# Telephone Connector Board

Revision v0.1 8/19/2020

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**Introduction**

This document describes the Telephone Connector board and how to assemble and install it.

**Revision History**

V0.1 – first pass – August 19, 2020

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# 1 INTRODUCTION

This board provides connectors to extend the MRCS power and phone bus (used by the EBF31A Battery Feed and ATSN Dispatcher/Operator Boards) to as many as 12 stations. Pads are provided for two bucking converters to develop 12VDC for buzzers, LEDs and Relay Latches and 7.5V for a Morse Code Buzzer Controller Board (MCBC).

I've been developing a series of circuit boards to perform the various functions needed to build a layout phone system, but I never made a central board to distribute the phone line and auxiliary power. In the past I assumed the user would use either telephone style "66 blocks" or barrier strips to distribute these signals, but that has become a road block for some users, so this board, with its on board screw terminals puts the basic connections in one place.

Features:

- Takes power from the 6-conductor modular telephone and +24V power bus (note to phone people: this is positive 24 to keep things simple for non-phone model railroaders)
- Two 6 conductor Jacks are provided for daisy chaining the bus. Connectors are oriented with the locking tab up for easy connection and disconnection.
- Connector pads provide up to 12 connections on 0.100 centers for Tip, Ring, +12 and Ground. (If you are assembling your own board and need less connections, you can use a terminal with fewer positions)
- Optional auxiliary 8 position screw terminal brings all lines on the bus and +7.5V out for easy access
- 2mm JST style socket for 7.5 power to Morse Code Buzzer Controller
- Polarity protection diode protects against use of non-reversing (DCC Bus 6 conductor cable)
- Pads for 2 LM2596 bucking converters: 1 provides 12V for buzzers, LEDs and Relay Latches etc., the other is for 7.5V to power a Morse Code Buzzer Controller. If not using an MCBC, this converter (they are inexpensive commodity items) need not be stuffed or can be used for any other voltage less than 24 or you can substitute a boost converter for any voltage up to 35..

All components are through-hole technology for ease of assembly and repair.

Most connection pads are on 0.100" centers. This provides a wide range of interconnect options and components. Connection options include screw terminal blocks, header pin connectors (male and female), soldered right angle headers, and direct soldered wires.

Schematic, circuit board layouts and CAD files are available on the product page on our website and on my GitHub page https://github.com/SethNeumann.

# 2 IDENTIFICATION AND INFORMATION

## 2.1. BOARD LAYOUT

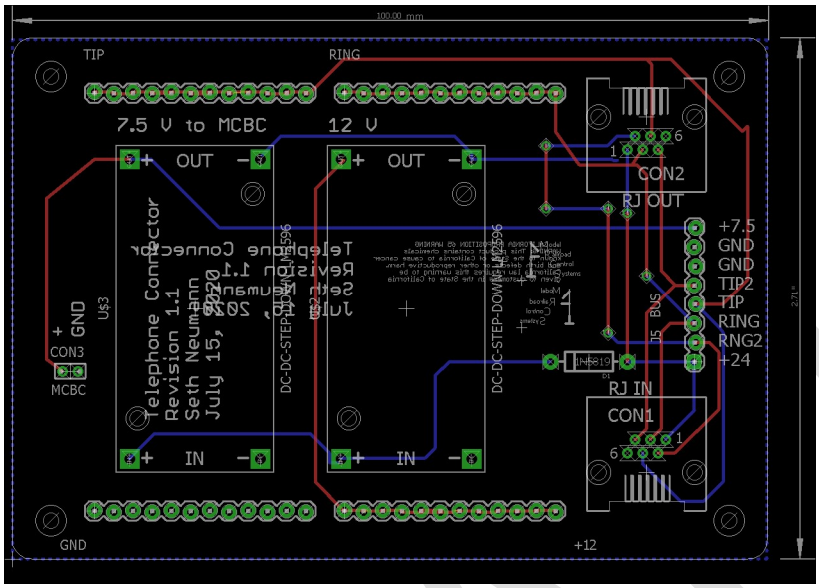


**Figure 1 - Rev 1.1 Board Layout**

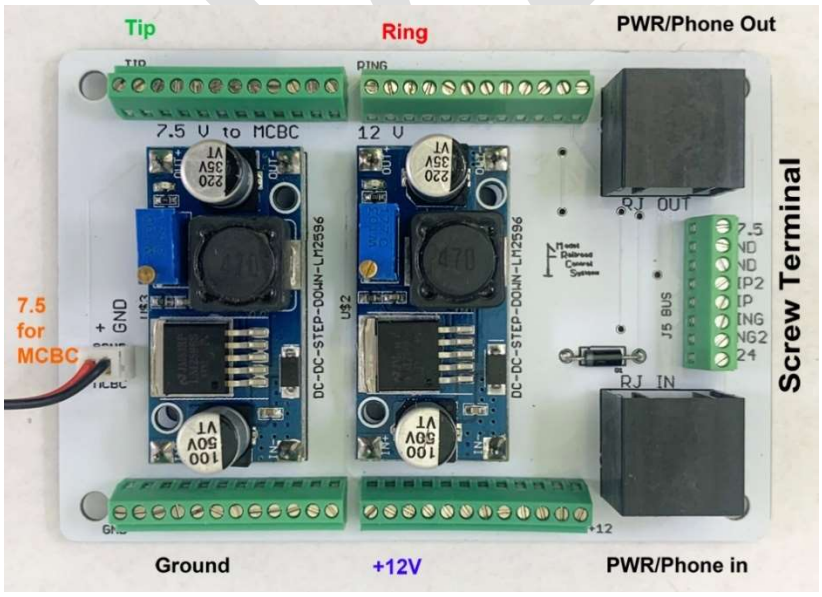


**Figure 2 - Telephone Connector Board Top View**

This board is sold as a single unit, assembled, and tested (white board) or as bare board (green board). If you are interested in alternate connectors, large quantities, or custom modifications please contact us.

## 2.2. BILL OF MATERIALS

| Qty | Value | Device | Package | Parts | Description | AMP |
|---|---|---|---|---|---|---|
| 4 | 12V, Ground, Tip and Ring | CONNECTOR-M08LOCK | 1X12_LOCK | J1,J2,J3,J4 | Header 12 0.100 | |
| 1 | 1N5819 | DIODEPTH | DIODE-1N4001 | D1 | Diode | |
| 2 | DC-DC-STEP-DOWN-LM2596 | DC-DC-STEP-DOWN-LM2596 | DC-DC-STEP-DOWN-LM2596 | U$2, U$3 | DC/DC Step-Down Regulator based on LM2596-ADJ chip | |
| 2 | RJ IN, OUT | CONNECTOR-RJ25-6P6C | RJ25-PANEL | CON1, CON2 | AMP connector inverted | 520250-3 |
| 1 | Screw Term Aux | CONNECTOR-M08LOCK | 1X08_LOCK | J5 | Header 8 | |
| 1 | To MCBC | 2mm JST | 1X02_LOCK_JST 2mm | CON3 | JST Connector | |
| 1 | PCB Board | | | | | |

**Table 1- Bill of Materials Rev 1.1**

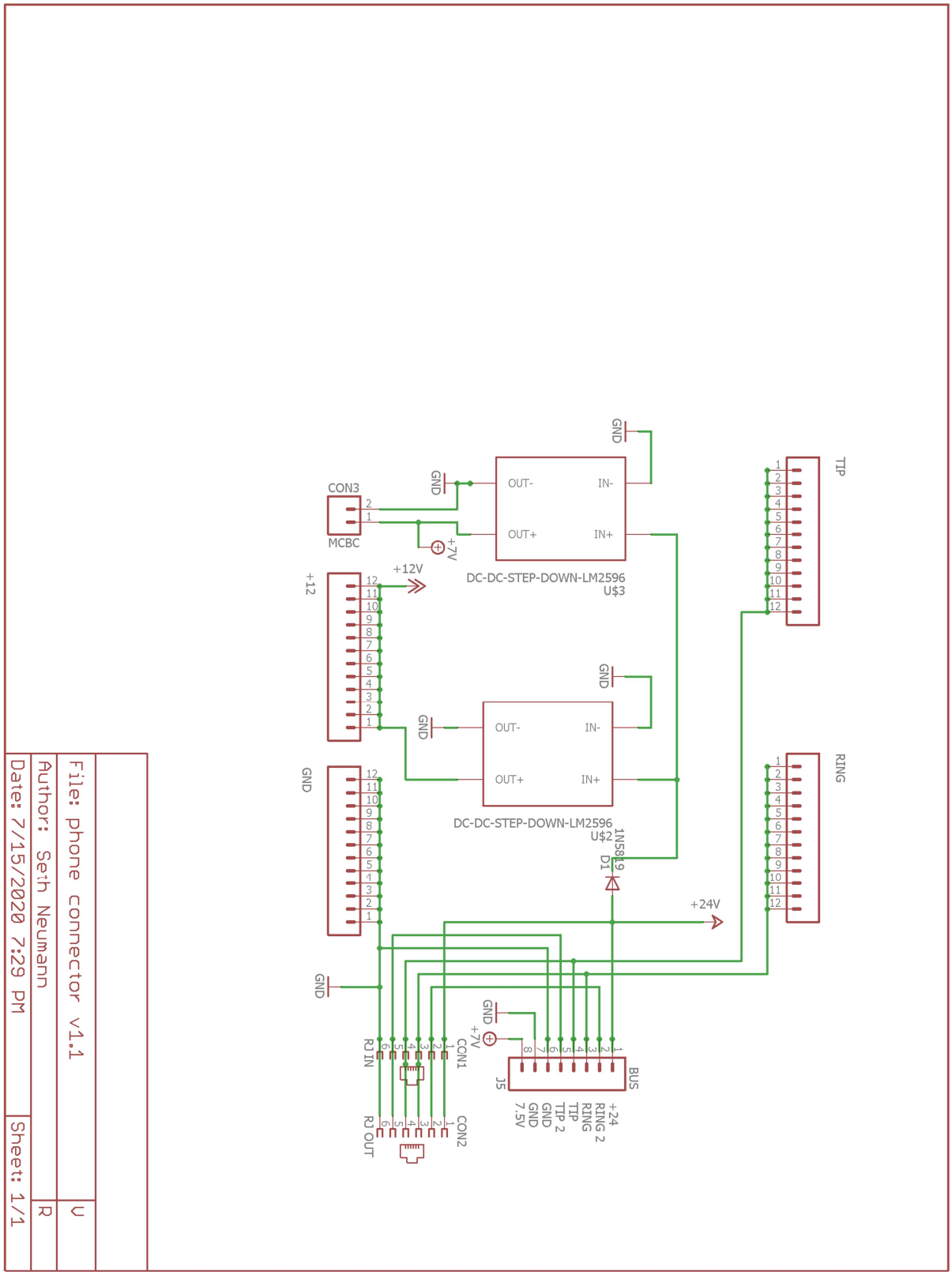


**Figure 3 - Rev 1.1 Schematic**

# 3 OPTIONS

## 3.1. BUS CONNECTOR

| Pin | Designation | Comment |
|---|---|---|
| 1 | +7.5 | Parallels the 2mm pads on the other side of the board, this cane be adjusted to any other voltage you like up to the 24V input |
| 2 | GND | Ground for 7.5 above – ground is connected to board ground. |
| 3 | GND | Ground from 24V input – ground is connected to board ground. Can be used as an alternate to T&R/Power bus input. |
| 4 | TIP2 | Tip of second pair, this just a pass through so the Telephone Connector can be anywhere on the daisy chain. |
| 5 | TIP | Telephone line Tip from bus |
| 6 | RING | Telephone line Ring from bus |
| 7 | RING2 | Ring of second pair, this just a pass through so the Telephone Connector can be anywhere on the daisy chain. |
| 8 | +24 | 24V input from T&R/Power bus input. Can be used as an alternate to T&R/Power bus input. |

**Table 2 - Bus Screw Terminal Connections**

## 3.2. CONNECTORS

- The distribution and bus connectors are on 0.100 centers (staggered slightly to hold the connectors in place during assembly). While our standard connector is the 0.100 screw terminal, you may substitute any 0.100 connector you prefer. If you are ordering an assembled and tested unit from MRCS and you would prefer a different connector, please contact us at sales@modelrailroadcontrolsystems.com and indicate your preference and we'll provide a quotation.
- Bus connectors are 6 pins modular RJ11 (phone line connectors) sometimes called RJ12 or RJ14.
- The connector for the 7.5V bucking converter is a 2mm JST type connector. We supply it with a plug and 4" leads. In the example I have extended it with 24Ga wire a male 2.1 mm barrel connector to power a Morse Code Buzzer Controller.

## 3.3. **ASSEMBLY**

**[ ]** All of the components are through-hole technology with wire leads. A lead bender is a useful tool for forming the leads at 90 degrees for easy insertion into the pad holes. The general rule is installing the lowest components first, working towards components that are higher off the board. This enables you to support the low components as you solder them.

**[ ] Diodes**

**[ ]** Install diode D1. Observe polarity – band towards bucking converters.

**[ ] JST Connector**

**[ ]** install the 2mm JST connector,

**[ ] Screw Terminals**

[ ] Install the "Tip", "Ring", "GND" and "+12" screw terminals. All the connections on each connector are tied together. If you need less than 12 connections, feel free to use a screw terminal with fewer positions. These are available in many sizes from 2 to 12 positions.

[ ] Install the Bus connection 8 position screw terminal, if you are using it.

[ ] Install the Bucking converters. I used 0.100 header pins for the input and output pins in the corners. You could also use pin and socket combinations or bare wire. Note that step-up converters are available with the same footprint, so if you want provide voltages as high as 35 Volts, it is just a parts substitution.

[ ] Install the Modular Connectors

# 4 TESTING

Testing your Telephone Connector board is quick and simple:

1. Use the supplied 6 conductor modular jumper to connect the "RJ in" connector to a nearby EBF31A or ATSN. Note: we use a standard telephone type cord where the connectors are reversed with respect to the "rib" that is one end is tab aligned with rib, on the other end the tab is on the smooth side. If you accidentally connect it upside down, the 1N5219 blocking diode will protect the circuit.
2. Check that polarity and voltage are correct on the ground and +12 terminal blocks
3. Check that polarity and voltage are correct on the ground and +24V, +7.5 on the bus connector, if equipped.
4. Use a telephone with a spade lug cord and check that there is "battery" present with green to tip and red to ring (you may need a pair of clip leads and some 24 Ga wire), also plug a modular telephone set into the "RJ out" connector and check for battery. The "battery check" is highly technical: pick up the handset and blow into the transmitter (microphone) and determine that you can hear yourself in the receiver side of the handset.

# 5 INSTALLATION AND CONNECTIONS

Buzzers are useful at manned stations but can add to the noise during an operating session when buzzing at an unmanned station. Some operators at manned stations may also find constant buzzing annoying if they are busy with other tasks. A solution is to buzz once and then light an LED to alert a passing crew or to remind yard operator to pick up the phone and contact the Dispatcher, we use the relay for this function. The LED is turned off automatically when the phone is taken off-hook. However, you need to have a way to easily distribute +12 and Ground to the phones with buzzers.

## 5.1 POWER CONNECTIONS

Note that 24 Ga wire can handle up to 0.6A (600 mA). So, the total current delivered over any conductor should not exceed 600 mA. From the Telephone Connector to any station should not be an issue as the most a phone would normally draw would be 30 mA for a buzzer (only when buzzing), 10 mA per LED (you might want one to indicate call waiting and another to show the circuit in use) and perhaps another 15 mA for a relay latch located in the phone for a total 65 mA, although the buzzer would only operate momentarily. That the leaves the station at about 10% of its theoretical maximum. However, the Telephone Connector can support up to 12 phones, or you might be running other 12V devices from a station's 12 V feed. The issue is that if 24V power is applied to the associated EBF31A or ATSN, then the bus cable supplying the other boards and Telephone Connector might be supplying more than 600 mA.

Also note that the bucking converter can only source 3A, and since most of us buy these from inexpensive suppliers on major commerce and auction sites, it is wise to allow a little margin of safety.

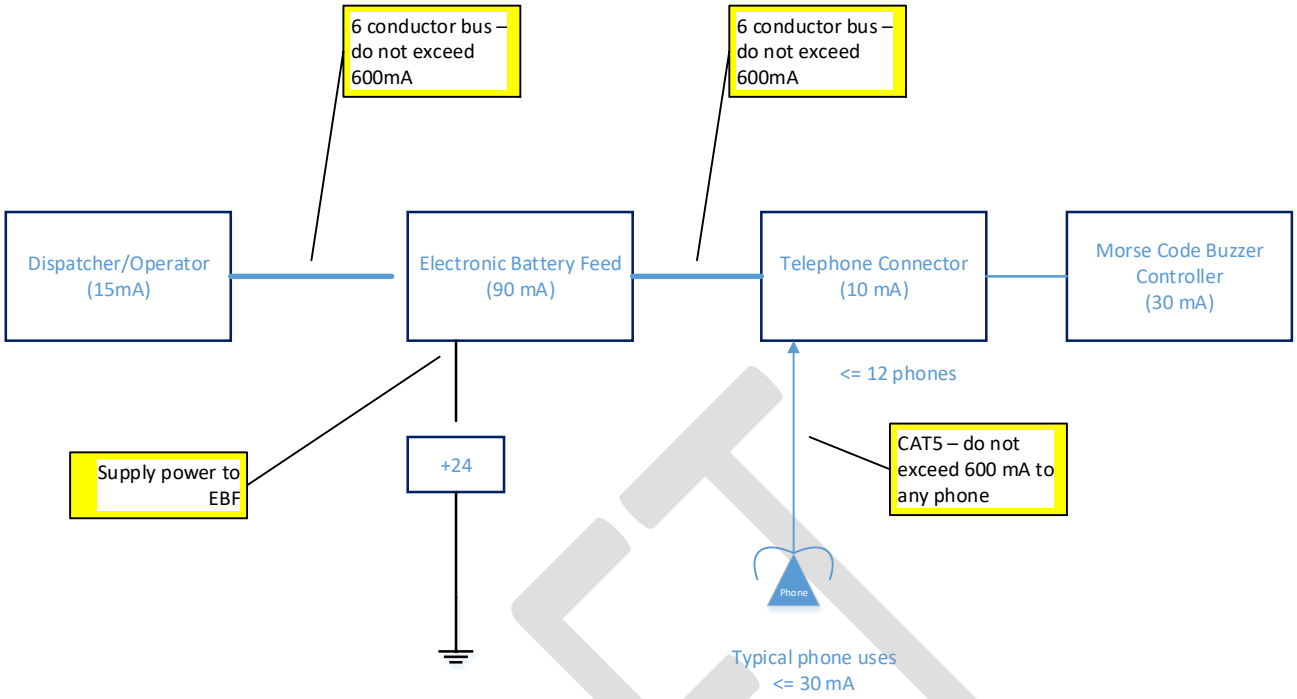


**Figure 4 - System Power Distribution**

The EBF31A draws 90 mA when the line is in use, the Dispatcher/Operator Board draws about 15 mA when the DS is speaking. So, if you apply power at the EBF31A, then you need to reserve 15 mA for the ATSN and have 585 mA available. Assume you are using our relay latch with an LED and all stations are indicating a waiting call (the buzzer has buzzed and is off), that is 25 mA per station. Assuming you have populated all 12 positions, you are drawing 300 mA. So, the total (15 + 300) is well short of 600. Our average system has a DS and 5 stations, so you will not ever get close. If you suspect you may exceed 600mA to all of the stations, apply power to the 24/GND screw terminals on the bus connector of the Telephone Connector Board. Then you can feed the ATSN and EBF over the bus (115mA) and each station can draw up to 600 mA.

If you supply 24VDC to the bus connector, you can then supply up to 3A total to all the loads fed by the telephone connector. See the Power Work Sheet and example below.

If in doubt, contact us! sales@modelrailroadcontrolsystem.com

Table of station accessory loads

| Device | Momentary | Constant | |
|---|---|---|---|
| LED | 10 mA | 10mA | |
| Off Hook Detector | O when idle | 20 mA Off-Hook | Can also be powered by local wall wart |
| Buzzer – on latch or button | 25mA | 0 | |
| Buzzer on MCBC | 25mA | | MCBC only buzzes one station at a time |
| Relay Latch | 40 mA (when buzzing) | 25 mA when waiting with LED on. | Relay + LED and buzzer momentarily<br><br>Can also be powered by local wall wart |
| Ring Generator | 150 mA (ringing) | | Many arrangements possible |
| Sounder | Need to calculate based on coil resistance | | Used with MCBC |

**Table 3 -Typical 12 V loads**

## 5.2 POWER WORKSHEET EXAMPLE

| Boards | Idle | Off-Hook | | Quantity | Total | Comment |
|---|---|---|---|---|---|---|
| EBF31A | 10 | 90 | | 1 | 90 | |
| Dispatcher/Operator Board | 5 | 15 | | 1 | 15 | |
| Telephone Connector | 20 | 20 | | 1 | 20 | internal loads always present |
| Morse Code Buzzer Controller | 5 | 30 | | 0 | 0 | assuming buzzers not sounders |
| | | | | | | |
| **Central Equipment (mA)** | | | | | **125** | **Do not exceed 2.5 A total or 600 mA over any bus connector cable** |
| | | | | | | |
| Stations with | | | | 6 | | |
| LED | | 10 | | 9 | 90 | If a station has 2 LEDs, enter total # LEDs in Quanity) |
| Off-Hook Detector | | 20 | | 1 | 20 | |
| Buzzer (not on MCBC) | | 30 | | 6 | 180 | |
| Relay Latch | | 25 | | 3 | 75 | |
| Other 12V load | | 100 | | 1 | 250 | Train Boss near one of the latch stations |
| | | | | | | |
| **Station Current total** | | | | | **615** | **Do not exceed 600 mA to any one station** |
| | | | | | | |
| ***Grand Total*** | | | | | ***740*** | **Do not exceed 2.5A, make sure your 24 V wall wart can supply this much current** |

**Table 4 - Power Work Sheet Example**

In this example we have an "average" layout phone system with 6 stations and a Dispatcher.

- 3 of the phones are manned: Staging, Yard Master and a tower. These have buzzers.
- 3 stations are "train order offices" they do not have Operators, so we want to buzz them briefly when called and then light a LED to alert the crews to call in for their orders. We have given them Relay Latches, Buzzers and LEDs
- We have also given the Stations "Line in Use" LEDs to let them know the line is in use and to pick up and wait for the conversation to be complete before talking
- One of the Train Order offices uses a decorator telephone that does not provide a spare contact, so we are using an Off-Hook Detector Board to support the Relay Latch.
- There is a Boulder Creek Engineering "Train Boss" talking hot box detector near one of the phones but no handy wall outlet for a wall wart, so we want to power the Train Boss (12V @ 250 mA) from the phone system.

Looking at the central equipment Boards, we have an EBF31A battery feed board, a Dispatcher using our Dispatcher/Operator Board, and the Telephone Connector Board. There is no Morse Code Buzzer Controller in this system. The total off-hook current required is 125 mA.

We have 6 stations (noted for reference)

- The three manned stations have buzzers and LEDs which light when the station is buzzed so the operators have visual indication the call is for them. The Train Order Stations have LEDs controlled by their Relay Latches, and the TO stations also have "Line in use" LEDs, for a total of 9 LEDs @ 10mA each for 90 mA. We enter 6 buzzers (this is being conservative: the DS has push buttons to operate the buzzers, so it would be hard to buzz more than two at once) so we will enter 6 buzzers @ 30 mA for 180 mA.
- The Crosley "302" decorator phone has a Relay Latch but no way to hold the latch, so we've added an Off-Hook Detector to work with the Relay Latch at that station for 20 mA
- The Train Boss in near the station with the Crosley 302 and will be powered from its cable. The Train boss uses 250 mA at 12V.

Adding up our station loads; we have 615 mA. The single most power-intensive station is the Crosley decorator phone with 2 LEDs (20mA), a buzzer, (30mA) an Off-Hook Detector (20 mA), a Relay Latch (25 mA) and the Train Boss at 250 mA for a total of 345 mA. The maximum our 24 Ga CAT5 can support is 600 mA, so the station is well within the limit.

The total power for all the stations and central equipment is 740 mA so a 24V at 1A wall wart type supply is adequate. 24VDC (regulated) wall warts are available at 1A and 2A, beyond that you need to use "desktop" power supplies, similar to laptop computer power supplies.

| Boards | Idle | Off-Hook | Quantity | Total | Comment |
|---|---|---|---|---|---|
| EBF31A | 10 | 90 | 1 | 90 | |
| Dispatcher/Operator Board | 5 | 15 | | 0 | |
| Telephone Connector | 20 | 20 | 1 | 20 | internal loads always present |
| Morse Code Buzzer Controller | 5 | 30 | 0 | 0 | assuming buzzers not sounders |
| | | | | | |
| **Central Equipment (mA)** | | | | **110** | **Do not exceed 2.5 A total or 600 mA over any bus connector cable** |
| | | | | | |
| Stations with | | | | | |
| LED | | 10 | | 0 | If a station has 2 LEDs, enter total # LEDs in Quantity) |
| Off-Hook Detector | | 20 | | 0 | |
| Buzzer (not on MCBC) | | 30 | | 0 | |
| Relay Latch | | 25 | | 0 | |
| Other 12V load | | | | | |
| | | | | | |
| **Station Current total (mA)** | | | | **0** | **Do not exceed 600 mA to any one station** |
| | | | | | |
| ***Grand Total (mA)*** | | | | ***110*** | **Do not exceed 2.5A, make sure your 24 V wall wart can supply this much current** |

**Table 5 - Blank Power Worksheet**

## 5.3 TELEPHONE CONNECTOR PHONE WIRING

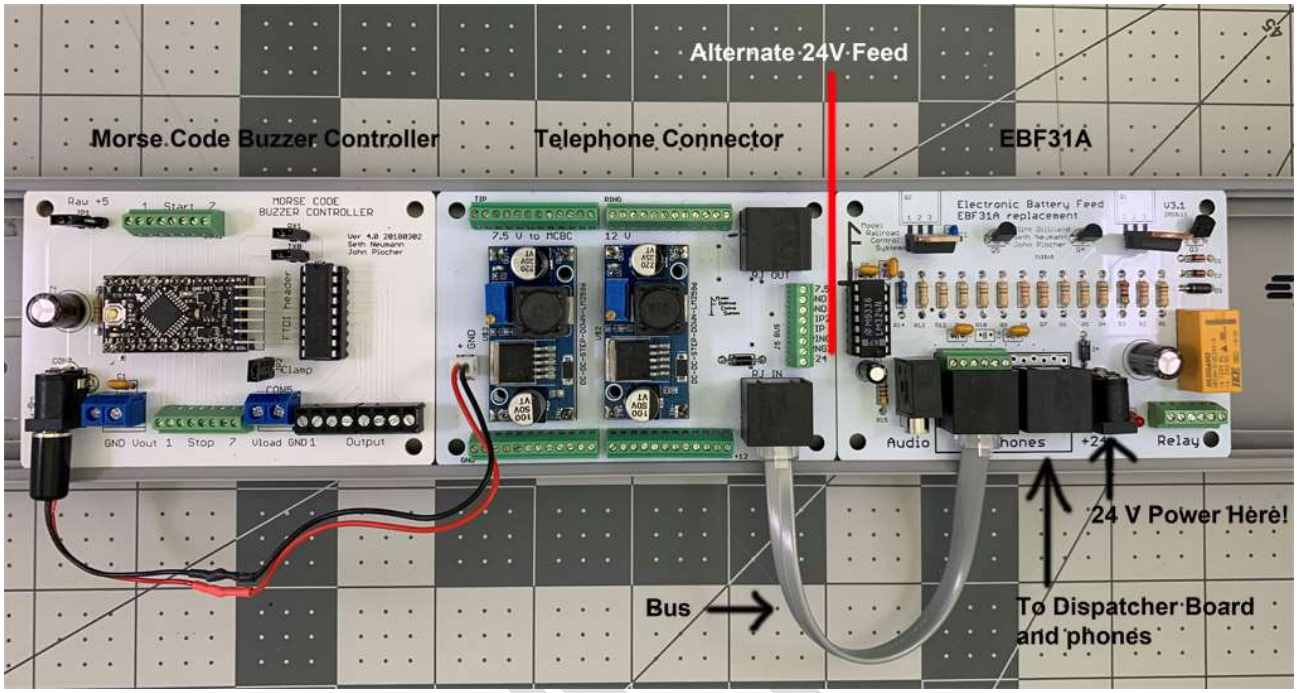


**Figure 5 - Telephone Connector (center) with MCBC and EBF31A**

For each CAT5 make these connections to the Telephone Connector and MCBC (if present) or to the phone buzzer and off contact if not.

| Position on Cat 5 | Color | Designation | Purpose |
|---|---|---|---|
| 1 | Wh/Bl | Tip | Tip of talk circuit (more or less ground) |
| 2 | Bl/Wh | Ring | Ring of talk circuit (more or less + Supply) |
| 3 | Wh/Or | STOP (A) | Switched side of contact aux closure from station* (grounded when station is OFF hook*) |
| 4 | Or/Wh | GND (A1) | Ground side of aux closure from station |
| 5 | Wh/Grn | GND (LG) | Ground |
| 6 | Grn/Wh | L | Switched output of EBF31A Relay with +12 |
| 7 | Wh/Brn | OUTPUT | Ground (black) side of buzzer |
| 8 | Brn/Wh | LED or buzzer supply | Hot (+12) side of buzzer |

**Table 6 - Typical Station Connections with Telephone Connector, MCBC and EBF31A**

The **BOLD Black, RED and GREEN** refer to connections on the telephone connector, MCBC and EBF31A respectively.

I suggest making a station list from 1-N (where N is the highest) and using that order for your station numbers. Use the corresponding position from left to right on the 4 signals on the Telephone Connector and send us the station list in the same order for the MCBC so you will connect all the leads to (say) Dolores on position 4 and Rico on position 6.

I recommend stripping the CAT5 back about 1' (use the tracer string as a zipper to open the sheath rather than using a stripper) and securing the end of the CAT5 sheath with a couple of T-25 staples or a 3/16" cable clamp to keep things orderly. Label the ends of the sheaths.

[Photo of track with the cables in).