

THE
EQUALIZER
INSTRUCTION MANUAL

DIGITAL DYNAMICS
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THE **EQUALIZER** INSTRUCTION MANUAL

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Introduction

Congratulations on your purchase of the Equalizer. After reading this manual and performing the installation steps, we are confident you will agree that the Equalizer is the most comprehensive and easiest to install product available for the conversion of MTH Protosounds locomotives to the Lionel Trainmaster Command Control System. It is the only product available that is guaranteed to install in any MTH Premier or RailKing engine equipped with the original Protosounds System. It is not intended for installation into newer Protosounds 2.0 locomotives.

The Equalizer is the result of several months of research and practical experience converting MTH and similarly built engines to operate with the Lionel TMCC system. Careful consideration was given to such factors as the physical size of the board, ease of mechanical installation, heat generation and dissipation, and electrical compatibility. Another important goal was to design a system that would enhance the value of an engine after installation, not degrade it. Lastly, and most importantly, it was desired to produce a system that would integrate MTH Protosounds with Lionel Trainmaster and achieving the minimum loss of functionality in either system.

The Equalizer meets all of its design criteria. The circuit board has the same physical footprint of the Protosounds DC Reverse Unit (DCRU) it replaces. It uses existing engine mounting hardware and wiring connections, assuring that the Equalizer will fit into all MTH Protosounds locomotives. Installation is virtually plug and play. No soldering is required for most installations.

Electrically, the Equalizer is 100% compatible with lighting systems in all MTH engines. There is no need to replace light bulbs, add resistors, and/or diodes, or to remove circuit boards that are an important part of the lighting system. The value of your engine is preserved, because it is not necessary to modify the engine in any way other than installing the Equalizer, which can be easily removed at any time if it is desired to restore the engine to its original factory configuration.

Remote ProtoCoupler operation is fully supported. In fact, the Equalizer enhances remote coupler operation, allowing either ProtoCoupler to be operated independently at any time in Command Mode. It is no longer necessary to select the coupler you wish to operate by means of a switch mounted under the engine.

Compatibility between Protosounds and TMCC has been achieved to an unprecedented degree. Virtually all Protosounds features such as Passenger Station Announcements (PSA), Freight Sounds, and other Neutral Sounds remain fully functional in both Conventional and Digital Command Modes. Additionally, all Protosounds features are now programmable via your CAB-1 in Command Mode.

The Equalizer has been carefully designed and tested to assure years of trouble free operation. The board is proudly manufactured entirely in the USA from the highest quality components available. I sincerely hope it brings you years of continued enjoyment.



Ed Bender
Digital Dynamics

Overview

Throughout this manual, the terms Digital Command Mode and Conventional Mode will be frequently used. Digital Command Mode refers to the full featured remote control operation of your engine from either Lionel's CAB-1 Controller or the MTH DCS Handheld Controller. In Digital Command Mode, a fixed voltage is applied to the track and each engine is addressed independently by a digital 'ID'. Buttons on the handheld controller activate features of the selected engine.

In Conventional Mode, engine speed is controlled by varying the voltage applied to the track. Engine direction is established by briefly interrupting track power, sequencing the engine from one directional state to the next each time power is interrupted. Other functions such as whistles and bells are also controlled from the power source. In its original form, the Protosounds System is a Conventional Mode system. Engine features are programmed and activated by generating different voltage sequences on the track. This can be accomplished either manually with a conventional transformer, or with a DCS or CAB-1 hand held controller operated in conjunction with a Lionel Command Base, Powermaster, or TPC Controller.

The Equalizer transforms your engine from conventional control to full digital command control. From your handheld remote, you can precisely control engine speed, activate horns and bells, open couplers, and activate special sounds. You can even assign engines to multiple engine lashups and operate them together as a single train.

In addition to the benefits of digital command control that the Equalizer brings to your engine, other enhancements make operation with Protosounds easier and more enjoyable.

You will not need to use your transformer or other special equipment to program engine features. All of the standard Protosounds features can be programmed and activated from simple keystrokes on your handheld controller.

Please be sure to read the section on setting up and operating your engine after completing the installation.

Notes

PROBLEM	LIKELY CAUSE/REMEDY
Engine will not exit RESET state when [AUX1][0] is pressed	Track voltage is too high. Reduce to 18V or less. Engine is not properly addressed. Check and/or reset engine ID# and engine type.
Engine does not enter NEUTRAL.	Throttle is not turned completely off. Engine is locked in FORWARD position. Use Protosounds RESET #18 to unlock.
Squeaking brake sounds are not heard	This feature must be activated before brake sounds can be generated. Also, track voltage may be set too low. Set track voltage to 14V or higher.
Engine will not move, or motion is erratic. Mechanical chattering can be heard.	The Trainmaster radio signal is not being received reliably. Check the antenna connection. There may be radio 'dead' spots on the layout. Use another engine to verify suspected poor reception areas.
Coupler sounds are not heard when couplers are opened	Track voltage must be greater than 14V Engine must be completely stopped and in NEUTRAL Coupler sounds will not play during FYS or PFA
Pressing CAB-1 BELL button has no effect	Engine must be programmed for separate BELL button. Use RESET #20
Protosounds is 'out of sync'. Neutral sounds are played while the engine is in motion.	Bring the engine to a stop and restart it. This will permit Protosounds to resynchronize with engine motion. If this fails, press [AUX1]-[0] and restart the engine.
Engine sometimes does not respond to Horn or Bell button	This condition may occur when the engine is started in motion before the completion of PFA/FYS effects. Normal Horn and Bell function will return when the sequence is completed.
Engine does not chuff when started or chuffing does not begin until engine is running at speed.	This will sometimes occur if the engine is moved during Cab Chatter playback, or it is shuttled back and forth quickly. Pressing [AUX1][0] before moving the engine will usually remedy this.

Basic Operation with TMCC

Operating an MTH engine with the Equalizer and Protosounds is very similar to operating other Lionel Trainmaster Command Control (TMCC) equipped engines. Most of the functions operate in exactly the same way. For instance, pressing the horn button will cause the engine horn to sound, increasing the throttle will increase engine speed, etc. Certain other CAB-1 activated features usually found on TMCC and Rallsounds equipped engines, such as manual diesel engine RPM control, CrewTalk, and Cab Chatter sounds are not available with Protosounds. However, there are other similar Protosounds features that are available from your handheld controller:

IMPORTANT

The Equalizer is designed to operate with a constant track voltage of 14V to 18V AC. Higher operating voltages are not recommended and may cause erratic operation and excessive heat buildup inside the engine. Lower operating voltages in the range of 14V to 16V AC will give you more prototypical operation with finer low speed control and without adversely affecting engine operation under heavy loads.

Due to the nature of the Protosounds system and the methods used by the Equalizer to establish communications between Protosounds and TMCC, there are certain features that operate differently than what you may be accustomed to. In order to understand how these features operate, a basic understanding of the Protosounds operating system will be helpful. Once you fully understand how Protosounds works, operation of its features with the Equalizer and your handheld controller will become intuitive.

A complete description of the Protosounds functions and how they operate can be found in the instruction manual that came with your MTH engine. Also, you should refer to the operating instructions that came with your Trainmaster system for detailed descriptions of individual functions. A basic overview is described in the following section.

Protosounds States

The Protosounds System, in addition to providing engine sound effects, was designed and manufactured to be a reliable, enhanced solid state replacement for the traditional mechanical reversing unit used by Lionel for decades. Operation is the same as a mechanical reversing unit, the engine sequences through Neutral-Forward-Neutral-Reverse each time power to the engine is briefly interrupted.

There are four distinct operating states associated with three-rail locomotives, NEUTRAL-BEFORE-FORWARD, FORWARD, NEUTRAL-BEFORE-REVERSE, and REVERSE. In addition to these, Protosounds adds a fifth state, known as RESET.

Most of the time while operating your engine, you will not need to be concerned with the different Protosounds states, since the Equalizer will automatically sequence Protosounds to the proper state in response to commands you give to the engine. The exception to this is RESET.

Reset State

When the engine is first powered up, it enters the RESET state. The engine cannot be moved while in RESET. Throttle commands are ignored until the engine exits RESET.

In RESET, you can enable or disable Protosounds features quickly and easily from your handheld controller.

To exit RESET in Command Mode, press [AUX1] then [0]. The engine will go to the NEUTRAL state, and await your further commands.

The RESET State cannot be re-entered until power is removed from the engine for more than approximately ten seconds. Remember, when operating in TMCC Mode, in order to remove power from the engine, power to the track must be shut off.

Operating States

Most of the time, your engine will be in one of two operating states. In digital command mode, the Equalizer has only two operating states, NEUTRAL and RUNNING.

Neutral

The NEUTRAL State is entered from RESET, or from RUNNING after the engine comes to a complete stop, and remains stopped for more than approximately one second. There are no NEUTRAL-BEFORE-FORWARD or NEUTRAL-BEFORE-REVERSE states. There is only NEUTRAL.

It is important to note that the CAB-1 throttle must be completely OFF, or the NEUTRAL State will not be initiated. It is also possible to enter NEUTRAL from RUNNING by pressing and holding the BRAKE button until the engine comes to a complete stop. However, as soon as the button is released, the engine will resume RUNNING in its last direction.

Running

An engine is in the RUNNING state any time it is in motion in any direction and at any speed. It can also be defined as the condition when the Throttle is completely turned OFF.

Troubleshooting

Each and every Equalizer is tested and burned in before shipment to insure that it is in working order when you receive it. Additionally, a great deal of time and effort has gone into the development of the Equalizer to make it as simple as possible to install and operate. Recognizing this, it is anticipated that problems, both genuine and perceived, will arise from time to time. If you consider that an 'Equalizer' engine has no less than three microprocessors on board, there are bound to be issues with user understanding and operation of such a complex product.

The first step in troubleshooting an engine is to determine whether or not it is receiving the proper radio signal. The Lionel R2LC contains the radio receiver and a microcontroller that performs many of the basic engine functions. If the R2LC board is operating properly, you should be able to address the engine and open it's Protocouplers, even if you have no other control over the engine. If you cannot perform this basic operation, then:

- the antenna is not functioning
- the track voltage is too low to fire the couplers
- you are using the wrong engine ID#
- the PROG/RUN switch is in the wrong position.

The next step should be to establish whether or not the R2LC is communicating properly with the Equalizer. Communication is by the same method the R2LC uses to communicate with a RailSounds system. The R2LC can also be programmed to communicate in a different format with a basic Signal Sounds system. If the R2LC is inadvertently reprogrammed to communicate in Signal Sounds format, the Equalizer will not function.

See the section in this manual on **Programming the Trainmaster Component - Engine ID Number and Engine Type**. Repeat this procedure if necessary. If you are unable to get your engine running, call Digital Dynamics for assistance.

The most commonly encountered problems and their remedies are listed in the accompanying table. As more experience and information is gathered, this table will be expanded to cover all possible problems and their remedies. Check the Digital Dynamics web site periodically for updates to this manual.

RESET #	OPERATION	DEFAULT	EQUALIZER SETTING
6	Engine Volume	Full	ANY
10	Coupler ON/OFF	ON	ON
18	RESET Default Settings	N/A	N/A
20	Remote Bell Button	ON	ON
23	Cab Chatter ON/OFF	ON	ON
25	Whistle/Horn in NEUTRAL	OFF	ON
27	Set Engine Chuff Rate	N/A	N/A
28	FYS/PFA Enable	ON	ON
40	Lockout	OFF	OFF
45	Squeaking Brakes	ON	ON

Figure 8 - Protosounds Feature Programming

Operation with QS-3000

The Equalizer will support operation of QS-3000. All of the basic functions such as engine horn/whistle, bell, coupler sounds, squealing brakes, freight yard or passenger station announcements, and other features will be fully functional. However, you may not be able to access all of the QS-3000 features. Generally, any feature that can be activated by combinations of HORN or BELL button presses, or by brief power interruptions will function. Those features that require different voltage levels in conjunction with HORN or BELL signals cannot be activated.

RESET programming of the QS-3000 system can be performed with the Equalizer from your CAB-1. Refer to your documentation before attempting to program the QS-3000, as the RESET sequence numbers are entirely different from Protosounds.

Protosounds Features with Trainmaster

While the Equalizer successfully combines the functions of Protosounds and Trainmaster Command Control, they are two distinctly different systems with certain operational differences between them. For example, there are certain Trainmaster features that have no Protosounds counterpart, and vice versa. There are also subtle differences in some of the basic engine functions. For this reason, it is important to read and understand this section describing the operation of Protosounds in the Trainmaster Command Control environment.

In this section, the different functions of the Equalizer are described in terms of operating your engine from the CAB-1 hand held controller. Most of the operations will appear identical to those of other Trainmaster equipped engines. You will also notice that there are some minor differences in the way certain features operate. If you are familiar with the conventional operation of the Protosounds system, operating these features will be intuitive. If not, it will be helpful to study the operating manual that came with your MTH engine.

The Equalizer will respond to two different sets of commands, depending on whether the engine is in RESET, or if it is in an operating state such as FORWARD, REVERSE, or NEUTRAL.

RESET State Commands

In the RESET state, you can activate or deactivate Protosounds features from your CAB-1 Controller. The CAB-1 AUX-1 commands are used to set the engine to the desired Protosounds RESET sequence. Then, the WHISTLE button is pressed one or more times, activating or deactivating the feature. Power must then be turned off to lock-in the programming.

RESET commands are activated from the CAB-1 by first pressing the [AUX1] key, the numeric keys [0] - [9] for the particular function, then the [AUX1] button again. For example, to program feature #20, press {AUX1}[2][0]{AUX1}.

To exit the RESET state and begin operation of your engine, press [AUX1] then [0]. To re-enter RESET, you must remove power from the engine for ten seconds or more, then power it up again.

Operating State Commands

Your engine will be an Operating State most of the time, responding to CAB-1 commands for movement, horn, bell, coupler, and other functions.

THROTTLE

The throttle controls engine speed. Throttle operation is consistent with other Trainmaster equipped engines. As the knob is turned clockwise, engine speed will increase. Turning the knob counterclockwise will slow the engine. When the throttle is completely OFF, Protosounds will enter NEUTRAL.

[DIR]

Engine direction is set by the [DIR] button. Although the engine direction is affected by the [DIR] button in the same way as other Trainmaster equipped engines, there are some slight differences in the way engine lighting is controlled.

In the Trainmaster Command Control environment, there is no NEUTRAL state. The engine is either in FORWARD or REVERSE with the throttle either at zero or at some

speed setting. The Equalizer creates a 'pseudo neutral' state by detecting when the engine throttle is all the way off. This is important since certain Protosounds features are available only in the NEUTRAL state. As a consequence, there is no 'neutral-before-forward' or 'neutral-before-reverse' state. What this means is that when engine direction is changed, bi-directional lighting will not be lit accordingly until the throttle is at least partially engaged from the fully stopped position. Normally, an engine's bi-directional lighting will toggle from front to rear and vice versa each time the CAB-1 direction button is pushed. Pressing the [DIR] button multiple times while the engine is stopped will produce no visible effect. The lighting will not change until the throttle is turned up, or the [BOOST] button is pressed momentarily. The lighting will always be correct for the engine direction when the engine is ultimately moved.

[WHISTLE]

The [WHISTLE] operates in a conventional manner. Engine whistle or horn sounds will be heard for as long as the button is pressed. However, unless this Protosounds feature is activated, the engine horn will not sound when the engine is stopped and in the NEUTRAL state. The default mode is no horn sound in NEUTRAL. Use Protosounds RESET feature #25 to program the engine to produce 'Horn sounds in Neutral'.

[BELL]

The engine bell is activated by momentarily pressing the [BELL] button. Pressing it again will turn the bell off. Specific Protosounds features, such as squeaking brakes and Passenger Station Sounds or Freight Announcements, are activated by pressing and holding the [BELL] button for three or more seconds while the engine is moving.

[BRAKE]

The [BRAKE] button will slow the engine when it is pressed. When it is released, the engine will resume speed. Braking rate is controlled by the engine or train MOMENTUM setting. When [BRAKE] is pressed and held long enough, the engine will come to a complete stop and enter NEUTRAL. When the button is released, the engine will resume its last direction and speed. If this feature is enabled, squeaking brake sounds will be heard as engine brakes are applied. See your engine Operating Manual for the specific method of programming this Protosounds feature.

[BOOST]

The [BOOST] button will increase engine speed when it is pressed. When it is released, the engine will resume its original speed. The Boost rate is controlled by the engine or train MOMENTUM setting.

[F] and [R]

These buttons open the Front and Rear Protocouplers. Either coupler may be opened at any time. Coupler sounds will be produced provided that the track voltage is set above 14V. Note that some engines will not reliably produce this sound effect unless the track voltage is precisely set within a specific range. If this is the case, you will hear two short horn/whistle blasts after the coupler is opened, rather than the coupler sound effects. Experimentation with different track voltage settings may improve the reliability of this effect.

[AUX1][7]

In the Operating Mode, [AUX1][7] will sound the bell for three seconds and then turn it off. This function is intended to activate PFA or FVS without the need to keep the bell button continuously pressed. See the following section on activating Protosounds Features, Passenger and Freight Yard Sounds, for further information.

Protosounds Programming Procedure

The Equalizer has built-in capability to program Protosounds features. The programming method is similar to the MTH Z-4000 Transformer or the QSI Sidekick accessory. There is no need to crank your transformer handle up and down to program in RESET. All programming is done with a few button presses on your CAB-1.

Begin by programming the engine to its factory default settings using RESET feature #18. This will assure that prior feature programming does not conflict with Equalizer operation. Then program each of the features to the required settings using the information from the following table. Note that there are some minor differences in feature programming among the numerous MTH engine types produced over the past several years. Consult your engine operating instructions for the correct programming information.

- Place the engine on the track and turn on power. You will hear two 'dings', signifying that the engine is in RESET.
- Select the engine by pressing [ENG] then the engine number.
- Program the desired feature by pressing [AUX1] then the numeric code on the CAB-1 Keypad. For single digit codes, do not enter a leading zero, as this will cause the engine to immediately exit from RESET. **Press each Key firmly and deliberately, pausing briefly between each entry.**
- If you entered the wrong code and want to start over, press and hold the [AUX2] button for one second. This will clear any entered digits, provided that [AUX1] has not been pressed a second time.
- After entering the desired code, press the [AUX1] button again.
- You will then hear a rapid succession of air release sounds, followed by the appropriate number of 'clanks and clinks' signifying the RESET sequence number entered.
- Press the CAB-1 [BELL] button once. A bell sound will be heard. One bell ring indicates that the feature is DISABLED. Press [BELL] again and you will hear two rings. Each time you press [BELL], Protosounds will alternately play one or two bells signifying that the feature is disabled or enabled.
- When you have finished programming the feature, shut down track power to lock it into memory.
- Wait 10-15 seconds to restore power. The engine will again be in RESET. Repeat the procedure as many times as necessary until Protosounds is programmed as desired.

You can program any Protosounds feature from your CAB-1. Remember that the engine must be in RESET in order to program it. You select the desired feature by entering the feature number on the CAB-1 numeric keys, and by pressing the [AUX1] button to enter it.

The Protosounds features commonly used with the Equalizer are described below and in the table that follows. Not all features are found in every engine. You should refer to your engine's operating instructions for a full description of each feature and how it works.

Engine Volume Adjustment (8)

You can set steam chuff or diesel engine volume to three levels, including off. The factory default level is full volume level. This setting does not effect the level of the horn and bell.

Proto-Coupler Operation (10)

If you would like to hear the sounds of couplers opening, then this feature should be enabled. Although with TMCC, couplers can be fired at any time, the sounds will be produced only when the engine is in NEUTRAL.

Reset Default Settings (18)

Restores all engine features back to factory defaults. Use this feature to restore engines that have been locked out, locked into a single direction, or are in an unknown programming state.

Remote Bell Button (20)

This feature should be enabled, since the CAB-1 controller has separate [BELL] and [WHISTLE] buttons. The engine bell can then be activated or deactivated at any time.

Cab Chatter (23)

This feature can be programmed either ON or OFF, depending on preference.

Whistle/Horn in NEUTRAL (25)

This feature should be enabled. The CAB-1 controller has separate [BELL] and [WHISTLE] buttons allowing you to operate the engine horn or whistle at any time, not just in NEUTRAL.

FYS/PFA Enable (Squeaking Brakes) (28)

This feature should be programmed ON if the ability to activate PFA or FYS is desired. On some engines, this RESET feature also enables activation of Squeaking Brake sounds. Once enabled, the feature is activated from the [BELL] button.

Remote Lockout (40)

This feature should remain OFF at all times. If you are unable to disable lockout, use RESET feature 18 to set the engine back to factory defaults.

Squeaking Brakes (45)

This is a separate RESET feature on some engines. Consult your engine's operating instructions to determine if this RESET sequence is functional. If this does not apply to your engine, use RESET feature 28.

[AUX1][8] and [AUX1][9]

In the Operating Mode, [AUX1][9] will turn on power to the engine's Smoke Unit if it is connected to the Equalizer. Holding the [9] button will temporarily boost voltage to the smoke unit, increasing its output. Pressing [AUX1][8] will turn smoke off.

Activating Protosounds Features

A popular feature of Protosounds is its ability to produce 'Cab Chatter' and Freight Yard Sounds (FYS) or Passenger Station Sounds (PFA) specific to the engine or road name.

Cab Chatter

When enabled, Cab Chatter will be generated automatically and at random each time the engine is stopped and is in NEUTRAL. This feature is activated and deactivated from Protosounds RESET sequence #23. You will want to disable this feature if the engine is to be used in any position other than as the lead engine in a multi-engine lashup.

Passenger and Freight Yard Sounds

To activate Passenger or Freight Sounds, depress and hold the [BELL] button for three seconds while the engine is moving in either the forward or reverse direction. When PFA/FYS is activated, a single whistle sound or air release sound will be heard, depending on the engine. Once the sound is heard, the [BELL] button can be released. Another momentary [BELL] press will turn the bell off. When the engine is completely stopped, it will enter NEUTRAL and begin playback of the PFA/FYS sequence.

Once PFA or FYS has started, you can step through the different parts of the playback sequence by pressing [AUX1] [0]. When the sequence has finished playing, you can move your engine in any direction. Your engine's instruction manual gives details operation of the PFA/FYS playback sequence.

If you do not wish to disturb the PFA/FYS announcements, do not activate the throttle or BOOST functions while the sequence is playing. If either is activated, the engine will be forced out of NEUTRAL, interrupting the playback sequence. The engine will not begin to chuff or ramp up diesel sounds until the PFA/FYS sequence has finished playing.

Other Engine Features

Smoke Unit

An MTH fan driven smoke unit can be connected to the Equalizer if you would like to remotely control the engines' smoke output. You can have the ability to turn smoke on and off, as well as operate the smoke boost feature from the CAB-1. You can connect the Equalizer either to a diesel smoke unit or to a steam smoke unit. You will need to install an optional one-pin tether between the engine and tender if you want to connect a steam engine smoke unit to the Equalizer.

Smoke is activated by pressing [AUX1][9] to turn it on, and [AUX1][8] to turn it off. Holding down the [9] button after pressing [AUX1] will activate smoke boost, temporarily increasing smoke output.

In Conventional Mode, the smoke unit is always active. If you wish to turn it off, use the SMOKE ON/OFF slide switch located under the engine.

Engine Lighting

Lighting circuits vary considerably among the hundreds of different MTH engines produced in recent years. The Equalizer is equipped to handle all lighting configurations.

The Equalizer provides three direct lighting outputs. J6 and J7 provide a regulated 1.2 volts for headlamp and backup lamp connections. These outputs are controlled by engine direction and can be turned on or off from the CAB-1 [AUX2] button. J6 and J7 are used as the primary directional lighting connections by most Premier diesel and electric engines. Premier Steam engines with backup lights on the rear of the tender get power for them from J6.

J9 provides a current limited output for direction connection to LED engine marker lamps. This output is always on.

Certain Premier diesel and electric engines use special circuits to generate constant voltage for headlights, marker lights, strobe lights, and cab lights. Connections from the Equalizer to these circuits provide control of directional headlights. However, the different marker lights, MARS lights, etc. connected to these circuits cannot be individually controlled from the CAB-1.

Setting Up Your Engine for Operation

In order to allow the Equalizer to properly operate Protosounds in the Trainmaster environment, you will need to program both the Trainmaster and Protosounds components of the system. You will need to set the Trainmaster engine ID number, as well as set the engine type for either diesel or steam. This will give the engine the ability to be individually controlled from your CAB-1. This operation is no different than setting the ID of any other Trainmaster equipped engine.

To maximize the functionality of the Equalizer, you will also need to change certain Protosounds features from their default factory settings.

Programming the Trainmaster Component

Engine ID Number and Engine Type

If you intend to run more than one engine with the Trainmaster system, you will want to assign a unique digital identification number to the engine. The default ID of your engine is set to #1, but it can be changed at any time to any number from 1 to 99. The CAB-1 controller is used to set the engine ID.

- Remove power to the track, remove the engine, and set the PROG/RUN switch to PROG.
- Place the engine back on the track and apply power.
- Program the engine ID Number by pressing [ENG] [#] then [SET]. Note that '#' can be any number from 1 to 99. The horn will not sound to acknowledge that the engine ID has been set. Protosounds will be in the RESET state and cannot acknowledge with a horn blast.

Next, the engine type must be programmed to establish communication between the R2LC receiver and the Equalizer board as well as determine how the smoke unit operates. Even if the engine does not have a smoke unit, or you decided not to connect it, you must perform this step.

- Press [AUX1] then [4] for Steam, or
- Press [AUX1] then [8] for Diesel and Electric Locomotives, or
- Press [AUX1] then [6] for RailKing Diesels w/ headlight connected to smoke output wire.

Programming of the Trainmaster component is now complete. Remove power and the engine from the track and set the PROG/RUN switch back to the RUN position.

You may find it helpful to develop a consistent method of assigning ID numbers to your locomotives. You may consider using the first two or last two digits of the engine number as the digital ID number. You may, of course, develop your own scheme to help you keep track of your locomotive ID numbers.

In the event you lose track of your locomotive's assigned ID, simply use the above procedure to reprogram it.

Programming Protosounds Features

In order to obtain the maximum number of Protosounds features from your engine, you will need to program Protosounds differently from the factory default settings. With the Equalizer, programming Protosounds features is quick, accurate, and easy.

turning the screw clockwise to tighten it. This practice ensures that the threads of the screw and the tapped hole engage together properly, preventing the tapped metal threads from damaging the soft nylon screw threads. The nylon screws provided in the installation kit are #6-32 x 5/16". In the event that the screws are too long and cannot be tightened down enough to secure the chassis, use a sharp blade to trim the screws to the proper length.

Protosounds Battery

The Protosounds system incorporates a battery to prevent interruption of engine sounds during brief periods of power loss to the engine. Because the Protosounds circuitry relies on these brief power interruptions to change from one state to the next, the rechargeable battery is an important part of the system. However, problems can arise if an engine is stored for a long period of time, and then operated with a weak battery. Unfortunately, this is a familiar problem to operators of Protosounds equipped engines.

If you will be operating your engine exclusively with the Trainmaster Command Control system or DCS with a constant track voltage, you can avoid this potential problem by removing the battery from the engine.

If the engine is to be occasionally operated in Conventional Mode, the Protosounds battery is necessary to keep the Protosounds system operating normally. It is important to operate the system with a fully charged battery, and the Equalizer contains circuitry that continuously charges the battery while the engine is in use. However, even with the Equalizer installed, Protosounds may still operate erratically, or not at all, if the battery is weak or dead.

If you store your engine for a long period of time, you should remove the battery and charge it externally before attempting to operate the engine. You may also want to consider replacing the battery with a NiMH type that does not have the "memory effect" weakness of the Protosounds NiCad battery.

For best results, special 9.4V NiMH batteries are available from Digital Dynamics. These batteries have a higher voltage under load and larger storage capacity than the standard 8.4V NiMH battery widely available.

Operation in Conventional Mode

The Equalizer is capable of operating your engine in conventional mode with an ordinary transformer. In this mode, the engine will function in the same way as it did with its original factory installed boards. The ability to program and activate Protosounds features from your transformer is retained, and most features will operate as they did before.

There are a few features that will no longer be available, or will operate differently after the Equalizer is installed.

The ability to remotely open Protocouplers in Conventional Mode is no longer available. It is possible to generate the sound effect of couplers opening, but the couplers themselves will not open.

While playing PFA or FYS sequences, the engine will no longer be locked out from movement during the playback sequence. The reason for this is that the engine is no longer under control of the Protosounds computer. Instead, the commands for FORWARD-NEUTRAL-REVERSE come from the Trainmaster R2LC control board. Stepping through the different phases of the playback is also affected. Recall that Protosounds requires power interruptions to step through the playback sequence. The R2LC will also see these power interruptions at the same time, and then cycle the engine through the one phase of the FORWARD-NEUTRAL-REVERSE sequence at each interruption.

With a little practice, this can be overcome. The R2LC is a bit more sluggish in its response to power interruptions than Protosounds. What this means is that the 'OFF' time needed by the R2LC to step to the next direction phase is slightly longer than what Protosounds requires to advance the PFA/FYS through the playback sequence. By interrupting power in short bursts, you can cycle through the entire PFA/FYS playback without any movement of the engine. All other aspects of engine operation remain the same.

Final Engine Assembly and Test

With most of the wiring completed and the boards firmly bolted to the chassis, connect the PROG/RUN Switch and Antenna to J13.

First, you will need to complete assembly of the Antenna plug by inserting the ends of the PROG/RUN Switch wires into the two unoccupied Antenna plug positions. Either wire may be placed in either position. Note the orientation of the pins before inserting them into the connector shell. When properly inserted, the pins will lock into the shell. Be sure to dress the switch wires to allow the engine shell, with antenna attached, to be freely placed and removed from the chassis.

When you are satisfied with the switch and antenna wiring, plug the connector into J13 at the back of the Equalizer board.

Neatly dress all wires, keeping them clear of any potential moving parts. Be sure all wires have enough slack to accommodate motor and truck movement. Replace plastic heat shields and any additional hardware that was factory installed.

Replace the shell on the engine or tender, but do not install the screws at this time.

The installation is not complete until the engine has been completely tested with its new circuits. A test track or layout complete with power source and the Lionel Trainmaster System with CAB-1 controller is needed to test the engine. The power source may be a conventional transformer, or any modern solid state train power supply such as a TPC Controller, Lionel Powerhouse/Powermaster, or a MTH Z-4000, Z-750, etc. The track voltage should be set to 18V or less. Use the procedure that follows to perform a basic test of your engine.

- Make sure power to the track is OFF.
- Carefully place the engine on the track with the shell in place, but not fastened. Note that some engine lighting circuits may not function until the body is tightly fastened to the chassis
- Apply power to the track. You should hear the familiar Protosounds double bell clang, indicating that the engine has entered the RESET state.
- If you do not hear the correct sounds, or you see smoke coming from places other than a smoke unit, immediately shut down power. Check for pinched wires or loose connectors inside the engine. Make sure that the engine volume control is properly connected to the top board and is turned up to full volume. Verify that the speaker is connected to the top board.
- Address the engine by pressing [ENG] then [1] on the CAB-1.
- Exit the RESET state by pressing [AUX1] then [0].
- Advance the throttle to check engine movement. Be sure to run the engine in both directions. Operation should be smooth and consistent in both directions.
- Check the operation of Protocoupler(s) by pressing the appropriate buttons on your CAB-1.
- Check engine lighting. Directional lighting should operate consistent with engine direction. In some cases, engine lighting will not function unless the shell is fastened to the chassis.

When you are satisfied that the engine is operating properly, fasten the body to the chassis. Steam engine installations require the use of nylon screws supplied with the installation kit to attach the body of the tender to the chassis.

To avoid damaging the threads of the nylon screws as they are installed, slowly turn the screw counterclockwise until you feel it drop into place. At this point, begin

mix is not too 'wet'. Once it has reached the desired consistency, apply it to the existing coal pile and let it dry. If necessary, you can later touch up any exposed areas with black paint.

This method of antenna placement has the advantage that it is permanent and not disturbed if it becomes necessary to open the tender at a later time.

Method C

This method is useful for die cast electric locomotives with pantographs, such as the GG1. The pantographs are electrically insulated from the metal engine body, and make an excellent antenna, either in the raised or lowered position.

Using an appropriate length of #22 or #24 wire, connect the two pantographs together. Solder the connection at the end farthest from the Equalizer board location.

Remove the copper adhesive tape from the end of the supplied antenna wire, as it is not needed. Use a pair of cutting pliers to cut it free. Then, strip away approximately 3/8 inches of insulation from the end of the wire and attach it to the pantograph. Solder it to the insulated pantograph lug together with the wire connecting the other pantograph.

Installation Instructions

Initial Testing

Perform a complete test of your engine and Protosounds system by running it briefly while testing its basic functions such as the horn and bell. If you are in doubt as to the condition of the Protosounds battery, it is also a good idea to leave the engine idling for a few hours with the track voltage set to about 12V. When you are satisfied that everything is operating normally, you may then remove the old boards from the engine and begin installation of the Equalizer.

Before undertaking installation of the Equalizer, it is important that you perform a basic functional test of the engine BEFORE removing any circuit boards. This is particularly important if the engine has been stored for a long period of time and its battery has been deeply discharged. The Equalizer will not function if the top Protosounds board is defective, or has become 'locked up' in an undefined state as a result of operating the engine with a weak or dead battery.

If you are in doubt as to the state of the Protosounds battery, either replace it with a new, fully charged battery, or simply disconnect it.

The instructions contained in this section are intended to serve purely as a guide to installation, not a step by step procedure. Although the primary electronic circuit components are virtually identical in every MTH Protosounds I engine, the connections to the boards will vary somewhat among the hundreds of different engines produced over the years. Before removing the old boards from the engine, be sure to make careful note of the connections and routing of the wires. These notes, along with the instructions that follow, will make installation of the Equalizer in any engine as easy as possible.

The procedure detailed in the following pages is applicable to all MTH Protosounds I engines. However, some engines may have additional connections that are described in another part of this manual. It is a good idea to read through the complete installation section and familiarize yourself with the procedure before actually performing any of the steps.

Protosounds Board Removal

To begin the installation, simply remove the screws that secure the engine or tender shell, and place the shell aside where it cannot be scratched or otherwise damaged during the installation. Be sure to put the screws in a place where they will not be lost.

Begin by removing the Protosounds boards from the engine. The boards may be fastened directly to the chassis, or more likely, fastened to a bracket attached to the chassis. In some instances, there may be a heat shield attached to the board and/or bracket to protect the engine shell from heat. It is a good idea to make a rough sketch of the boards and mechanical components before removing them.

Protosounds system boards are fastened to the engine chassis by one of two methods. A one-piece heatsink/mounting bracket is commonly used to vertically mount the complete board assembly to the chassis. Small screws accessible from

the underside of the chassis fasten the bracket. Remove the small screws then lift the bracket and circuit boards from the chassis. Once the board and bracket are free of the chassis, remove the boards from the bracket. Start with the screw that fastens the voltage regulator to the bracket. Do not put any stress on the voltage regulator, as it is easily broken from the circuit board. Note that there is a clear insulator installed between the voltage regulator and the bracket. Also note that a plastic shoulder washer insulates the screw from the voltage regulator. Do not lose any of this hardware. All of these components will be needed to install the Equalizer.

Next, remove the front end of the board from the bracket by removing the long screw that extends through the bracket and through the bottom board. With the board free of the bracket, go on to the next page to continue the installation.

The other method of board mounting orients the boards horizontally on the chassis. A long screw extends through the chassis and through a cylindrical metal spacer to the bottom board. A nut pressed in to the board retains the screw. Do not remove this screw until the other end of the board is detached from the chassis.

A small L-shaped metal bracket supports the back end of the board. If possible, remove this bracket from the chassis rather than from the board mounted voltage regulator. It is attached to. Do not put any stress on the voltage regulator, as it is easily broken from the circuit board.

Remove the long screw supporting the front side of the board. Place the screw in a secure place, as it will be reused to install the Equalizer.

After removing the boards from the engine, detach the small L-bracket from the voltage regulator. Note that there is a plastic shoulder washer and a small, clear insulator installed between the IC and the bracket. Do not lose any of this hardware. All of these components will be needed to install the Equalizer.

After the boards are completely free of the chassis, undo all of the electrical connections.

Unplug the connections to the top board, noting the orientation of all connections before removing them. Depending on your engine, there will be at least two connections, possibly three. Disconnect the two-pin loudspeaker connector, and the three-pin connector for the volume control. Multiple unit engines may have an additional 4-pin connection to the top board. These connections are for Proto-Coupler and lighting control of an external engine unit. Make a note of this connection before disconnecting it.

Some diesel and electric engines will have two pairs of RED and BLK wires soldered directly to the back of the bottom Protosounds board. These wires may alternately be colored BROWN and BLUE. These connections are for control of lighting circuits installed in the locomotive shell. Do not unsolder these wires. Instead, trace them back into the wiring harness and undo the wire nuts that secure them. Be sure to make notes of the existing connections before undoing them.

For the final disassembly step, separate the top board from the bottom board. The boards may be held together with a special plastic clip, or wrapped with a few turns of electrical tape to keep them firmly engaged. Undo the clip by gently prying both sides of the top half slightly outward until it disengages from the lower half. Remove the clip from the bottom board and save it for later installation. Otherwise, completely remove any electrical tape securing the boards together and separate them by gently pulling them apart. Set aside the Protosounds bottom board, as it is no longer needed.

Method A

One solution for steam locomotives is to use the entire tender body as the antenna. To do this, the tender body must be electrically insulated from the tender chassis as described in the following procedure.

Using a small piece of fine sandpaper, remove the paint from the inside of the tender shell at the optimum antenna location. The paint should be removed for the entire length of the copper antenna strip. After removing the paint, apply the copper foil antenna strip to the inside of the metal shell. Do not peel the adhesive from the copper foil strip all at once. Instead, peel away the paper at the end opposite the wire, exposing a small amount of the adhesive surface. Place the exposed end of the strip where you want it, then slowly peel the paper back as you firmly apply the remainder of the copper strip to the tender. Once the copper strip is in place, cover it with a piece of electrical tape.

Do not plug the antenna into J13 until the plug assembly is fully assembled and the engine is ready to test.

Insulate the tender shell from the chassis by wrapping black electrical tape tightly around the perimeter of the chassis, making sure that every area that comes in contact with the shell is covered. Pay special attention to the ends of the chassis, as these can be the most troublesome spots.

After completing final installation and test, fit the tender shell to the chassis. Make sure that the body is fully seated on the chassis. Use a razor or Exacto knife to trim away any exposed tape. If you have a volt/ohm meter, check that there is no continuity between the engine and chassis. Make sure that measurements are made on exposed metal. Painted surfaces will not give correct readings.

As the final step, the tender is fastened to the chassis with four #6-32 black Nylon screws from the installation kit. Do not install the screws at this time. Wait until the engine has been thoroughly tested.

Method B

If for some reason you are unable to insulate your tender body from the chassis, you may consider installing the antenna outside the tender. The antenna can be placed on top of the coal load, then covered with another layer of coal. In order for this to be successful, the antenna must be placed significantly above the sides of the tender. You may need to build up the coal load before placing the antenna on top and covering it with another layer of coal. You will likely need to drill a small hole in the top of the tender so that the antenna wire can be extended outside.

For best results, extend the antenna with an additional piece of wire and loop it back and forth, folded in a serpentine fashion on top of the coal load. Any type of wire can be used to extend the antenna. For the best appearance, fine black stranded wire should be used. This type of wire is readily available at most hobby stores, or it can be salvaged from miniature light bulbs. Use an adhesive to hold the antenna in place as it is routed back and forth.

Building up the coal pile, whether on top of a real coal load or a molded load is relatively easy. When done properly, it can also enhance the appearance of your engine.

Use a mix of epoxy and scale coal to build up the load. You can even use charcoal granules, used in fish tank filters and inexpensively obtained at any pet store, as a convincing coal replacement. Mix the epoxy and coal together, adding coal until the

Program/Run Switch

The PROG/RUN Switch is pre-wired with a pair of crimped pins at the end of its wires. Do not insert the pins into the Antenna Plug Assembly until after the engine antenna has been installed.

If your engine or tender has the proper pre-punched holes in the chassis, you may simply mount the switch to the chassis using the included fasteners. If there are no unused switch cutouts in the chassis, remove the Protocoupler Select Switch and install the PROG/RUN in its place. Dress the two switch wires to their destination at J13, but do not insert the pins into the connector shell at this time. Alternatively, you may consider removing the pins from the supplied switch and solder them to the switch already installed on the chassis.

To avoid future confusion, the PROG/RUN switch should be consistently oriented in the same direction in every engine. The switch should be installed so that it is in the RUN position when the slide lever is moved toward the front of the engine or tender. This is the open position – the lever should be over the unwired switch terminal. Conversely, the switch is closed and in the PROG position when the lever is positioned over the two wired terminals. It is a good idea to indicate the RUN position by placing a visible identifying mark on the outside of the chassis next to the switch. Use a fine point permanent marker to inscribe a small 'R' next to the run position. A small dot of contrasting paint can also be used.

Antenna

The antenna is a critical element of the Lionel Trainmaster System. It is important to properly locate the antenna within the engine in order to obtain maximum signal reception. Improper placement of the antenna can contribute to erratic operation and continued operator aggravation.

The Equalizer antenna consists of an adhesive foil copper strip attached to a length of wire. Plastic body diesel locomotives present little or no obstacles to antenna installation. The optimum location is along the inside of the engine roof, as far as possible from circuit boards and other wiring. Determine the best location, then apply the copper foil antenna strip to the inside of the body shell. Do not peel the adhesive from the copper foil strip all at once. Instead, peel away the paper at the end opposite the wire, exposing a small amount of the adhesive surface. Place the exposed end of the strip where you want it, then slowly peel the paper back as you firmly apply the remainder of the copper strip to the shell. A spot of hot glue applied to both ends of the strip will prevent the antenna from coming loose from tension applied to the wire.

Do not plug the antenna into J13 until the plug assembly is fully assembled and the engine is ready to test.

Antenna Considerations for Die Cast Engine or Tender Bodies

Locomotives or tenders with die cast metal bodies present a special problem for the Trainmaster antenna. The signal radiating from the track cannot penetrate the metal shell to be received by the antenna and radio receiver inside. The antenna must be placed outside the engine, or the engine's metal body itself must be converted to an antenna.

Preparing the Equalizer Board

Remove the Equalizer from its static protective bag. Familiarize yourself with the layout of the board and its connections before proceeding. You will notice that there are electrical connectors on both sides of the board, and that they are virtually identical to those on the Protosounds board you just removed. All connections are polarity keyed and color coded to minimize the chance of incorrectly inserting them. In addition to these, there are connections to the rear side of the board not shown in the illustration. The two RED/BLK wire pairs are for control of the engine's directional lighting circuits. The single BLU wire is for Smoke Unit control.



Figure 1 – Equalizer Board Connections – Bottom View

The table below identifies and describes the function of the connectors mounted on the rear of the Equalizer board.

CONN	COLOR	FUNCTION
J1	YEL	Motor (-) Terminal
J2	RED	Center Roller Pickup
J3	BLK	Engine Chassis Ground
J4	WHT	Motor (+) Terminal
J6	GRN	Backup Light (1.20VDC @ 100mA regulated)
J7	BLU	Front Light (1.20VDC @ 100mA regulated)
J11	BLU	Protocouplers
J13	--	Antenna, PROG/RUN Switch

There are additional connectors located on the front side of the board. These are shown in figure 2. The functions of these connectors are described in the table below.

CONN	COLOR	FUNCTION
J5	--	R2LC TrainMaster Receiver Module
J8	WHT	Protosounds Battery
J9	YEL	LED Marker lights
J10	--	Factory Programming/Test
J12	--	Tachometer Input/Slave Output
J14	--	Smoke Unit (wire)
JP1	--	Protosounds Top Board
JP2	--	Protosounds Top Board

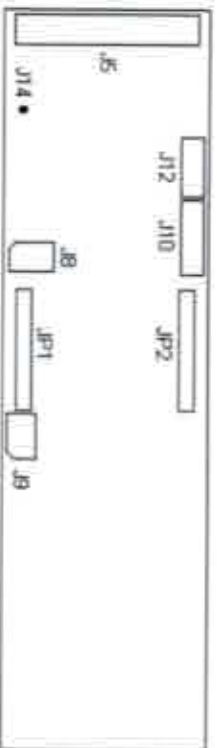


Figure 2 - Equalizer Board Connections - Top View

Most MTH locomotives manufactured since mid-1996 use color-coded plugs that mate with colored sockets on the ProtoSounds boards, allowing the circuit boards to be removed from the engine without cutting wires.

Older engines have their wires soldered directly to the board. If this description fits your engine, you must install the Modular Connector Kit before you can install the Equalizer. Otherwise, proceed to the next installation step.

Installing the Optional Modular Connector Kit

The Equalizer was designed to mate with plug connectors used on earlier, post-1996 MTH production engines. Installation of the Modular Connector Kit will make your engine compatible with this system that facilitates circuit board removal and installation.

The kit consists of five separate plug assemblies with wires attached. These are spliced onto the ends of the engines' power and motor wires.

Five of these are two-pin plugs. There are two for the power connections to the board, and two for the motor connections. A fifth two-pin plug assembly is for the ProtoSounds battery. There is also a 4-pin plug assembly for ProtoCoupler connections.

Begin by carefully cutting the four power and motor wires from the back of the ProtoSounds bottom board. Use a pair of diagonal cutters to snip the wires, leaving about 1/8" of wire and insulation attached to the board. If in the future you need to replace the original board, these wire ends will help you re-establish the original connections.

Some early production MTH steam locomotives use a variation of the common wire color convention for the connections through the tether. In these engines, the WHT and RED wires are interchanged. This results in the WHT and BLK wires as the power connections, and the RED and YEL wires as the motor connections. Be sure to verify all connections before proceeding.

Start with one of the motor leads. Strip away about 3/8" of insulation from the end, then slide a piece of the small diameter heat-shrink tubing down the wire, away from the end. Attach one of the single-wire plug assemblies by neatly twisting the ends of the wires together, then applying solder to the connection. The wire ends should be twisted together so that the heat-shrink tubing will completely cover the connection when it is slid over the exposed wire. Use a hair dryer to shrink the tubing after it is in place. Repeat this procedure for the other motor lead.

Tether Connections to Unpowered Units

In order to maintain proper operation of directional lighting and ProtoCouples, the tether connection between a powered unit and other unpowered unit(s) must be properly wired to the Equalizer. The tether connection consists of four (4) wires. Two of these (usually RED/BLK) are for engine lighting, and the other two (usually WHT/BLU) are used by the ProtoCoupler in the unpowered unit. You do not need to modify the unpowered locomotive. All work is performed in the powered unit where the Equalizer is installed.

Begin at the point in the powered unit where the tether is exposed, revealing the four wires inside the cable. Trace the RED wire to its connection to the bottom of the ProtoSounds board. This wire will be soldered in place. Cut it free with a small pair of cutting pliers, leaving only 1/4" to 1/2" of insulated wire on the board. Make a sketch or note indicating the location where the wire was removed. Repeat this procedure for the BLK wire.

Connect the RED and BLK tether wires to the corresponding RED and BLK wires soldered to the bottom of the Equalizer board. A wire nut or solder can be used to secure the connections. Be sure to wrap any exposed connections with electrical tape or shrink tubing. Secure any unused RED/BLK wires so that no short circuits can occur.

The WHT wire from the tether is soldered to the Coupler Select switch. Remove this connection by either cutting or de-soldering the connection to the switch.

The BLU wire will either be soldered directly to the bottom ProtoSounds board, or go to the 4-position BLU ProtoCoupler plug. If it is soldered to the board, use a pair of cutters to remove it. If the wire goes directly to the BLU plug, leave it as is.

small circuit board attached to the engine's main power connector, or it may be connected directly to the center rail pickup roller. Without disturbing the other connections, remove the RED switch wire from the other connections.

Prepare the short RED wire by trimming a small amount from the end, then strip away about 1/4" of insulation. Connect the RED wire to the bare end of the single tether wire. Use a wire nut, or if you prefer, secure the connection by soldering it. If you choose, you can remove the short RED wire from the switch, and solder the tether connection directly to the switch terminal.

After the connection is made, use a plastic ty-wrap to secure the wire to adjoining wires on the engine chassis and thread the connector end under or around the chassis so it is accessible to its mating wire coming from the tender. Be certain that the wire is not pinched when the boiler is replaced, or that the wire does not interfere with rear truck and wheel movement.

If you choose not to connect the Equalizer to the smoke unit, you should add a series diode to the smoke unit 'hot' lead to prevent premature failure of the heater element. Constant high track voltage will shorten the life of the heater element considerably. A 1N4000 type diode installed in series with the smoke unit 'hot' lead will reduce the voltage by approximately half. Smoke output will be diminished slightly, but operation of its internal motor will not be affected.

The RED and BLK power plug assemblies have two wires each. Both wires of the RED plug should be soldered to the pickup roller wire. A larger diameter piece of heat-shrink tubing is provided for this connection. The same procedure is required for the BLK common connection.

Cut the RED and BLK battery wires from the old board. Strip away about 3/8" insulation from the wires and splice them to the RED and BLK wires of the remaining two-pin plug.

Finally, the 4-pin plug is spliced onto the Protocoupler connections. Be sure to observe the proper orientation of the plug and the order of the connections.

DIP Switch

Observe the small, 4-position switches located on the top of the Equalizer board, visible under the R2LC module near the edge of the board. These switches are programmed at the time the board is tested to the settings shown in figure 3. The Equalizer will not function properly unless these switches are correctly set. S1 is the leftmost switch position nearest the edge of the board.

SWITCH #	POSITION
S1	OFF
S2	ON
S3	OFF
S4	ON

Figure 3 - DIP Switch Operating positions

Securing the Boards

Like the original Protosounds Motor board it replaces, one end of the Equalizer board is attached to the chassis and supported by a voltage regulator soldered to the back of the circuit board. Exercise care when removing or installing the board, or when replacing the engine body on the chassis. The application of excess force will stress the solder connection and may result in the voltage regulator breaking free from the board. When removing the board, always unfasten the voltage regulator first. When installing the board, the voltage regulator should be attached only after the board is well supported by its other mount. Avoid installing and removing the board more than necessary.

C A U T I O N

Failure to properly insulate the voltage regulator will result in certain damage to the Protosounds top board immediately upon application of power. Double-check your work to ensure that the metal tab of the voltage regulator is electrically isolated from its mounting bracket. Use a volt-ohmmeter if available. Under no circumstances will Digital Dynamics be held liable for damage to Protosounds boards resulting from improper installation.

Vertical Mounting Method

Begin by fastening the Equalizer board to its mounting bracket. Position the boards for mounting in the same orientation they were removed from the bracket. Insert the long machine screw through the mounting bracket, and through the hole at the end of the Equalizer board. Be sure to replace any spacers that may have been originally installed between the board and the chassis.

Place the nylon washer, then the #4 nut on the end of the machine screw. Make a few turns of the screw to hold everything in place. Do not tighten the nut at this time.

Line up the hole in the voltage regulator component extending from the rear of the board with the corresponding hole in the mounting bracket. Insert the insulator between the back of the device and the metal bracket. Place the shoulder washer on the screw, then insert the screw through the hole in the component, through the hole in the insulator, and then into the threaded hole in the bracket. Make sure the shoulder washer is seated properly, and that the clear insulator remains in place while the screw is tightened. It is very important that this component is electrically insulated from the mounting bracket and mounting screw.

After securing the voltage regulator to the mounting bracket, tighten the nut at the other end of the board. Do not over tighten.

Retrieve the Protosounds top board and inspect the two rows of pins protruding from the back of the board. Make sure all pins are straight and evenly aligned. Use small pliers or tweezers to straighten crooked pins.

Carefully insert the Protosounds board into the mating connectors of the Equalizer. The two boards should be aligned as shown in figure 4. Be sure that each pin is engaged in its socket. If any pins become bent or misaligned, remove the top board, correct the problem, and try again.

The two boards should engage completely. However, there may be some components soldered to the back of the Protosounds top board that prevent this. In particular, there may be two small capacitors on the back of the top board that interfere slightly with the two large relays on the Equalizer. If this is the case, you should be able to gently bend the capacitors out of the way. These two capacitors are visible at the top right in figure 4.

Secure the boards together by wrapping them with two or three complete turns of electrical tape to prevent them from separating. Do not block access to any of the electrical connectors with the tape.

The complete assembly can now be fastened to the chassis. Be sure there is sufficient access to all electrical connectors before tightening the mounting screws.

Proceed to the next section to complete the electrical connections.

Remove the remaining wire from the switch. This is the wire for the front ProtoCoupler. Strip approximately $\frac{1}{4}$ " insulation from the end and connect it to the bare end of the coupler extension wire provided in the installation kit. Insert the pin at the end of the extension wire into the empty position of the ProtoCoupler plug. Insert the plug into J11 on the back of the Equalizer board.

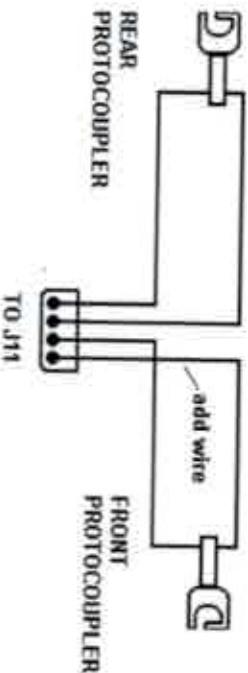


Figure 7 - Modified ProtoCoupler Wiring

Smoke Unit Connections

MTH Fan driven smoke units can be connected to the Equalizer for remote ON/OFF control. The smoke unit consists of a small circuit board, a small motor, and a smoke chamber with heater. The primary electrical connection to the smoke unit is through a small 2-pin connector. One wire of this connector is normally grounded to the chassis, while the other is connected to the pickup roller through a chassis mounted slide switch.

For diesel locomotives, locate the 'hot' lead to the smoke unit ON/OFF switch. This lead is usually RED and connected to the center rail pickup roller. The connection is usually made at a central wiring point, bundled with other RED wires and secured with a wire nut. Remove the wire nut by twisting it counterclockwise. Isolate and remove the RED wire leading to the smoke ON/OFF switch, and firmly twist the remaining wires together, securing them with the wire nut. Connect the isolated RED wire to the Equalizer BLU lead. Solder and insulate the connection, or use a wire nut.

For Steam locomotives, connection of MTH smoke units to the Equalizer is slightly more complicated, because the electronics are located in the tender, and the smoke unit is in the boiler. You will need an optional one-pin connector assembly to make the connection from the electronics in the tender to the smoke unit in the engine. This connector assembly is available from Digital Dynamics. It consists of two lengths of wire, each with a small connector on one end.

The wire with the female connector is installed in the tender by simply attaching its bare end to the BLU wire from the Equalizer board, and threading it out through the opening in the tender shell along with the main 4-pin tether. Use a plastic ty-wrap to secure the wires together inside the shell to provide strain relief to the single wire.

The other wire, terminated at one end with a male pin, is wired to the engine. Remove the boiler from the engine and locate the chassis mounted Smoke ON/OFF switch, usually found under the cab. The switch will have two wires connected to it, usually colored RED and BLU. The short RED wire is connected from the switch to a

Protocoupler Connections

Protocoupler connections to the Equalizer are made via J11, a 4-pin receptacle located on the bottom rear of the board. Depending on your engine, you may need to make slight changes to the wiring of the Protocoupler circuit to allow independent operation of each coupler. Steam engines, and other engine types having only one operational Protocoupler do not require any circuit modifications. If this is the case, insert the BLU 4-pin Protocoupler plug into J11 and proceed to the next section.

Diesels equipped with two Protocouplers require modification of the circuit to bypass the Coupler Select Switch. This switch is no longer needed since independent control of the Protocouplers is now possible with the Equalizer. Although cab units such as GM E-series, F-series, Alco PA and FA type locomotives have only one Protocoupler per unit, the Coupler Select Switch in the powered unit must be bypassed in order to operate both Protocouplers of back-to-back A-A units.

If your engine consists of multiple units, with directional lighting and Protocouplers at each end, see the section on wiring Multiple Unpowered Units later in this manual before proceeding.

If your engine does not have Protocouplers, they are easy to add, and will increase the functionality and your enjoyment of the engine. Protocoupler kits for steam and diesel engines are available from Digital Dynamics.

For engines having both front and rear Protocouplers, the BLU Protocoupler connector is wired at only three of its four positions. Follow the instructions below and refer to the accompanying diagrams of figures 6 and 7 to help you complete the Protocoupler wiring.

Examine the wiring of the Coupler Select Switch on the engine chassis. A single wire from each of the couplers is connected at the ends of the switch. The center switch wire leads to the BLU Protocoupler plug.

Remove the wire from the center position of the Coupler Select Switch. Then, remove the wire leading to the rear Protocoupler. Next, strip approximately ¼" insulation from both wires and connect them together using a wire nut. You may solder the connections if you prefer.

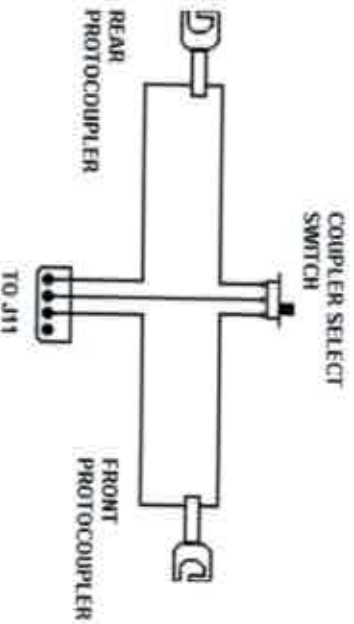


Figure 6 – Protocoupler Factory Wiring

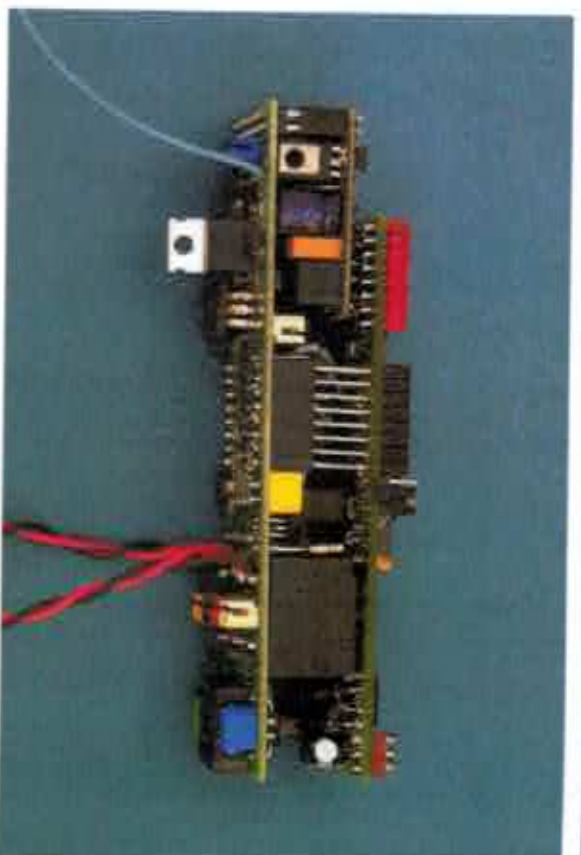


Figure 4 – Equalizer Board Mating

Horizontal Mounting Method

Horizontal installation requires that most of the electrical connections be made before the board is mounted on the chassis. You will not have access to many of the connectors after the board is fastened in place.

Correctly position the Equalizer board on the chassis. Install the colored plugs into the back of the board at J1, J2, J3, and J4. Connect the RED (power), BLK (ground), YEL and WHT (motor) plugs into their corresponding colored sockets. It is not necessary to install the remaining plugs at this time unless it will not be possible to do so after the board is installed on the chassis.

Retrieve the long machine screw that held the original board in place. Install it through the chassis in its original location, then place the large metal spacer over the screw. Next, carefully position the Equalizer circuit board over the chassis allowing the screw to extend upward, completely through the board. While firmly holding the screw from the bottom, place the nylon washer, then the #4 nut on the end. Make a few turns of the screw to hold the board and spacers in place. Do not tighten the nut at this time.

Retrieve the small L-shaped metal support for the back end of the board. Line up the hole in the voltage regulator that extends from the rear of the board with the threaded hole in the metal support. Insert the insulator between the back (metal side) of the voltage regulator and the metal bracket. Place the shoulder washer on the screw, then insert the screw through the hole in the voltage regulator, through the hole in the insulator, and then into the threaded hole in the bracket. Make sure the support is oriented properly and the shoulder washer is seated properly before tightening the screw. Be sure that the insulator remains in place while the screw is tightened. It is very important that this component is electrically insulated from the

mounting bracket and mounting screw. Once the bracket is installed and everything is in place, tighten the front and rear mounting screws to secure the board.

Retrieve the Protosounds top board and inspect the two rows of pins protruding from the back of the board. Make sure all pins are straight and evenly aligned. Use small pliers or tweezers to straighten crooked pins.

Carefully insert the Protosounds board into the mating connectors of the Equalizer. The two boards should be aligned as shown in figure 4. Be sure that each pin is engaged in its socket. If any pins become bent or misaligned, remove the top board, correct the problem, and try again.

The two boards should engage completely. However, there may be some components soldered to the back of the Protosounds top board that prevent this. In particular, there may be two small capacitors on the back of the top board that interfere slightly with the two large relays on the Equalizer. If this is the case, you should be able to gently bend the capacitors out of the way. These two capacitors are visible at the top right in figure 4.

Secure the boards together by wrapping them with two or three complete turns of electrical tape to prevent them from separating. You will have to carefully thread the tape underneath the boards to completely wrap them together. Use a small screwdriver to push the tape all the way through. Do not pinch any wires against the board or block access to any of the electrical connectors with the tape.

Electrical Connections

If you have not already done so, replace the colored plugs into the back of the Equalizer board at J1, J2, J3, and J4. Firmly insert the RED (power), BLK (ground), YEL and WHT (motor) plugs into their corresponding colored sockets.

Engine Lighting

The GRN and BLU sockets, J6 and J7, are provided for directional control of commonly used 1.5V lamps. Steam engines will use J6 for the backup light connection. Many Prehmer diesel engines will use J6 and J7 for front and rear lights. Make whatever connections to J6 and J7 are appropriate for your engine based on the connections that were made to the bottom Protosounds board that was removed. See the following sections if your engine's lighting circuits are different from what is described here.

If the tender is equipped with LED marker lights, connect them to J9 on the top side of the Equalizer board.

With most of the connections to the bottom board complete, reconnect the volume control to the 3-pin connector on the top board. Reconnect the speaker to the 2-pin connector.

Special Lighting Connections for Premier Diesel/Electric Engines

A typical MTH locomotive may have two or more special circuits to control engine lighting. Small circuit boards located in various parts of the engine generate constant voltage for headlamps, marker lights, classification lights, and may also contain circuitry for strobe or MARS lights. The Equalizer's two RED/BLK wire pairs are used to control these lighting circuits. Under no circumstance should these wires be connected directly to any lamp bulbs.

If your engine does not use these connections, either secure them with electrical tape, or remove them completely. Do not twist any of the wires together. They must be insulated separately. Preferably, use a pair of cutting pliers to clip them from the back of the Equalizer board. This will not void the warranty.

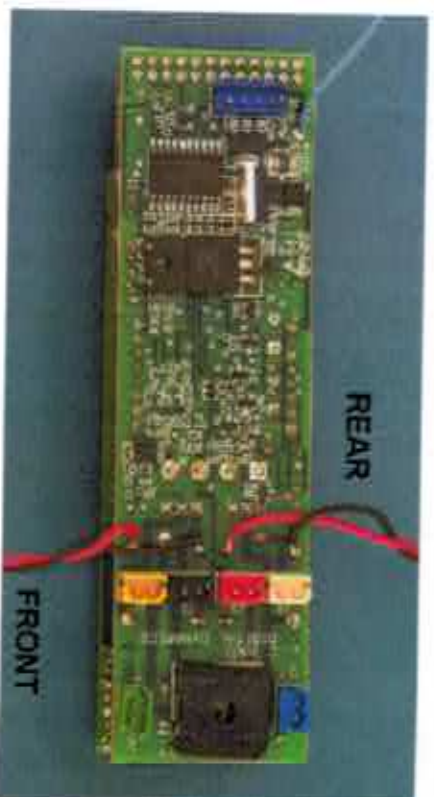


Figure 5 – Lighting Control Wires

Locate the RED/BLK wires from the engine's FRONT lighting circuit. Connect this pair to the wire pair marked FRONT in figure 5. Use the wire nuts that you previously removed to secure the connection. The RED/BLK pair from the engine's rear lighting circuit connects to the Equalizer wires marked REAR.

Lighting for RailKING Engines

The lighting circuits in many RailKING engines usually consist of nothing more than a simple 14V bulb connected directly to the center rail electrical pickup roller. This type of lighting is not directional, and will remain on as long as the engine is powered.

The 14V bulb will burn out from exposure to the constant high track voltage used by the Trainmaster system. Either replace the bulb with an 18V or 24V bulb, or you can add a diode in series with the 14V bulb to reduce the voltage. The direction of the diode is not important. Use a 1N4000 type diode, available at Radio Shack.

If you would like to have the ability to control the headlamp, use the BLU Smoke Unit control wire to power it. First, disconnect the power lead to the bulb. This wire is usually RED and is connected to the center rail pickup. Trim the insulation from the end of the BLU Smoke Unit wire, and twist it together with the headlamp wire. Solder the connection and wrap it with electrical tape or a wire nut.

Although the light will not be directional, you will have the ability to turn the light on and off with the CAB-1 [AUX1][9] and [AUX1][8] functions. You will need to program the R2LC receiver as a steam or diesel with cab light. See the section on 'Programming the Trainmaster Component' for specific programming information.