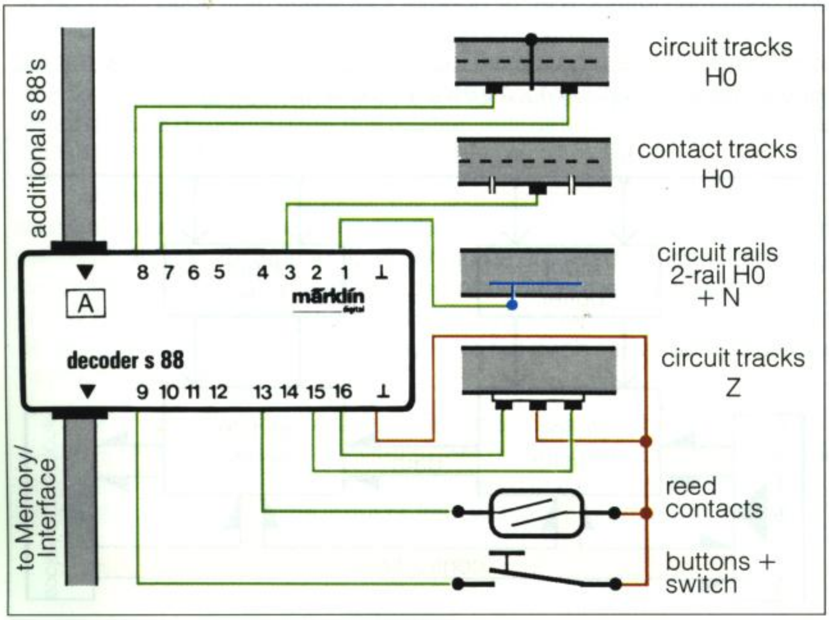
Contact track areas –

They can be created only on symmetrical 3-rail track. The contact track areas (made up with 2295 or 5145 track sections) consist of a length of track with an insulated outer running rail connected to a contact socket on a track detection module (see illustration 58). The insulated rail is bridged to the normal running rail on the opposite side when a train with uninsulated wheel sets passes over it. A continuous contact is produced which is independent of the train's direction of travel and which always switches the (ground) potential of the rails.

## Reed contacts –

They are activated only by cars or locomotives equipped with a magnet. When the magnet on the unit passes over the reed switch, a short impulse is produced. By mounting the reed switch and the magnet off center in the track and on the car or locomotive, this type of contact can be made dependent on the position of the unit on the track and the direction in which it is travelling. Reed contacts are potentialfree; i. e. they must be connected to the ground socket (⊥ socket) on the track detection module.

*Hooking up the track detection contacts to the s 88 track detection module*




ill. 58

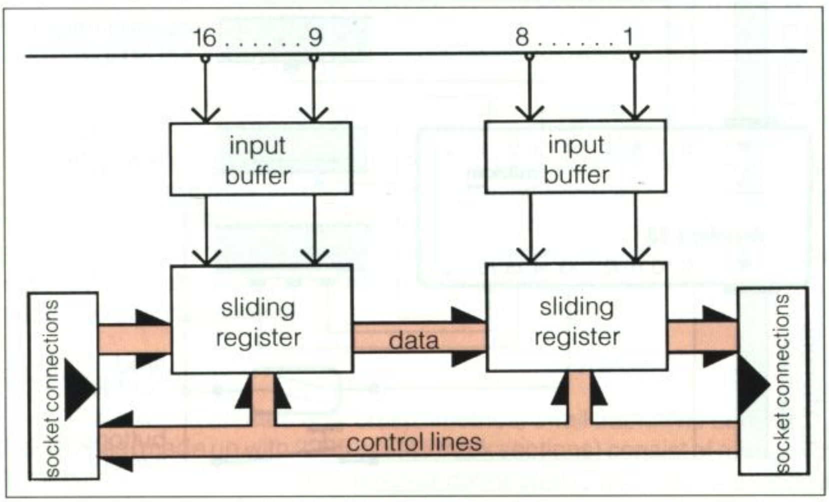
## Button contacts –

These contacts along with circuit rails as the complementary element in the track can only be used in 2-rail systems. They are dependent on the direction of travel of the train and produce an impulse. They conduct the potential of the car or locomotive frame which changes with the direction of travel in DC operation (according to the polarity of the track). The track detection module evaluates the impulses only when they are conducting a negative potential. Contact between the "button" on the car or locomotive and the circuit rail is not always registered due to the asymmetrical installation of the latter in the track and the changing polarity.

## Third or center rail –

In digital as well as conventional operation with AC power, the third or center rail always has a negative potential which can be evaluated by the track detection module. The third rail potential can therefore be evaluated as a continuous contact for track detection signals from model railroad signal settings. The third rail potential can also be used as an indexing signal for turntables and transfer tables.

*Block wiring diagram of the s 88 track detection module*




*ill. 59*

## Evaluating track detection signals

With the Memory a module is evaluated using a preset program stored in the Memory. The use of the track detection module with the Memory is described at length in the chapter "Memory" (beginning on page 34).

Evaluation of track detection signals is not a preset process in the case of the Interface and a computer. The evaluation procedure is determined by a computer program. When the evaluation procedure is carried out by a computer, the switching reaction can take place either when the contact is reported as "occupied" or as "free". A time delay of the switching or control reaction can also be programmed into the procedure. When used with a computer, the track detection module can also be used to control locomotives. A fuller description of this can be found in the chapter "Interface" (beginning on page 54) and "Computer Control" (beginning on page 108).

## How the track detection module functions

The s 88 track detection module is an encoder; it translates incoming information into a data format the Digital system can process.

The track detection module has two eight position input buffers. The first buffer stores the information from contacts 1 through 8 and the second stores information from contacts 9 through 16. At a control command from the Memory or a computer the data in the input buffers are taken over into the two eight-position sliding registers of the encoder and then transmitted byte by byte at regular intervals to the Memory or Interface. At each interval the information is shifted over one register until all of the requested data has been transmitted.

When the Interface is used, you have the choice during the read-in procedure (as already described in the section on the Interface) of whether the information in the input buffers should be erased or preserved during this procedure. If the information at the input buffers is not erased, then contacts that have been transmitted as activated will continue to be read in as being in this status, although they have not been activated again in the interim period.

Track detection modules used in conjunction with the Memory are read in only when the latter is in the extern mode. The information from the track detection modules is automatically read in a cyclical fashion. The information is erased at the input buffers with each read-in procedure.

## How does Märklin Digital function?

The basic difference between digital and conventional model railroad control has been explained at the beginning of this book. In the following pages the manner in which the Märklin Digital system functions will be described in detail.

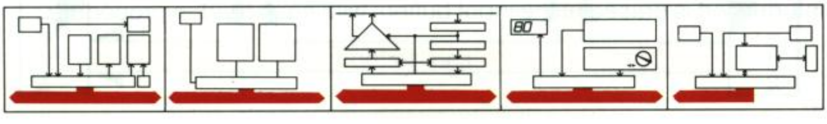
This chapter can be skipped if you are only interested in how to hook up and operate the system.

### The internal "Digital bus"

All necessary electrical connections are automatically made when a control component is plugged into the Central Unit, Central Control or another control component using the multi-pin connector on the sides of each unit. These connections are the lines for the power supply to the micro-processors and LED displays in the control components, two lines for transmitting data and addresses, as well as the lines for parallel transmission of the "emergency halt" and "release" commands. The collective term for all of these lines connecting all control components to each other is "Digital bus".

The most important lines for internal communication between control components are the two lines for data and address transmission. Control requests and commands as well as acknowledgement signals are sent over these lines. The technical term for these lines is IIC bus (or $I^2C$ bus). The manner in which communication is organized is described as follows.

*Common connection for all control components using the internal "Digital bus"*




*ill.60*

## Internal data transmission on the IIC bus

The exchange of information between the Central Unit or the Central Control and the control components as well as between individual control components takes place on two lines of the Digital bus, the IIC bus.

Each data transmission between the Digital control components begins with a start signal, the start bit. The receiving component then knows that information is being sent at this time. It begins to store the arriving information intended for it within the rhythm of the sender frequency. After receiving a byte (8 bits), the receiving component sends a receipt signal to the sender. The information transmission is ended by a stop signal consisting of 2 bits.

## Turning the Digital layout on (initialization)

When the power supply is turned on, all Digital components are in a definite beginning condition ("reset mode"). On the Central Control this "reset" can be activated by simultaneously pressing the "stop" and "go" buttons instead of unplugging and plugging in the electrical cord on the transformer(s) as in the case of a short circuit or other problem.

Immediately after the Digital layout is turned on, the control components are placed in the operating mode (initialized) by the Central Unit or Central Control using a data transmission.

During initialization the Control 80's and the Interface receive their software addresses from the Central Unit or Central Control in the order in which they are connected to the latter. The number "99" flashes briefly at this time on the LED display of the Control 80. The Control 80 and Interface therefore do not need to have an address set with a group of coding switches.

After the initialization of the control components, power begins to flow to the layout. DC current is present in the track as long as no information is being sent. The center rail or center studs have negative potential relative to the running rails in this operating state.

# Controlling locomotives

When a locomotive address is entered at a Control 80 or sent from a computer to the Interface, the microprocessor in these two units checks to see if the address is valid and not in use already. If the answer is no to either of these questions, the address in question will blink on the LED indicator display of the Control 80. If the address can be used, a four-byte unit of information is sent to the Central Unit or Central Control. Example: Control 80 no. 1, locomotive 12, operating level 7, auxiliary function switched on. The individual bytes have the following meaning:

Start signal

| | | |
|---|---|---|
| 1st byte | – receiving component address: | Central Unit |
| 2nd byte | – sender address: | Control 80 no. 1 |
| 3rd byte | – locomotive address: | 12 |
| 4th byte | – control information: | operating level 7 and function on |

Stop signal

The receiving component (Central Unit) acknowledges the receipt of each individual byte by means of a receipt bit. After receiving all 4 bytes, the Central Unit/Central Control checks whether the locomotive address is in use by another Control 80 or by the Interface. If this is the case, the Central Unit sends a "busy" signal to the Control 80 which in turn causes the indicator display for the locomotive address to blink. The Control 80 now sends a control request approximately every second to the Central Unit or Central Control. The indicator display does not stop blinking until the address is reported as "free". The Central Unit/Central Control has now set up a memory storage area for this address in which the current locomotive data are stored. The Control 80 is informed of this procedure by means of a receipt signal which likewise consists of four bytes:

Start signal

| | | |
|---|---|---|
| 1st byte | – receiving component address: | Control 80 no. 1 |
| 2nd byte | – sender address: | Central Unit |
| 3rd byte | – locomotive address: | 12 |
| 4th byte | – control information: | operating level 7 and function on |

Stop signal

When several locomotives are being controlled at the same time by means of two or more Control 80's connected to the Central Unit, the latter can create up to ten memory storage areas for locomotive data. For this reason no more than 10 Control 80's can be connected to the Central Unit or 9 to the Central Control. The internal data processing actually allows 15 (14 with a Central Control) Control 80's to be hooked up because 15 addresses can be assigned for them in the initialization. The control requests for Control 80's with the addresses 11 to 15 are not transmitted cyclically because the requests cannot be stored in the Central Unit or Central Control. Requests from these units can only be transmitted when the speed controller setting is changed or when the auxiliary function is switched on or off. If an Interface is added to the system, it must be counted as an address.

When a locomotive address is released by the entry of another address, the new address and data are transferred to the corresponding memory storage vacated by the first address. The operating information for the released locomotive does, however, remain stored in the locomotive decoder.

## Controlling solenoid accessories

Turnouts and signals are controlled from the Keyboard, Switchboard with track diagram control board, Memory or a computer. The coding switches on the Keyboard and Switchboard are used to assign these units to the addresses for solenoid accessories. A turnout or signal address is assigned to a specific pair of buttons on the Keyboard (or set of sockets on the Switchboard) within the group of 16 addresses of which they are a part.

The Memory also has a set of coding switches. The address set here is only necessary for purposes of internal identification.

The hardware address that is set is always transmitted by the Keyboard, Switchboard and Memory over the IIC bus together with the switching request to the Central Unit/Central Control. The control information being sent refers to the address of the decoder and not to the consecutive address of the solenoid accessory. In the example below switch "9" on Keyboard number 2 is to be set for "branch". Keyboard number 2 is responsible for decoder addresses 5 through 8. Turnout "9" is connected to triple socket number 1 on decoder number 7 (the 3rd decoder on the 2nd Keyboard). The assignment of Keyboards and Switchboards to the consecutive turnout and decoder addresses can be found in the "Code Table for k 83 and k 84 decoders" (see page 166).

The three bytes transmitted in this example to the Central Unit or Central Control have the following meaning:

Start signal

| | |
|---|---|
| 1st byte – receiving component address: | Central Unit |
| 2nd byte – sender address: | Keyboard no. 2 |
| 3rd byte – control information: | decoder no. 7 triple socket set red |

Stop signal

When the Central Unit receives a switching request, it first checks whether there is already a switching request in the system. If this is the case, the second switching request is not accepted and the data bus for Keyboards, Switchboards and Memories is switched to "busy". If no switching request has been processed at the Central Unit, the (second) request is accepted and sent to the layout in the next available position in the transmission cycle. After the request has been carried out, the Keyboard is sent an acknowledgement signal which is also three bytes long. It consists of the following:

Start signal

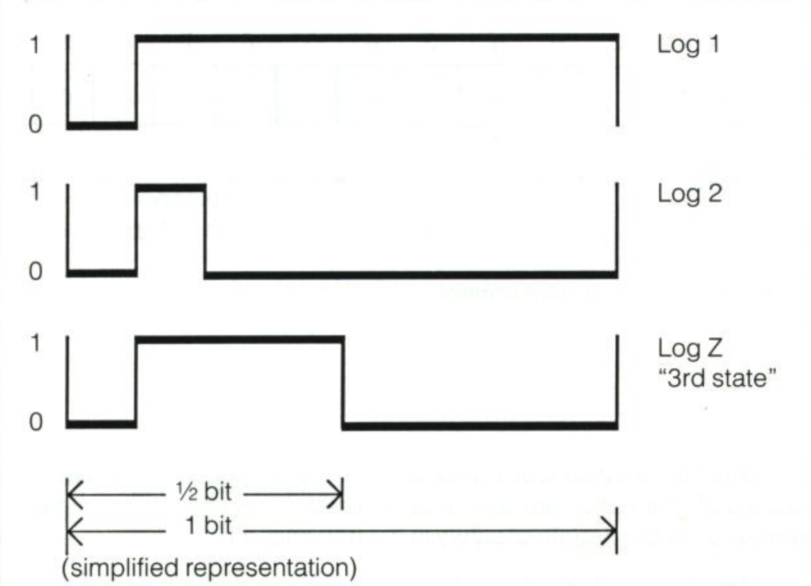
| | |
|---|---|
| 1st byte – receiving component address: | Keyboard no. 2 |
| 2nd byte – sender address: | Central Unit |
| 3rd byte – receipt signal: | decoder no. 7 triple socket set 1 red |

Stop signal

The indicator display on the Keyboard or the track diagram control board connected to a Switchboard does not change until the Central Unit has confirmed that the switching request has been carried out. The Central Unit/Central Control will keep sending the switching command as long as the corresponding button on the Keyboard is pressed. The moment the button is no longer being pressed, the Central Unit sends a "shutoff" command for the solenoid accessory. This ends the switching procedure and the Central Unit is now ready to receive a new switching request.

The Memory does not send its own address along with a switching request to the Central Unit; it sends the address of the Keyboard responsible for the switching request in question. This Keyboard does not really have to be present. As a receiving component, the Memory has the address of the Central Unit and is therefore always "listening in".

When controlling solenoid accessories with the Interface and a computer, the duration of the switching request by the computer does not determine how long the accessory is activated. What is required in this instance is the command to turn on (the accessory) and the command to turn off (the accessory) after a specific amount of time (depending on how fast the turnout or signal sets itself). However, in this instance the data bus is not switched to "busy", so that the switching request of the computer can be overridden and turned off by a switching request from a digital control component.




*ill. 61*

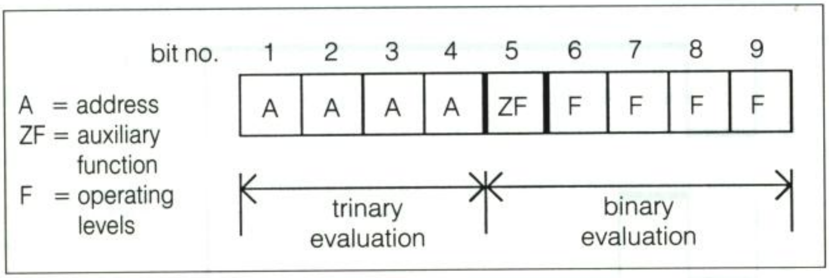
*The three states of the "trinary" data format*

## Data transmission to the model railroad layout

The same principle of serial, digital information transmission is used to transmit information to the receiving components on the layout as is used for the internal Digital bus. There are, however, significant differences in the data formats.

A "third" state is introduced into the otherwise binary data format in order to keep transmitted data as compact as possible. This third state divides a bit into two more parts. The "third" bit is structured in such a way that the level is switched from 1 (high) to 0 (low) according to the durational half of the bit. This allows not only 2 but 3 states to be represented in a bit (that is actually no longer a bit). The technical term for this is "trinary".

As a result of this compact data format, all commands sent by the Digital system to receiving components have data that are 9 pulses long (the term bit would no longer be correct due to the three possible states).




ill. 62

*Data format for locomotive control*

When information is being transmitted to the model railroad layout, the 9 pulses of information are sent twice in direct succession to insure the greatest possible degree of safety in the transmission.

The "trinary converter" in the Central Unit's microprocessor takes over the transformation into the trinary data format of the binary control signals from the unit's main processor. The Märklin chip in the receiving components has the corresponding circuit for evaluating the address part of the control information.

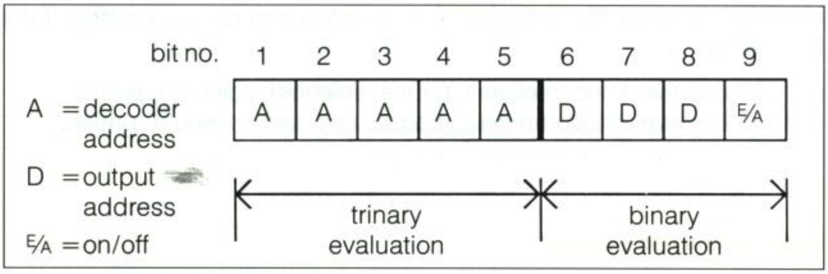
The control information for locomotives (c 80/c 81 decoders) differs basically from that for solenoid accessories (k 83/k 84 decoders) in the division of the 9 pulses into an address and a control part. They also differ in the transmission frequency.

## Controlling locomotives

Four positions are sufficient for coding the locomotive address. $3^4$ results in 81 possibilities for addresses, of which the address "00" is not used. The transmission of the operating information including the auxiliary function occurs in the remaining 5 positions which are only used binarily. The frequency of the data transmission for locomotive control is approximately 5 kHz.

When only one locomotive address is called up, the Central Unit sets up only one memory storage area and the data transmission by the Central Unit takes place according to the following scheme:

locomotive 1, locomotive 1, pause, locomotive 1, locomotive 1, pause...




ill. 63

*Data format for switching solenoid accessories*

When several locomotives are called up, the Central Unit sets up a separate memory storage area for each locomotive address and the data for each area are sent in succession. The transmission pattern is as follows:

locomotive 1, locomotive 1, pause, locomotive 2, locomotive 2, pause, locomotive 3, locomotive 3, pause...

## Switching solenoid accessories

The first 5 positions are used for the address ($3^5$ results in 243 possibilities, of which 64 are used as decoder addresses) for controlling solenoid accessories. The address does not refer to the individual triple socket set at the decoder, i.e. the consecutive turnout address, but to the address for the decoder as a whole; hence, 64 addresses suffice for controlling 256 functions. The remaining 4 positions are only used binarily. They differentiate the individual triple socket sets on the decoder and the switching commands "on" and "off". The data transmission for solenoid accessory control is done at a frequency of approximately 10 kHz.

The transmission pattern for solenoid accessory control is as follows:

solenoid, solenoid, pause, solenoid, solenoid, pause...

Only one switching command for solenoid accessories can be inserted at a time into the Central Unit's sending cycle. A second switching command cannot be inserted until a shutoff command has been sent for the first.

If locomotives are also being controlled at the same time through the Central Unit, then the switching command for a solenoid accessory is inserted after each transmission of the memory storage area content for a locomotive:

> locomotive 1, locomotive 1, pause, solenoid, solenoid, pause, locomotive 2, locomotive 2, pause, solenoid, solenoid, pause, locomotive 3, locomotive 3, pause...

## Power output transmission

Only a very slight amount of power is required for data processing in the Central Unit and in the control components.

In the Digital system information and power are transmitted in a signal for controlling the model railroad layout. Therefore, the control signal sent by the Central Unit must be sufficiently amplified. The output end level is used for this purpose in the Central Unit, Central Control and Booster.

The end levels are protected against overloads and short circuits by two protective electronic circuits which shut off current to the model railroad layout when necessary. A current limiter cuts in at loads over 2.5 amps. The voltage control shuts off power when the output voltage for the end level falls below approximately 12 volts. Only the negative potential of the exit signal is kept under surveillance in both protective circuits. This is reasonable and sufficient because the negative portion carries a heavier load than the positive. The switching output for solenoid accessories and the auxiliary function of locomotives is taken exclusively from the negative portion of the output signal.

In the event of a short circuit these safeguards shut off power to the layout. The internal Digital bus is not turned off, however, so that the indicator displays on the control components (Control 80, Keyboard, Switchboard and Memory) can still be viewed. At this time address changes can even be carried out on the Control 80 and a position command can be entered at the Keyboard. The latter is carried out immediately after power is restored to the layout.

## Which components are needed for operating a model railroad with Märklin Digital?

The modular design of the Märklin Digital system allows you to set up the controls to suit your personal ideas and the needs of the railroad layout.

The examples described here are intended to demonstrate the basic setups for different control tasks. Each additonal example shows one of the many possibilities for expansion.

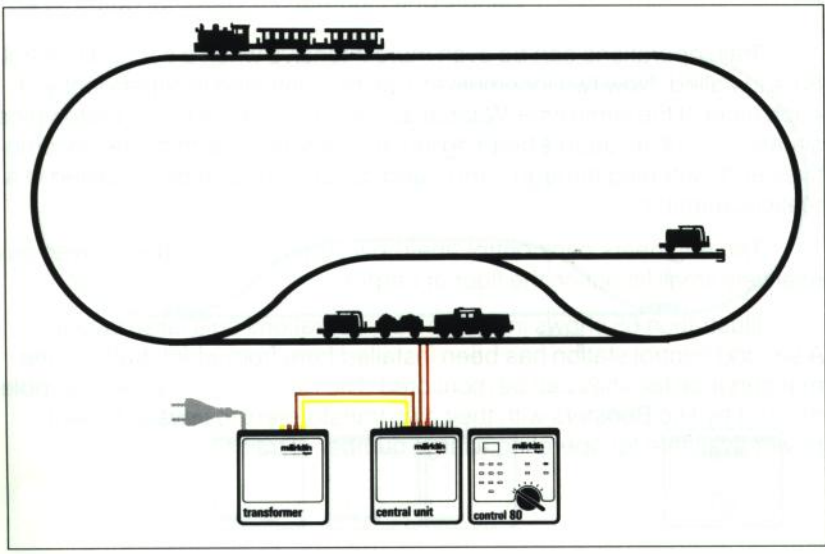
### Train operation

The basic setup for digitally controlled train operation consists of:

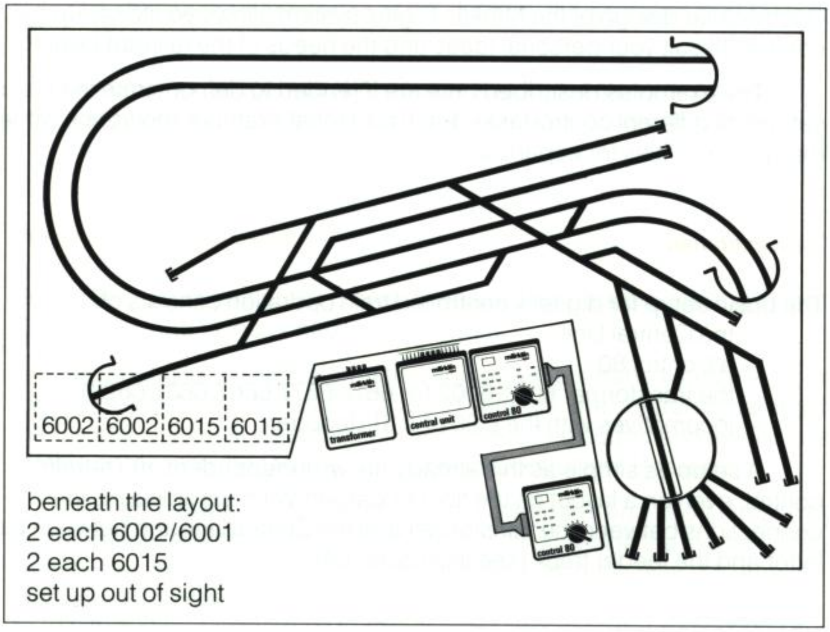
- the Central Unit
- a Control 80
- the transformer 6001/6002 (or 6611, 6671/6667, 6631/6627)
- locomotives with the c 80 or c 81 decoder

A setup as simple as this already allows independent, multi-train control, even on a layout on the floor or carpet! Wiring is limited to the connections between the transformer and the Central Unit and between the latter and the feeder track (see illustration 64).

*Basic setup for digitally controlled train operations*




*ill. 64*




ill.65

*Intensive train operations on a large layout with a second control station for the maintenance facilities area*

Train operations can be even more intensive when a second Control 80 is installed. Now two locomotives can be controlled independently of each other at the same time. Without any additional wiring busy prototypical situations such as double heading locomotives, trains with pusher locomotives and switching through cars in and out of trains can be modelled in a realistic manner.

Two engineers can control "their" own trains independently even on a relatively small layout on the floor or carpet.

Illustration 65 shows intensive train operations on a large layout. A second control station has been installed here from which traffic in the maintenance facilities can be monitored. The Central Unit has been supplemented by two Boosters with their own transformers to have sufficient power available for operating a large number of trains.

## Controlling turnouts and signals

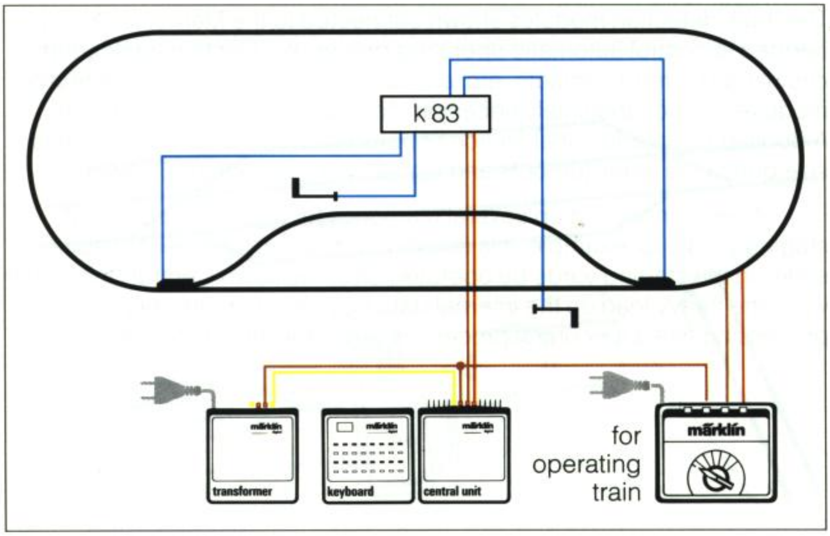
To switch turnouts and signals with the Digital system you need at least the following:

- the Central Unit
- a Keyboard
- a transformer
- a k 83 decoder for every four turnouts/signals

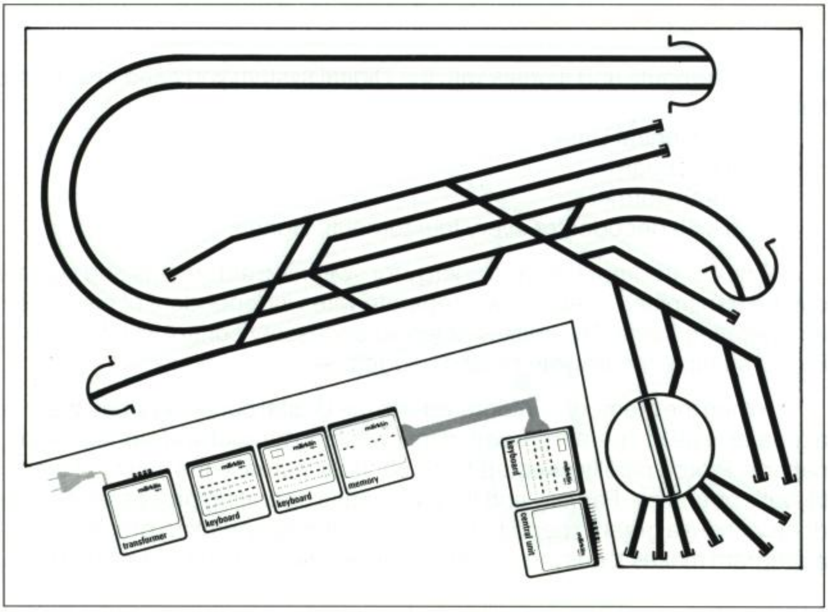
The control impulses and energy for switching all turnouts and signals can be transmitted over just two separate wires independent of the current for operating trains. This makes solenoid accessory control with Märklin Digital suitable for all systems and gauges.

When the Memory is integrated into the Digital control system, there is a greater level of operating comfort for switching turnout and signal combinations. Prototypically oriented route controls increase the safety of the layout's operation. Partially and fully automatic operating processes can be done without a great expenditure in wiring. Storing operating processes as a program makes it easy to quickly achieve new ideas for operating trains.

*Basic setup for switching turnouts and signals*




*ill. 66*




ill. 67

*Controlling solenoid accessories on a moderate size layout with Keyboard and Memory*

---

The track detection modules shown connected to the Memory are only needed to control automatic operating processes. Contact track areas, circuit tracks, reed contacts, etc. are connected to them. Track detection modules are not absolutely necessary for manually controlled layouts. A Booster as an additional source of power is useful with a layout of this size due to the many turnouts and signal lamps all requiring power.

When connecting up several Memories for automatic control of staging yards, for example, it is recommended that the solenoid accessories in the staging yards be operated off of their own Central Unit. Otherwise, the heavy load on the internal data bus would create very long processing times for control processes being run simultaneously.

## Märklin Digital and track diagram control boards

The basic setup (in addition to the track diagram control board) needed for controlling a model railroad using a track diagram control board in conjunction with Märklin Digital is the following:

- the Central Unit
- a Switchboard
- an Adapter 60 or Adapter 180
- a transformer
- a k 83 decoder for every four turnouts

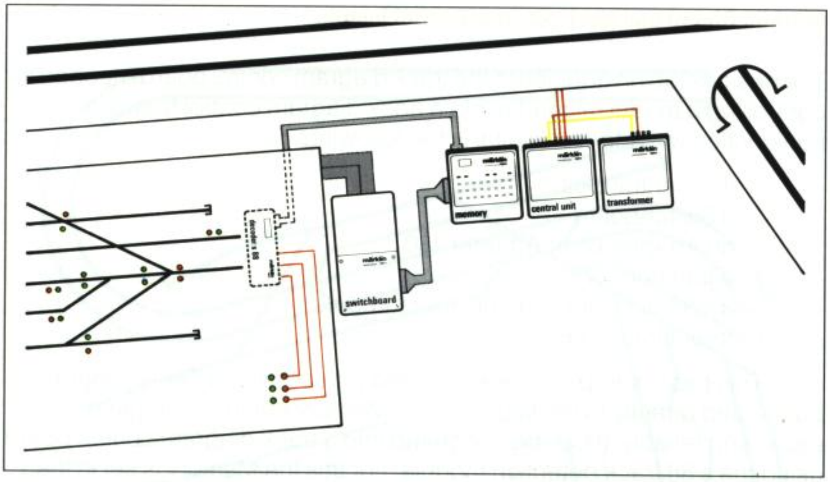
(see illustration 68)

This basic setup can be expanded with additional Switchboards connected directly to the first one. The Memory controls complete routes easily and reliably. It can be integrated into a track diagram control board using the s 88 track detection module. For this the Memory is set in the "extern" mode.

If the layout is to be operated by several people, it can be very interesting to set up several control stations. Operations become more varied when each operator has his own control panel for his area. The operators should have parallel control and switching capabilities for routes commonly used by more than one train. The same Switchboard addresses

*Basic setup for switching turnouts and signals in conjunction with a track diagram control board*


*ill. 68*




ill. 69

*Track diagram control board with route switching using the Memory – individual functions are controlled using the Switchboard*

can be assigned to several units for this purpose, thus allowing parallel controls and indicator displays. On large layouts additional control stations should be placed in close proximity to parts of the layout with concentrated operations (example: maintenance facilities or switch yards) to enable better monitoring and control of the operations (see illustration 69).

## Controlling locomotives and solenoid accessories

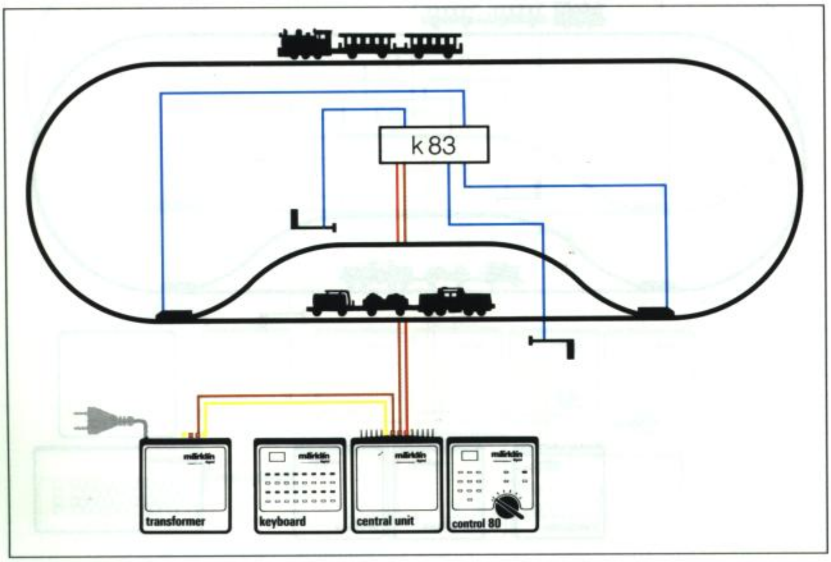
For total control of the model railroad with the Märklin Digital system you need at least the following:

- the Central Unit
- a Control 80
- a Keyboard
- a transformer
- locomotives with the c 80 or c 81 decoder
- a k 83 decoder for every four turnouts

(see illustration 70)

This basic setup can be expanded in the same manner as the descriptions given for the separate control tasks for operating trains and for controlling solenoid accessories.

*Basic setup for operating trains and controlling solenoid accessories*




*ill. 70*

## Computer control

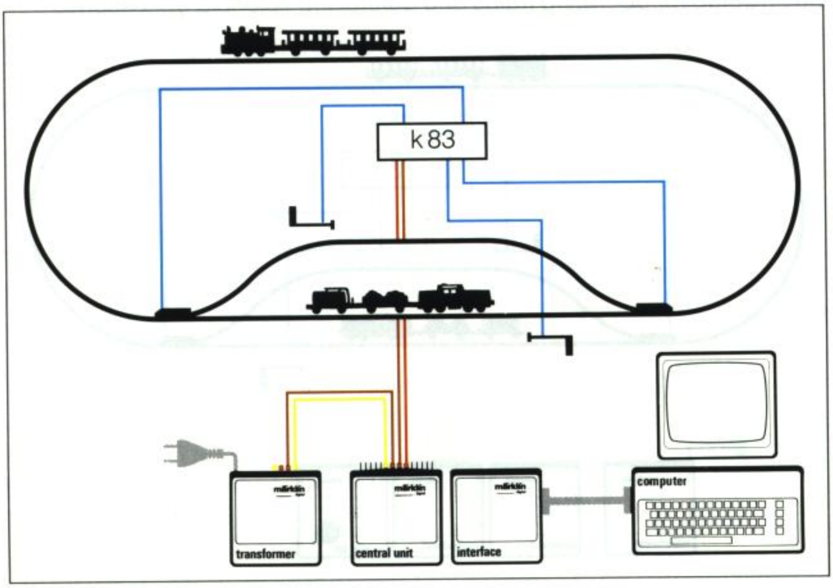
The basic setup for controlling a model railroad with a computer is as follows:

- a computer with a serial interface RS 232 or a suitable user port
- the Central Unit
- the Interface
- a transformer
- locomotives with a c 80 or c 81 decoder
- a k 83 decoder for every four turnouts
- a cable to connect the Interface to the computer

(see illustration 71)

This basic setup allows you to manually control all of the functions for a model railroad, i. e. train operations, turnouts, signals, etc. Time-controlled operations can also be achieved with this basic setup. Pure time controls, however, often do not function with enough flexibility and cannot react to disturbances in operation.

*Basic setup for controlling a model railroad using a computer*

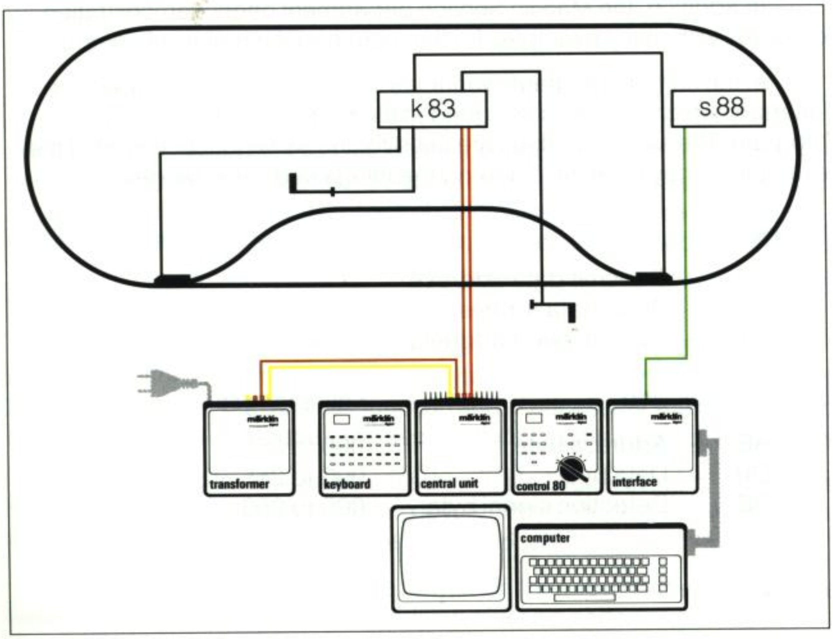



*ill. 71*

If automatic operations processes are to be activated from the layout, the s 88 track detection module is needed for sending detection signals. Using circuit tracks, contact track areas, etc., it registers the operating conditions on the layout so that the computer can send corresponding control commands (see illustration 72). Manual control of the operations parallel to the computer is possible by expanding with the Digital control components.

Parallel manual control can be used for extremely busy operating conditions on the layout (ex. maintenance facilities, loading sidings). However, there are control tasks that are not particularly suitable for a computer because they require more precision than the latter is capable of (ex. a crane or other loading equipment, helper locomotive operations on grades with curves) and because they lack detection signal capabilities (ex. crane position).

*Expanding with track detection modules and control components for parallel manual control*




*ill. 72*

## General remarks

The Interface enables the use of a computer with a digitally controlled model railroad. This combination results in unlimited possibilities for the control, monitoring and organization of the railroad. Some of these possibilities will be presented in the following pages.

The conditions which the computer must fulfill to be suitable for controlling the Digital layout as well as the connection to the Interface are described in the chapter "Interface" (beginning on page 54).

All of the examples given here can be written in BASIC, the most popular program language. The printed sample programs make use of subprogram technology so that they can be monitored and reconstructed. The actual send and receive commands differ slightly for the various makes of computers. Therefore, they are given in this text only with their functions. Type-specific commands should be used in the appropriate position for a usable program. These commands are listed in a test and demonstration program which can be ordered from

Märklin Service
Postfach 1242
D-7332 Eislingen, Federal Republic of Germany

In addition, the Märklin Service department offers demonstration diskettes with many examples for the more popular makes of computers.

In the sample programs variables are used, i.e. combinations of letters, to which a value is assigned at the beginning of or during the program. The same variables are used for the same function in all of the examples. They have the following meanings and value ranges:

## Initialization

TD – Transmit data address
RD – Read data address
CTS – Clear to send address

## Data transmission

| | | value ranges |
|---|---|---|
| AB | – Address byte | 000 to 255 |
| DB | – Data byte | 000 to 255 |
| RB | – Detection signal byte | 000 to 255 |

Locomotive control

| | | value ranges |
|---|---|---|
| LA | – Locomotive address | 001 to 080 |
| LG | – Locomotive speed | 000 to 015 |
| LF | – Locomotive function | 000 or 016 |
| Vmin | – minimum speed | 001 to 014 |
| Vmax | – maximum speed | 001 to 014 |
| MS | – weight simulation | 000 to 999 |

Turnout control

| | | |
|---|---|---|
| ST | – turnout Position | 032 to 034 |
| WA | – turnout address | 000 to 255 |

Track detection signals

| | | |
|---|---|---|
| MNR | – Module number | 001 to 031 |
| KN | – Contact number | 001 to 016 |

These variables are given for the more complex and powerful programs, i.e. they are individually defined for each locomotive, turnout or module address used. In addition, the locomotive address (for example) is placed after the variable: Vmax (LA) indicates the maximum operating level permissible or useful for locomotive address LA.

## Direct control

"Direct control" is understood as "manual control by computer". The computer simulates the Control 80 and Keyboard with a greater or lesser degree of operating ease. The control commands are entered on the computer's keyboard and the commands entered are carried out directly.

### Locomotive control

The computer must send a two-byte command to the Interface in order to control a locomotive. The first byte contains the information about the operating level, the auxiliary function and, if necessary, the command to change the direction of travel. The second byte has the locomotive address.

15 operating levels can be called up in the Digital system. "0" stands for halt and "1 to 14" signify operating levels with increasing levels of speed. A change in the direction of travel is called up with the value "15".

If the auxiliary function is to be turned off, then 16 must be added to the value of the operating level. This addition must be performed for each operating command as long as the function is to remain on. It must also be done when there is a change in the direction of travel (see table). When the function is turned off, it likewise changes over (unseen) with the direction of travel.

### Table "Values for locomotive control"

| Function | off | on | Function | off | on |
|---|---|---|---|---|---|
| halt | 0 | 16 | operating level 8 | 8 | 24 |
| operating level 1 | 1 | 17 | operating level 9 | 9 | 25 |
| operating level 2 | 2 | 18 | operating level 10 | 10 | 26 |
| operating level 3 | 3 | 19 | operating level 11 | 11 | 27 |
| operating level 4 | 4 | 20 | operating level 12 | 12 | 28 |
| operating level 5 | 5 | 21 | operating level 13 | 13 | 29 |
| operating level 6 | 6 | 22 | operating level 14 | 14 | 30 |
| operating level 7 | 7 | 23 | reverse direction | 15 | 31 |

Values over 31 are not accepted as a data byte for locomotive control; they are interpreted as position or control commands for other functions.

The second byte contains the locomotive address (01 to 80). Addresses under 10 do not have to be entered into the computer as a two-digit number because the computer skips over a preceding "0". Addresses sent to the Interface which are over 80 are accepted, but no data are transmitted to the Central Unit.

### Sample Program 1: direct locomotive control

```
100 gosub 900:                               rem initialization
102 :
110 input"operating level:";            LG:  rem enter operating level
112 input"locomotive address:";         LA:  rem enter locomotive
                                             address
114 DB=LG:AB=LA:                             rem define DB and AB
116 gosub 920:                               rem call up subprogram
118 goto 110:                                rem return to start
120 :
900 subprogram "initialization"
902 :
920 subprogram "send 2 bytes"
```

Program 1 first initializes the task channel or the Interface on the computer. After that the entry of the operating level and the locomotive address is requested in two steps. The data are assigned to the data byte DB and address byte AB before the subprogram "send 2 bytes" is called up. The subprogram first checks whether the Interface is ready to receive and then transmits the data. Once the subprogram has been carried out, the main program returns to the entry lines.

If the program is to be safeguarded against the entry of unauthorized values, the following lines must be added:

```
111 if LG<0 or LG>31 then goto 110
113 if LA<1 or LA>80 then goto 112
```

Locomotives can also be controlled using one or more Control 80's parallel to controlling locomotives with the computer. Only the locomotive called up by the computer cannot be called up with the Control 80. It can be taken over by a Control 80 when it has been released by the computer. This occurs when a command is sent (from the computer) for another locomotive (a fictitious one if necessary).

## Turnout and signal control

All functions covered by the k 83 and k 84 decoders can be controlled with the computer. Turnout control is representative of these functions and will be described below.

A two-byte command must be sent to the Interface for controlling a turnout. The first byte contains the control command:

| | |
|---|---|
| Position "+" (straight, green) | Value 33 |
| Position "−" (branch, red) | Value 34 |

The second byte contains the consecutive turnout address (0 to 256). The assignment of consecutive turnout addresses to decoders and Keyboards can be found in the "Code Table for k 83 and k 84 decoders". An exception is the address "256". It cannot be given in a byte because it corresponds to $2^8$. It is therefore transmitted as address "0".

The switching current for the turnout is turned on with the transmission of the data and address bytes. It remains on until the computer sends the Interface a shutoff command:

| | |
|---|---|
| Shut off switching current: | Value 32 |

This shutoff command is not directed to a particular turnout, but is sent out as a general command. An address byte does not therefore have to be sent with the shutoff command. If an address byte is placed after the command anyway, it will be accepted by the Interface.

Important:

The shutoff command must always be included in the programming; otherwise, the turnout solenoids will be damaged by the constant current sent to them.

Sample Program 2: direct turnout control

```
100 gosub 900:                 rem initialization
102 :
110 input"position:"; ST:      rem enter position command
112 input"address:"; WA:       rem enter turnout address
114 DB=ST:AB=WA:               rem define DB and WA
116 gosub 920:                 rem call up subprogram
118 goto 110:                  rem return to start
120 :
900 subprogram "initialization"
902 :
920 subprogram "send 2 bytes"
```

Like program 1, program 2 first initializes the output channel or the Interface of the computer. After that the entry of the position and the turnout address is requested in two steps. Before the subprogram "send 2 bytes" is called up, the data are assigned to the data byte DB and the address byte AB. As soon as the subprogram is carried out, the main program returns to the entry lines.

This program should first be tried out with an uncoupler track or a light bulb as a user, because the duration of the switching impulse can best be determined in these instances.

The program described above has two disadvantages: first, the shutoff command must be entered separately and there is the danger that it will be forgotten. Second, the entry of the address is requested – unnecessarily – for the shutoff command. An individual subprogram written for switching solenoid accessories which automatically sends the shutoff command after a certain period of time is more reliable and easier to use. Three lines are added in the main program and line 116 is changed so that now the new subprogram for controlling solenoid accessories is called up and the address is not requested with the shutoff command (which does not now have to be entered separately anymore). Here a new subprogram is called up which sends only a 1-byte command. Program 2 is supplemented as follows:

### Sample Program 2: direct turnout control

```
100 gosub 900:                  rem initialization
102 :
110 input"position:"; ST:       rem enter position
                                command
111 if ST=32 then goto 114:     rem skip address
112 input"address:"; WA:        rem enter turnout address
114 DB=ST:AB=WA:                rem define DB and AB
115 if ST=32 then gosub 960:    rem call up subprogramm A
116 if ST=33 then gosub 940:    rem call up subprogramm S
117 if ST=34 then gosub 940:    rem call up subprogramm S
118 goto 110:                   rem return to start
120 :
900 subprogram "initialization"
902 :
920 subprogram "send 2 bytes"
922 :
940 subprogram "send 2 bytes + shutoff"
942 :
960 subprogram "send 1 byte"
```

### Evaluating (testing) track detection modules

Track detection modules are not necessary for manual operation, because all processes are monitored. However, it is useful to design a program with which the regular function of the track detection locations can be checked even during the construction of the model railroad, i. e. during the wiring phase.

### Program 3

```
100 gosub 900:                  rem initialization
102 :
110 input"module no.:"; MNo:    rem enter position command
112 AB=192+MNo:                 rem define AB
114 gosub 980:                  rem call up subprogram R
116 goto  110:                  rem return to start
118 :
900 subprogram "initialization"
902 :
980 subprogram "send 1 byte and indicate track detection signal"
```

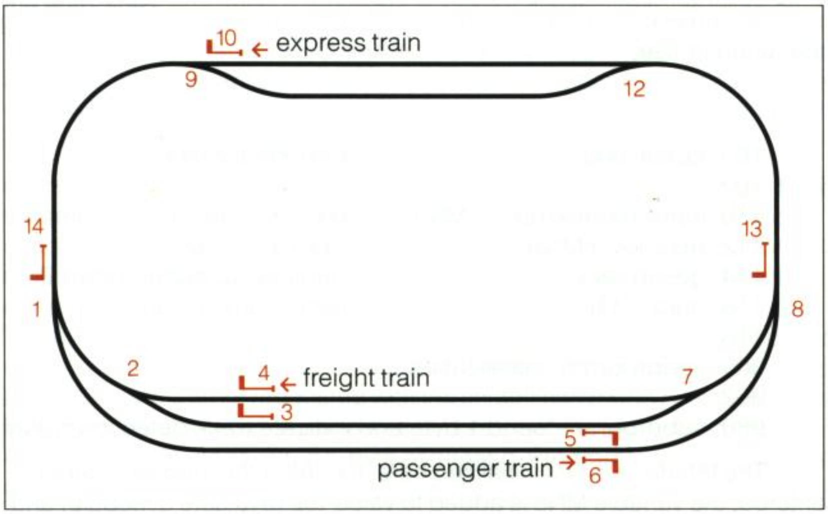
The Interface is first initialized here, too. After the module number is entered, the variable MNo is added to value 192 (evaluate a module) and assigned to the send byte AB. The subprogram called up sends a read-in command and receives 2 bytes from the Interface as acknowledgement. These are evaluated and the result is displayed on the computer monitor. The process then returns to the main program which again awaits the entry of a module number.

## Time control

The simplest form of automatic control of a model railroad is control with the aid of time delays. Locomotives, turnouts and signals are operated according to a precisely determined time schedule. The locomotives are controlled mainly by indirect means – using the train control capabilities of the signals.

The advantages of time control lie chiefly in the simplicity of the program structure. Moreover, with time control there is no need for track detection signals from the layout.

*Sample layout (schematic). The trains are standing in their departure positions.*




*ill. 73*

The operating procedure is set up in such a way that there must be a definite pause between specific program steps. This pause is determined by the running or waiting times of the trains. In addition, a certain "tolerance time factor" must be added to the calculations to smooth out minor differences in the running times. The pauses are programmed with a "time loop". They cause the computer to wait past the built-in clock or past a "for-next-loop" until the next command can be carried out.

Time-controlled processes are suitable for prototypical model railroad operations involving control of staging yards and as a computer-controlled schedule standard. Operating models such as traffic light layouts, cable cars and lighting installations (for buildings, streets, etc.) can be operated realistically using time controls.

A small sample program for the layout shown in illustration 73 will serve to explain this.

The trains must be standing in the right departure positions at the start of the program and they must be travelling in the correct direction.

### Initialization of the Interface

### Program start

- set turnouts for the express train
- give the express trains its exit signal and accelerate it to its running speed
- ● wait 5 seconds
- reset exit signal to stop
- ● wait 15 seconds
- slowly brake the train (it is stopped first at the signal)
- ● 5 seconds "safety time"
- set turnouts for the passenger train
- give passenger train its exit signal and accelerate
- ● wait 7 seconds
- reset exit signal to stop
- ● wait 20 seconds
- slowly brake passenger train (it will also be stopped at the signal first)
- ● 5 seconds "safety time"
- set turnouts for freight train to pass through
- give freight train "highball" signal and accelerate
- ● wait 5 seconds
- brake freight train to pass through station area
- ● wait 8 seconds

- accelerate freight train again
- ● wait 3 seconds
- brake freight train (it will be stopped at the signal)
- ● 5 seconds "safety time"

Return to the start of the program, if it is to be run several times.

This example shows that a small pause is always needed between the different train trips to smooth out differences in the running times of the trains. The time for the freight train to pass through the station can only be estimated. The decelerated part of its run takes place only approximately in the vicinity of the station.

During the waiting periods the computer could carry out other switching functions or control other trains, example: a commuter train on a branch line.

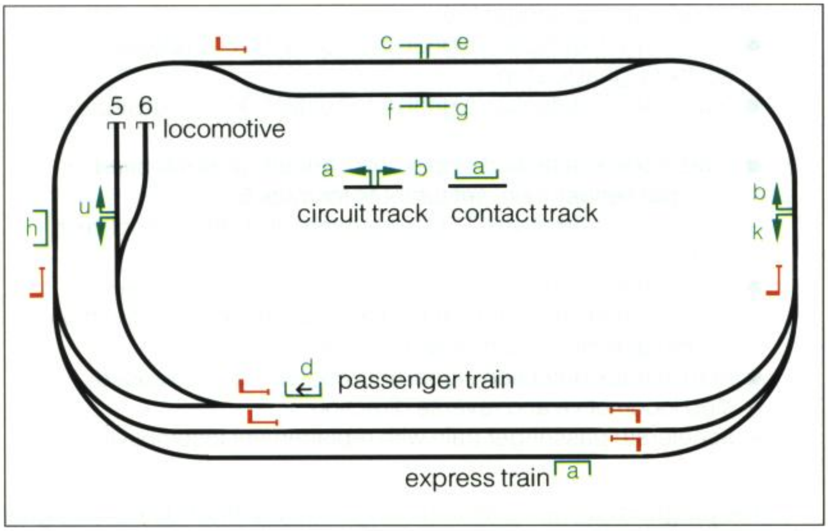
The advantage of this system versus conventional automatic controls lies in the varied possibilities for designing the program. When a new program is set up, a totally new operations procedure can be achieved without any changes to the layout. Several "schedules" can be stored and called up at any time. The length of the operating procedure is only limited by the storage capacity of the computer, practically speaking.

## Train controlled operation procedures

The limits of time control are reached when the object is to control a train precisely with respect to its direction of travel (example: to stop the train at a particular spot without blocks or to establish differences in running times and react to them).

For such control tasks the computer must have the ability to recognize when the train has reached a particular spot on the layout. Using the track detection module as a link, the computer can register when circuit tracks, contact track areas, reed contacts, etc. are activated. Very precise braking and switching is possible with the fast reaction time of the computer when track detection signals are being read in and evaluated. In an evaluation procedure only those track detection locations need be evaluated whose activation or release the computer must react to as its next task.

Circuit tracks and contact track areas have been installed on our familiar sample layout and a track detection module has been hooked up. The blocks at the signals are no longer needed. The signals now have only a cosmetic function (see illustration 74).




ill. 74

*Sample layout with track detection locations (circuit tracks and track contact areas)*

This example will demonstrate how a train-controlled program can be set up.

The trains are brought to their departure positions before the program is started. During the course of the program there will be a change of locomotives on the passenger train. The class 86 locomotive is equipped with TELEX couplers.

## Program start with initialization

- set turnouts and exit signal for the express train
- accelerate express train
- ● read in track detection signal until contact "a" is released
- set exit signal to stop
- ● read in track detection signal until contact "h" is released
- slowly brake express train
- ● read in track detection signal until contact "a" is released
- stop express train and set turnouts for the passenger train, give passenger train "highball" signal

- accelerate passenger train
- ● read in track detection signal until contact "d" is released
- set exit signal to stop
- ● read in track detection signal until contact "k" is released
- brake passenger train
- ● read in track detection signal until contact "d" is released
- stop passenger train, set turnouts for track 5
- switch on locomotive's TELEX couplers and set locomotive in motion
- ● read in track detection signal until contact "n" is released
- stop locomotive, switch off TELEX couplers, reverse direction
- set replacement locomotive in motion
- ● read in track detection signal until contact "d" is released
- stop locomotive and reverse direction
- accelerate passenger train with replacement locomotive
- ........

The program can be continued as desired. The track detection signals from the layout enable a situational control of the layout in which the actual position of the train is taken into consideration. In comparison to time control there are considerable advantages and additional operating possibilities.

Flexibility is the advantage in comparison to conventional automatic controls. A train passing over a circuit track can activate quite different control processes at various points in a program.

The operating concept should be considered in the planning of the layout so that the track detection locations are correctly placed.

## Schedule operations

Many model railroaders operate according to a schedule worked out in advance. With a computer-controlled model railroad a schedule can be achieved using a combined time and train-controlled program.

Operation on the layout can be even more interesting when the computer sets up operating tasks with a random generator (example: a trackside factory's need for freight cars) or when it "discovers" breakdowns in operations which require a response from the station master.

A combination of computer and manual control is possible with schedule operations. The computer takes over the monitoring of staging yards and hidden areas of the layout.

Following the established schedule, it brings trains up to the entry signal for the station where they can then be transferred to manual control. Interesting operations procedures such as changing locomotives or switching through cars can be carried out with manual control.

Following the schedule, the computer takes over the train standing ready at the exit signal and places it again on its track in the staging yard.

## Introductory remarks

All solenoid accessories with single or double solenoid mechanisms which require a short impulse of current to be switched (example: turnouts, signals, uncoupler tracks, etc.) can be operated with the k 83 decoder.

Users requiring a long impulse or a constant source of current are switched with the k 84 decoder. The k 84 decoder can be replaced by a k 83 with four universal relays.

The wiring diagrams presented in this chapter can be used for all gauges and systems. Any differences in the diagrams due to differences in systems will be pointed out when necessary. Differences in the color coding for the wiring with other makes of equipment must be kept in mind.

## Hooking up turnouts and signals to the k 83 decoder

The brown and red sockets are used to provide power to the decoder. The sockets of the same colors on the opposite side of the decoder can be used to connect other k 83 or k 84 decoders.

The four sets of triple sockets, each with a red, yellow and a green socket, are used to hook up turnouts and signals.

The solenoids are supplied with power by means of the yellow socket. The yellow wire from the turnout or signal mechanism is connected to it. On H0 turnouts and semaphore/target signals 7036 through 7042 this wire also provides the connection for the illumination.

The green and red sockets on each triple set are the switching outputs for the decoder. The two blue wires are connected here in such a manner that the "straight" or "green aspect" position is connected to the green socket on the decoder (it corresponds to the green button on the Keyboard). The "branch" or "red aspect" is connected to the red socket (it corresponds to the red button on the Keyboard).

---

Important tip:

All solenoid accessories switched using a k 83 decoder must always have their yellow wires connected to a k 83 decoder. If the yellow wires are connected to the accessory socket (yellow) on a transformer, the result will be malfunctions in the system! This must also be kept in mind if the turnout or signal is also controlled using circuit tracks.

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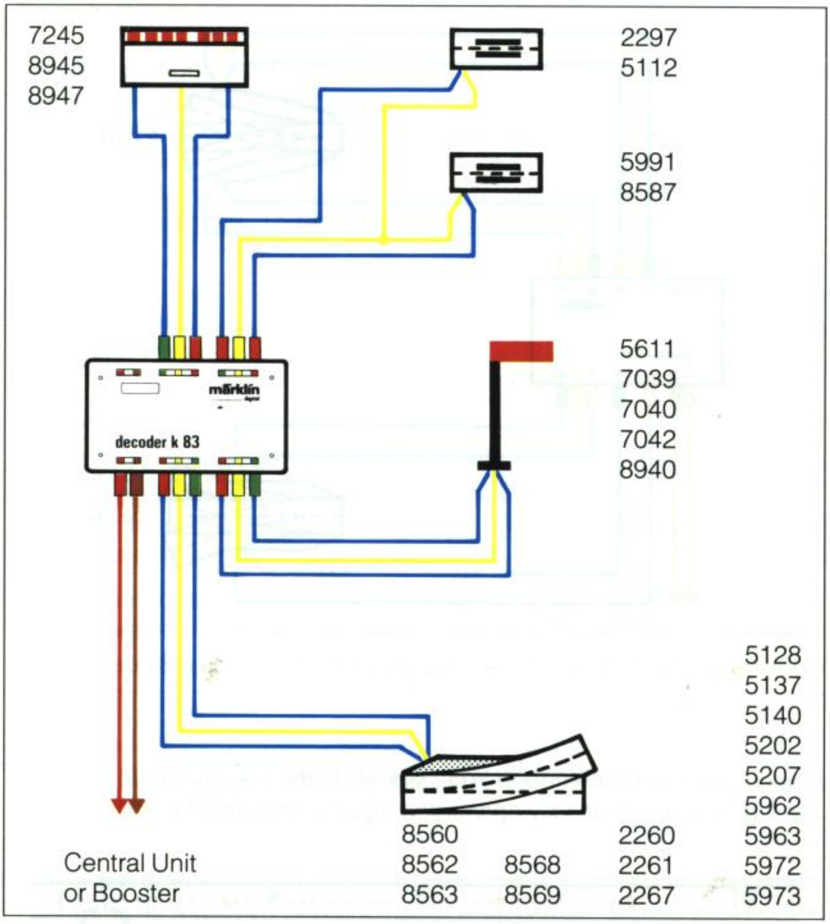


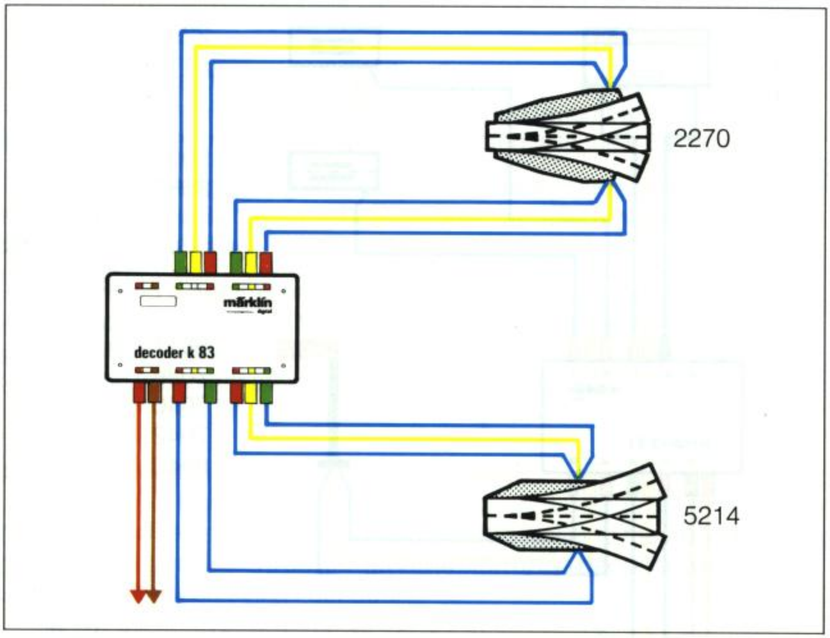

*ill. 75*

*Basic hookup of solenoid accessories to the k 83 decoder*

## Turnouts

### Special note:

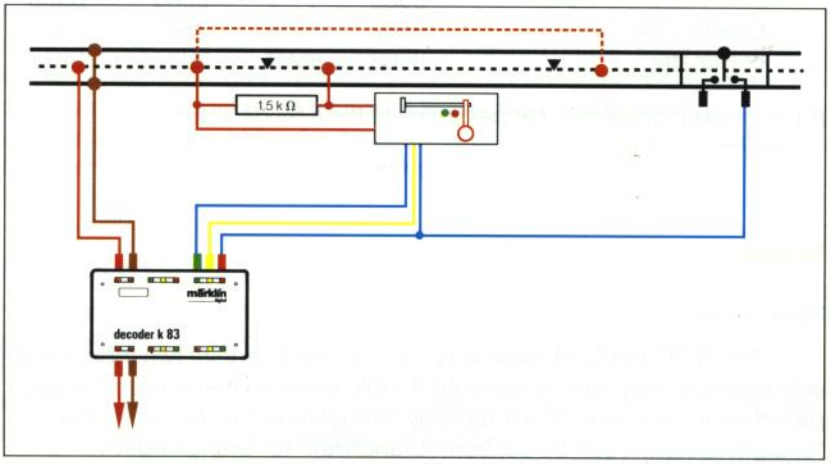
The 2270 and 5214 three-way turnouts each require two triple socket sets because they have a separate double solenoid mechanism for each pair of switch tongues. The three-way turnout must first be set for the "straight" before it can be set from "branch left" to "branch right".



ill. 76

*Hooking up the 2270 and 5214 three-way turnouts to the k 83 decoder*

*Hooking up the 7036 through 7042 signals to the k 83 decoder.
The signal is automatically connected again to the circuit track.*



ill. 77

## Semaphore/Target Signals

Hooking up signals is the same procedure as that for turnouts. In addition, there is the train control capability of the home and track block signals. With digital train operation, the block insulation point should be bridged by a 1.5 kiloOhm resistor so that the locomotives do not lose their "memory". The dotted electronic bridge keeps power flowing to the area of track between two signals. This bridge should always be installed with block signals.

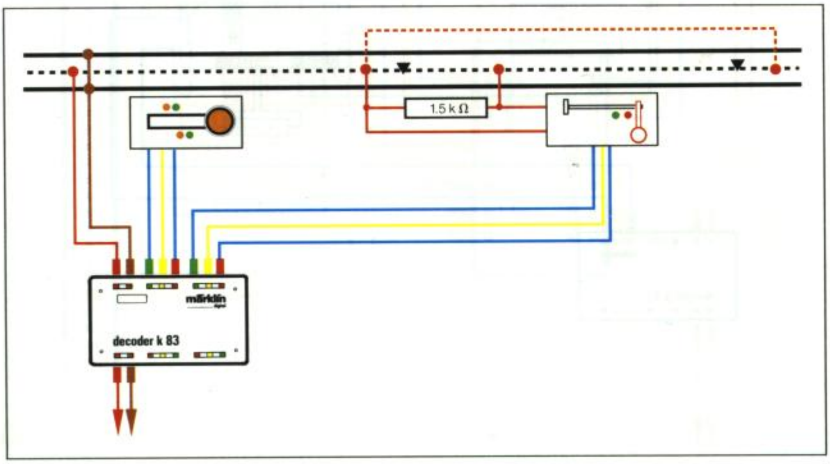
Circuit tracks which automatically reset the signals to the stop aspect after the train has passed are connected up parallel to the decoder (see illustration 77).

Special note:

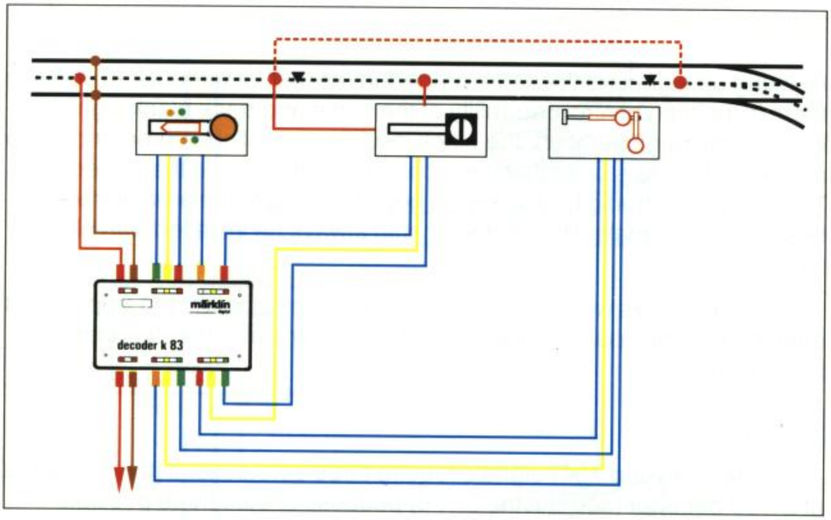
The 7038 und 7041 signals require three connections (for blue wires) at a k 83 decoder (see illustration 79) because of their three possible settings (aspects). The fourth connection can be used for another signal with three settings or for hooking up an uncoupler track.

If the signal mechanisms (in H0) are mounted below the layout baseboard or if for some other reason (example: 2-rail systems) they are not

*Wiring diagram for a 7039 signal with a 7036 distant signal and train control capabilities*




*ill. 78*




ill. 79

*Combination of 7041 exit signal with a 7042 track block signal and the 7038 distant signal*

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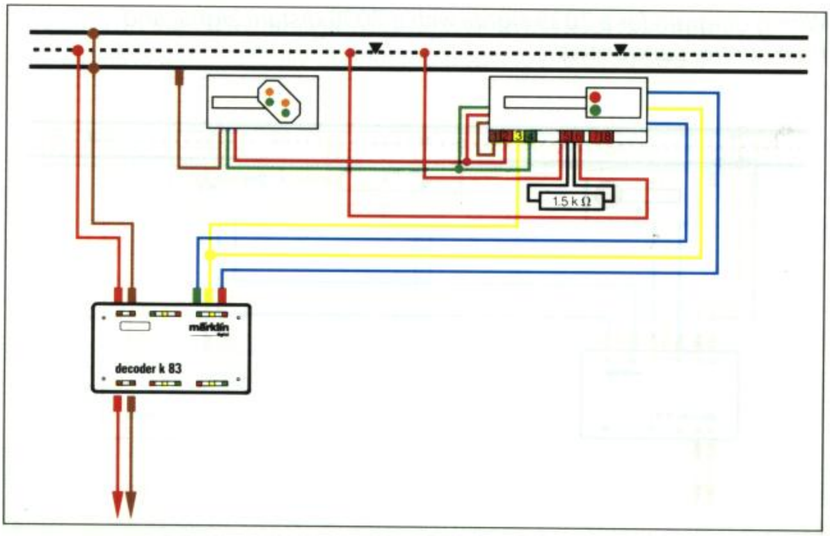
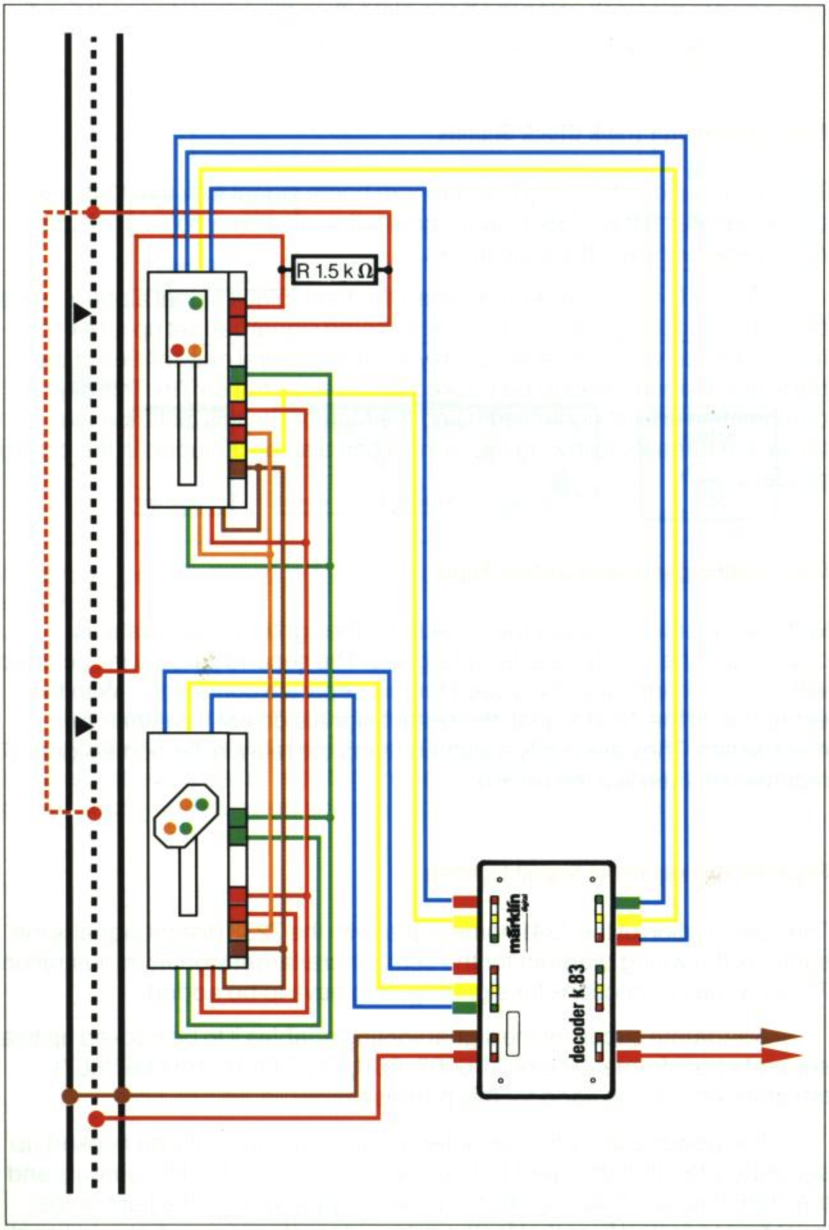
*Hooking up the 7239 color light signal with the 7236 distant signal to the k 83 decoder*




ill. 80




ill. 81

*Combination of the 7241 home signal with the 7238 distant signal* grounded to the track using the base plate, then the ground connection for the signal lighting must be done with an additional brown wire.

## Exit Signals with Track Block Signals

The combination of the 7041 semaphore home signal with the 7042 track block signal and the 7038 distant signal is the most common signal combination encountered at station tracks.

On the German Federal Railroad the track block signal alone is used to control switching maneuvers and the home signal can set up an exit only in conjunction with it. As a result only the train control capabilities of the track block signal need to be hooked up (see illustration 79). This signal combination is best controlled using the Memory. In this instance the turnout or turnouts following the signals can also be included in the control process.

## Color Light Signals with Distant Signal

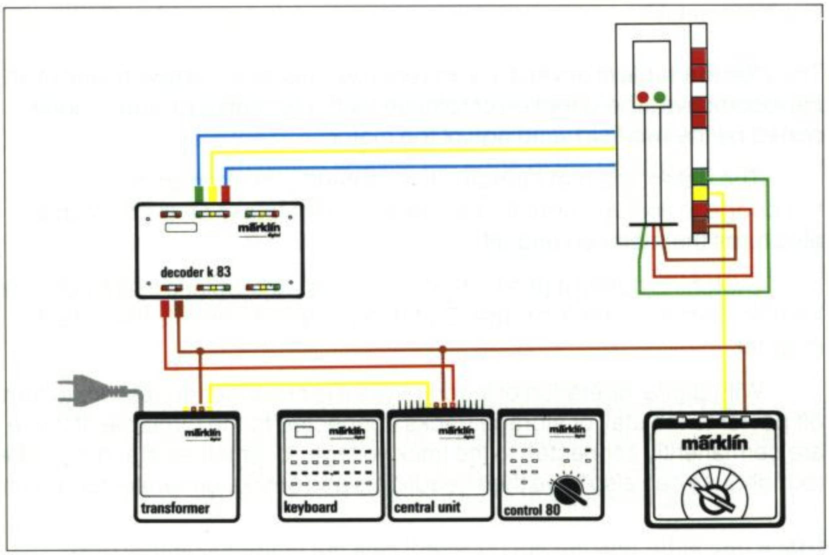
With the color light signals the hookup for the lighting is separate as opposed to the semaphore/target signals. The second yellow wire included with the color light signals is used for this separate connection. With the exception of the 7238 signal, the distant signals do not have their own mechanism. They are jointly switched using the relay in the home signal's mechanism (see illustration 80).

## Separate Hookup of the Signal Lighting

The combination of the 7241 home signal with the 7238 distant signal is the same as the wiring diagram for the semaphore/target signals in illustration 78. Only the connections for signal lighting have to be added.

A separate circuit for the signal lighting enables it to be hooked up to a separate transformer. The 6001/6002, 6611, 6627/6631 and 6667/6671 transformers can be used for this purpose.

The power supply for the lanterns/lights can basically be hooked up separately for all illuminated turnouts and signals. On the H0 turnouts and the 7036 through 7042 signals the power supply wire for the light bulbs must be separated from that for the solenoid mechanism and an additional wire (white would be best) must be soldered to it.




ill. 82

*Hooking up the illumination for the color light signals to a separate transformer*

Lighting with its own separate power supply can be turned off during the day as with the prototype. The brightness of the lights can be reduced to a realistic level by using resistors in the 16 volt power supply or by using a power supply with a lesser voltage (approximately 12 volts).

## The 7186 turntable

The 7186 turntable is driven by a universal AC/DC motor similar to that of an H0 locomotive. The direction of rotation for the turntable bridge is determined by the two field windings of the motor.

The detent magnet operates the centering mechanism that causes the bridge to line up correctly with the entry/exit tracks on the turntable; it also turns the motor on and off.

Switching output 4 (the first set of sockets) determines the direction of rotation for the turntable bridge. Switching output 3 controls the detent magnet.

With digital operation of locomotives it is no longer necessary to turn off power to the stall or storage tracks connected to the turntable. If these are permanently connected to the track voltage, locomotives standing in the roundhouse can also have their headlights and smoke generator turned on.

Tip:

A method of controlling the turntable with track indexing using the Memory is illustrated and described on page 153.

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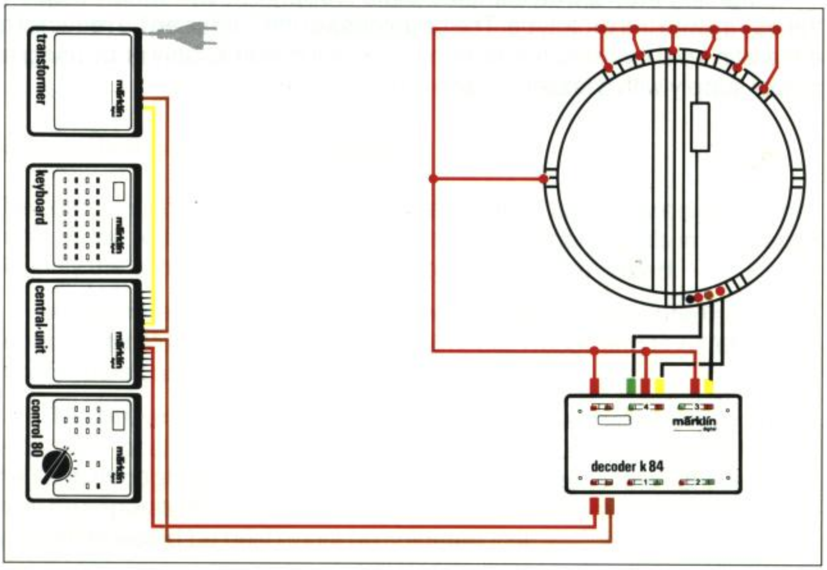
*Controlling the 7186 turntable with the k 84 decoder*




*ill. 83*

## The 7294 Transfer table

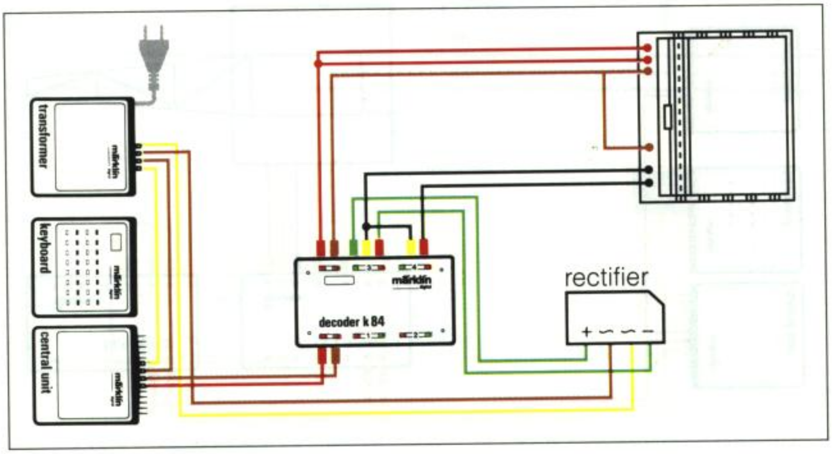
The transfer table is powered by a DC motor. For this reason a rectifier is required (see illustration 84). The transfer table deck (or bridge) is centered by means of gaps in the power rails and by the motor's deceleration. Diodes prevent the deck from hitting against the edge of the table pit at the end in either direction.

The direction of travel for the deck is chosen by changing the polarity of the motor. With an additional wire to provide the motor with power at the gaps in the power rails, the deck can be set in motion or moved further down its rails.

The transfer table is operated with half-wave DC current so that no more than two switching outputs on the decoder are needed. The positive half wave causes the deck to travel "up", the negative half wave causes it to travel "down". Switching output 4 is used to switch between the two half waves. The second switching (3) output turns the deck on and off.

With digital operation the stall tracks on the transfer table can also be permanently supplied with power. Locomotives on these tracks can then have their auxiliary function turned on at any time.

*Controlling the 7294 transfer table with the k 84 decoder*



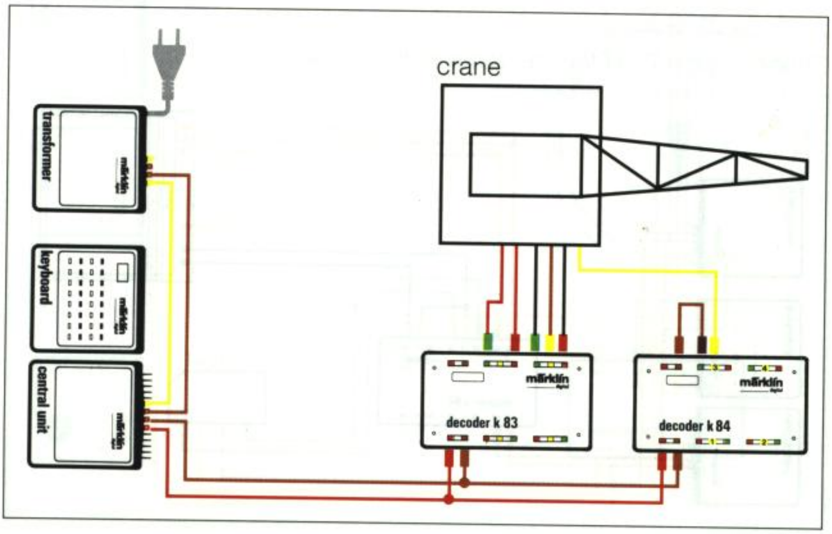

*ill. 8684*

## The 7051 crane

The 7051 crane has two universal AC/DC motors for turning the cab and raising/lowering the hook. They can be controlled using the k 83 decoder. Care must be taken that the brown wire from the crane is connected to a yellow socket on the decoder (see illustration 85).

The lifting magnet cannot be controlled directly with the k 83 decoder as the decoder can only turn on one output at a time. Therefore, either a universal relay must be placed in the line to the lifting magnet or the magnet can be connected to a k 84 decoder as shown in illustration 85.

*Hooking up the 7051 crane to the k 83 and k 84 decoders*



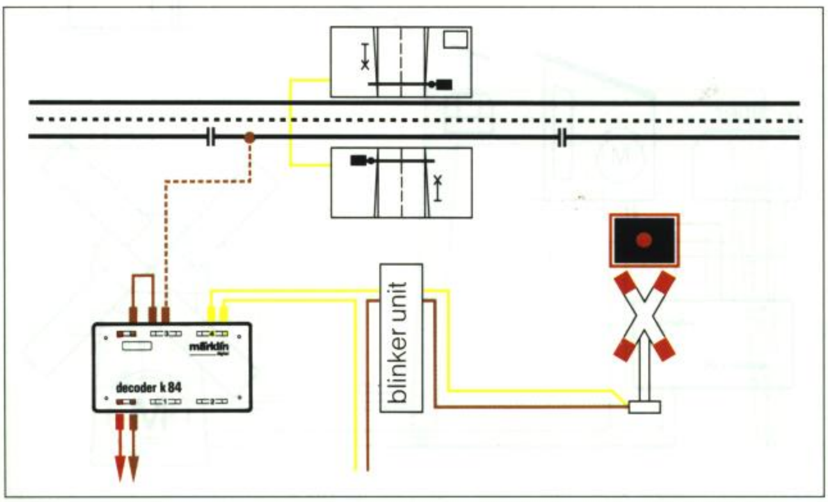

*ill. 85*

## Grade crossings and warning lights

The electrically operated grade crossings 7192, 7292 and 7592 are controlled by the wheels of a train passing over the grade crossing. A length of track on both sides of the grade crossing is equipped with contact tracks for this function and the crossing gates and warning lights are connected to a special section of track which is in turn connected to the contact tracks. This setup can also be used with digital operation.

If the contact area at the grade crossing is bridged by a ground contact which is switched by a k 84 decoder (see illustration 86), then the ground contact can be activated using the Keyboard, track diagram control board or the Memory. A prototypical combination of the grade crossing with an automatic train-stopping signal is possible and the contact area can be kept very short.

*Hookup for the 7192, 7292 and 7592 crossing gates*



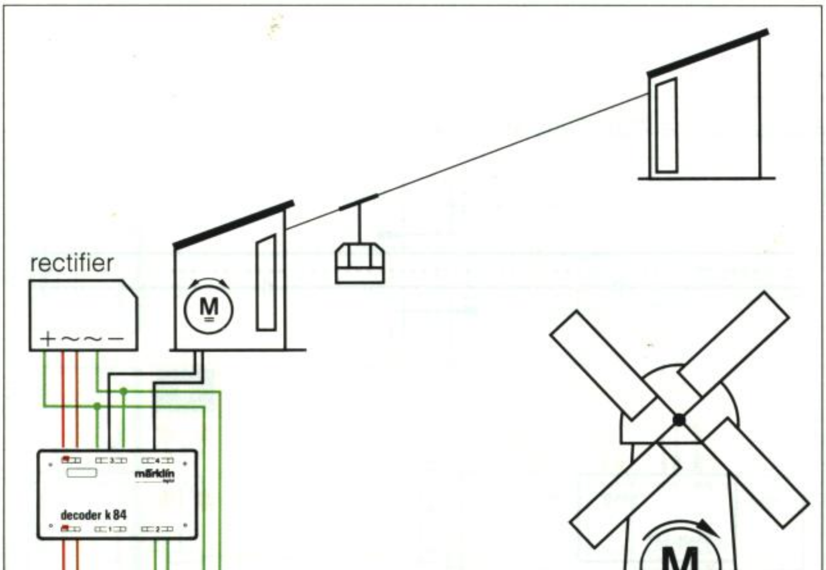

*ill. 86*

## Cable car, windmill and lighting installations

These operating models are merely turned on and off. They are connected to the k 84 decoder's switching outputs (socket sets) (see illustration 87).

The models must be supplied with voltage matched to their specifications. Some models require DC power.

*Hookup for a cable car, windmill and lighting installation to the k 84 decoder*



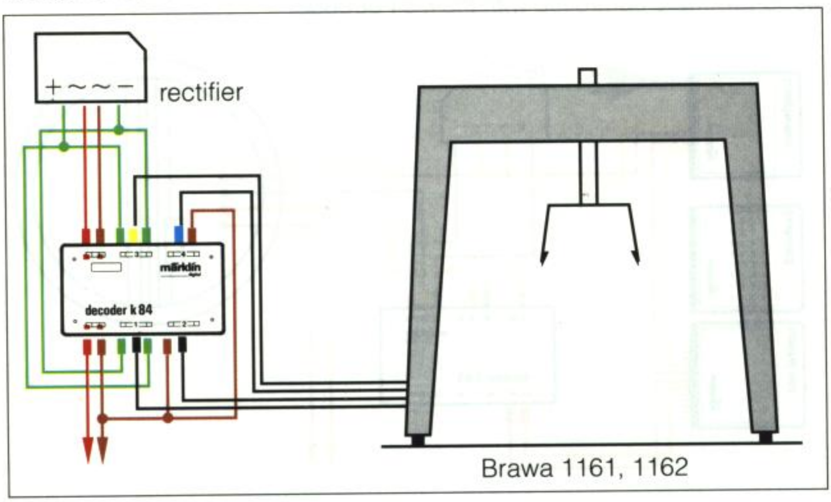

*ill.87*

## Operating models with DC motors (ex. Brawa container crane)

These operating models enrich the operations on a model railroad. They can be connected to the k 84 decoder. They are operated with half-wave DC current to keep the cost of the circuit as low as possible. One switching output (set of sockets) determines the direction of rotation for the mechanism being controlled and a second switching output on the decoder is responsible for turning the mechanism on and off.

The container crane shown in illustration 88 as an example has two motors. It therefore requires four decoder outputs for its control.

*Brawa container crane controlled with the k 84 decoder*




*ill. 88*

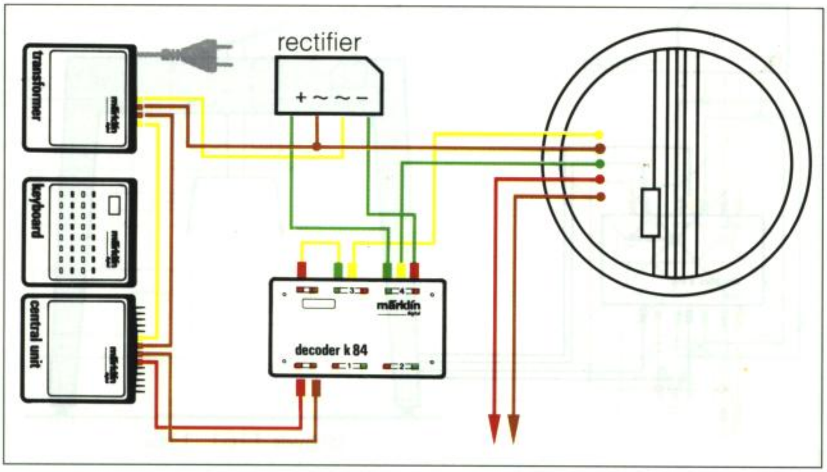
## Z Scale turntable and transfer table

The same switching circuit is used to operate the 8998 turntable and 8994 transfer table. A DC motor moves the turntable/transfer table bridge. The bridge's motor is supplied with current from contact rails laid in the pit and is stopped by means of gaps in these rails. With the use of an additional continuous power rail the bridge's motor can be turned on in such a way that the bridge starts at or passes over these locations. The direction of travel for the bridge is determined by the polarity of the current.

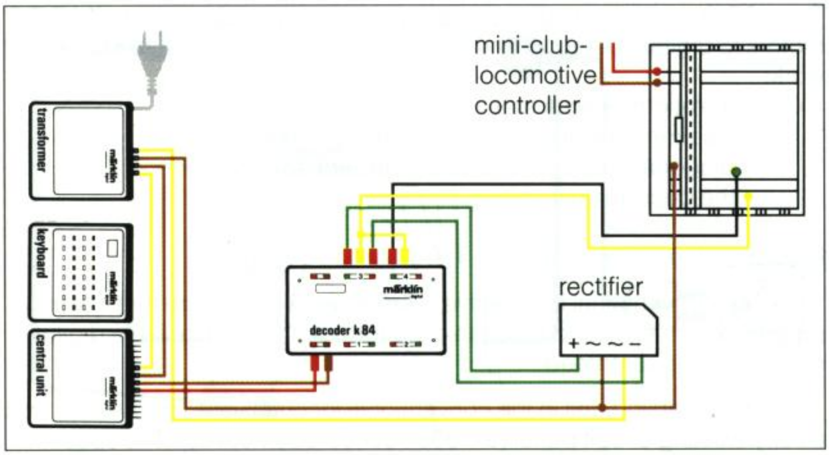
As with the H0 version, a protective diode at each end of the pit on the transfer table prevents the bridge from running up against the edge of the pit.

The current for operating locomotives on the bridge and the stall tracks is supplied by a separate mini club-power pack (see illustrations 89 and 90).

*8998 Turntable controlled with the k 84 decoder*




*ill. 89*




ill. 90

*8994 Transfer table controlled with the k 84 decoder*

The c 80 decoder is used to convert all locomotives with universal AC/DC motors to digital operation. The following equipment is required for expert work:

- a static-free work mat
- a soldering station with temperature control
- diagonal cutting pliers, wire strippers, tweezers
- the decoder test unit

## Preparing the locomotive

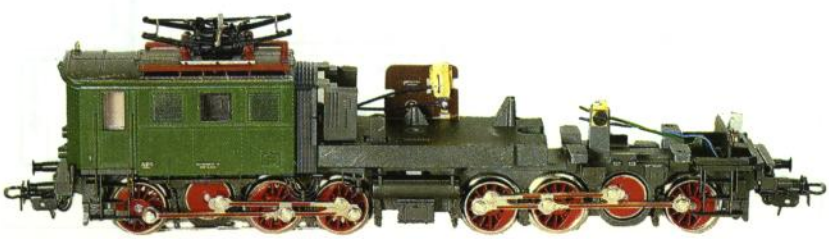
The conventional locomotive is first checked to insure that it works properly electrically and mechanically, for only then can reliable digital operation be guaranteed.

The reversing unit in the conventional locomotive is removed as well as any existing circuit panel (ex. 3300 series locomotives). The space created by the removal of these components is used for the installation of the decoder.

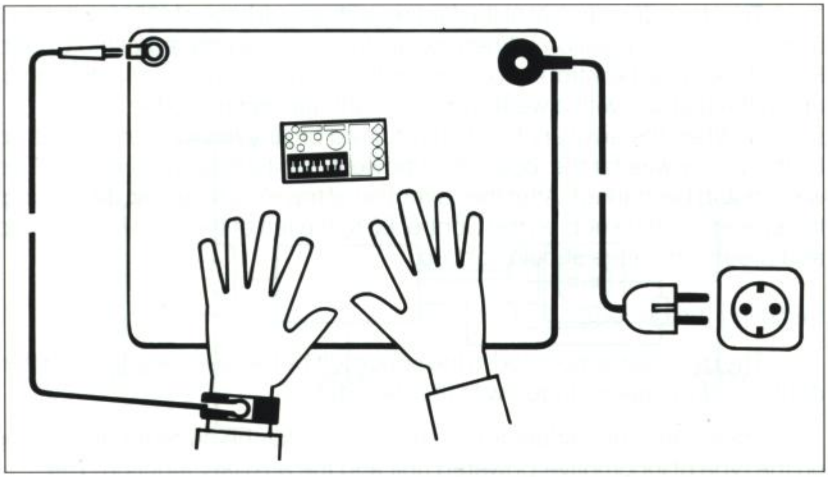
The c 80 decoder must be taken out of its special packaging only on a static-free work mat. This work mat protects it from being destroyed by static charge. The wrist band must be worn before touching the decoder to avoid differences in electrical potential.

Before being installed, the c 80 decoder is checked with the decoder test unit. All of the decoder wires are connected to the respectively colored sockets on the test unit for this purpose. The red wire should be connected last to avoid a "no load" situation.

*Conventional locomotive with the reverse unit and circuit panel removed*



*ill. 91*



ill. 92

*Static-free work mat*

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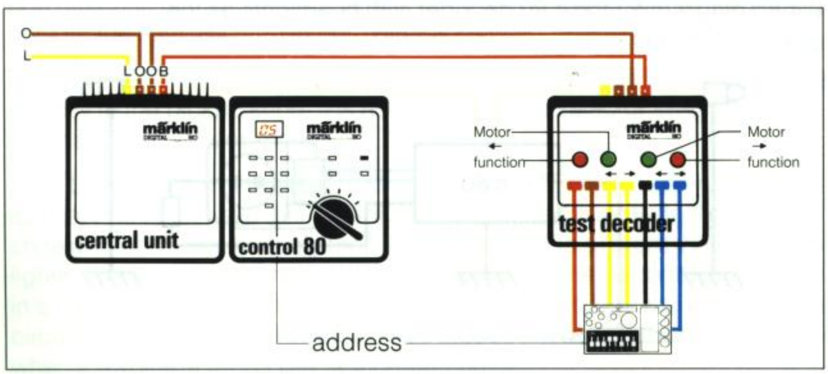
*The c 80 decoder hooked up to the test unit*




ill. 93

The decoders are set at the factory with an address of "25" (switches 2 and 7 in the "on" position). When the address "25" is entered at the Control 80 and the speed kontrol knob is turned to the right, a green indicator lights up on the test unit with a weak or bright light depending on the speed setting. When the auxiliary function is turned on, the red indicator lights up by the yellow wire for the locomotive/powered unit's forward direction. This wire should be marked. After the "direction of travel" is reversed (by turning the speed control knob on the Control 80 to the left of the "0") the other red and green indicators should light up.

## Installing the decoder

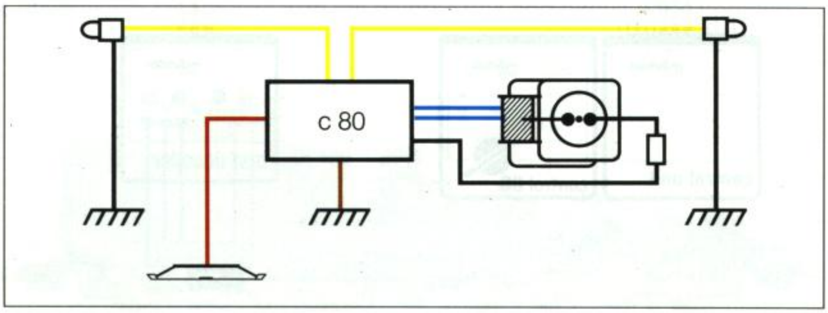
The decoder is mounted in the space left by the reverse unit using the double-sided tape included with the decoder.

There are slight differences in the hookup for the decoder depending on the type of locomotive/powered unit and the auxiliary function. The following illustration shows the wiring diagram for steam and diesel locomotives with headlights as the auxiliary function.

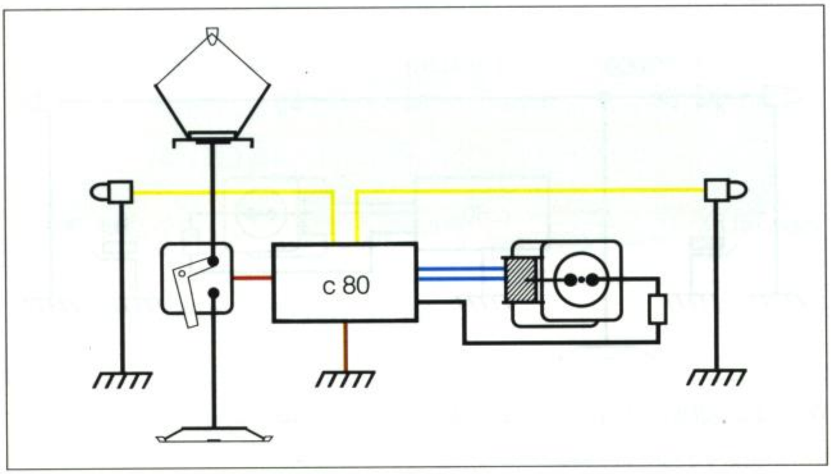
The soldering station should be set at a temperature of 350–400 degrees Centigrade (660–750 degrees Fahrenheit) for the required solder work. When measuring the decoder wires for cutting, allow enough length for the locomotive/powered unit's trucks to move freely.

On diesel locomotives the yellow auxiliary function wire marked for the forward direction is soldered to the headlight socket at the end of the

*Wiring diagram for the c 80 decoder with headlights as the auxiliary function*




*ill. 94*




ill. 95

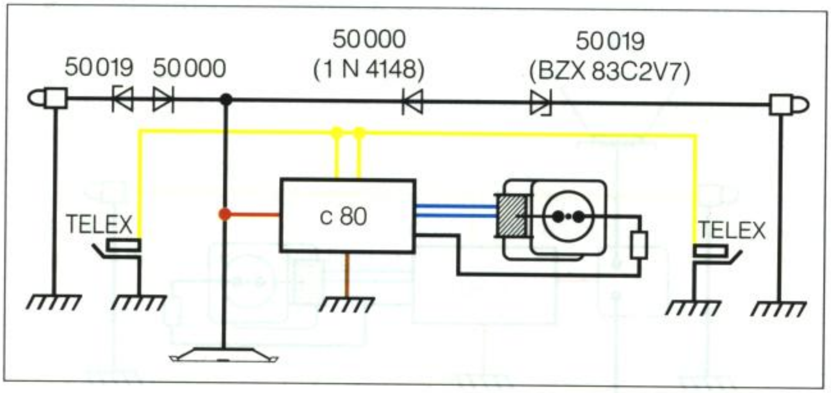
*Wiring diagram for the c 80 decoder in electric locomotives*

locomotive with the pickup shoe truck (cab 1). On steam locomotives the smoke stack should be at the forward end of the unit with respect to the direction of travel.

On locomotives with headlights at only one end the second yellow wire does not need to be hooked up. The headlight then burns only in the one direction of travel. If both yellow wires are soldered to the headlight socket, the light will burn in both directions.

On electric locomotives the red wire on the decoder is not connected directly to the pickup shoe; it is hooked up to the selector switch for catenary and track operation.

Locomotives converted to Digital with the TELEX coupler as the auxiliary function have their headlights connected directly to the pickup shoe and burn continuously (see illustration 96). To prevent the locomotive lighting's power consumption from extinguishing the decoder's "memory" in a block section, a protective diode and a zenier diode are placed in the circuit in front of each light bulb. These diodes interrupt current to the bulbs when the voltage drops below a certain point.

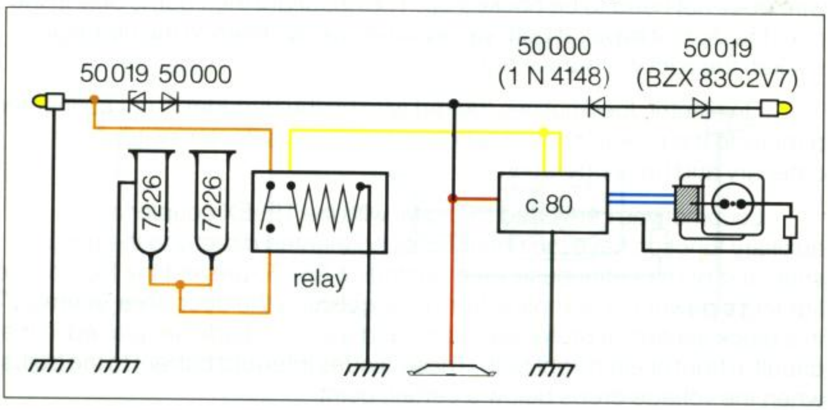



*Wiring diagram for a locomotive with TELEX couplers*

*ill. 96*

Auxiliary functions drawing more current than 700 milliamps must have a relay included which protects the end level of the decoder against an overload. The type used is a single-solenoid relay which automatically returns to a start position after the switching current is turned off. With this circuit the 3102 locomotive, for example, can be equipped with two smoke generators (see illustration 97). This circuit can be installed separately for both directions of travel.

*Hookup using a relay for an auxiliary function with a higher current draw*




*ill. 97*

ill. 98

*Locomotive with c 80 decoder installed*

After the installation is complete, the decoder is set for the desired locomotive address. The switch settings for the address can be found in the "Code table for locomotives" (appendix, page 165).

After a short test run the locomotive body can be put back on. When doing this care must be taken that no wires are pinched. This can lead to short circuits which may destroy the decoder under certain circumstances.

The c 81 decoder is used to convert all locomotives with DC motors to digital operation with Märklin 3-rail/center stud track. The only requirements for this are potential-free motor connections and enough room in the locomotive for the decoder.

Although many steps have already been described in the conversion with the c 80 decoder, they will be repeated here for the sake of completeness.

The following equipment is needed for expert conversion of a locomotive:

- a static-free work mat
- a soldering station with temperature control
- diagonal cutting pliers, wire strippers, tweezers
- fine toothed metal saw, file or cutting tool
- the decoder test unit

## Preparing the locomotive

The conventional locomotive is first checked to insure that it works properly electrically and mechanically, for only then can reliable digital operation be guaranteed.

DC locomotives of other manufacturers with a mechanical (Fleischmann, Rivarossi, etc.) or an electronic reverse unit must have this unit removed. Often the space gained by the removal of this component is sufficient for the installation of the decoder. Otherwise, room must be made for the decoder by altering the locomotive frame or the ballast weight. All wire connections between the motor, frame, wheel pickups and headlights must be unsoldered.

It is very important to have potential-free motor connections. The brush holders cannot have any conductive connection with the frame or the wheels. Before installing the decoder, this potential-free condition must be checked without fail using suitable testers (ex. an Ohmmeter).

Many manufacturers offer replacement parts for locomotive/powered units with brush plates that do not have potential-free motor connections (these parts are already installed on AC versions of these units). Often it is possible to cut or separate the conductive lines on a brush plate using a sharp knife or a fine-toothed metal saw.

This procedure is specially suitable for locomotives with their headlight bulb sockets and power circuits assembled on a printed-circuit board.

The locomotives must be equipped with a third-rail pickup shoe. Care must be taken in mounting it that there is sufficient room for it to flex upward when going over switches so as not to cause a derailment or short circuit. It is also important that the pickup shoe press down sufficiently on the center studs.

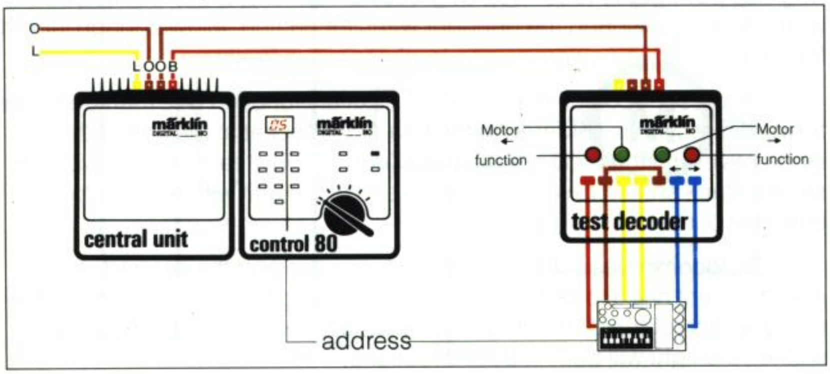
## Testing the decoder

The c 81 decoder must be taken out of its special packaging only on a static-free work mat. This work mat protects it from being destroyed by static charge. The wrist band must be worn before touching the decoder to avoid differences in electrical potential.

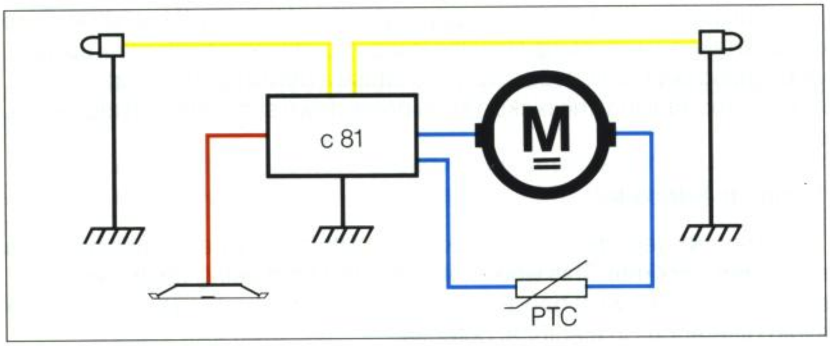
Before being installed, the c 81 decoder is checked with the decoder test unit to insure that it works properly. All of the decoder wires are connected to the respectively colored sockets on the test unit for this purpose. The red wire should be connected last. The black terminal must be bridged to the brown terminal with a length of wire.

The decoders are set at the factory with an address of "25" (switches 2 and 7 in the "on" position). When the address "25" is entered at the Control 80 and the speed control knob is turned to the right, the green indicators light up on the test unit by the blue wires. When the auxiliary function is turned on, the red indicator lights up by the yellow wire for the locomotive/ powered unit's forward direction. This wire should be marked. After the "direction of travel" is reversed, the other red indicator will light up along with both green indicators.

*Checking the c 81 decoder with the decoder test unit*




*ill. 99*




ill. 100

*Wiring diagram for a c 81 decoder with headlights as the auxiliary function*

## Installing the decoder

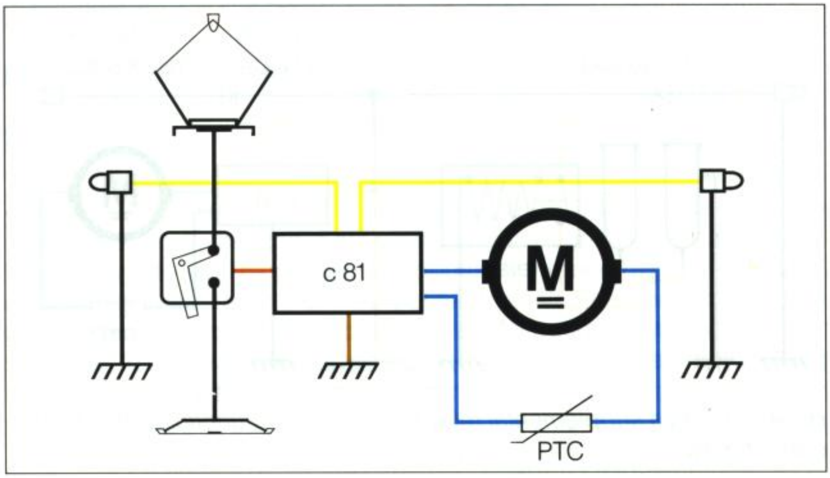
The installation of the c 81 decoder is in principle the same as that for the c 80 decoder. For the sake of completeness – and chiefly because there are differences in the wiring diagrams – all of the work steps will be repeated here.

There are slight differences in the hookup of the decoder depending on the type of locomotive/powered unit and the auxiliary function. Illustration 100 shows the wiring diagram for steam and diesel locomotives with the headlights as the auxiliary function.

The soldering station should be set at a temperature of 350–400 degrees Centigrade (660–750 degrees Fahrenheit) for the required solder work. When measuring the decoder wires for cutting, allow enough length for the locomotive/powered unit's trucks to move freely.

On diesel locomotives the yellow auxiliary function wire marked for the forward direction is soldered to the headlight socket at the end of the locomotive with the pickup shoe truck (cab 1). On steam locomotives the smoke stack should be at the forward end of the unit with respect to the direction of travel.

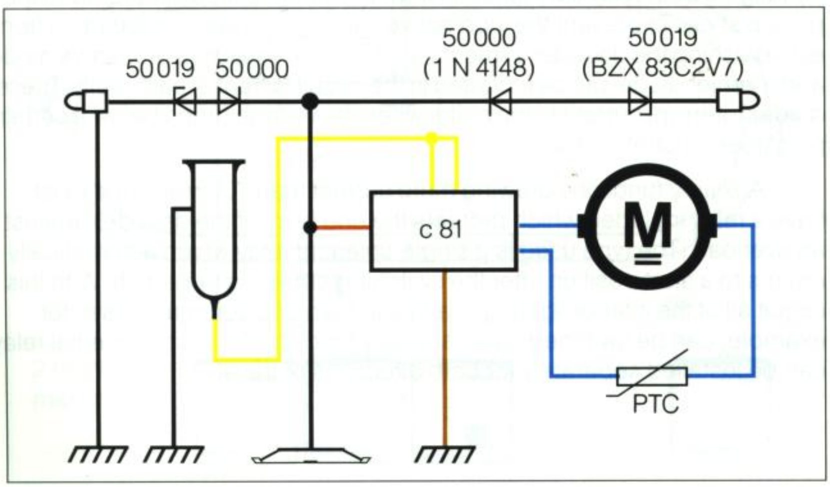
On locomotives with headlights at only one end the second yellow wire does not need to be hooked up. The headlight then burns only in the one direction of travel. If both yellow wires are soldered to the headlight socket, the light will burn in both directions.



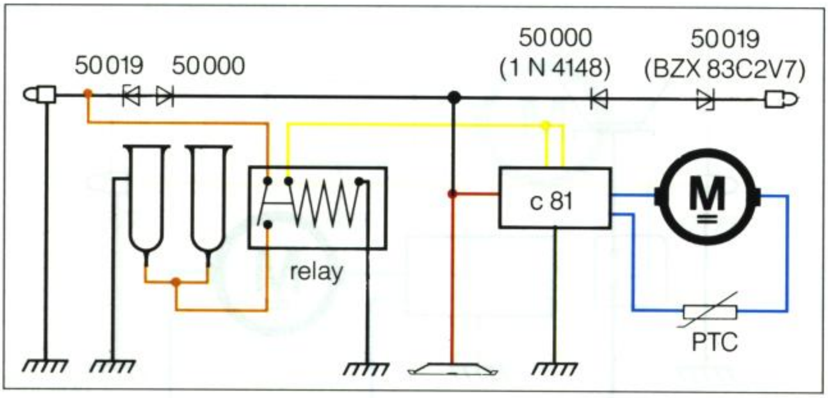

ill. 101

*Hookup for the c 81 decoder in electric locomotives*

*Separation of the headlights from the rest of the circuit using zenier diodes*




ill. 102




ill. 103

*Hookup using a supplemental relay for an auxiliary function with a higher current draw*

On some locomotives from other manufacturers that are delivered as an AC version with the pickup shoe already installed, attention must be paid to whether the frame is conducting the third-rail potential!

On electric locomotives the red wire on the decoder is not connected directly to the pickup shoe; it is hooked up to the selector switch for catenary and track operation.

Locomotives converted to Digital with something other than the headlights as the auxiliary function have the latter hooked up directly to the pickup shoe. To prevent the locomotive lighting's power consumption from extinguishing the decoder's "memory" in a block section, a protective diode and a zenier diode can be included in the circuit in front of each bulb. These diodes interrupt current to the bulbs when the voltage drops below a certain point (see illustration 102).

Auxiliary functions drawing more current than 700 milliamps must have a relay included which protects the end level of the decoder against an overload. The type used is a single-solenoid relay which automatically returns to a start position after the switching current is turned off. With this circuit all of the interior lighting in a railcar train or a commuter train, for example, can be switched as an auxiliary function. The supplemental relay can be installed separately for both directions of travel.

## Example of partially and fully automatic operating procedures

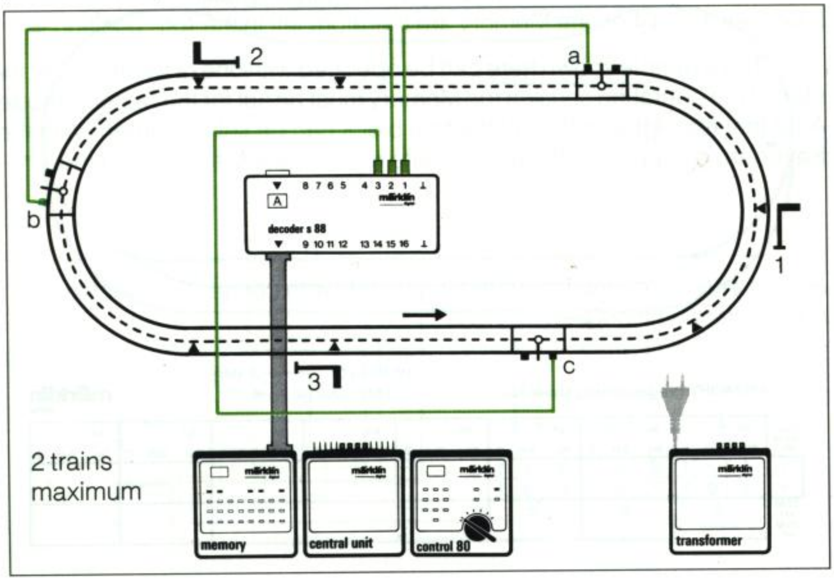
### Block operations with the Memory and s 88

### Example 1: Block operation controlled by circuit tracks

#### Setup

The setup of the layout is the same diagram as that for conventional operation (see illustration 104). The entire route is divided into blocks for one direction of travel; the blocks are protected by a signal at the start of each block. The individual blocks are approximately the length of two trains and a circuit track is located in the middle of each block. Reed switches can be used instead of circuit tracks, or circuit rails for button contacts (in 2-rail systems). In this example changes in the track layout of an already existing model railroad are hence not necessary.

*Setup for block control with circuit tracks (schematically for one direction of travel)*




*ill. 104*

## Hookup

The circuit tracks are hooked up to the s 88 track detection module so that the trains can request routes. Because we are dealing with switching requests, the contacts are connected as follows:

- a with socket 1 for route "A1"
- b with socket 2 for route "A2"
- c with socket 3 for route "A3"

Since the program works without interlocking, the release contacts for these contacts, 9 (for A1), 10 (for A2) and 11 (for A3), do not need to be used (see illustration 104, page 149).

## How the automatic circuit functions

A train entering a block subsequently sets the block signal to "stop" to prevent another train from entering this block. Since it has left the previous block, it can simultaneously set the signal for this block to "go". Hence, 2 switching commands can always be put together:

- Signal 1 "red" and signal 3 "green"
- Signal 2 "red" and signal 1 "green"
- Signal 3 "red" and signal 2 "green".

Interlocking is not necessary with block operation using circuit tracks for control, since there is no additional safeguard resulting from its use. Switches 3 and 4 on the Memory are therefore left in the "off" position.

The example shown here can be operated with one or two trains. At the start of the operating session the Memory must be set for the "extern" mode. After that the signal in front of the free block can be set for "green" with the Keyboard or by calling the appropriate route on the Memory, and the

---

*Routes entered on the programming sheets with connections for the track detection modules*

**MEMORY Programming sheet No.** 1 / without interlocking 3 off 4 off — märklin digital

| Command No. | SR A / 1 | | | SR A / 2 | | | SR A / 3 | | | SR ... / ... | | | SR ... / ... | | | SR ... / ... | | | SR ... / ... | | | SR ... / ... | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D |
| 1 | 1 | r | 1 | 2 | r | 1 | 3 | r | 1 | | | | | | | | | | | | | | | |
| 2 | 3 | g | 1 | 1 | g | 1 | 2 | g | 1 | | | | | | | | | | | | | | | |
| TDM set | a | | | b | | | c | | | | | | | | | | | | | | | | | |
| TDM rel. | — | | | — | | | — | | | | | | | | | | | | | | | | | |

ill. 105

automatic process will begin. By turning off the "extern" mode with the "off" button, external switching requests are no longer processed and the block operations stop automatically.

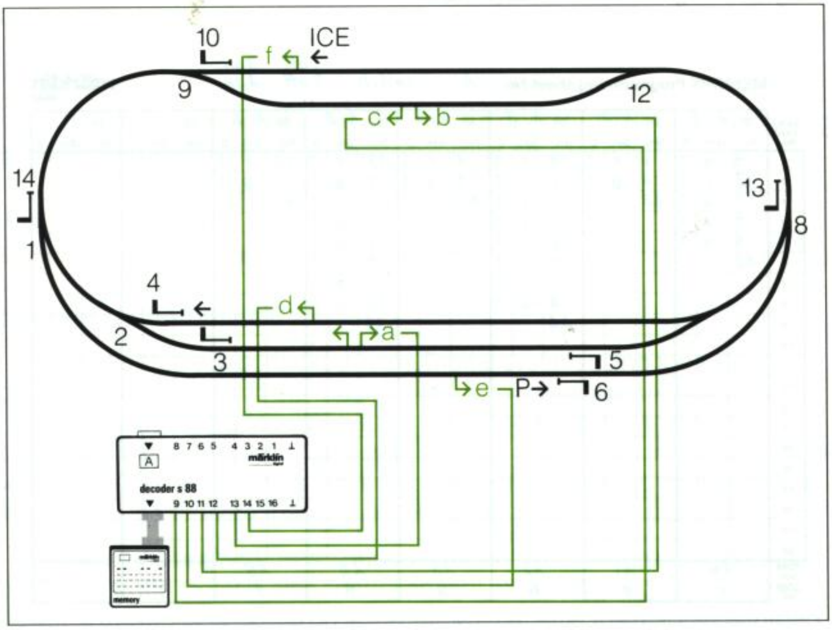
With digital operation the locomotives must be given operating commands at the start of the operating session.

## Example 2: Automatic operation for changing trains controlled using circuit tracks or contact areas

### Setup of the layout and the starting position of the trains

Example 2 is based on a loop program. Each route in this "loop" calls up the next one as a sequential route until the last route calls up the first one again and the program repeats itself. In contrast to example 1, the switching sequence is not controlled by the request contacts of the route to be switched, but by the release contacts of the existing route. With this

*Setup of the layout for example 2 – the trains are in the start position*




*ill. 106*

switching method there is no accidental switching by additional pickup shoes mounted on a train (ex. passenger cars with interior lighting).

## How the program functions

By pressing button "A1" on the Memory the route for the passenger train ("P" in illustration 106) is switched and its exit is set. The valid route "A1" (see programming sheet, illustration 107) contradicts the next route "A2" and route "A2" cannot be set until "A1" is released. The release contact (9) is connected to circuit track "c". When the passenger train passes over this circuit track, it releases the valid route "A1" and the sequential route "A2" is set.

The exit signal is set for "stop" and the entry signal is set for "green". The current valid route "A2" must contradict the sequential route "A3" so that the Memory does not immediately switch the latter. In addition, a command having only this function (in this example the command "Signal 14 red" fulfills the contradiction of the routes) is included in route "A2" if necessary.

---

*Programming sheet for example 2*

**MEMORY Programming sheet No.** A / switch 1 off 2 off 3 on 4 on — märklin digital

| Command No. | SR A/1 | | | SR A/2 | | | SR A/3 | | | SR A/4 | | | SR A/5 | | | SR A/6 | | | SR …/… | | | SR …/… | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D |
| 1 | 8 | g | 1 | 6 | r | 1 | 14 | r | 1 | 4 | r | 1 | 13 | r | 1 | 10 | r | 1 | | | | | | |
| 2 | 12 | r | 1 | 14 | g | 1 | 2 | r | 1 | 13 | g | 1 | 9 | g | 1 | 5 | g | 1 | | | | | | |
| 3 | 1 | g | 1 | A3 | | | 1 | r | 1 | A5 | | | 1 | r | 1 | A1 | | | | | | | | |
| 4 | 5 | r | 1 | | | | 9 | r | 1 | | | | 2 | g | 1 | | | | | | | | | |
| 5 | 6 | g | 1 | | | | 12 | r | 1 | | | | 7 | g | 1 | | | | | | | | | |
| 6 | A2 | | | | | | 8 | r | 1 | | | | 8 | r | 1 | | | | | | | | | |
| 7 | | | | | | | 7 | r | 1 | | | | 12 | g | 1 | | | | | | | | | |
| 8 | | | | | | | 4 | g | 1 | | | | 10 | g | 1 | | | | | | | | | |
| 9 | | | | | | | A4 | | | | | | A6 | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | | | | | | | | |
| TDM set | A6 | | | A1 | | | A2 | | | A3 | | | A4 | | | A5 | | | | | | | | |
| TDM rel. | c | | | e | | | b | | | d | | | a | | | f | | | | | | | | |

ill. 107

After “A2” ist released by the passenger train (with circuit track “e”), the exit for the freight train is set by “A3”.

When the freight train has finished its run and has released route “A3” with circuit track “b” and “A4” with “d”, the ICE will start. Its route and the exit signal were set by route “A5”. It passes the station without stopping, releasing route “A5” with circuit track “a”. It returns to its starting position where it releases route “A6” with circuit track “f”. Now route “A6” calls up “A1” again as a sequential route and the process begins anew. The passenger train starts again...

The routes have the following tasks:

- A1 close entry for ICE / route + exit for P
- A2 close exit for P / open entry for P
- A3 close entry for P / route + exit for G
- A4 close exit for G / open entry for G
- A5 close entry for G / route + exit for ICE
- A6 close exit for ICE / open entry for ICE

With digital operation the locomotives must be given their operating commands before the automatic process begins.

The program can be interrupted or ended at any time by pressing the “off” button. It is continued by releasing the valid route with the “clear” button.

### Tip

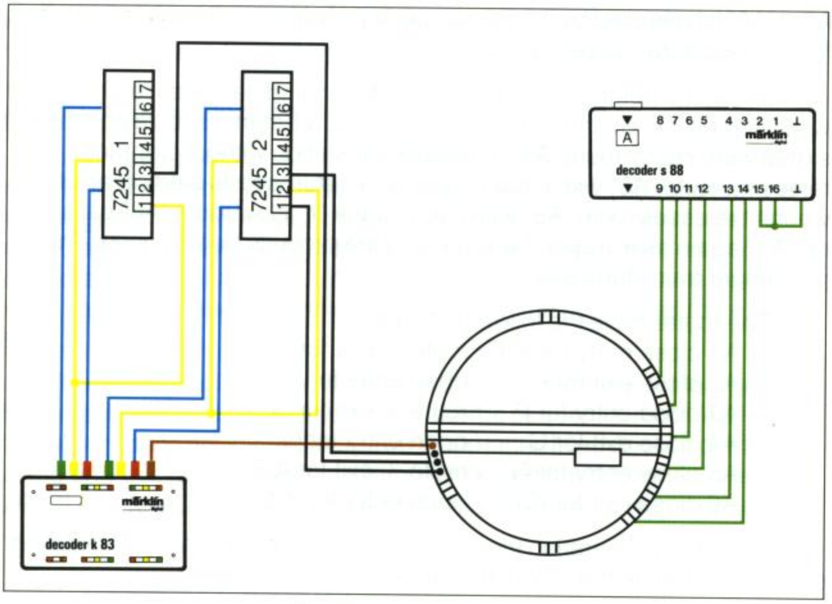
This programmed process can also be operated in the same manner and with the same Memory program by using contact areas.

## Controlling the turntable with track indexing

### Hooking up the turntable

The turntable is controlled in the Digital system using the k 84 decoder. The motor and the magnet (which releases the centering mechanism and simultaneously turns on the power to the motor) are controlled in the conventional system through the accessory circuit (yellow wire). With Digital operation power is supplied from the red socket on the decoder or the red terminal on the Central Unit (see illustration 108).

Switching output 1 on the decoder turns the centering magnet on and off. Power to the motor is also controlled by it. When the magnet is activated, power to the motor is turned on at the same time. After the magnet is turned




ill. 108

*Hookup for the 7186 turntable with detection signal for the turntable deck position*

off, the turntable deck will continue to move until the centering mechanism has aligned the deck track precisely with the stall track.

The direction in which the deck turns is determined by the second switching output (set of sockets) on the k 84 decoder. Just as with a Märklin locomotive, power is switched from one field winding to another and the motor reverses direction. To simplify the circuit the turntable deck or bridge always turns in the same direction in this example.

The Märklin 7186 turntable supplies current only to that stall track which is aligned with the deck. This example of a circuit used the turning on and off of the track current by the turntable deck as a detection or feedback signal for the position of the deck. You may ask why the third rail potential is used. In conventional as well as digital operation this potential has a negative polarity relative to the potential of the running rails and can be evaluated by the track detection module. The third rails for the pit edge tracks "a" to "f" are connected to the sockets "9" to "14" of the s 88 track detection module.

MEMORY Programming sheet No. ........ / ........ märklin digital

| Command No. | SR A/1 | | | SR A/2 | | | SR A/3 | | | SR A/4 | | | SR A/5 | | | SR A/6 | | | SR A/7 | | | SR A/8 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D |
| 1 | 1 | g | 1 | 1 | g | 1 | 1 | g | 1 | 1 | g | 1 | 1 | g | 1 | 1 | g | 1 | 1 | g | 1 | 1 | r | 1 |
| 2 | A8 | | | A8 | | | A8 | | | A8 | | | A8 | | | A8 | | | A8 | | | | | |
| 3 | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | | | | | | | | |
| TDM set | — | | | — | | | — | | | — | | | — | | | — | | | — | | | — | | |
| TDM rel. | a | | | b | | | c | | | d | | | e | | | f | | | T socket | | | T socket | | |

*ill. 109*

*Programming sheet for controlling the turntable with track indexing*

## Programming the Memory

The centering magnet on the turntable is switched on with the identical routes "A1" to "A7" (see programming sheet, illustration 109) and then the sequential route "A8" is requested. It switches the magnet off again. The Memory must be set for operation "with interlocking" so that the magnet is not shut off until the deck has reached the desired track. Now the sequential route "A8" (which contradicts routes "A1" to "A7") can be switched if "A1" to "A7" have been released. The release takes place when the turntable deck has reached the desired track and turned on the current there. The turntable ist designed in such a way that the release always occurs rapidly enough to allow sufficient time for the magnet to be turned off before the deck moves past a stall track.

Route "A7" is intended for those turntable entry tracks not set up with a power shutoff circuit. When this route's release contact, socket "15" on the track detection module, is connected to the ground socket (⊥), release occurs immediately. The turntable starts and rotates one track further, regardless of its starting position.

Route "A8" (which shuts off the centering magnet) can also be released directly. Therefore, contact "16" on the track detection module is also connected to the ground socket.

### Tips

If the headlights or smoke generator for locomotives should also function in the locomotive sheds, then the shed tracks can all be supplied with power using additional hookup wires. It is then necessary to insert a track insulator after the short piece of track that is connected directly to the turntable. It is possible to solder the wire from the track detection module directly to the underside of the turntable and insert the track insulator on the pit edge track mounted on the turntable edge. This is especially recommended with K track because of the 2291 adapter track which is required with the turntable.

When this program is supplemented by automatic direction reversing of the transfer table deck at the end points of its track, track indexing can be programmed for the transfer table. The catenary connections can be used in this instance for an easier way of reporting the deck's position.

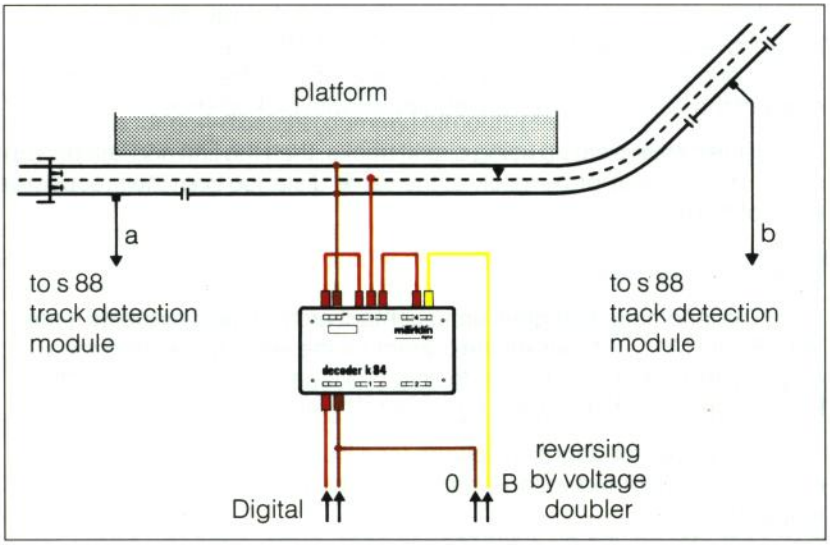
## Push/pull commuter train operation for layouts with digital or conventional train operation

The push/pull commuter train circuit described here with the 6043 Memory can be used for layouts with conventional train control as well as for layouts with Digital control.

### Setup

Only the end of the commuter train route, i. e. a final section of track in a stub siding in a station is included in the circuit. In this way the push/pull commuter train's route can be used jointly with other trains (see illustration 110). This automatic circuit can be set up with two end points (push/pull traffic) as well as with one end point and a reverse loop.

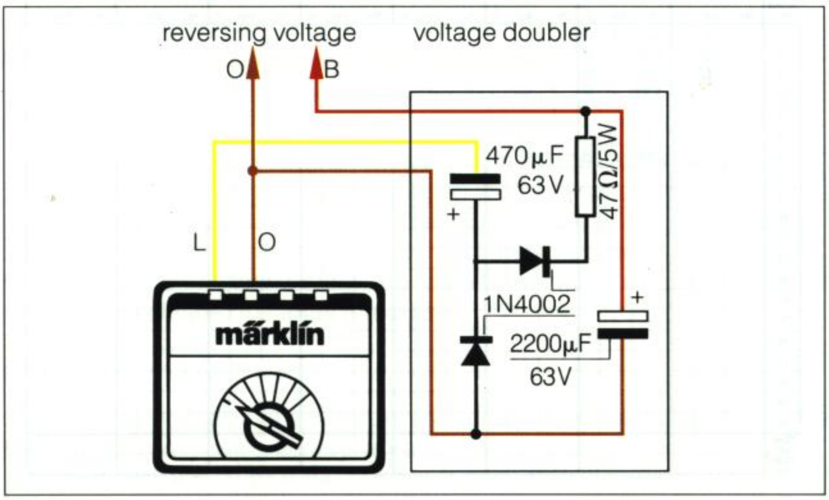
On a push/pull route with only one train only one of the circuits needs to be set up. Only one contact area or circuit track is necessary at each end of the push/pull route. Contact areas or circuit tracks with the same function at both end points can be connected together in this case. If several trains are to be included in the push/pull operations, then the circuit must be set up separately for both end points. Each end point must have its own Memory program.




ill. 110

*Setup and wiring for an end point on a push/pull route. The second end point has the same setup in reverse. The "a" and "b" contacts for both end points can be connected together.*

*Circuit for doubling voltage*




ill. 111

Using contact areas to request routes has the advantage that the locomotives/cars can be in any order desired. Whether the locomotive is pulling or pushing the train does not matter. It also does not matter how many of the cars in the train are equipped with pickup shoes.

If the circuit is set up using circuit tracks, then the first and last pickup shoes should be approximately at the same distance from their respective ends of the train.

## How the circuit works

The incoming train goes up to contact area "a" and requests route "A1". Route "A1" switches off the current for the entire track (switching output 1 "red") and switches on the high voltage impulse to reverse the locomotive's direction (switching output 2 "green").

The circuit for doubling voltage (see illustration 111) provides the conventional doubled voltage impulse to which Digital locomotives also respond.

*Programming sheet for "Automatic push/pull commuter train circuit"*

**MEMORY Programming sheet No.** 1 / switch 3 on 4 off — märklin digital

| Command No. | SR A/1 | | | SR A/2 | | | SR …/… | | | SR …/… | | | SR …/… | | | SR …/… | | | SR …/… | | | SR …/… | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D |
| 1 | 1 | r | | 2 | r | 1 | | | | | | | | | | | | | | | | | | |
| 2 | 2 | g | | 250 | r | 8 | | | | | | | | | | | | | | | | | | |
| 3 | | A2 | | 251 | r | 8 | | | | | | | | | | | | | | | | | | |
| 4 | | | | 252 | r | 8 | | | | | | | | | | | | | | | | | | |
| 5 | | | | | ---- | | | | | | | | | | | | | | | | | | | |
| 6 | | | | 1 | g | 1 | | | | | | | | | | | | | | | | | | |
| 7 | | | | 256 | r | 8 | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | | | | | | | | |
| TDM set | | | | | | | | | | | | | | | | | | | | | | | | |
| TDM rel. | | | | | | | | | | | | | | | | | | | | | | | | |

(Rows 2–5:) determine the waiting time at the station. about 3 seconds per "turnout". insert additional "turnout" for longer.

(Row 7:) "safety margin" ← (see text)

ill. 112

Route "A1" calls up sequential route "A2"which immediately switches off the increased voltage impulse (switching output 2 "red"). The point at which the train continues on can be delayed by inserting switching commands for non-existant (dummy) turnouts (see programming sheet, illustration 112). After that the exit for the push/pull commuter train is released (switching output 1 "green").

Additional (two) switching commands are inserted so that a locomotive or car which may still be standing on contact area "a" does not immediately activate the entire switching process again. When the train leaves, it releases route "A1" using the second contact area "b" (or a circuit track) and thereby erases a possible existing request.

The automatic circuit for push/pull commuter operations can be set up for another reverse and wait cycle using contact area "a".

### Tip

The k 84 decoder panel used in illustration 110 can be replaced by a k 83 decoder and two 7245 universal relays.

Transformers 6001/6002, 6611 or 6627/6631 can be used for the voltage doubling circuit.

The increased voltage impulse cannot be used on model railroads with DC train operation to change locomotive direction. A polarity reversing circuit must be used here instead.

## Partially automatic staging yard control with the Memory

### Setup

The staging yard needs an entry signal in whose block contact tracks can be inserted. Each track in the staging yard is likewise equipped with a contact area (see illustration 113) in the vicinity of the exit signal (or of the corresponding block section). This contact area must be far enough from the entry turnouts so that the first axle of the longest train reaches it when the last axle has cleared the entry turnouts.

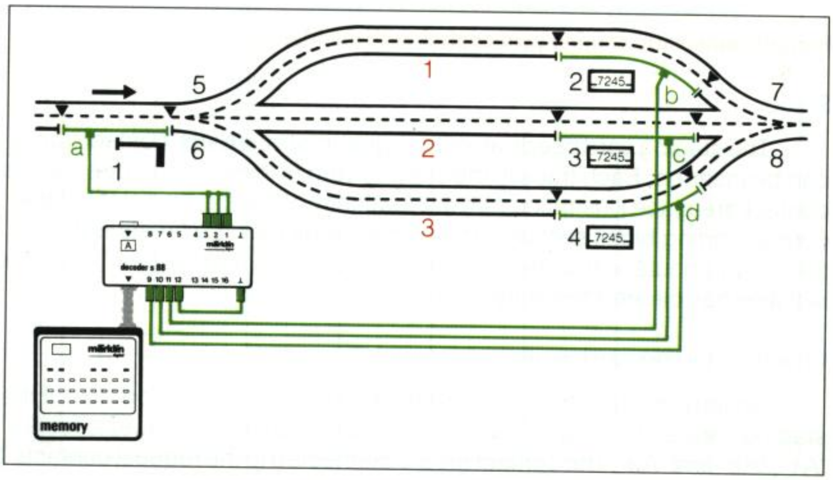
### How the staging yard works

An arriving train stops before entry signal 1 (see illustration 113) for the staging yard and, using contact area "a", simultaneously requests routes "A1", "A2" and "A3". The contact area is connected to the request contacts 1 through 3 on the track detection module. Contact areas "b", "c" and "d" report whether the affected track is occupied. They are connected to release contacts 9 through 11 on the track detection module. They prevent entry into an occupied track (see programming sheet, illustration 114).

The Memory checks in succession which of the requested routes "A1", "A2" and "A3" can be switched. If all three tracks in the staging yard are occupied, then no entry is switched. The Memory does not set the turnouts and switch the entry signal for "green" until, for example, track 2 becomes free.

The train now enters the staging yard and is stopped before the exit signal. It remains standing on contact area "c" which releases route "A2". Sequential route "A4", which resets the entry signal to "red", cannot be set until now. "A4" is immediately released again since its release contact is connected directly to the ⊥ socket on the track detection module.

*Setup for a small staging yard with contact areas*




*ill. 113*

Route tasks:

- "A1" entry to track 1 and entry signal "green" → "A4"
- "A2" entry to track 2 and entry signal "green" → "A4"
- "A3" entry to track 3 and entry signal "green" → "A4"
- "A4" entry signal "red" (+ block signal in front of it "green")

When the staging yard is incorporated into a block system, the signal in front of the entry signal to the staging yard can be set for "green" with route "A4".

The exit for trains from the staging yard is controlled manually in this partially automatic example.

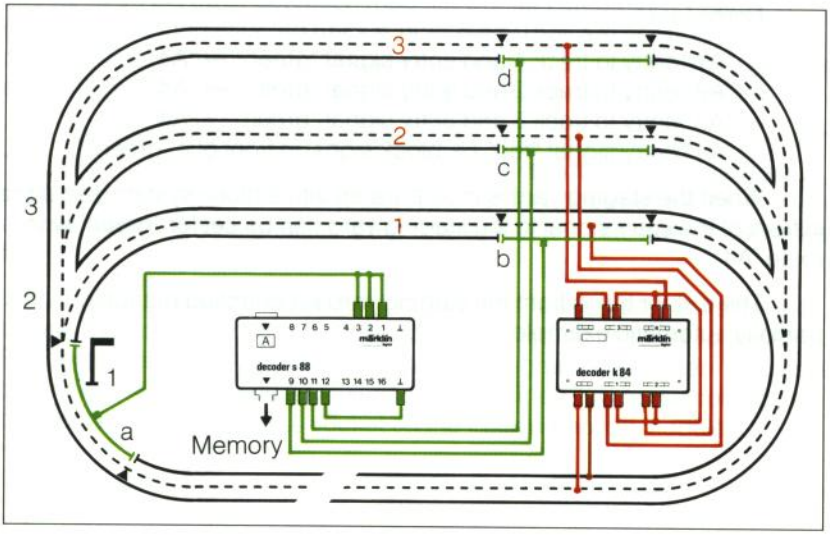
*Programming sheet for partially automatic staging yard control*
*Connections to the s 88 track detection module*

**MEMORY Programming sheet No.** 1 / switch 1 off 2 off 3 on 4 on

märklin digital

| Command No. | SR A / 1 | | | SR A / 2 | | | SR A / 3 | | | SR A / 4 | | | SR / | | | SR / | | | SR / | | | SR / | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D |
| 1 | 5 | r | 1 | 5 | g | 1 | 5 | g | 1 | 1 | r | 1 | | | | | | | | | | | | |
| 2 | 6 | g | 1 | 6 | g | 1 | 6 | r. | 1 | | | | | | | | | | | | | | | |
| 3 | 1 | g | 1 | 1 | g | 1 | 1 | g | 1 | | | | | | | | | | | | | | | |
| 4 | A4 | | | A4 | | | A4 | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | | | | | | | | |
| TDM set | a | | | a | | | a | | | | | | | | | | | | | | | | | |
| TDM rel. | b | | | c | | | d | | | T socket | | | | | | | | | | | | | | |

*ill. 114*




ill. 115

*Setup for a staging yard with fully automatic control using the Memory. Connections to the s 88 track detection module*

## Fully automatic staging yard control

The setup for the demonstration layout is the same as that for the previous example. All that is needed is another universal relay or the switching output on the k 84 decoder (see illustration 115).

In contrast to the previous example, the routes control the exit of one train in addition to the entry of another. The train entering track 1 simultaneously activates the exit for the train on track 2. The train entering track 2 sets up the exit for the train on track 3 and this train sets up in turn the exit for track 1.

The exit signals or universal relays receive train operating current by means of an additional universal relay (UFS 4) so that a train does not attempt to exit without regard for whether the block beyond the staging yard is free. This additional universal relay is integrated into the block system beyond the staging yard and passes train operating current on to the other three relays only when the block is free.

MEMORY Programming sheet No. ....../......                                                                märklin digital

| Command No. | SR A/1 | | | SR A/2 | | | SR A/3 | | | SR A/4 | | | SR .../... | | | SR .../... | | | SR .../... | | | SR .../... | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D | No. | Set. | D |
| 1 | 2 | r | 1 | 2 | g | 1 | 2 | g | 1 | 1 | r | 1 | | | | | | | | | | | | |
| 2 | 5 | r | 1 | 3 | r | 1 | 3 | g | 1 | 8 | g | 1 | | | | | | | | | | | | |
| 3 | 8 | r | 1 | 6 | r | 1 | 7 | r | 1 | | | | | | | | | | | | | | | |
| 4 | 1 | g | 1 | 8 | r | 1 | 8 | r | 1 | | | | | | | | | | | | | | | |
| 5 | 6 | g | 1 | 1 | g | 1 | 1 | g | 1 | | | | | | | | | | | | | | | |
| 6 | A4 | | | 7 | g | 1 | 5 | g | 1 | | | | | | | | | | | | | | | |
| 7 | | | | A4 | | | A4 | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | | | | | | | | |
| TDM set | a | | | a | | | a | | | | | | | | | | | | | | | | | |
| TDM rel. | b | | | c | | | d | | | T socket | | | | | | | | | | | | | | |

ill. 116

*Programming sheet for fully automatic staging yard control*

Thus, if a train is given the exit signal from the staging yard although the next block is occupied, it will remain at a halt because the "UFS 4" has interrupted the train operating current.

Route tasks:

- "A1" entry to track 1 and exit from track 2 → "A4"
- "A2" entry to track 2 and exit from track 3 → "A4"
- "A3" entry to track 3 and exit from track 1 → "A4"
- "A4" entry signal to "red" and block signal set to "green"

## Setting a decoder address with the eight coding switches (coding)

By selecting a particular pattern of switch settings, each Digital decoder can be given an "address" which can be used to call it up or assign it to a control component. This address can be changed as often as desired by using other switch settings.

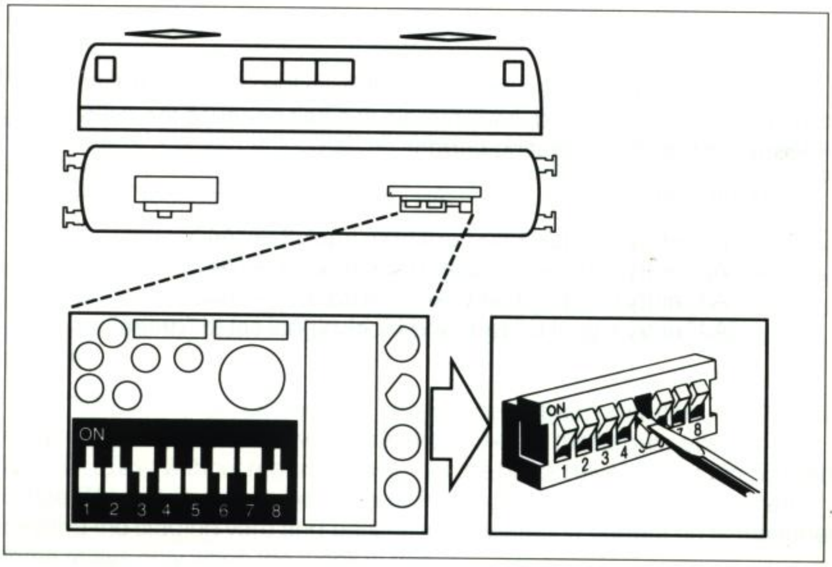
The c 80 and c 81 decoders are set at the factory with the address "25" (coding switches 2 and 7 "on"), the k 83 and k 84 are set to be operated from Keyboard 1, button pairs 1 through 4 (coding switches 1, 4, 6, and 7 "on").

In this example a c 80 decoder is to be programmed for the address "52". The locomotive body must first be removed in order to be able to set the eight coding switches. Then the decoder is accessible (see illustration 117).

The "General Code Table for c 80 and c 81 Locomotive Decoders" gives the switch settings for the desired decoder addresses (see page 165). The coding switches are set in the positions given in the code table by carefully using a small screwdriver or a pair of tweezers. The locomotive address "52" is given in this example:
" – 2 – – – – – 8".

(see page 168)

*Setting the decoder address*




*ill. 117*

## Coding Table for the c 80 and c 81 Locomotive Decoders

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 01 | – | 2 | 3 | – | 5 | – | 7 | – |
| 02 | – | – | 3 | – | 5 | – | 7 | – |
| 03 | 1 | – | – | 4 | 5 | – | 7 | – |
| 04 | – | 2 | – | 4 | 5 | – | 7 | – |
| 05 | – | – | – | 4 | 5 | – | 7 | – |
| 06 | 1 | – | – | – | 5 | – | 7 | – |
| 07 | – | 2 | – | – | 5 | – | 7 | – |
| 08 | – | – | – | – | 5 | – | 7 | – |
| 09 | 1 | – | 3 | – | – | 6 | 7 | – |
| 10 | – | 2 | 3 | – | – | 6 | 7 | – |
| 11 | – | – | 3 | – | – | 6 | 7 | – |
| 12 | 1 | – | – | 4 | – | 6 | 7 | – |
| 13 | – | 2 | – | 4 | – | 6 | 7 | – |
| 14 | – | – | – | 4 | – | 6 | 7 | – |
| 15 | 1 | – | – | – | – | 6 | 7 | – |
| 16 | – | 2 | – | – | – | 6 | 7 | – |
| 17 | – | – | – | – | – | 6 | 7 | – |
| 18 | 1 | – | 3 | – | – | – | 7 | – |
| 19 | – | 2 | 3 | – | – | – | 7 | – |
| 20 | – | – | 3 | – | – | – | 7 | – |
| 21 | 1 | – | – | 4 | – | – | 7 | – |
| 22 | – | 2 | – | 4 | – | – | 7 | – |
| 23 | – | – | – | 4 | – | – | 7 | – |
| 24 | 1 | – | – | – | – | – | 7 | – |
| 25 | – | 2 | – | – | – | – | 7 | – |
| 26 | – | – | – | – | – | – | 7 | – |
| 27 | 1 | – | 3 | – | 5 | – | – | 8 |
| 28 | – | 2 | 3 | – | 5 | – | – | 8 |
| 29 | – | – | 3 | – | 5 | – | – | 8 |
| 30 | 1 | – | – | 4 | 5 | – | – | 8 |
| 31 | – | 2 | – | 4 | 5 | – | – | 8 |
| 32 | – | – | – | 4 | 5 | – | – | 8 |
| 33 | 1 | – | – | – | 5 | – | – | 8 |
| 34 | – | 2 | – | – | 5 | – | – | 8 |
| 35 | – | – | – | – | 5 | – | – | 8 |
| 36 | 1 | – | 3 | – | – | 6 | – | 8 |
| 37 | – | 2 | 3 | – | – | 6 | – | 8 |
| 38 | – | – | 3 | – | – | 6 | – | 8 |
| 39 | 1 | – | – | 4 | – | 6 | – | 8 |
| 40 | – | 2 | – | 4 | – | 6 | – | 8 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 41 | – | – | – | 4 | – | 6 | – | 8 |
| 42 | 1 | – | – | – | – | 6 | – | 8 |
| 43 | – | 2 | – | – | – | 6 | – | 8 |
| 44 | – | – | – | – | – | 6 | – | 8 |
| 45 | 1 | – | 3 | – | – | – | – | 8 |
| 46 | – | 2 | 3 | – | – | – | – | 8 |
| 47 | – | – | 3 | – | – | – | – | 8 |
| 48 | 1 | – | – | 4 | – | – | – | 8 |
| 49 | – | 2 | – | 4 | – | – | – | 8 |
| 50 | – | – | – | 4 | – | – | – | 8 |
| 51 | 1 | – | – | – | – | – | – | 8 |
| 52 | – | 2 | – | – | – | – | – | 8 |
| 53 | – | – | – | – | – | – | – | 8 |
| 54 | 1 | – | 3 | – | 5 | – | – | – |
| 55 | – | 2 | 3 | – | 5 | – | – | – |
| 56 | – | – | 3 | – | 5 | – | – | – |
| 57 | 1 | – | – | 4 | 5 | – | – | – |
| 58 | – | 2 | – | 4 | 5 | – | – | – |
| 59 | – | – | – | 4 | 5 | – | – | – |
| 60 | 1 | – | – | – | 5 | – | – | – |
| 61 | – | 2 | – | – | 5 | – | – | – |
| 62 | – | – | – | – | 5 | – | – | – |
| 63 | 1 | – | 3 | – | – | 6 | – | – |
| 64 | – | 2 | 3 | – | – | 6 | – | – |
| 65 | – | – | 3 | – | – | 6 | – | – |
| 66 | 1 | – | – | 4 | – | 6 | – | – |
| 67 | – | 2 | – | 4 | – | 6 | – | – |
| 68 | – | – | – | 4 | – | 6 | – | – |
| 69 | 1 | – | – | – | – | 6 | – | – |
| 70 | – | 2 | – | – | – | 6 | – | – |
| 71 | – | – | – | – | – | 6 | – | – |
| 72 | 1 | – | 3 | – | – | – | – | – |
| 73 | – | 2 | 3 | – | – | – | – | – |
| 74 | – | – | 3 | – | – | – | – | – |
| 75 | 1 | – | – | 4 | – | – | – | – |
| 76 | – | 2 | – | 4 | – | – | – | – |
| 77 | – | – | – | 4 | – | – | – | – |
| 78 | 1 | – | – | – | – | – | – | – |
| 79 | – | 2 | – | – | – | – | – | – |
| 80 | 1 | – | 3 | – | 5 | – | 7 | – |

## Coding Table for the k 83 and k 84 Decoders

| Keyboard Switchboard | Buttons | Dec. No. | Successive Addresses | Switch "on" | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1, 2, 3, 4 | 1 | 1, 2, 3, 4 | – | 2 | 3 | – | 5 | – | 7 | – |
| 1 | 5, 6, 7, 8 | 2 | 5, 6, 7, 8 | – | – | 3 | – | 5 | – | 7 | – |
| 1 | 9, 10, 11, 12 | 3 | 9, 10, 11, 12 | 1 | – | – | 4 | 5 | – | 7 | – |
| 1 | 13, 14, 15, 16 | 4 | 13, 14, 15, 16 | – | 2 | – | 4 | 5 | – | 7 | – |
| 2 | 1, 2, 3, 4 | 5 | 17, 18, 19, 20 | – | – | – | 4 | 5 | – | 7 | – |
| 2 | 5, 6, 7, 8 | 6 | 21, 22, 23, 24 | 1 | – | – | – | 5 | – | 7 | – |
| 2 | 9, 10, 11, 12 | 7 | 25, 26, 27, 28 | – | 2 | – | – | 5 | – | 7 | – |
| 2 | 13, 14, 15, 16 | 8 | 29, 30, 31, 32 | – | – | – | – | 5 | – | 7 | – |
| 3 | 1, 2, 3, 4 | 9 | 33, 34, 35, 36 | 1 | – | 3 | – | – | 6 | 7 | – |
| 3 | 5, 6, 7, 8 | 10 | 37, 38, 39, 40 | – | 2 | 3 | – | – | 6 | 7 | – |
| 3 | 9, 10, 11, 12 | 11 | 41, 42, 43, 44 | – | – | 3 | – | – | 6 | 7 | – |
| 3 | 13, 14, 15, 16 | 12 | 45, 46, 47, 48 | 1 | – | – | 4 | – | 6 | 7 | – |
| 4 | 1, 2, 3, 4 | 13 | 49, 50, 51, 52 | – | 2 | – | 4 | – | 6 | 7 | – |
| 4 | 5, 6, 7, 8 | 14 | 53, 54, 55, 56 | – | – | – | 4 | – | 6 | 7 | – |
| 4 | 9, 10, 11, 12 | 15 | 57, 58, 59, 60 | 1 | – | – | – | – | 6 | 7 | – |
| 4 | 13, 14, 15, 16 | 16 | 61, 62, 63, 64 | – | 2 | – | – | – | 6 | 7 | – |
| 5 | 1, 2, 3, 4 | 17 | 65, 66, 67, 68 | – | – | – | – | – | 6 | 7 | – |
| 5 | 5, 6, 7, 8 | 18 | 69, 70, 71, 72 | 1 | – | 3 | – | – | – | 7 | – |
| 5 | 9, 10, 11, 12 | 19 | 73, 74, 75, 76 | – | 2 | 3 | – | – | – | 7 | – |
| 5 | 13, 14, 15, 16 | 20 | 77, 78, 79, 80 | – | – | 3 | – | – | – | 7 | – |
| 6 | 1, 2, 3, 4 | 21 | 81, 82, 83, 84 | 1 | – | – | 4 | – | – | 7 | – |
| 6 | 5, 6, 7, 8 | 22 | 85, 86, 87, 88 | – | 2 | – | 4 | – | – | 7 | – |
| 6 | 9, 10, 11, 12 | 23 | 89, 90, 91, 92 | – | – | – | 4 | – | – | 7 | – |
| 6 | 13, 14, 15, 16 | 24 | 93, 94, 95, 96 | 1 | – | – | – | – | – | 7 | – |
| 7 | 1, 2, 3, 4 | 25 | 97, 98, 99, 100 | – | 2 | – | – | – | – | 7 | – |
| 7 | 5, 6, 7, 8 | 26 | 101, 102, 103, 104 | – | – | – | – | – | – | 7 | – |
| 7 | 9, 10, 11, 12 | 27 | 105, 106, 107, 108 | 1 | – | 3 | – | 5 | – | – | 8 |
| 7 | 13, 14, 15, 16 | 28 | 109, 110, 111, 112 | – | 2 | 3 | – | 5 | – | – | 8 |
| 8 | 1, 2, 3, 4 | 29 | 113, 114, 115, 116 | – | – | 3 | – | 5 | – | – | 8 |
| 8 | 5, 6, 7, 8 | 30 | 117, 118, 119, 120 | 1 | – | – | 4 | 5 | – | – | 8 |
| 8 | 9, 10, 11, 12 | 31 | 121, 122, 123, 124 | – | 2 | – | 4 | 5 | – | – | 8 |
| 8 | 13, 14, 15, 16 | 32 | 125, 126, 127, 128 | – | – | – | 4 | 5 | – | – | 8 |

| Key-board Switch-board | Buttons | Dec. No. | Successive Addresses | Switch "on" |
|---|---|---|---|---|
| 9 | 1, 2, 3, 4 | 33 | 129, 130, 131, 132 | 1 – – – 5 – – 8 |
| 9 | 5, 6, 7, 8 | 34 | 133, 134, 135, 136 | – 2 – – 5 – – 8 |
| 9 | 9, 10, 11, 12 | 35 | 137, 138, 139, 140 | – – – – 5 – – 8 |
| 9 | 13, 14, 15, 16 | 36 | 141, 142, 143, 144 | 1 – 3 – – 6 – 8 |
| 10 | 1, 2, 3, 4 | 37 | 145, 146, 147, 148 | – 2 3 – – 6 – 8 |
| 10 | 5, 6, 7, 8 | 38 | 149, 150, 151, 152 | – – 3 – – 6 – 8 |
| 10 | 9, 10, 11, 12 | 39 | 153, 154, 155, 156 | 1 – – 4 – 6 – 8 |
| 10 | 13, 14, 15, 16 | 40 | 157, 158, 159, 160 | – 2 – 4 – 6 – 8 |
| 11 | 1, 2, 3, 4 | 41 | 161, 162, 163, 164 | – – – 4 – 6 – 8 |
| 11 | 5, 6, 7, 8 | 42 | 165, 166, 167, 168 | 1 – – – – 6 – 8 |
| 11 | 9, 10, 11, 12 | 43 | 169, 170, 171, 172 | – 2 – – – 6 – 8 |
| 11 | 13, 14, 15, 16 | 44 | 173, 174, 175, 176 | – – – – – 6 – 8 |
| 12 | 1, 2, 3, 4 | 45 | 177, 178, 179, 180 | 1 – 3 – – – – 8 |
| 12 | 5, 6, 7, 8 | 46 | 181, 182, 183, 184 | – 2 3 – – – – 8 |
| 12 | 9, 10, 11, 12 | 47 | 185, 186, 187, 188 | – – 3 – – – – 8 |
| 12 | 13, 14, 15, 16 | 48 | 189, 190, 191, 192 | 1 – – 4 – – – 8 |
| 13 | 1, 2, 3, 4 | 49 | 193, 194, 195, 196 | – 2 – 4 – – – 8 |
| 13 | 5, 6, 7, 8 | 50 | 197, 198, 199, 200 | – – – 4 – – – 8 |
| 13 | 9, 10, 11, 12 | 51 | 201, 202, 203, 204 | 1 – – – – – – 8 |
| 13 | 13, 14, 15, 16 | 52 | 205, 206, 207, 208 | – 2 – – – – – 8 |
| 14 | 1, 2, 3, 4 | 53 | 209, 210, 211, 212 | – – – – – – – 8 |
| 14 | 5, 6, 7, 8 | 54 | 213, 214, 215, 216 | 1 – 3 – 5 – – – |
| 14 | 9, 10, 11, 12 | 55 | 217, 218, 219, 220 | – 2 3 – 5 – – – |
| 14 | 13, 14, 15, 16 | 56 | 221, 222, 223, 224 | – – 3 – 5 – – – |
| 15 | 1, 2, 3, 4 | 57 | 225, 226, 227, 228 | 1 – – 4 5 – – – |
| 15 | 5, 6, 7, 8 | 58 | 229, 230, 231, 232 | – 2 – 4 5 – – – |
| 15 | 9, 10, 11, 12 | 59 | 233, 234, 235, 236 | – – – 4 5 – – – |
| 15 | 13, 14, 15, 16 | 60 | 237, 238, 239, 240 | 1 – – – 5 – – – |
| 16 | 1, 2, 3, 4 | 61 | 241, 242, 243, 244 | – 2 – – 5 – – – |
| 16 | 5, 6, 7, 8 | 62 | 245, 246, 247, 248 | – – – – 5 – – – |
| 16 | 9, 10, 11, 12 | 63 | 249, 250, 251, 252 | 1 – 3 – – 6 – – |
| 16 | 13, 14, 15, 16 | 64 | 253, 254, 255, 0 | – 2 3 – – 6 – – |

The switches printed as numbers must be in the "on" position (here switches 2 and 8). A "–" means that these switches are to set in the "off" position (here switches 1, 3, 4, 5, 6, and 7). If all of the switches are in the correct position, the setting of the decoder address is complete.

Addresses for k 83 and k 84 decoders are set in the same way as those for locomotive decoders. In addition, the table shows in a line from left to right the Keyboard/Switchboard number and the button pairs to which the decoder is to be assigned, the successive decoder number and turnout address as well as the settings for the coding switches.

The successive turnout addresses are only important for control using a computer. Coding and addressing in computer operation are facilitated by their inclusion in this table.

## Coding Table for Keyboard and Switchboard

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | – – – – | 5 | – – 3 – | 9 | – – – 4 | 13 | – – 3 4 |
| 2 | 1 – – – | 6 | 1 – 3 – | 10 | 1 – – 4 | 14 | 1 – 3 4 |
| 3 | – 2 – – | 7 | – 2 3 – | 11 | – 2 – 4 | 15 | – 2 3 4 |
| 4 | 1 2 – – | 8 | 1 2 3 – | 12 | 1 2 – 4 | 16 | 1 2 3 4 |

## Coding table for memory

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | – – – – | 2 | 1 – – – | 3 | – 2 – – | 4 | 1 2 – – |