Motor Mite

Instruction Manual

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Rev 05-06

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1 Overview

The Motor Mite is a miniature, full featured Trainmaster Command Control upgrade for small O Gauge and S Gauge locomotives and other powered rail vehicles. The system is composed of two small circuit boards that plug together to form a compact package. The Lionel R2LC circuit board receives and interprets commands from the Trainmaster Control system, and in turn, controls the locomotive motor speed and direction. It also operates engine lighting, a smoke unit, electrocouplers, and has the capability to control a Lionel Railsounds or SignalSounds system.

All of the electrical connections to the Motor Mite are made through the motor control board, which contains the power circuitry required to drive the locomotive motor. The Motor Mite is factory configured to operate either an AC or DC motor.

The assembled Motor Mite board has an overall length of 1.50", a width of 1.25", and a maximum height profile of approximately 0.85".

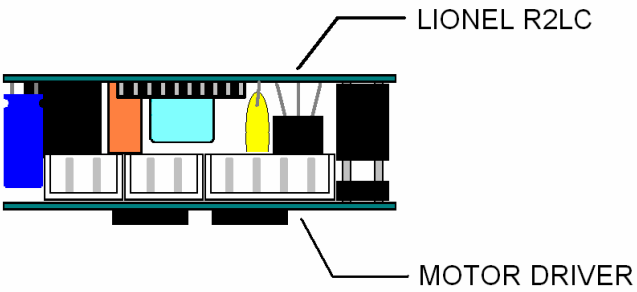

Figure 1 - Motor Mite Physical Configuration

Primary electrical connections for power and motor control are made to the Motor Mite via four wires for the DC version, or five wires for the AC version. The wires are a special high strand count, highly flexible type, and color coded for ease of identification.

Miniature connectors permit convenient connection to the antenna, engine's headlamps, smoke unit, and electrocouplers. Connection to an optional Railsounds or SignalSounds system can be made via a dedicated connector.

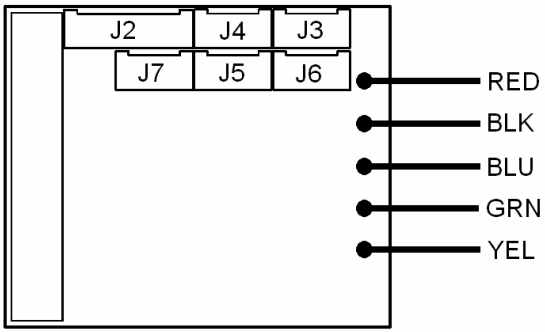

Figure 2 - Motor Mite Electrical Connections

1.1 Electrical Connections

To facilitate installation, the Motor Mite is shipped with its power and motor leads attached to the board. The leads are color coded to help guide you to their proper connections.

RED	Track power
BLK	Common
BLU	Motor armature (+)
GRN	Motor field (AC Motor only)
YEL	Motor Armature (-)

Table 1 – Power and Motor Connections

Miscellaneous connections to the antenna, lighting and coil couplers are made through miniature connectors J2 through J7. Three accessory cables are provided for lighting and/or smoke unit connections. Each cable has a RED and BLK wire, and is terminated on one end by a 2-pin plug. When the plug is inserted into J3 thru J7, the RED wire is powered while the BLK wire is common.

J2 provides connections to the radio antenna as well as the conventional connections to an optional Railsounds or Signalsounds system.

J2	Antenna, Railsounds
J3	Rear Headlamp
J4	Front Headlamp
J5	Front Electrocoupler
J6	Rear Electrocoupler
J7	Smoke/Strobe/Cab Light

Table 2 – Miscellaneous Electrical Connections

A small slide switch is attached to the board by two wires. The switch is used to configure the Motor Mite into either the PROGRAM mode or RUN mode. Wherever possible, the switch should be mounted on the engine chassis to permit external access and convenient mode selection.

1.2 Motor Mite Applications

The Motor Mite was designed for the smallest physical size possible, permitting it to be installed into small engines and other powered rail vehicles that are too small to accommodate standard sized TMCC circuit components. In order to do this, compromises had to be made in the circuit's ability to drive large sized motors, or multiple motor configurations.

The compact size of the Motor Mite is made possible by the use of highly efficient, state of the art miniature components in its design. To further reduce its size, sophisticated thermal design techniques have been employed to minimize heating of circuit components, eliminating the need for bulky metal heatsinks and/or mounting brackets.

The Motor Mite is capable of supplying a maximum of 4 amps of motor current. This is more than adequate for the applications for which it is intended. If your locomotive motor requires more than 4 amperes of current in normal operation, then the Motor Mite is not suitable. Instead, you will need to use a high capacity motor driver such as the AC/DC DLX.

It is also important to monitor your track voltage. Excessively high track voltage will cause unnecessary heating of the Motor Mite and reduce its motor drive capability. When possible, limit track voltage to no more than 18 volts. Operating voltage in the range of 14V to 16V will give the best results.

By following the guidelines of installation and operation as outlined in these instructions, you can be assured that your Motor Mite will remain within a safe range of operation.

1.2.1 Where the Motor Mite Can Be Used

The Motor Mite is best utilized in the types of engines and other vehicles that closely match its capability. These include, but are not limited to:

DC Motor Applications

- Small O-Gauge steam switchers such as Docksiders, tank engines, and other small, lightweight steam locomotives having a single DC motor
- Small O-Gauge diesels such as Plymouth switchers and Beeps
- Traditional sized O-Gauge diesel locomotives with up to four truck mounted miniature motors
- O-Gauge Budd cars, electric MU cars, trolleys and other light duty rail cars
- Maintenance vehicles, inspection cars, speeders, and other powered vehicles that traditionally do not pull a consist

AC Motor Applications

- O-Gauge Budd cars and MU cars provided the train length is limited to no more than two or three cars. The actual number will depend on the weight of the individual cars.
- Trolleys and other light duty rail cars
- Maintenance vehicles, inspection cars, and other powered vehicles that do not pull a consist
- Post-war American Flyer locomotives with a single AC motor

There are countless applications for the Motor Mite. However, in determining whether or not the Motor Mite is suitable for use in your application, you must take certain factors into consideration. These include, but are not limited to:

- The number and type of motors. As a rule, the Motor Mite will handle only one AC motor, one standard sized DC motor, or up to four miniature DC motors. In S-Gauge applications, dual DC motor operation is possible provided train lengths are kept to a reasonable length.
- Train length. As more cars are added to your train, the amount of current the motor requires will increase accordingly. Keep trains to a reasonable length at all times. If you must run long trains, do what real railroads do – add more engines!
- Grades. Motor current will increase as the engine climbs a grade and then must pull the remainder of the train up the grade. The steeper the grade, and the longer time the engine must work to pull the entire train up the grade means that more motor current will be required.

1.2.2 Where the Motor Mite Can NOT Be Used

Finally, there are common applications where the Motor Mite should not be used. In these cases, use the AC/DC DLX instead.

- Any large O-Gauge Lionel die cast steam locomotive with either an AC or DC motor, including types with a 'Scout' motor
- All Lionel locomotives with two AC motors
- Locomotives from any manufacturer having two full size DC can motors. A full size can motor is defined as one having a diameter of approximately one inch.
- Diesel, electric, or steam locomotives from any manufacturer having a single large Pittman motor or large Mabuchi motor. 'Large' is defined as a motor with a diameter of more than one inch.

* * * IMPORTANT * * *

Use of the Motor Mite in any non-recommended application, or in any application where it is likely to be subjected to unusual thermal and/or electrical stress will void its warranty.

1.3 What's Required for Installation

A minimum amount of soldering skill is required to perform this installation successfully. If you do not possess the proper soldering equipment or the expertise, you should refer installation to your dealer or to Digital Dynamics.

If you think that the wiring of your particular engine is different from what is described in this manual, do not attempt installation unless you have some experience with electrical circuits. Instead, contact Digital Dynamics for assistance.

1.3.1 Tools

The tools listed below are required to complete a quick and reliable installation. Other tools and accessories may be used, but are not required.

- Low power soldering iron
- Rosin core solder
- Small wire cutters
- Small long-nosed pliers
- Wire strippers
- Small Phillips screwdriver
- Small flat blade screwdriver
- Electrical tape or shrink tubing

After completing your installation, you will need a test track or working layout equipped with a power source, the Lionel Trainmaster System and a CAB-1 controller in order to perform a thorough test of your engine in both Command and Conventional modes.

1.3.2 What's Supplied

In addition to this instruction manual, you received a complete Motor Mite system consisting of a Lionel R2LC Trainmaster Receiver circuit board, motor driver board, and an installation kit.

1.3.2.1 Installation Kit Contents

The parts kit contains miscellaneous electrical and mechanical hardware to help you complete your installation. It includes:

- Antenna w/ cable and connector
- Three (3) accessory cables w/ connectors
- Two (2) 1uF non-polarized capacitors (AC version only)
- Three (3) Plastic Ty-Wraps
- Four (4) Wire Nuts
- Two (2) 2-56 screws
- Two (2) 2-56 nuts

2 Installation

Please take the time to read and thoroughly understand the instructions in this manual. While it is unlikely that any damage may occur to your engine, improper installation of this product may cause permanent damage to its circuit components.

Since there are so many different types of engines available from at least a half dozen different manufacturers, it is impossible to describe an exact installation procedure for each case. For the most part, all engines are identical in that they have a motor, one or two headlights, couplers, and possibly a smoke unit and sound system. There will be differences or special cases among all of these features. However, the fundamental instructions remain the same, and special cases will be dealt with where appropriate. The installation procedure begins with the fundamental steps. As these steps are completed, proceed to the section that most closely matches the type of engine you are working on.

Before beginning the installation, remove the body from the locomotive and place it aside where it won't be damaged. Remove all exposed headlamp bulbs from the chassis so they are not broken during the installation. Place the chassis on a clean, level work surface.

Examine the engine wiring and make notes or drawings of existing connections before removing components or disconnecting any wires. At the same time, determine the optimum location to mount the Motor Mite so that wire lengths can be kept to a minimum.

Before settling on a final mounting location, be sure that the engine shell will fit on the chassis with the unit in place. Survey the proposed board location for potential interference with moving parts. Finally, be sure that no metal parts will come in contact with the circuit boards.

Only after you are satisfied that there will be no clearance problems should you proceed with removal of any existing components or wiring.

> Always exercise caution when handling the Motor Mite. Due to manufacturing tolerances that can result in variation of component heights, some boards may not fit as closely together as others. Also, note that certain components on the R2LC can interfere with the Motor Mite driver board unless they are gently bent out of the way. The Motor Mite is shipped with its boards mated together, and with the R2LC components already adjusted for minimum mechanical interference. Do not attempt to force the boards closer together, since damage may result.

The following sections detail specific installation steps for 2-Rail and 3-Rail locomotives with either AC or DC motors. After performing the preliminary steps above, proceed directly to the section that applies to your locomotive.

2.1 Installation Instructions for 3-Rail Locomotives

2.1.1 3-Rail Locomotives with DC Motors

This section describes installation of the Motor Mite into a 3-Rail locomotive having a single, standard sized DC motor. It also applies to locomotives having two miniature DC motors including some Lionel and K-Line models that have their motors horizontally mounted within the truck assemblies.

1. Begin by making a note of all existing electrical connections. Be sure to note the wire colors, as well as their connections.
2. Next, remove the wires that connect the reversing unit to the motor(s) by unsoldering them at the motor end.
3. Disconnect the track power connections to the reverser.
4. Remove any connections to engine lighting from the reverser.
5. Remove the reversing unit from the chassis

2.1.1.1 Circuit Board Mounting

Once you have determined the optimal location on the engine chassis to mount the Motor Mite, you can begin the installation.

1. Gently separate the two boards to permit easy access to the connectors on the motor driver board. Place the R2LC board aside for the moment.
2. Clean the mounting area with alcohol to remove any dirt and grease. Wait for the area to dry before proceeding.
3. Attach the motor driver board to the chassis using two strips of foam tape. Press firmly to ensure good contact.

2.1.1.2 Wiring the Motor and Power

Figure 3 illustrates the Motor Mite power and motor connections for a DC motor. Use wire nuts to secure all electrical connections, or, if you prefer, solder and insulate the connections with either electrical tape or heat shrink tubing.

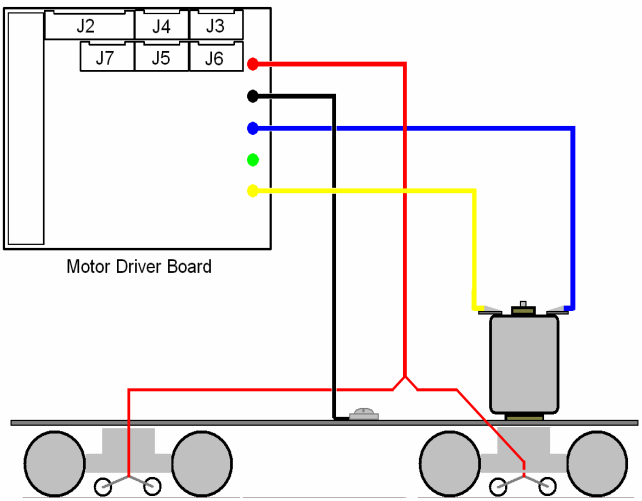

Figure 3 – DC Motor and Power Connections for 3-Rail Locomotives

Before starting the procedure, see section 4.1.3 to see if it applies to your engine.

1. Connect the RED wire to the engine center rail pickup roller(s).
2. Connect the BLK wire to the frame or other electrical return to the outside common rails.
3. Connect the BLU wire to the motor (+) terminal. There is usually a small red dot painted near one of the terminals that indicates (+).
4. Connect the YEL wire to the motor (-) terminal.

If after completing the installation the engine runs in the wrong direction, simply reverse the BLU and YEL wires at the motor terminals.

2.1.1.3 Additional Wiring

The remaining electrical connections to the Motor Mite may include engine lighting, electrocouplers, smoke unit, and antenna. Refer to the remainder of instructions and illustrations that are continued in section 2.4.

2.1.2 3-Rail Locomotives with AC Motors

This section describes installation of the Motor Mite into a Lionel locomotive with a single AC motor. Refer to figure 4 while performing the following steps.

1. Begin by making a note of all existing electrical connections. Be sure to note the wire colors as well as their connections.
2. Next, remove the wires that connect the reversing unit to the motor(s) by unsoldering them at the motor end.
3. Disconnect the track power connections to the reverser.
4. Remove any connections to engine lighting from the reverser.
5. Remove the reversing unit from the chassis.

2.1.2.1 Circuit Board Mounting

Determine the optimal chassis location to mount the Motor Mite. Before permanently mounting the unit, be sure there is no interference with any part of the engine shell. Also check that the board and its wires will not interfere with any moving parts. After you are satisfied with a location, attach the motor driver board to the chassis.

1. Gently separate the two boards to permit easy access to the connectors on the motor driver board. Place the R2LC board aside for the moment.
2. Clean the mounting area with alcohol to remove any dirt and grease. Wait for the area to dry before proceeding.
3. Attach the motor driver board to the chassis using two strips of foam tape. Press firmly to ensure good contact.

2.1.2.2 Wiring the Motor and Power

The open frame AC Universal motor is commonly found in Pre-war and Post-war era Lionel engines. This motor has three connections, plus a common (ground) connection from the field winding that is usually soldered directly to the motor casing or other solid connection to the common outside rails.

Pay special attention to the wiring instructions and wiring diagrams when connecting the Motor Mite to this type of motor, since the connections may be different to what you are accustomed to. Refer to the wiring diagram of Figure 4 while performing the following procedure.

1. Keeping the leads as short as possible, solder one lead of a non-polarized 1uF capacitor to each of the motor brush terminals. This is illustrated in figure 4.
2. Attach the remaining capacitor leads to the motor case. This can be accomplished by loosening the screws that hold the brush cover to the motor, and wrapping the capacitor lead of the adjoining brush terminal around the brush cover screw.
3. Repeat this procedure for the other motor brush terminal.
4. Refer to your notes to determine the colors of the wires that were removed from the motor. Connect the BLU wire from the Motor Mite to the brush terminal from which the old BLU wire was removed.
5. Solder the GRN wire from the Motor Mite to the motor field terminal. This terminal is located between the two brush terminals.
6. Solder the YEL lead from the Motor Mite to the remaining brush terminal.
7. Connect the RED wire from the Motor Mite to the engine pickup rollers.
8. Connect the BLK wire from the Motor Mite to a solid engine common. The best connection can be made where the negative end of the field coil is soldered to a tab on the side of the motor. Solder the Motor Mite BLK wire to this point. In most cases, you cannot obtain a reliable common connection through the chassis.

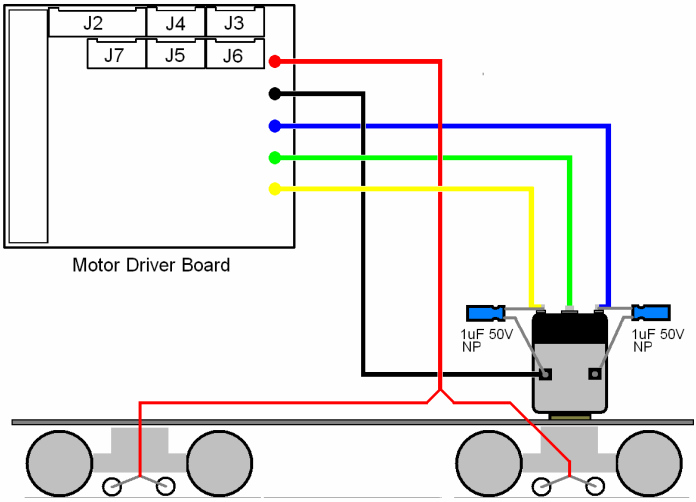

Figure 4 – AC Motor and Power Connections for 3-Rail Locomotives

2.1.2.3 Additional Wiring

The remaining electrical connections to the Motor Mite may include engine lighting, electrocouplers, smoke unit, and antenna. Refer to the remainder of instructions and illustrations that are continued in section 2.4.

2.2 Installation Instructions for 2-Rail Locomotives

2.2.1 2-Rail Locomotives with DC Motors

This section describes installation of the Motor Mite into 2-Rail locomotives having a single, standard sized DC motor. It also applies to locomotives having two miniature DC motors.

You must first establish a convention for power connections to the engine. Since TMCC operation requires AC track power, there is one powered rail, and one common rail. Connect the Motor Mite RED wire to the electrical pickup that contacts the AC powered rail when the engine is facing forward. Power pickup may be through insulated metal wheels, or through a separate sliding show.

1. Begin by making a note of all existing electrical connections. Be sure to note the wire colors as well as their connections.
2. If the engine has an electronic or mechanical reversing unit, remove the wires that connect it to the motor by unsoldering at the motor end.
3. Disconnect the track power and remaining connections to the reverser.
4. Remove the reverser from the chassis.
5. If the engine has no reverser, it may have a diode bridge installed to permit it to run with AC track power. Disconnect all wires from the bridge and remove it from the chassis.

2.2.1.1 Circuit Board Mounting

Once you have determined the optimal location on the engine chassis to mount the Motor Mite, you can begin the installation.

1. Gently separate the two boards to permit access to the connectors on the motor driver board. Place the R2LC board aside for the moment.
2. Clean the mounting area with alcohol to remove any dirt and grease.
3. Attach the motor driver board to the chassis using two strips of foam tape. Press firmly to ensure good contact.

2.2.1.2 Wiring the Motor and Power

Refer to figure 5 to wire the Motor Mite to engine power and motor. Use the enclosed wire nuts to secure all electrical connections, or, if you prefer, solder and insulate the connections with either electrical tape or heat shrink tubing.

1. Connect the Motor Mite RED wire to the electrical pickup that contacts the AC powered rail when the engine is facing forward. Power pickup may be through insulated metal wheels, or through a separate sliding show.
2. Connect the Motor Mite BLK wire to the engine's power pickup for the opposite rail.
3. Connect the BLU wire to the motor (+) terminal. There is usually a small red dot painted near one of the terminals that indicates (+).
4. Connect the YEL wire to the motor (-) terminal.

If after completing the installation the engine runs in the wrong direction, simply reverse the BLU and YEL wires at the motor terminals.

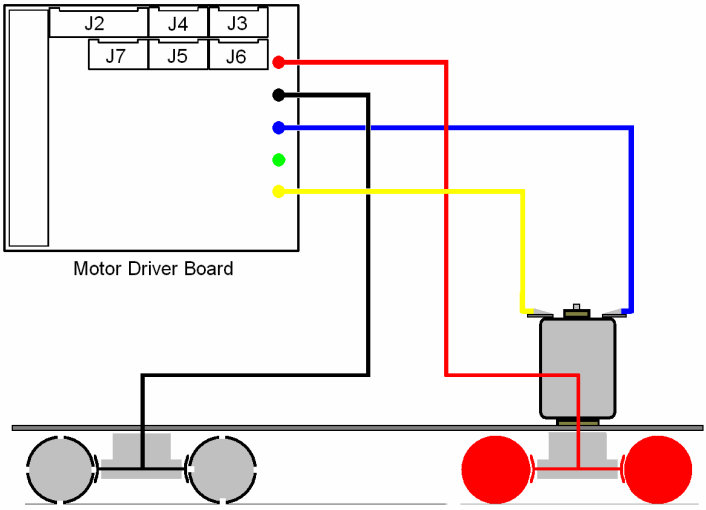

Figure 5 – DC Motor and Power Connections for 2-Rail Locomotives

2.2.1.3 Additional Wiring

The remaining electrical connections to the Motor Mite may include engine lighting, electrocouplers, smoke unit, and antenna. Refer to the remainder of instructions and illustrations that are continued in section 2.4.

2.2.2 2-Rail Locomotives with AC Motors

This section describes installation of the Motor Mite into an American Flyer locomotive with a single AC motor. Most of the steam locomotives were manufactured with their mechanical reverser installed in the tender and connected to the motor through a removable 4-wire harness. Some later versions of the locomotive have a fifth wire permanently connected from engine to tender. Also note that some very early production engines have the reverser inside the boiler and have only a 2-wire harness connecting the tender.

In every case, the Motor Mite connections to the motor are the same. To avoid confusion, ignore any original engine wiring diagrams you may have and use the diagrams shown in figures 6 and 7 as the motor wiring guide. Be careful to maintain the correct connections through the tether.

Begin by disassembling the locomotive and. Before removing any wires, be sure to make note of their connections in the event you may want to restore the engine to its original condition in the future. Skip any steps that do not apply to your locomotive.

1. Remove the tether plug from the locomotive.
2. Remove the drawbar screw and separate the locomotive from the tender.
3. Remove the two screws that hold the connector receptacle to the inside of the cab.
4. Remove the locomotive body from the frame and place it aside.
5. Remove the tender body from its chassis.
6. Disconnect all wires from the reverse unit and remove it from the chassis. The wires should be removed as close to the reverse unit as possible.

2.2.2.1 Circuit Board Mounting

Determine the optimal chassis location to mount the Motor Mite. Before permanently mounting the unit, be sure there is no interference with any part of the chassis or body. Also check that the board and its wires will not interfere with any moving parts such as swiveling trucks or their guides. If a sound system is to be installed, locate the Motor Mite to one end, leaving as much room as possible for the sound system components. After you are satisfied with a location, attach the motor driver board to the chassis.

1. Clean the mounting area with alcohol to remove any dirt and grease. Wait for the area to dry before proceeding.
2. Gently separate the boards to permit easy access to the connectors on the motor driver board. Place the R2LC board inside its protective static bag and put it aside for the moment.
3. Attach the motor driver board to the chassis using two strips of foam tape. Press firmly to ensure good contact.

2.2.2.2 Wiring the Motor and Power

During the Motor Mite wiring procedure for steam locomotives, you will be required to trace each connection through the harness and locomotive mating connector to the motor terminals. For engines where the Motor Mite is mounted within the same unit as the motor, make all connections exactly as shown in the wiring diagram.

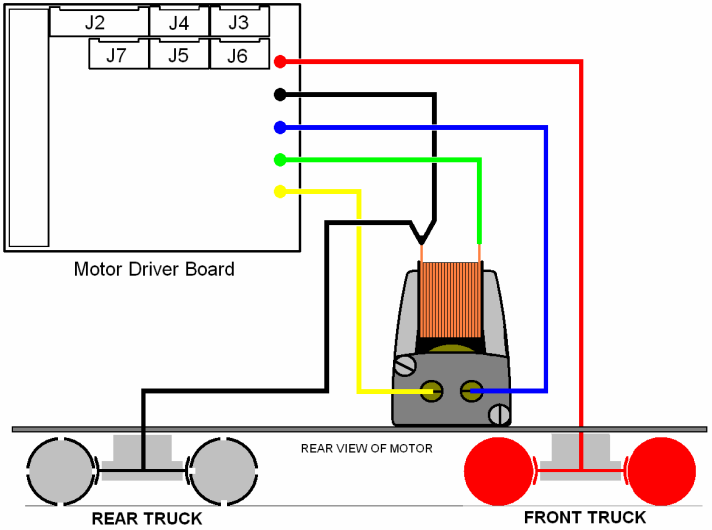

Figure 6 – AC Motor and Power Connections for 2-Rail Locomotives

Refer to figure 6 while performing the following procedure. If you are working with a tethered connection, skip to the next procedure.

1. Prepare the motor terminals by removing any broken wire ends and excess solder from them.
2. Remove the insulation and any extraneous connections from the two field wire ends.
3. Strip approximately ½" insulation from the ends of the five Motor Mite wires and tin the wire ends.
4. Carefully solder the BLU and YEL Motor Mite wires to the motor terminals.

5. Solder the GRN Motor Mite wire to the motor field wire. Insulate the connection with electrical tape or shrink tubing.
6. Connect the BLK Motor Mite wire to the motor field wire together with the rear truck electrical pickup wire. Secure and insulate the connection.
7. Attach the RED Motor Mite wire to the front truck pickup wire and secure the connection.

Motor and power connections are now completed. Proceed to section 2.2.2.3.

Tether Connection

1. Prepare the tether by neatly trimming the individual wire ends. All wires should be of equal length after trimming.
2. Strip approximately ½" of insulation from each wire end.
3. Examine the locomotive connector to determine how each of the four individual wires connect to the motor through the tether. Refer to figure 7 for clarification.
4. Strip approximately ½" insulation from the ends of the five Motor Mite wires.
5. Attach the BLU, YEL, and GRN Motor Mite motor wires to their corresponding tether wires. Secure the connections with the supplied wire nuts. If you prefer, solder the connections and insulate with heat shrink tubing or electrical tape.
6. Connect the BLK Motor Mite wire to the remaining tether wire, together with the rear truck electrical pickup wire and secure the connection.
7. Attach the RED Motor Mite wire to the front truck pickup wire and secure the connection.

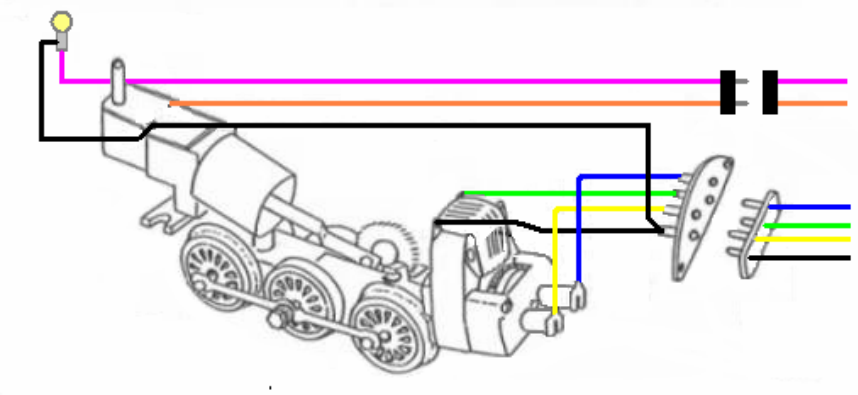

Figure 7 – Locomotive Tether Connections

2.2.2.3 Additional Wiring

Additional connections between the locomotive and tender will be required to operate the headlamp and smoke unit. To make these connections, you will need to add a two-circuit tether. The tether may be a permanent wired connection, or preferably, it will have male and female mating connectors to allow easy separation of the two units.

Figure 7 illustrates the connections to the headlamp and smoke unit from the Motor Mite located in the tender. Note that the common connections to the headlamp and smoke unit are made through the motor circuit. Therefore, only the hot (RED) connection from J4 and J7 is needed.

1. Place the tender aside and retrieve the locomotive.
2. Remove the two wires that connect the smoke unit and headlight to the motor. Cut the wires close to the motor spade lug without disturbing the other wires.
3. Clean and strip the ends of the two wires.
4. Examine the two wires attached to the smoke unit and headlight, noting which of the two wires is soldered to the outside of the headlamp socket. This will be the 'common' connection.
5. Referring to figure 7, attach the common wire from the smoke unit and headlight to the locomotive connector that mates with the BLK Motor Mite wire.
6. At the smoke unit, detach the opposite (not the common) wire from the headlamp.

The smoke unit and headlamp are now independent of each other and can be individually controlled from the CAB-1 when connected to the Motor Mite. You will need a 2-wire tether to make the connections between the engine and tether.

Continue to the next section for instructions how to connect the headlamp and smoke unit to the Motor Mite.

2.3 Additional Engine Connections

2.3.1 Engine Lighting

Miniature connectors J3, J4, and J7 provide connections for engine lighting. The outputs are compatible with common 12V or 14.4V bulbs found in many engines and lighted rolling stock. Bulbs of this type may be connected directly to the Motor Mite.

If your engine has factory installed directional lighting operated from a solid state reverse unit, it is likely that the bulbs are rated at 1.5V. If this is the case, the bulbs must be replaced with equivalent sized bulbs with a 12V or 14.4V rating.

Use one of the supplied two-wire accessory cables to connect the headlamp bulb to the Motor Mite. If the bulb has two leads and is insulated from the chassis, simply splice the bulb leads to one of the accessory cables. For 2-Rail engines, it is important to keep both of the bulb leads insulated from the chassis. Solder and insulate the connections with shrink tubing or electrical tape.

For 3-Rail engines with bayonet style or other bulbs mounted in a socket on the chassis and connected by a single wire, connect only the RED wire of the accessory cable to the bulb. The unused BLACK lead should be tied up, or cut off completely.

Once wired to the accessory cables, plug the engine's front headlamp into J4 and the rear headlamp into J3.

There is an additional Motor Mite output which can be used to operate either a cab light, strobe light, or smoke unit. This output is controlled by the CAB-1 AUX1-8 and AUX1-9 functions. If you would like to use this output for smoke unit control, see the instructions in section 2.5.

The strobe light or MARS light must be either a 12V or 14.4V bulb. Connect it to J7 using one of the accessory cables. Also, see section 4.1.2 for correct programming of the R2LC to provide a strobe light function.

If your engine does not already have one, a cab light can be added easily. A small 12V bulb can be secured to the inside of the cab and connected to J7. Use silicone adhesive to attach the bulb leads to the roof of the cab. Make sure to leave adequate clearance between the bulb and the plastic body, or damage to the plastic may result. See section 4.1.2 for correct programming of the R2LC to provide cab light operation.

2.3.1.1 Marker Lamps

Engine marker lights are usually miniature LEDs which require additional components in the circuit before they can be connected to the Motor Mite. LEDs are current devices, therefore a series resistor is needed to limit LED current. Also, a series diode is required to protect the LED from high peak reverse voltage when connected to an AC source. The value of the resistor depends on the efficiency of the LEDs and the level of brightness desired. A resistor value in the range of 470 Ohms to 510 Ohms is usually appropriate.

To minimize wiring, engine marker lights are often connected to the same circuit as the front headlamp. The LED circuit shown in figure 8 is easily constructed and can be connected in parallel with the front headlamp. Be sure to observe the polarity of the diode and LEDs in the example. If you are driving an LED headlamp, or any LED marker lights without a parallel incandescent bulb, you will need to add a 1K ohm resistor from the driver output to common. This resistor is necessary to ensure that enough current is drawn from the output to keep the triac driver turned on continuously.

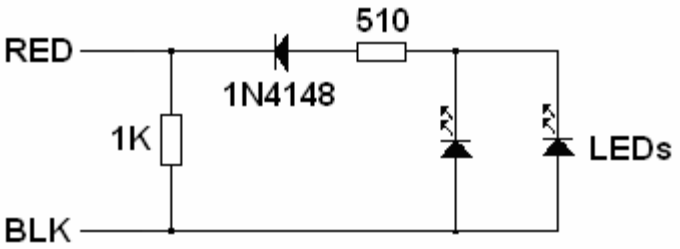

Figure 8 - Connection to LED Marker Lamps

2.3.2 Electromagnetic Coil Couplers

If your locomotive is equipped with electromagnetic coil couplers, you will want to connect them to the Motor Mite for remote CAB-1 operation. This type of coupler has a coil of wire wrapped around the coupler arm. It may or may not have the traditional 'thumbtack' for magnetic remote control track operation. Digital Dynamics stocks a number of different types of electrocouplers suitable for most applications. Please call for information.

Electrocouplers sold by Digital Dynamics are fitted with miniature 2-pin plugs that are compatible with the Motor Mite electrocoupler receptacles. For other types, you may be required to splice an additional 2-wire accessory cable to the electrocoupler wires. Note that in some cases, only one wire connection is necessary since the return circuit is completed through the engine chassis.

After installing the electrocouplers and routing the wires through the engine frame, plug their connectors into J5 (front) and J6 (rear).

2.3.3 Smoke Units

If your engine has a smoke unit and you would like the ability to control its operation from your CAB-1, you can connect it to the Motor Mite following the procedure below. These instructions apply to mechanical puffing units as well as to modern motorized types. Note that connection of a motorized smoke unit to the Motor Mite will not provide synchronized puffing without the addition of additional circuitry.

1. Locate the power lead to the smoke unit. Power may come directly from the engine pickup roller, or it may connect to the smoke unit via an ON/OFF switch located underneath the engine.
2. Disconnect the power lead that connects the switch to the pickup roller. This is usually colored RED
3. Locate one of the 2-wire accessory cables in the installation kit. Attach the RED smoke unit power lead to the BLACK wire of the accessory cable.
4. If the smoke unit has a BLACK common connection, attach it to the RED lead of the accessory cable.
5. The smoke unit can now be plugged into J7.

Be sure to check your Postwar smoke unit before connecting it to the Motor Mite. If the heating element is shorted, or its resistance is very low, it will damage the smoke unit driver on the R2LC circuit board. Postwar type smoke units designed for use with smoke pellets consist of a few turns of nichrome wire on a ceramic element. Measure the resistance with an ohmmeter. If it is significantly less than 15 ohms, you should replace it, preferably with a modern type designed for use with liquid smoke.

2.3.4 PROG/RUN Switch

The PROG/RUN switch should be positioned in a convenient location where it can be easily accessed. Some engines may have a similar switch already in place that was used by the original electronic reverse unit. Simply remove the old switch and replace it with the switch from the Motor Mite. Even if no switch is present, many engines have a pre-punched hole in the chassis to accommodate a switch.

The switch is in the RUN position when it is open, with the slide lever over the unused terminal. In the PROG position, the switch lever is directly over the two wired terminals.

2.3.5 Sound Systems

The Motor Mite is compatible with the advanced state of the art Lionel Railsounds® system. A wide variety of Railsounds boards is available from Digital Dynamics and come with complete installation instructions. Please call or write for further information.

The Motor Mite will operate all Lionel SignalSounds and Railsounds systems from version 2.5 to the present version. Connection to a Railsounds system is made via the 4-pin connector J2 on the Motor Mite. The appropriate connection cable is supplied with any Railsounds systems purchased from Digital Dynamics. Please see the Railsounds Installation Manual for further instructions.

You may also use your Motor Mite to operate a SignalSounds unit to obtain a good quality horn and bell. While SignalSounds boards are not generally available for sale, they can be recycled from Lionel engines that have been upgraded to full Railsounds.

SignalSounds is a small plug-in type board that can be mounted to the engine chassis with a single screw. A special connector is needed to make electrical connections to the board. You can obtain a pre-wired connector, including loudspeaker, from Digital Dynamics. Please call for further information.

3 Antenna Installation

Antenna installation and location is critical to your engine functioning reliably under the TrainMaster system. The antenna must be located where it can best receive the signal radiating from the track. As a general rule, antenna location is fairly forgiving in plastic bodied engines, as the plastic does not interfere with the radio signal. However, 3-Rail die-cast or brass locomotives will limit or completely block the signal from the antenna.

Plastic Body Locomotives

1. Place the locomotive body upside down on a soft surface such as an old towel.
2. Remove the antenna from the parts kit. The antenna is the adhesive backed copper strip with a wire soldered to it.
3. Remove the adhesive backing from the copper strip.
4. Starting at the rear of the loco body, place the copper strip antenna lengthwise along the inside center of the roof.
5. Cover the copper tape with a strip of plastic electrical tape to prevent its peeling off.
6. Extend the antenna wire for as long a distance as possible inside the locomotive, then loop it back to where it will connect to the Motor Mite circuit board.
7. Place the locomotive body along side the chassis and plug the antenna wire into connector J2.
8. Carefully plug the R2LC board into the motor driver board. Some components of the R2LC may have to be moved slightly in order for the boards to fully engage.
9. Place the engine body on top of the chassis. Do not fasten it to the chassis until after tests are completed.

Metal Body Locomotives

Metal engine bodies present a special problem for TrainMaster® electronics, since the radio signal cannot be received if the R2LC circuit board and antenna are enclosed within the metal engine body. If your 3-Rail engine has a diecast metal body, you will need to electrically isolate it from the chassis.

> Note for 2-Rail Installations
>
> The metal bodies of 2-Rail engines are already electrically insulated from both rails. Therefore, the antenna can be attached directly to the engine body without further modification.

1. After identifying a suitable location for the antenna inside the shell, completely remove the paint from the area using fine sandpaper.
2. Remove the paper backing and apply the copper antenna strip to the bare metal inside of the shell. Cover the antenna with black electrical tape to prevent it from peeling off.
3. Extend the antenna wire for as long a distance as possible inside the locomotive, then loop it back to where it will connect to the Motor Mite circuit board.
4. Place the locomotive body along side the chassis and plug the antenna wire into connector J2.

5. Carefully plug the R2LC board into the motor driver board. Some components of the R2LC may have to be moved slightly in order for the boards to fully engage.
6. Using black electrical tape, cover the chassis at every location that comes in contact with the tender shell. Usually, you need only wrap the tape around the sides of the chassis with part of the tape overlapping on top. When the tender shell is installed, the tape will not be visible.
7. Place the shell on the chassis, and use an ohmmeter to test for zero continuity between the two. Be sure to make the measurements on an area free of paint. If you do not have access to an ohmmeter, carefully inspect the chassis and tender shell for any areas that may be in contact with each other. Correct as necessary.
8. After testing is completed, fasten the shell to the chassis with nylon screws. After tightening the screws, make sure that there is still no electrical continuity between the shell and chassis. Nylon screws are available at many hardware stores, hobby dealers, or from Digital Dynamics.

Other Antenna Options

When the Motor Mite is installed within the boiler of a die cast steam locomotive or inside a small diecast diesel switcher, it may not be possible to electrically isolate the body from the chassis. However, if the engine has exterior handrails, it may be possible to use them as an antenna. In order to do this, the handrails must be mounted by plastic stanchions with no part of the handrail making direct contact with metal. If plastic stanchions are not available, plastic sleeving can be placed along the handrails in the areas that contact metal or where the handrail passes through the locomotive body. With a little bit of work, it is often possible to realize a very effective antenna using this method.

4 Testing Your Installation

Do not place your engine on the track without first verifying that your transformer's circuit breaker is operating normally. The circuit breaker should trip immediately when a short circuit is present, or a load that exceeds the transformer's rating is placed on the track. If there is a problem with the installation, the circuit breaker will prevent the Motor Mite from sustaining permanent damage.

Also, carefully inspect all solder connections for short circuits and loose or frayed wires. Make sure all wire nuts are tight. Pay particular attention to areas where the circuit board may potentially come in contact with metal parts of the engine. Also, it is important that any unused wires do not come in contact with any part of the circuit or any exposed metal parts. Either cut-off unused wires, or wrap their ends with electrical tape in order to prevent short circuits. After completing the inspection, you can begin the test.

1. It is very important that you remove all other locomotives from the track, and make sure that track power is OFF.
2. Make sure your Trainmaster® system is properly connected. If necessary, refer to the instructions that came with your Lionel Trainmaster® system.
3. Verify that your system is operational by observing the RED and GREEN indicators on the Command Base as buttons are pressed on the CAB-1.
4. After verifying all of the above, it should be safe to place the locomotive on the track.
5. Hold the locomotive firmly while you apply power to the track. This will prevent possible damage to your locomotive in the event it starts up unexpectedly due to a malfunction or improper installation.
6. Turn on power. Observe that the engine headlamp is lit steadily. A flickering headlight is the sign of poor signal reception and possibly a bad antenna connection.
7. If the engine lighting is not lit, and there is no evidence of any major malfunction, press the [AUX2] button on the CAB-1 to light it.
8. Make sure that none of the circuit components, including any wires, are hot to the touch, and that no smoke or burning odor is present. Otherwise, shut down power immediately.
9. Using the CAB-1 controller, press [ENG][1], then slowly turn the red throttle button clockwise. If the installation was performed properly, the engine will begin to move forward.
10. Run the engine in forward and reverse at low and high speeds to verify that it is operating properly. If the engine has directional lighting, make sure the lights are in sync with the engine direction.
11. If installed, check the operation of the electrocouplers.

Use the Troubleshooting section to help you determine the problem if the engine does not respond as it should, or any of its features is not functioning properly.

4.1 Programming the Engine

4.1.1 Engine ID#

The Motor Mite is shipped with its engine ID set to number '1'. You can change this number from 1 to 99 at any time from your CAB-1. You will need access to the PROG/RUN switch in order to make changes. In addition to setting the engine ID number, the R2LC can be programmed to operate additional lighting features or a smoke unit.

4.1.2 Engine Features

The R2LC Command module has a general purpose output that can be configured to operate a strobe light, cab light, or smoke unit. Additionally, the R2LC digital output (J2) will operate either a SignalSounds or Railsounds system.

Use the following table to determine how to program the board to operate the features of your engine.

Code	Engine Type	Feature 1	Feature 2	Feature 3	Feature 4	Feature 5
4	Steam w/ Railsounds	Headlamp	Rear Lamp	Front Coupler	Rear Coupler	Smoke Unit
5	Diesel w/ Railsounds	Headlamp	Rear Lamp	Front Coupler	Rear Coupler	Strobe Light
6	Diesel w/ Railsounds	Headlamp	Rear Lamp	Front Coupler	Rear Coupler	Cab Light
8	Diesel w/ Railsounds	Headlamp	Rear Lamp	Front Coupler	Rear Coupler	Smoke Unit

Table 3 – R2LC Feature Codes

To program the engine ID number and engine features, follow this procedure.

1. Make sure the Command Base and/or PowerMaster is properly connected to the track and the PowerMaster CMD/CONV switch is set to the CMD position.
2. Set the engine PROG/RUN switch to PROG.
3. Place the engine on the track and apply power.
4. On the CAB-1, press [ENG] then the desired ID number (1 - 99) for the locomotive.
5. Press [SET] to lock-in the ID number.
6. Press [AUX1] [N], where N = the engine feature code.
7. Remove power from the track and set the PROG/RUN switch back to the 'RUN' position.

4.2 Conventional Mode Operation

In the absence of the Trainmaster command environment, a Motor Mite equipped engine will operate like any other engine with a conventional reversing unit, cycling from Neutral to Forward to Neutral to Reverse each time power is momentarily interrupted. While in Conventional Mode, cycling of locomotive direction can be overridden by placing the Engine ID programming switch in the 'PROG' position. This will lock the engine direction into Forward. You must replace the switch back to the 'RUN' position if you wish to run the engine in Command mode.

To test the engine in Conventional Mode:

1. If there is a Command Base operating nearby, remove power from it by unplugging its wall transformer.
2. If you operate your layout with a Lionel Powermaster or similar track controller, set its CMD/CONV switch to the CONV position.
3. Place the engine on the track and slowly increase the track voltage. The engine lighting should come on and increase in brightness with increasing track voltage.
4. Cycle the engine through FORWARD-NEUTRAL-REVERSE using the direction button, or by briefly cycling power to the track. The engine should respond just like one equipped with a mechanical reversing unit. Directional lighting should be consistent with engine direction.
5. If the engine fails to operate in Conventional Mode, make sure the TrainMaster signal is not present on an adjacent track or anywhere else nearby. The only way to ensure this is to turn off the signal source by removing power to any Command Base located nearby.

See the following troubleshooting section if the engine fails to operate correctly.

4.3 Troubleshooting

When correctly installed, the Motor Mite will give years of reliable service. However, improper installation may cause permanent damage to the circuit or give less than optimum performance. First, check all wires for solid, reliable connections and be absolutely certain that there are no short circuits, or bare wires coming in contact with each other or with the locomotive chassis.

If the engine does not operate in Command Mode, remove the power from your Command Base and see if the engine operates in Conventional mode. If Conventional mode operation is normal, then it is likely that a problem exists with the engine's antenna. Provided the headlight is connected directly to the Motor Mite headlight output, its flickering is a sure indication that the engine is having difficulty receiving the Trainmaster signal. Make sure the antenna is properly connected, or if it is mounted to a metal engine shell, that the shell is electrically isolated from the chassis. You will need an ohmmeter or continuity tester to verify isolation.

If the headlight glows steadily in Command Mode, but the engine does not respond to CAB-1 commands, it may be necessary to reset the engine ID#. If the engine does not respond to programming, repeat the procedure using #99 as the engine ID. If this restores engine operation, use the procedure one more time to set the ID to the value you want.

Use the table on the pages following to diagnose and correct installation problems. If your specific problem is not described here, or the suggested solution does not solve the problem, contact Digital Dynamics for further instructions.

4.3.1 Overcoming Erratic Operation At Low Speed

Inexpensive locomotives and track accessory vehicles that use miniature DC motors may exhibit jumpy or erratic operation at low speeds after installing the Motor Mite and operating with Trainmaster Command Control. These motors are easy to identify as they are noticeably smaller than the ubiquitous RS-365 Mabuchi motor. Often, they are mounted horizontally within the trucks of diesel locomotives and are clearly visible when the engine is turned over.

Erratic operation is caused by a combination of these factors:

- The miniature motors are designed to operate at 12V or less.
- The Trainmaster system operates with a fixed, high track voltage of 16V to 20V.
- The Motor Mite employs a full wave motor driver circuit instead of a less expensive half wave driver. A full wave driver has the capability to deliver more power to the motors.
- Despite the 31 throttle steps the Trainmaster system provides, the first few steps are often too large to allow the motors to start smoothly.

Fortunately, there are three easy and inexpensive methods that can be employed to correct the problem. Each method is discussed in the following sections.

4.3.1.1 Reduced Track Voltage

Satisfactory operation can be achieved by lowering the track voltage from the normal range of 18V – 20V to an operating range of 10V – 14V. This method can be used to correct erratic operation of single or dual motor locomotives. The optimum operating voltage is best determined by experimentation. The disadvantage of this method is that other engines operating on the same track may perform poorly with reduced voltage.

4.3.1.2 Series Connected Motors

Low speed operation of dual motor locomotives can be dramatically improved with a minor change to the engine wiring. By simply changing the motor wiring from a parallel to series connection, the voltage to each motor is reduced by half. This method will limit the maximum power that can be delivered to the motors, resulting in more or less the same operation that would be realized from a half wave driver.

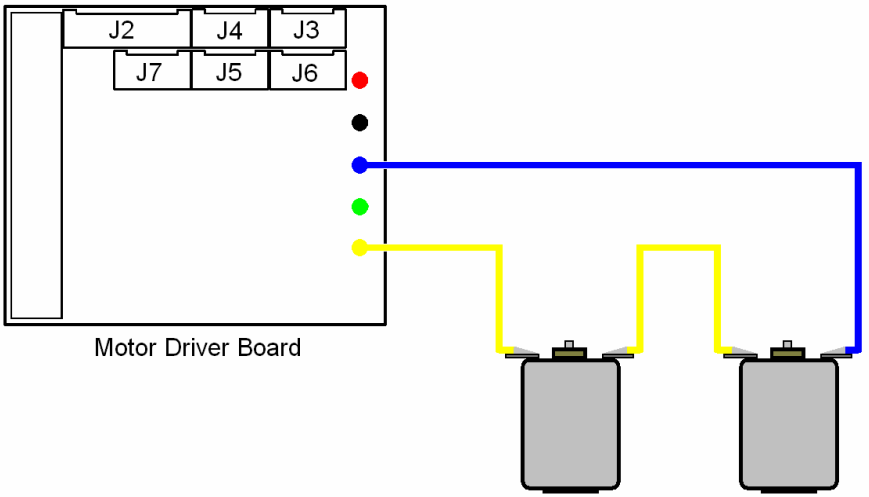

Figure 9 – Series Connected Motors

4.3.1.3 Series Diodes

Motor voltage can be reduced effectively by adding diodes in series with the motor as shown in figure 10. One of the motor leads is cut and the two ends are connected to the AC terminals of a diode bridge. The (+) and (-) terminals of the bridge are connected together to complete the circuit. If more voltage reduction is needed, add a second diode bridge to the other motor lead. All diode bridges should be rated at 4A, minimum.

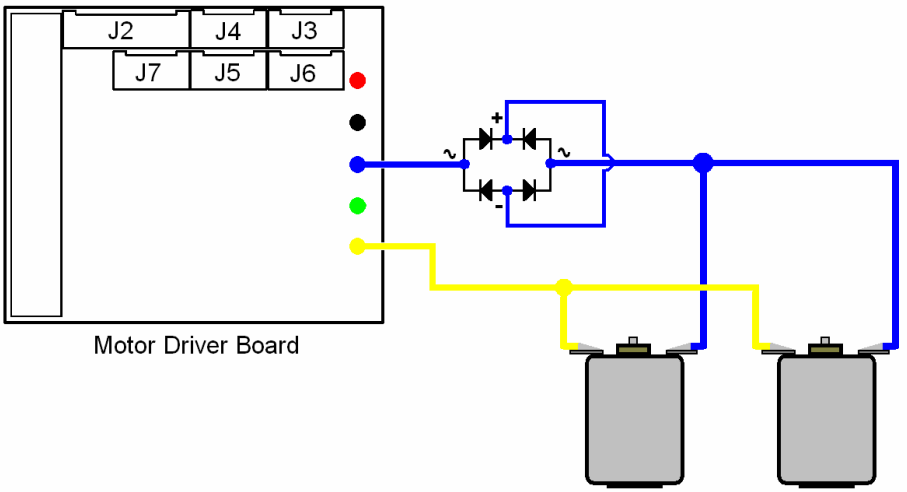

Figure 10 – Motor Connection With Series Diodes

4.3.2 Troubleshooting Guide

Locomotive Always Starts Up in Conventional Mode and Does Not Respond to CAB-1 Commands	Check that the Trainmaster® System is operating properly using a known working engine. Verify that the proper Engine ID is being used at the CAB-1 Controller. Remember that the default engine ID # is set to '1'.
Locomotive Direction Is Out Of Sync With Headlamps	Either the headlamp wiring is reversed, or the motor armature wires are reversed. If the default engine start-up direction is reverse, then the motor is incorrectly wired and the headlights are correct. Reverse the BLU and YEL motor leads.
Locomotive Runs In One Direction Only (AC motors)	One of the motor armature wires has been reversed with the field wire. Another possibility is that your Lionel locomotive was equipped with a two position E-unit and a dual-wound field coil, which is wired differently than the traditional scheme. Contact Digital Dynamics for instructions.
Railsounds does not operate properly in Command Mode	Engine feature code may be improperly programmed. Refer to section 4.1.2 and program the engine for Railsounds operation.
Smoke unit not operating, cab light blinking, or strobe light does not blink	Engine feature code is improperly programmed. Refer to section 4.1.2. The smoke unit may be connected through a manual switch. Make sure the switch is set to the ON position.
Engine lurches forward when CAB-1 throttle is first turned up.	Reset engine Stall Speed. If the condition persists, it is due to a motor that is very sensitive to pulsed operation. One remedy is to lower the track voltage until the condition stops. The preferred method is to add a resistor to the motor circuit to reduce motor sensitivity. See section 4.3.1 of this manual.
Locomotive stops or stutters for no apparent reason	This may be caused by poor signal reception and likely occurs at the same location on your layout. First, verify that the Command Base is receiving commands reliably from your CAB-1 remote. The indicators on the Command Base will change from RED to GREEN as it receives signals from the CAB-1 each time a button is pressed. Erratic flickering of these lights is an indication that the CAB-1 batteries are weak and need to be replaced. If your installation includes a Railsounds or Signalsounds system, run the engine completely around the layout with the horn button of the CAB-1 held down. The horn should sound continuously as the engine runs around the layout. Interruption in the horn sound is an indication that there may be a weak signal in that portion of the layout. Other measures you can take include thoroughly cleaning your track and engine pickup rollers, cleaning and resurfacing the motor brushes and armature, and replacing the pickup rollers if they show signs of excessive wear. If necessary, bend the pickup roller arm so that it exerts maximum pressure on the track
Electrocouplers open randomly or unlit headlamps flicker while engine operates	Trim excessive lead lengths wherever possible and dress the wires controlling lamps and couplers as far away as possible from motor and power pickup leads, and form a twisted wire pair with the power lead and ground lead wherever possible. Insert a 1/4W resistor in series with the board and the headlamp and/or electrocoupler. Use a value of 3.3 Ohms to 5.6 Ohms, whichever works best.
Engine stops running after operating normally for several minutes. Engine returns to operation after a few minutes have elapsed.	This is an indication that the Motor Mite is overheating due to excessive load. Allow a few minutes for the circuit to cool down then reduce the track voltage and remove a few cars from the train. If the condition persists, consider replacing the Motor Mite with a heavier duty motor driver like the AC/DC DLX.
Engine Lighting does not work	There are several possible causes: Lighting may be turned off. Press AUX2 on the CAB-1 to turn lighting on. If this does not restore lighting, check each bulb for the correct voltage rating. At a minimum, all bulbs should be rated for 12V operation.

5 Notes

Limited Warranty

Digital Dynamics warrants to the original consumer purchaser that this product will be free of defects in materials and workmanship for a period of one year from the date of original purchase. This warranty does not cover service, repair, or replacement to correct any damage caused by improper installation, improper connection, external electrical fault, accident, disaster, misuse, abuse, or modifications to the product. All other express or implied warranties, including the implied warranty of merchantability and fitness for a particular purpose, are hereby disclaimed.

If this product is not in good working order as warranted, the sole and exclusive remedy shall be repair or replacement. In no event shall Digital Dynamics, or any dealer, distributor, or authorized installation and/or repair service provider be liable for any damages in excess of the purchase price of the product. This limitation applies to damages of any kind, including but not limited to, direct or indirect damages, lost profits, lost savings or other special, incidental, exemplary or consequential damages whether for breach of contract, tort or otherwise, or whether arising out of the use of or inability to use the product, even if Digital Dynamics, or any dealer, distributor, or service provider has been advised of the possibility of such damages or any claim by any other party. Some states do not allow the exclusion or limitation of incidental or consequential damages so the above limitation or exclusion may not apply to you.

During this one year warranty period, the product will either be repaired or replaced (at our option) without charge to the purchaser, when returned either to the dealer with proof of the date of purchase or directly to Digital Dynamics when returned prepaid and insured with proof of date of purchase.

Some states do not allow limitations on how long an implied warranty lasts, so such limitations may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Repairs

Each and every Digital Dynamics product is thoroughly tested before it is shipped. The likelihood that it is not working when it reaches you is very small. However, if after troubleshooting it yourself you cannot get it to work properly, you should return the product to Digital Dynamics postage paid. Do not include the engine unless instructed to do so, and include a note indicating the problem. If the product is within the warranty period, it will be repaired and returned to you free of charge. Digital Dynamics products that are out of warranty will be repaired for a service charge of $20. Lionel components that are out of warranty will be replaced at the prevailing price.

Do not send a locomotive unless you are instructed to do so. In the event it becomes necessary to ship a locomotive, a minimum service fee of $35 plus return shipping and insurance fees will be charged. These fees cover handling and packing of the locomotive and will apply whether or not the product is covered by warranty. Please call or email for return authorization before returning anything.

To obtain return authorization call (203) 778-3599, 4PM to 8 PM (EST), or request authorization by email to info@digitdynam.com. Return defective products to:

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48 E Starrs Plain Road
Danbury CT 06810