
EBF31A Assembly Instructions

Revision v0.3 12/02/15

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Introduction

This document describes the functional blocks of the EBF31A and how to assemble it.

Revision History

v0.1	07/08/2014	SN
v0.2	07/09/2014	SN added options and testing
v0.3	12/02/2015	SN updated references to point at modelrailroadcontrolsystems.com

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1. EBF31A SYSTEM OVERVIEW

The *Electronic Battery Feed 31A* provides power and off hook detection for a telephone talk circuit suitable for a Model Railroad dispatchers' line. EBF31A:

- operates on 24 volts regulated DC, draws about 100 mA
- will support at least 4 phones off hook at once, suitable for reading and copying orders on a TT&TO railroad
- has a double-pole, double throw relay ("2 form C contacts" for you phone guys) rated at 2A, with screw terminals for control of auxiliary circuits
- has an LED "off hook" indicator
- has an RJ11 jack and screw terminals for the phone line
- has a 2.5mm center positive jack and screw terminals for power (supplies available from Jameco, Amazon)
- has a line level isolated monitor output on a stereo 3.5 mm audio jack
- fits the same 2.75" DIN Rail that MRCS cpNodes and IOX16/32 expanders use
- uses standard semiconductors available from Jameco and similar suppliers

The EBF31A consists of three main sections.

- 24V Battery Feed suitable for a layout telephone system
- Off-Hook indicator LED and (optional) relay
- 600 ohm line level monitor circuit

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

Pads for I/O connections are standardized on .100" centers. This provides a wider range of interconnect options and components. Port connection schemes include screw terminal blocks, header pin connectors (male and female), soldered right angle headers, and direct soldered wires. Auxiliary connectors are provided on RJ11 (for tip, ring and second pair), 2.5mm center positive barrel connector (for power) and 3.5mm stereo jack for line level audio.

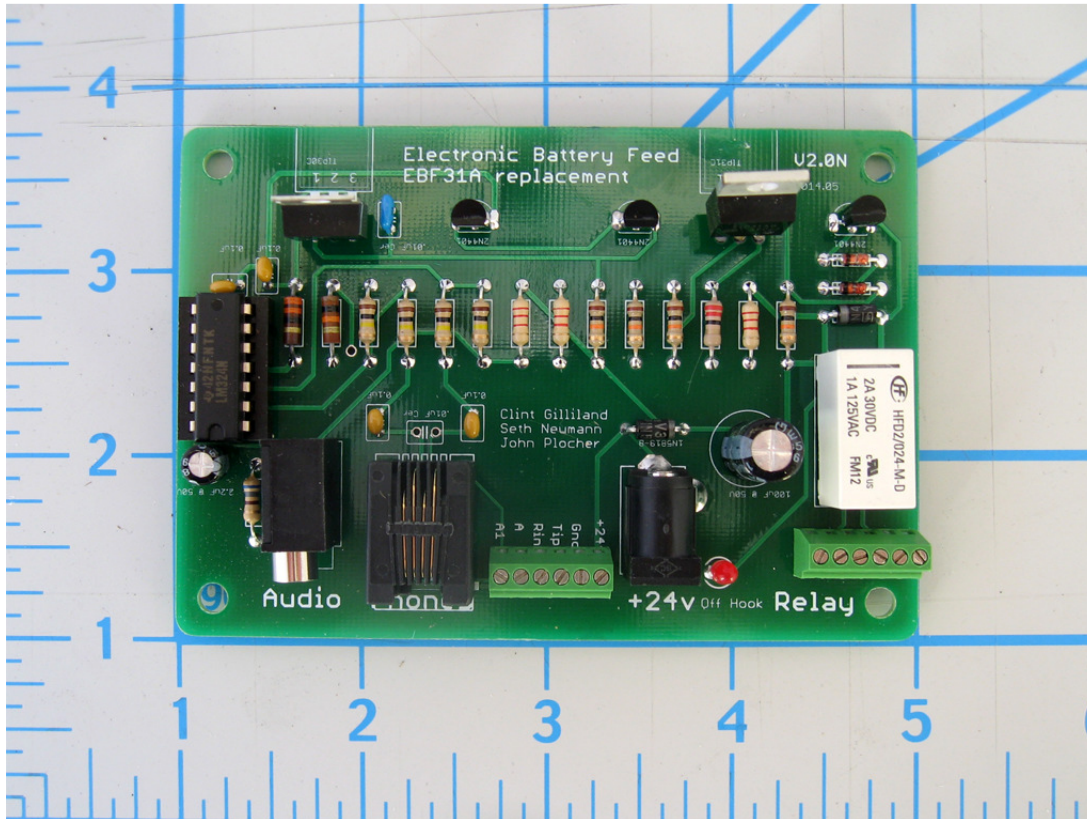


Figure 1 EBF31A Top View

2. CONNECTIONS

2.1. POWER

The EBF31A uses regulated 24V DC. 120 mA is sufficient, although most commercial 24 VDC supplies start at 1A. Modern “Wall Warts,” open frame power modules, or traditional telephone supplies may be used. If your supply has a 2.5mm center positive plug, you may plug it in to the barrel jack, J1. If not use, pins 1 and 2 of JP3. Pin 1 is +24V and Pin 2 is ground. Since the EBF31A draws a maximum of 120mA, you can use wire as small as 24Ga for the power connections which will easily fit into the miniature screw terminals. D4 will protect the board if you connect power upside down, but the circuit will not work until you have polarity correct.

2.2. TIP AND RING (TELEPHONE)

The two sides of a traditional telephone line are called TIP (the more grounded side) and RING (the side towards supply or “battery”). These terms derive from the Tip/Ring/Sleeve plug (like a modern stereo plug) used on manual switchboards. All phones in the system are in parallel across the Tip and Ring. Tip and Ring are available on the center pair of the RJ11 jack so you can plug a test phone directly into the EBF31A: if you can hear yourself talk through the handset of the test phone you’re on the air! If you want to distribute signal through telephone style punch blocks or barrier strips, use

pins 3 and 4 of JP3. Again, 24 Ga wire is sufficient as the EBF31A is set at the factory to source about 65 mA of current to the phones.

2.3. AUXILLARY PAIR TO PHONE

Some phones are arranged to provide a contact closure (“A Lead”) on the second pair on the RJ11. This pair is brought out to pins 5 and 6 of JP3. This closure can be used to indicate which phone or phones are off hook which is useful for signaling and busy indication.

2.4. RELAY CONNECTIONS

EBF31A includes a DPDT (“2 form C” for you phone guys) relay, which operates when the circuit is off-hook, rated at 2A @ 30VDC which can be used for various control functions. Most common is to gate power to LEDs located at each station to indicate the line is in use and new callers should listen for a break in the conversation before barging in. The contacts are available are on JP2

2.5. 600 OHM LINE LEVEL AUDIO

An isolated 600 ohm line level connection is provided on JP1. This provides the same signal on the left and right channel of the mini-stereo (3.5mm) jack so any powered computer speaker can be used.

3. BILL OF MATERIALS

A quantity of zero denotes an alternate component or a component that may be used in a particular configuration. C6, which may be needed to suppress high frequency oscillations, is an example.

Part	Quantity	Value	Description	Comment	Vendor	Part
C1	1	.01uF Cer	CAPACITOR, American symbol		Jameco	25507
C2-C5	4	0.1uF	CAPACITOR, American symbol		Jameco	15270
C6	0	.01uF Cer	CAPACITOR, American symbol	no stuff	Jameco	15229
C7	1	100uF @ 50V	POLARIZED CAPACITOR, American symbol		Jameco	29962
C8	1	2.2uF @ 50V	POLARIZED CAPACITOR, American symbol	audio out option	Jameco	158327
D1, D2	2	1N4148	Diode		Jameco	36038
D3	1	1N4002	Diode	relay option	Jameco	76961
D4	1	1N5819-B	1.0A SCHOTTKY BARRIER RECTIFIER		Jameco	177965
IC1	1	LM324N	OP AMP	audio out option	Jameco	23683
J1	1	Jameco 101187-RA	DC POWER JACK		Jameco	101187
J2	1	phone jack	RJ25-PANEL		Jameco	852449
JP1	1	RS 2168149	3.5mm Audio Jack vertical	audio output option	Jameco	2168149
JP2, 3	2		Header 6	1 is relay option, other is required	Electronics-Salon	
K1	1	G5V-2-24V	OMRON PCB Relay	futurlec calls it HFD2-24	Futurlec	
LED1	1	Off Hook	LED3MM, Red		Jameco	2006713
Q1	1	TIP31A	NPN Power Transistor TO220		Jameco	1192850
Q2	1	TIP32A	PNP Power Transistor TO220		Jameco	1959328
Q3-5	3	2N4401	NPN Transistor TO92		Jameco	783498
R1,4,5,6,13	5	10K	Resistor		Jameco	691104
R2,7,8	3	2K2	Resistor		Jameco	690945
R3	1	22R	Resistor		Jameco	661837
R9,10,11,12	4	100K	Resistor		Jameco	691340
R14	1	33R	Resistor		Jameco	691227
R15	1	680	Resistor		Jameco	690822
U\$1	1	BOARD	BOARD EBF31A		Seed	

Table 1- Bill of Materials

4. ASSEMBLY

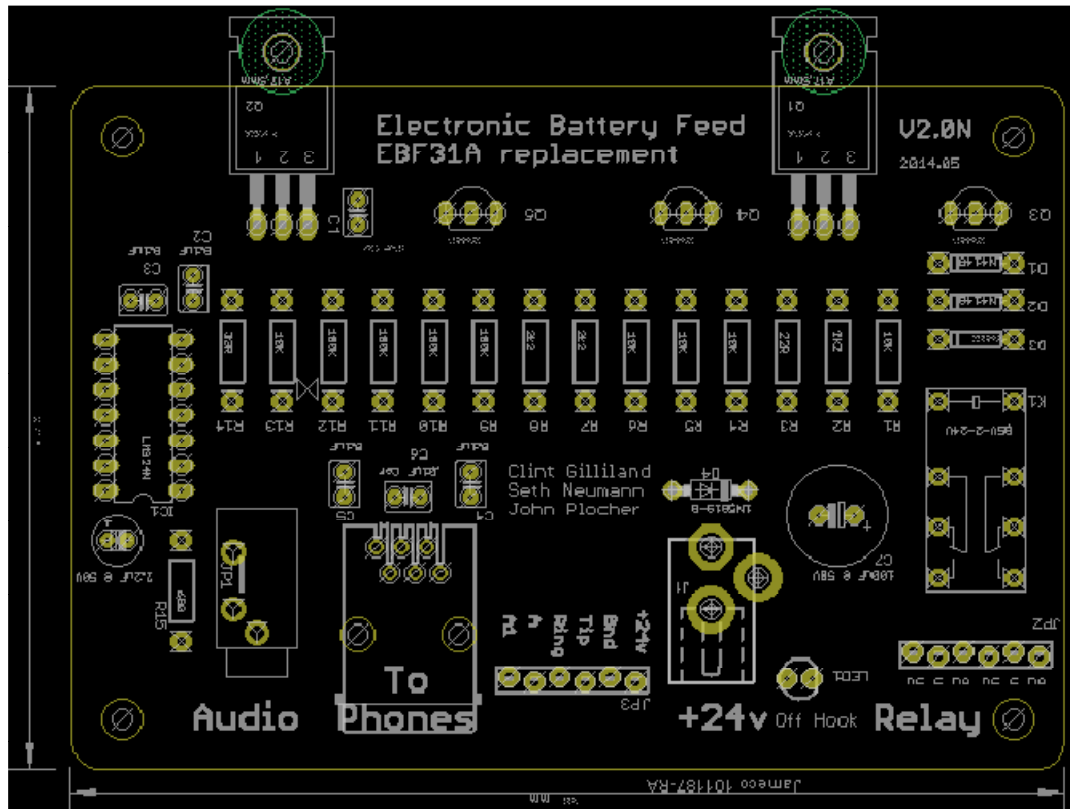


Figure 2 - EBF31A Component Layout

4.1. OPTIONS

There are three options you should consider if you're assembling your EBF31A (Assembled and Tested units come fully equipped, but MRCS will consider custom configurations in orders of 10 or more):

- Relay and associated terminal block
- Isolated Line level output
- Connectors

4.1.1. Relay

Relay K1 provides a DPDT ("2 form C") relay rated at 2A @ 30VDC. If you don't need the contacts, you can omit K1 and its associated terminal block JP2 as well as diode D3. This configuration is similar to the Western Electric 2A KTU, except you get an off-hook indicator!

4.1.2. Isolated Line Level Output

This option provides a monitor output for the line, which is useful for recording the dispatcher and for driving a small speaker so the dispatcher or anyone listening with the dispatcher can hear

stations calling for the dispatcher. Output is roughly one milliwatt into 600 ohms and can drive an amplified speaker. The parts involved are:

- 14 pin socket for IC1
- IC1
- Resistors R9-R12 and R15
- Capacitor C8
- Audio Jack JP1

4.1.3. Connectors

The EBF31A is designed for flexibility in connections, but you don't need to use all of the connectors:

- J1, the 2.5mm barrel power connector, parallels pins 1 and 2 on JP3, so it may be omitted if you don't want to use a 2.5mm plug. (There are 2.1mm jacks with the same tab configuration, although MRCS prefers to use 2.1mm barrel jacks for 12VDC or less). On the other hand you can feed the EBF31A through a power supply with a plug and then distribute 24V to other circuits via pins 1 and 2 of JP3.
- J2 is an RJ11 jack and it parallels pins 3 and 4 on JP3, so if you're planning on distributing Tip and Ring via JP3, you don't need the modular jack. Again, MRCS recommends using J2 for easier testing (just plug a phone in). If you're using J1 for power and J2 for tip and ring, you might omit JP3.
- The A/A1 lead contacts on JP3 may not be used in your application in which case you might substitute a 4 terminal 0.100 terminal for JP3
- JP2 and JP3 are on 0.100 centers and you can substitute any header or terminal of that size you like

4.2. DETAILED ASSEMBLY

All of the components are through-hole technology with wire leads. A useful tool is a lead bender for forming the leads at 90 degrees for easy insertion into the pad holes. Start with inserting the lower height components. The general rule is install 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.

Resistors Diodes - Check options below before installing all resistors!

Install Resistors R1 - R8 and R13 and R14 across the middle of the boards. Try to keep the gold tolerance band on the same side for easier reading of values

Install Resistor R9-R12 and R15 (near the IC socket) if you are using the line level monitor feature

Install diodes D1-D4. Note D1 and D2 are smaller and clear.

Install C1 (.01uF) near Q2

Install C2 and C3 (.1uF)

Monolithic Capacitors

Install C4 and C5 (.1uF) if you are using the line level monitor feature

Install C1, R1. The value depends on line speed. Use the table in the schematic to select the value.

Off Hook LED.

LED1 Pad near “hook” label is +. Observe the polarity of the component. Long lead on LED is Positive.

IC Socket (if you are using the line level monitor feature)

Socket for IC1 if you are planning to use the monitor feature - notch towards C8

Small Signal Transistors and Electrolytic Capacitors

Install Q3-Q5

Install C8 if you are planning to use the monitor feature, + towards edge of board

Install C7, + towards relay K1

Relay and Jacks

Install J1 unless you will not be using a 2.5mm plug to power your EBF31A

Install JP3 unless you will be using the modular jack (J2) only and are powering via J1

Install relay K1 and JP2 unless you do not need auxiliary contact closures

Install J2 unless you will be using JP3 only, we recommend installing J2 anyway so you can do a quick test

Install JP1 if you are planning to use the monitor feature

Large Transistors

Install Q1 and Q2 - the fins face the edge of the board

Install IC1 if you are planning to use the monitor feature, match notch with the socket and take care not to bend the legs

5. SCHEMATIC

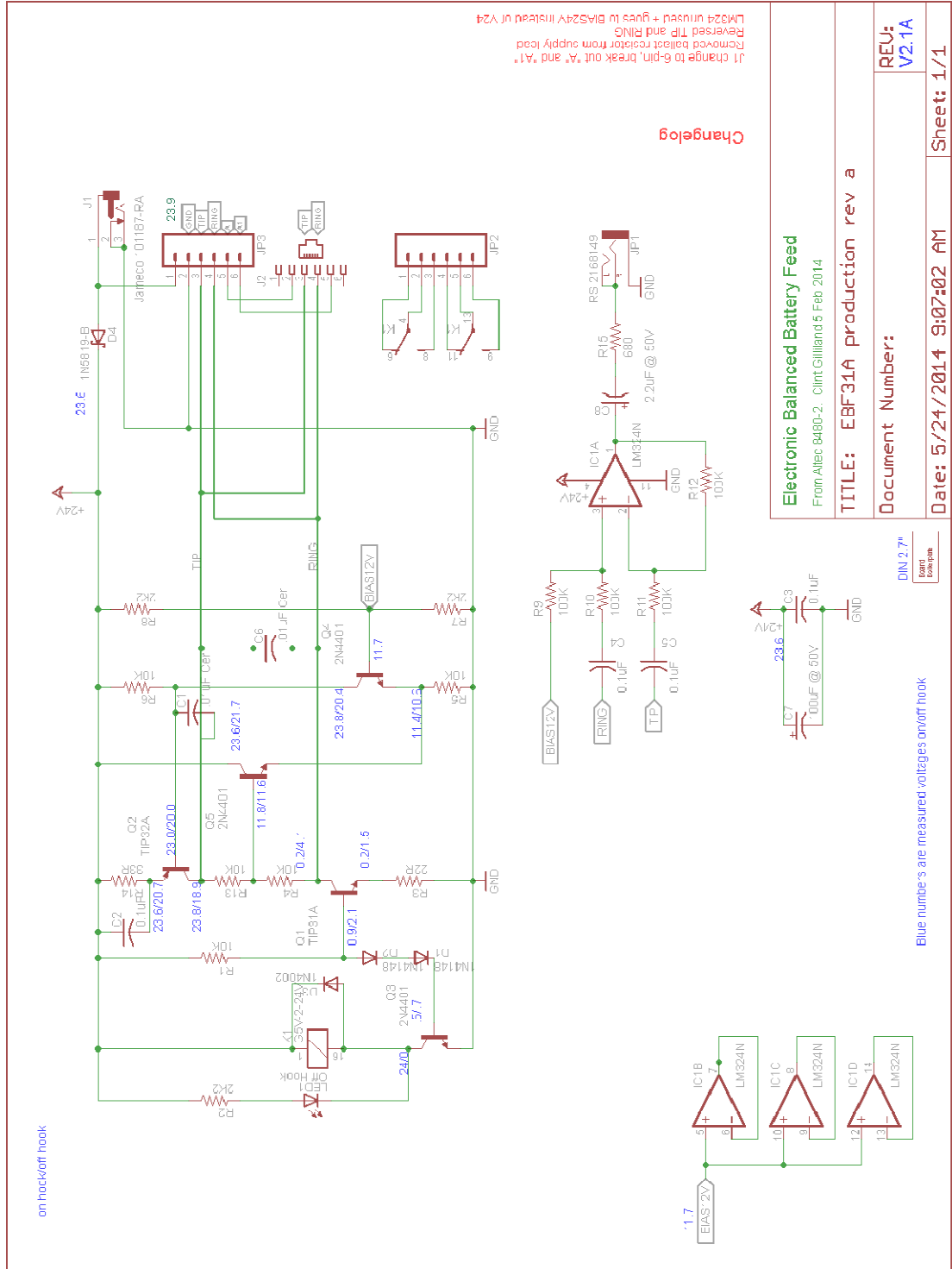


Figure 3 EBF31A Schematic with nominal voltages

6. TESTING

Testing your EBF31A is quick and simple:

1. Mount the board securely on standoffs or in a piece of 2.75" DINRail
2. Apply 24VDC regulated power with a 2.5mm center positive plug to J1 or use pins 1 and 2 of JP3
3. Plug a standard phone into J2 (note: you may need a small screw driver or hobby knife to release the locking tab)
4. Take the phone off hook and talk or blow into the mouthpiece. If you can hear yourself in the earpiece, you should be OK!
 - a. Check to see that LED1 illuminates.
 - b. You should hear relay K1 click softly when you go off hook and again when you go back on hook.
5. If you assembled the EB31A yourself, refer to the schematic, (figure 3 above) and check the on and off hook voltages as shown on the schematic drawing

7. HISTORY AND BACKGROUND

The *Electronic Battery Feed 31A* grew out of a series of clinics I've been presenting since 2004 at various model railroad events on "Communications for Model Railroads" This material has also appeared as a 3 part series in 2011 in the Operations SIG's journal, the "*Dispatcher's Office*" and will appear as a chapter in a forthcoming OPSIG book. The clinic is available at <http://www.modelrailroadcontrolsystems.com/content/Communications%20for%20Model%20Railroads%202015.pdf> I suggest you familiarize yourself with this clinic before installing a phone system for your model railroad

The key element in the phone systems I've advocated are "battery feed relays" and these have become scarce over time. As a result I consulted with some of the designers I've worked with over my career in telecommunications and collaborated to develop a solid state alternative to the venerable Battery Feed relay. My colleague and partner Clint Gilliland recalled an Altec circuit (the 14586A Dial Long Line Appliqué) from the 60s which provided the needed functionality:

- high impedance audio source
- Low DC resistance
- Robust with regards to shorts and crosses to various supply voltages

Clint and I reviewed the circuit, removing anything not needed for a model railroad Battery Feed source. We then substituted all of the older semiconductors in the Altec design (actually all are still available!) with modern parts that are widely used in the model railroad community in an effort to make it more economical for hobbyists building one or a few units.

MRCS offers the EBF31A as a bare board and as an assembled and tested unit. Our friend John Plocher patiently guided us through the intricacies of EagleCAD.

By the way "31A" refers to the Western Electric designation for the 31A Key Telephone Unit which provided a single line talk pair in office intercoms in the 40s and 50s.

8. SUBSTITUTION

In the unlikely event you can't find the transistors, you can substitute pretty freely:

- Almost any small signal NPN transistor can be used in place of the 2N4401, the 2N3904 is almost an exact match for the specs. The only concern is that Q2 and Q3 be well matched, in practice any 2 from the same batch will be fine -- transistor processes are immensely better today than in 1964 when Altec designed this circuit. So if you have two transistors on a tape next to each other, you'll be fine.
- Q1 is a TIP31C and any **odd** numbered (**NPN**) TIP3X will work in a pinch
- Q2 is a TIP 30C and any **even** numbered (**PNP**) TIP3X will work in a pinch
- You may ask why we used such high powered transistors for Q1 and Q2, the reason is that TIP3Xs are cheaper than using a smaller transistor and a heat sink.

D4 is a 1N5819B Schottky diode which protects against reversing the power supply. It is selected for its low forward drop, but in a pinch a 1N4001 or 1N4002 will do, however voltages will shift by 0.3 volts.

Capacitors of higher voltage ratings may be used but physical fit may become an issue