Part III - DCS Implementation

In the following section, we'll discuss all the things to consider when implementing DCS for the first time. We'll look at this from two perspectives. One is planning a new layout with DCS and the other is adding DCS to an existing layout.

1. Planning For a New DCS Layout

When building a new layout that will incorporate DCS, planning for DCS before layout construction begins can make DCS operation on the completed layout more effective and enjoyable. This section looks at several key aspects of layout construction from a DCS point of view:

- TIU channel usage
- Wiring considerations
- TIU channel assignment and placement
- AIU connection and placement
- Transformer considerations

This section is not intended to discuss track planning, physical benchwork construction, scenery or anything else unrelated to actual DCS operation. Those topics, while very important, are completely outside of the scope of this book.

TIU Channel Usage

Every TIU has four channels for control and operation of O gauge engines. Two of these channels are designated as Fixed Channels. Whatever voltage is applied to the TIU's input of each Fixed Channel is always present at the output of that Fixed Channel. These channels are ideal for operation of command control engines, such as MTH's PS2 engines or Lionel's TMCC engines, because command control engines operate based upon commands sent to individual engines rather than changes in track voltage. Command control operation is based on the premise that there is always voltage sufficient to operate command control engines (typically 18 volts) present in the tracks.

The other two channels on every TIU are Variable Channels. Variable Channels allow the voltage input to the channel to be regulated such that the voltage present at the output of each Variable Channel may be different from the voltage present at the TIU's input for that Variable Channel. These channels are ideal for control of conventional, non-command control engines because conventional engines operate based upon changes in voltage in the tracks. Lower track voltage causes conventional engines to run slower while higher track voltage causes conventional engines to run faster, and interrupting the voltage to the track activates the reversing unit in conventional engines.

While tracks connected to Variable Channels can be used to run either command control or conventional engines, tracks connected to Fixed Channels are really only suitable for operation of command control engines.

Although Variable Channels can be made to operate as Fixed Channels, Fixed Channels can only be made to operate as Variable Channels through the use of Z4K Tracks (see section Advanced Features and Functions for how to use Z4K Tracks). When planning for a new DCS-based layout, it's a good idea to have some idea regarding which loops of mainline and which sidings will operate command control engines, which will operate conventional engines and which, if any, may operate both at one time or another. Once a determination is made regarding which layout loops or sidings will be dedicated to command control engines, conventional engines or both, the operator can begin to determine how to assign TIU channels to the various sections of the layout.

Wiring Considerations

An often asked question in regards to DCS is, "how many feet of track will one TIU support?" The answer is a definite, "that depends." In order to properly answer this question, it's important to first understand DCS signal strength.

DCS Signal Strength

When using a PS2 engine to measure the DCS signal strength on a particular section of track, the engine will report some value from 1 to 10. If DCS signal strength is exceptionally low, an error message may be displayed instead of a value. A value between 8 and 10 is generally described as strong, between 6 and 7 is generally described as adequate and from 1 to 5 is described as low. While many operators strive for a consistent DCS signal strength of 10, it's a proven fact that nearly all DCS commands will operate just fine when DCS signal strength is 7 or higher.

The DCS signal becomes weaker if it is either split too many times or if it is spread over too many linear feet of track. It is also subject to degradation if the wire that carries the DCS signal and transformer voltage is of insufficient quality or size, or if the recommended wiring method, described below, is not used. It quickly becomes obvious that the DCS signal strength will vary based upon several major factors:

- The number of times the signal from a single TIU channel is split to feed track blocks and sidings
- The total number of feet of track upon which the DCS signal from a single TIU channel is spread
- The size and quality of the wire used between the TIU and the tracks
- The wiring scheme used, e.g., buss wiring vs. "home run" or "star" type wiring (more on that a little later)
- The conductivity of the tracks themselves

In general, the highest DCS signal strength will be obtained by adhering to the following guidelines as closely as possible:

- Attempt to limit the number of track blocks or sidings from a single TIU channel to no more than 12 - 15
- Limit track blocks to no more than 11 or 12 track sections where sections, long or short, all count. If sections are all short, consider soldering connections between sections to make longer ones. Regardless, track blocks should not exceed 100 feet in length
- Use 16 gauge or higher stranded wire from the TIU to the tracks. Generally, 16 gauge stranded wire is sufficient for any wire run that is 30 feet or less and is often good for longer distances. Above 50 feet, 14 ' gauge stranded wire is recommended
- Use only high-quality, paired wire
- Use Home Run or Star-type wiring
- Ensure that track segments are tightly connected, and that the rails are clean and free of rust

If all of these guidelines are closely followed, a single TIU can provide sufficient DCS signal strength for as much as 1,000 feet of track, depending upon a number of factors. These include the length of wire runs, the gauge of wire used and the number of times the DCS signal is split through terminal blocks.

Home Run/Star Wiring Methods

While the 2-way communication between the DCS Remote and the TIU is done wirelessly, DCS provides 2-way communication between the TIU and PS2 engines through the rails. PS2 engines receive commands through the center rail and respond to, or acknowledge, commands using the outside rails. Although DCS has been proven to work very well using a number of different wiring schemes, it works best when there is a clear path for command and acknowledgement between the TIU and PS2 engines.

This clear path is best obtained when the wires for the center and outside rails are run as pairs. Home Run or Star wiring is done as described below using transformers, TIU channels, and terminal blocks. A terminal block is any device that will accept of pair of wires as input and then splits that pair into several pairs of wires for output. It's a good idea to use only one terminal block for one TIU channel.

A pair of wires is connected between the output of a transformer and the input to a TIU channel. The wire from the Hot transformer post is connected to the red TIU input terminal, and the wire from the transformer Common post is connected to the associated black TIU input terminal.

It's very important to make these connections correctly. If you're at all unsure about which terminal post on your transformer is Hot and which is Common, consult the instructions that accompanied your transformer or review the Transformer Compatibility information in Appendix D of the DCS Users Guide that is included in DCS kits containing the DCS Remote and TIU. This guide is also available for download from MTH's Protosound 2 web site (refer to DCS Resources in Part I of this book).

Another pair of wires is connected between a TIU channel output and the input to a terminal block. The wire from the red TIU output post is connected to the input terminal of the terminal block designated as Hot and the wire from the black TIU output post is connected to the input terminal of the terminal block designated as Common.

Pairs of wires are connected from the terminal block to each track block or siding, ensuring that the Hot wire goes to the middle rail and that the Common wire connects to one or both of the outside rails. Either use a track lock-on or solder the wires to the rails. Regardless, ensure that connections are tight.

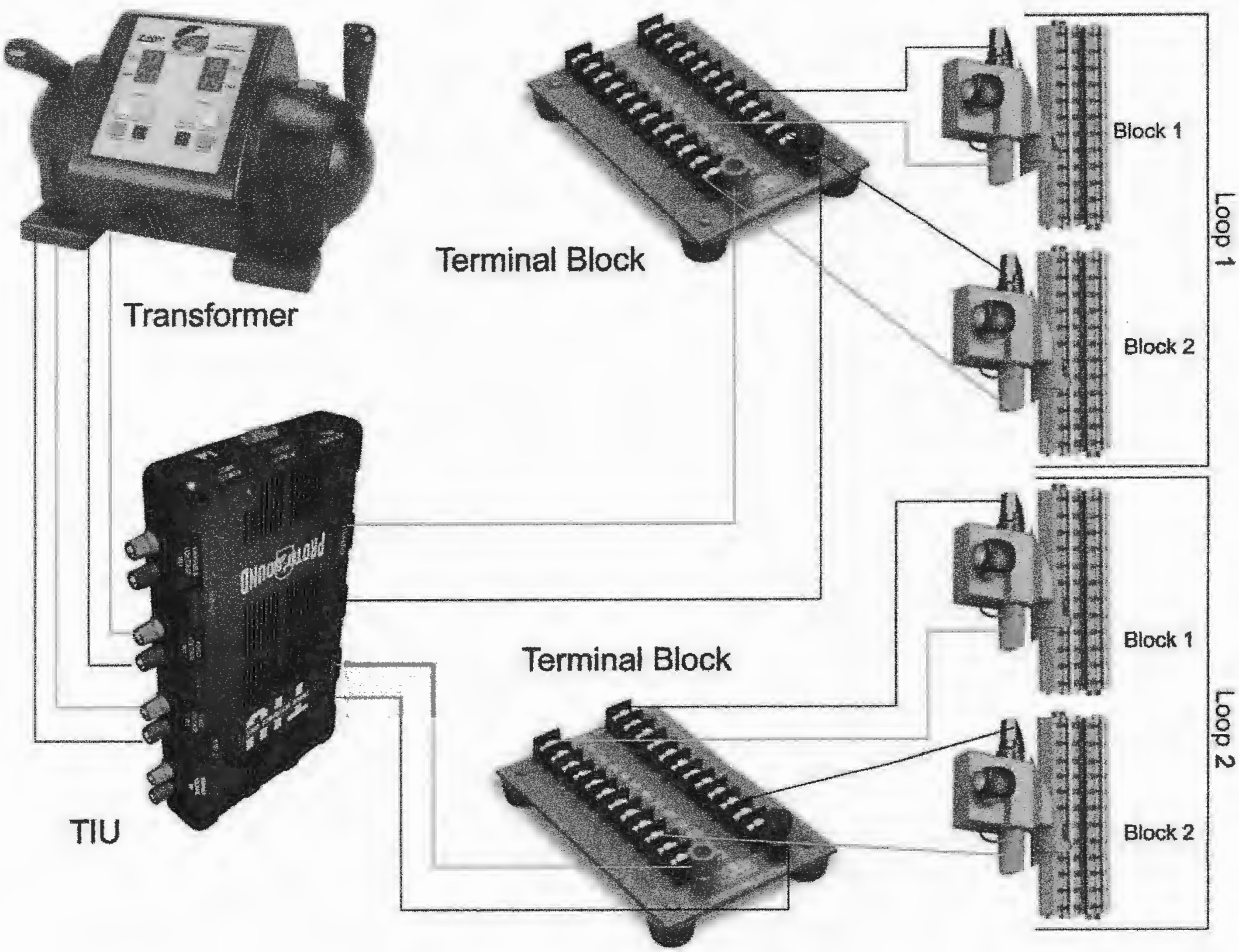

Figure 12 Star/Home Run Wiring Diagram

Length of Wire Runs

As a general rule, it is best to keep the length of wire runs as short as possible after the DCS signal has been split, as when one channel of the TIU is input to a terminal block and the terminal block then is split to feed several track loop and sidings. This is most easily accomplished when terminal blocks are placed in such a way that each one is as equidistant as is practical from each of the track blocks to which it is connected.

It would then follow that TIUs should be placed in such a way that each one is as equidistant as is practical from each of the terminal blocks to which it is connected. This would tend to reduce the length of wire paths, giving first priority to the wires connecting the terminal blocks to the tracks with second priority to the wires connecting the TIUs to the terminal blocks. Last priority would be given to the wires connecting the transformers to the TIU's. This makes sense since the weakest (after the splits) DCS signals would have the shortest path to follow and the paths between the transformers and the TIUs, which have no DCS signal at all, would be the longest.

One caveat, however, is that some blocks may be toggle-switched, causing the wire path to go from a terminal block to a control panel before going on to the tracks. This only goes to point out that wiring schemes will rarely, if ever, be perfect. Wiring trade-offs and compromises are generally part of designing a layout.

Using the Proper Size Wire

As mentioned previously, the vast majority of layouts will perform just fine if 16 gauge, stranded wire is used for wiring from the transformers, through TIUs and terminal blocks, and to the tracks for runs of up to 30 or 40 feet. If a particular wire run is 50 feet or longer, 14 gauge stranded wire is recommended.

Switch track wiring can be 20-22 gauge, stranded wire, with 20 gauge recommended if wire runs are very long. Further, ensure that, whenever possible, switch tracks are not powered by voltage that passes through a TIU channel.

Accessory wiring should be based on how much current the accessory is expected to draw. In general, accessory wiring is recommended to be 18 gauge, stranded. However, accessories that draw very low amperages can be connected with smaller gauge wires and accessories that draw larger amperages can, if necessary, be wired with 16 gauge wire. Rarely, if ever, will accessories require larger than 16 gauge wire.

Regardless, the smallest wire that can easily be accommodated by the AIU SW and ACC port terminals is 18 gauge. If it's necessary to use 16 gauge wire with an accessory controlled by an AIU, the wire end that goes into the AIU terminals should be solder tinned.

Track Blocks

A track block is a section of track that is electrically isolated from other sections of track by insulating the center rail of the track section from the center rails on either side of it. There are good reasons for wiring layouts using track blocks.

Toggle Switches

Appropriate use of toggle switches can provide several benefits:

- PS2 engines may be kept on toggle-switched sidings when not in use. This limits time on the engine's chronometer to actual time when the engine is in use and also reduces wear use of the electronics in the engine
- Passenger cars with many lights and cabooses may be kept turned off to preserve bulb life and reduce current draw when not in use
- Cabooses, other cars and conventional locomotives with smoke units will not have their smoke units run unnecessarily
- Conventional locomotives that either start up in forward, or that would go into forward if power was momentarily interrupted, may be kept turned off until it is desired to operate them

There are several considerations when using toggle switches:

- Toggle switches need not switch both the Hot and Common wires of the wire pair. Only the Hot wire needs to be switched. This allows use of toggle switches that are single pole, single throw (SPST)
- Only high quality toggle switches that are rated for 12 amps at 18 volts should be used. This would be the equivalent of 1.8 amps or greater at 125 volts
- Toggle switches increase wire paths by adding wire runs from terminal blocks to control panels and then to tracks, rather than directly from terminal blocks to the tracks. This needs to be taken into consideration when selecting wire gauge based on wire run length
- It may be more advantageous to have a toggle switch control a relay that turns power on and off to a track block if use of the toggle switch would greatly increase the wire run length between the terminal block and the tracks.

The Magic Light Bulb

Placing an 18 volt light bulb across either the input to a terminal block or the output of a TIU channel can provide a great improvement in DCS signal strength. Why this works is much less important than the fact that it simply does. The author has seen improvements where DCS signal strength went from 4's and 5's to solid 10's simply by using the 18 volt light bulb across the input to a terminal block.

Additional light bulbs placed at the ends of sidings nearly guarantee that the siding will have a signal strength of 10. The author's practice is to place lighted bumpers on all sidings.

Summary of DCS Wiring Tips and Techniques

The following summarizes the various DCS wiring guidelines for use when constructing a new layout that will utilize DCS:

- Locate the TIUs centrally on the layout to all terminal blocks to which they will be connected (refer to TIU Channel Assignment and Placement below)
- Run 14 or 16 gauge wire from the transformers to each of the TIU's inputs
- Run 14 or 16 gauge wires directly from the TIU outputs to the center of each of the areas of the layout that each channel supports
- Place a terminal block at each of these locations. Use only one terminal block for any TIU channel
- Run 16 gauge wire to each track block directly from the associated terminal block. If the track block is controlled by a toggle switch, run wires from the terminal block to the toggle switch and then on to the track block. DO NOT connect an output from a terminal block as the input to another terminal block
- Attempt to limit the number of track blocks or sidings connected to a terminal block channel to no more than 12-15
- Limit one TIU channel to no more than approximately 250 feet of track
- Place an 18 volt light bulb across each terminal block's inputs, one bulb for each terminal block. Alternatively, instead place the bulbs across the output terminals of each TIU channel

- Additionally, consider placing bumpers with lighted bulbs (not LEDs) at the end of each siding where DCS Signal strength is an issue. Alternatively, connect an 18 volt bulb across the end of such sidings
- If possible, use a separate transformer for switch motor power rather than using track power
- All wire should be either paired (like speaker wire) or, even better, twisted pair, to reduce signal loss on the longer runs. O Gauge Railroading Magazine sells 14 and 16 gauge wire that is excellent for wiring DCS (and other) layouts
- Use lock-ons specifically made for your tracks or solder all connections to the rails
- Crimp spade connectors to the end of every wire that gets screwed into a terminal block, unless you use terminal blocks that place the wire in a hole or slot and then screw down on top of it. Regardless, the intention is to get a very tight connection
- Isolate all track blocks from all other track blocks by ensuring that the center rails of each block are isolated from adjacent blocks. It's NOT necessary to isolate the outside rails from block to block.

TIU Channel Assignment and Placement

There are two schools of thought as regards TIU placement and, depending upon which one you use during layout construction, there will be an impact on the length of the wire runs from the transformers to the TIUs, from the TIUs to the terminal blocks, and from the terminal blocks to the tracks. Regardless of which method of TIU placement is used, it's a good idea to locate TIUs so that there is a direct line of sight between the TIUs and the DCS Remote whenever possible. This is best accomplished by physically placing TIUs so that they are at, or above, the height of the tracks whenever possible.

Loop Assignment of TIU Channels

This is the most straightforward method for assigning TIU channels to tracks. TIU channels are simply assigned to individual loops of track and are powered by one transformer handle for each TIU channel. If loops are small, one TIU channel may be connected to more than one loop by using one terminal block for all loops serviced by this channel. However, it still remains a good idea to limit the number of track blocks or sidings connected to a single TIU channel to 12-15.

If power requirements for loops are low, multiple TIU channels for multiple loops can be fed from a single transformer handle by splitting the output of the transformer handle into two or more TIU channel inputs.

If power requirements for a single loop are more than can be accommodated by a single transformer handle, more than one transformer can be used with more than one TIU channel to set up power districts as discussed previously in Initial Wiring Considerations.

The advantages of loop assignment of TIU channels is that wiring is straightforward and uncomplicated, and that if Variable Channels are used, operation of conventional engines is facilitated over multiple loops because a single power source is used for these loops.