

Application Note 002 for the EBF31A - “Hot Line”

Introduction

Our friend, Dave, needed a “Hot Line” to connect two yards and asked us to design a circuit to set it up. A hot line (in telephony, it’s known as a “ring-down line”) is arranged so that picking up either phone, causes the other to ring. Once the called phone answers, ringing stops and the parties can talk. Once both phones go back “on-hook” the circuit resets and is ready for the next call. Many variations are possible, but we’ll focus on a couple of inexpensive options that are useful on model railroads.

- Hot line using buzzers
- Hot line using buzzers with Morse Code Buzzer Controller for unique “ring” cadence at each station
- Hot line using ringers

Dave likes the sound of ringers as his 1975 era ConRail layout was a little too modern for Morse Code. We’ll come back to the buzzer options later.

For this example, you’ll need:

- [EBF31A](#) electronic battery feed from Model Railroad Control Systems
- 2 phones, (Dave has a wall phone and a desk phone)
- A small [ringing generator](#) (20-30Hz @ 75-105 Volts) and power supply if required
- 2 DPDT relays, I used 12V relays (and sockets) as I need to supply 12V for the ringing generator but 24V relays running off the EBF31As’ power supply are OK, also. These are available from [Jameco](#) and many other suppliers.
- 24 Volt DC 1A regulated power supply with 2.5mm plug
- 12 Volt supply capable of at least .5A – I used a small “bucking converter” that is powered from the 24V supply and can easily supply the .25A needed by this circuit
- A small piece of 1/2” plywood (8” x 12”)
- A way to mount the EBF31A (and in my case, the bucking converter). I used #4 x 1/2 sheet metal screws and standoffs, but a piece of [DINRail](#) would do.
- A drill driver, some #8 x 1/2 pan head screws and basic hand tools will complete the job

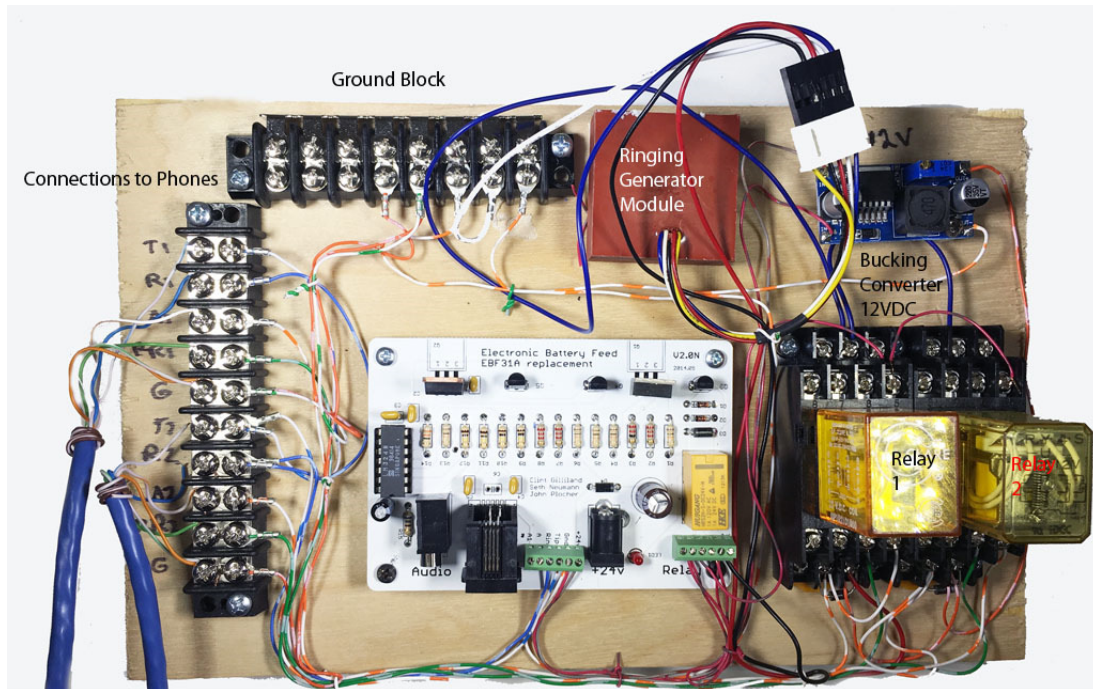


Figure 1 – Hot Line System

1. Find a location

Find a location near or between the phones. Make sure a 3 prong grounded outlet is available so you can power the system and have some light to work while you do the installation. You may need two or three outlets depending on how you power the system (24V, 12V and Ringing generator – this example only needs one). Take precautions if the area is subject to moisture.

2. Mount the Pieces to the Backboard

A. Mount the EBF31A

- I used #4 x 1/2 sheet metal screws and standoffs, but a 6" piece of [DinRail](#) would do too.
- The DIN Rail is Digikey Part 1437685-12-ND and it is available in the Model Railroad Control Systems website: <http://www.modelrailroadcontrolsystems.com/telephone/>

B. Mount the Relays

- I used "Ice Cube" type relays and sockets from Jameco
- I used # 6 x 3/4 sheet metal screws to mount the sockets.
- Hint: do your wiring with the relays out, it's much easier to get into the terminals!

C. Mount the Bucking Converter

- I used a small, inexpensive, bucking converter (a little switching power supply that reduces voltage – boost supplies are available, too. Check Amazon, eBay or your favorite off-shore supplier) to provide 12 volts. These are adjustable, and you can use more than one if you need more voltages. I wanted 12V to power my relays and the ringing generator module.
- If you have a 12VDC bus running around your layout which can provide another .25A, then you can use it, be sure to tie the grounds together.
- You can also use a 12V wall wart if you've got one handy, be sure it's regulated (unregulated wall warts can put out as much as 16V and may damage the ringing generator). Again, tie the grounds together.

D. Mount the Terminal Blocks

- There is no magic to this, but the more clearly the system is laid out, the easier it will be to trouble shoot and manage.
- I provided a terminal strip (using a little jumper that Radio Shack made) to provide a common ground tie point. If you can't get these (RS is web only and spotty on inventory at this writing) just run a bus wire along one side of the ground strip. You may want to do a similar 12V bus, but I just daisy-chained the 12V as there are only three places it goes.
- I provided another terminal block for the station (phone) connections. It really needs 12 positions (6 per phone) but two per phone are ground and I had 10 position terminal blocks handy, so I used a 10-position block and put both grounds under one screw for each phone.

E. Mount the power supply.

Jameco offers 24V wall warts with 2.5mm plugs, and a quick check of Amazon or eBay may find you a bargain.

- The power supply should be 24 Volts DC Regulated with at least 0.5A current capacity, 1A is typical. Multiple EBF31As may share a suitable supply (allow 120 mA per EBF31A). You want a supply with a 2.5mm center positive plug. You can also use the screw terminals on the EBF31A if a suitable plug isn't available.
- Take the 2.5mm plug and insert it into the +24V jack on the EBF31A -- if you're using DIN Rail you will need to notch the rail for the power plug
- Note that there are a couple of styles of 2.5mm plugs with different interior diameters. If yours doesn't work, just cut the plug off and insert the +24 lead into the screw connector terminal marked +24 and the ground side to "Gnd." If you get it wrong it won't hurt anything, it just won't work. If this is the case, reverse the wires. If the wires from your power supply won't fit, just splice them to a short length of 20Ga or smaller wire (Red for +24, Black for Ground)

F. Wire the Backboard

Use the schematic and instructions below

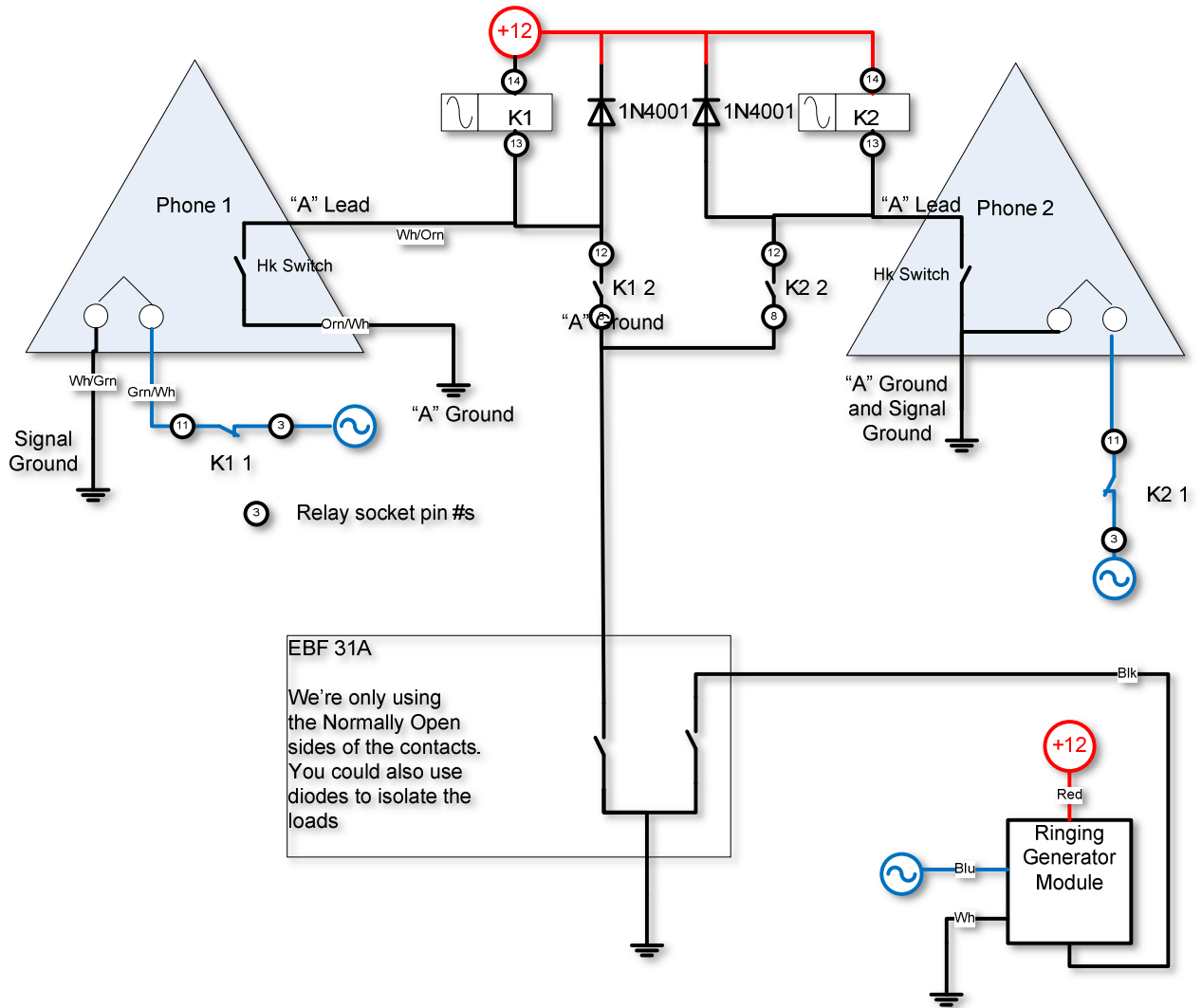


Figure 2 - Hot Line Control

Wiring:

- Wire Tip and Ring (not shown here) from the EBF31A to the terminal strips for the phones.
- Wire the grounds from the EBF, input and output of the bucking converter (or the ground of a separate 12V wall wart), the white output wire of the ringing generator module, the center positions of the two relay contacts on the EBF, and the A ground and Signal Ground of the phone together. Note I used a terminal strip with a shorting jumper.
- Connect the Blue ringing output of the ringing generator to the normally closed side of the first contact of each phone's relay (I've shown pin 3 on the socket I used).
- Connect the other side of the ringing contact (11) to the Signal lead from each relay to the terminal strip of its respective telephone.
- Connect the black wire of the ringing generator to one of the normally open contacts on the EBF31A
- Connect the normally open side of the other contact of the EBF31A to the one side of a normally open contact (I used 8) on each phone's relay
- Connect the other side of the NO contact (12) on each relay to one side of its winding (13) along with the anode side of a 1N4001 diode and the A lead terminal of its phone.

- Connect the cathode of the diode to the other side of the winding (14) and to 12VDC from the bucking converter or 12V wall wart.
- Connect the Red wire of the Ringing Generator to 12VDC from the bucking converter or 12V wall wart.

Designation	Cat 5 Color	EBF31A	K1	K2
Tip (Phone 1)	White/Blue	Tip		
Ring (Phone 1)	Blue/White	Ring		
A (off hook) (Phone 1)	White/Orange		12,13 (Cathode)	
A Ground (Phone 1)	Orange/White	Ground		
Signal Ground	White/Green	Ground		
Signal (Ring)	Green/White		11	
Tip (Phone 2)	White/Blue	Tip		
Ring (Phone 1)	Blue/White	Ring		
A (off hook) (Phone 1)	White/Orange			12,13 (Cathode)
A Ground (Phone 1)	Orange/White	Ground		
Signal Ground	White/Green	Ground		
Signal (Ring)	Green/White			11

Table 1 - 10 Position Terminal Strip

Bill of Materials

item	Quan	Description	P/N - explanation	Vendor
1	1	500/2500 set	modified for 6 wire operation	MRCs, eBay, Garage sale
2	1	554/2554 Set	modified for 6 wire operation	MRCs, eBay, Garage sale
3	1	EBF31A	Electronic Battery Feed with DPDT relay	MRCs
4	1	12 Volt Ringing Generator	Power Components PCR-SIN03V12F20-C	MRCs, eBay
5	2	relay 4PDT	P/N 291507,	Jameco
	2	Socket for above	P/N 2167470	Jameco
6	1	8-term	8 Position RS term block	Radio Shack
7	1	8-jump	8 Position RS jumper	Radio Shack
8	1	10 position terminal strip	P/N 208900	Jameco
9	1	male cable for ring gen, 4 position 0.100 Male		
10	2	1N4001	Diode	Jameco
11	1	buck converter for relays, ring generator	LM2596 adjustable buck converter	eBay, Amazon
12	25	spade lug	RS 6403070, Mouser 571-614982	Radio Shack, Mouser
13	10	sheet metal screw screws	for boards, sockets, #4, #6	hardware store
14	6	stand-offs	for boards, or use Evergreen or Plastruct Tubing	hardware store, hobby shop
15	1	24V Power regulated Power supply w/ 2.5mm plug	P/N 1953671	Jameco
16	1	6 cond modular connection block	SKU: IC625SB6WH	Showme cables
17	1	6P6C modular socket for desk set	P/N 124039	Jameco
		6 conductor modular cable for desk set	SKU: 15-302-007R	Showme cables
18	optional	D-Sub Crimp Tool for spade logs	SKU: 93-100-014	Showme cables
19	1	Backboard	6x10 scrap of plywood	

Table 2 - Bill of Materials

3. Mount the Backboard

Mount the backboard to keep everything organized and off the floor -- especially if your floor is subject to flooding! Nothing is heavy so you don't need to drill into a stud, drywall anchors are fine. Use #6 or #8 screws and the 1/2" plastic anchors. These are strong enough to hold forever but remove easily and leave a hole that can easily be patched if you need the room for something else later.

4. Prepare the Phones

Phone should be arranged to use 3 pairs:

- Tip and Ring (two sides of the talk pair)
- Separate off-hook indication ("A" Lead and Ground) using a second contact on the hook switch
- Ringer (Buzzer) signal and ground

Designation	Phone Cord	Cat5 Color	In Phone*
Tip	Green	White/Blue	Y or RR
Ring	Red	Blue/White	L2 on Dial or <i>Network</i>
A (off-hook indication)	Yellow	White/Orange	A (or L1 or G)
A Ground	Black	Orange/White	K (or L1 or G)
Signal Ground	White	White/Green	E1
Signal (Ringing in this case)	Blue	Green/White	E2

Table 3 – Phone Connections

* Note networks and DTMF (touch tone) dials differ, so your phone may be different. The terminals in italics are tie points only (no connection to internal components and may be used interchangeably)

In other notes I've usually reserved the Wh/Grn, Grn/Wh pair for a LED, but in this case we're using it for signaling as desk sets typically have only 2 and occasionally 3 pairs. If your desk phone (500/2500) only has 2 pairs you'll need to find a 3 pair cord or if it's modular use a 6P6C jack and 6 conductor cord instead of the usual 6P4C (only has 4 wires equipped). Jameco carries one (their part 124039 – see BOM) and it can be installed with minor trimming of the case, which should be well within the skills of any model railroader.

We don't need to use dials as this is a Hot Line, but you can leave the dial in the circuit if you prefer. Here are links to notes on various types of phones:

Cup Hook Phones

<http://www.modelrailroadcontrolsystems.com/content/Telephone%20App%20Note%202%20-%20Cup%20Hook%20Phone%20Installation.pdf>

Wall Sets:

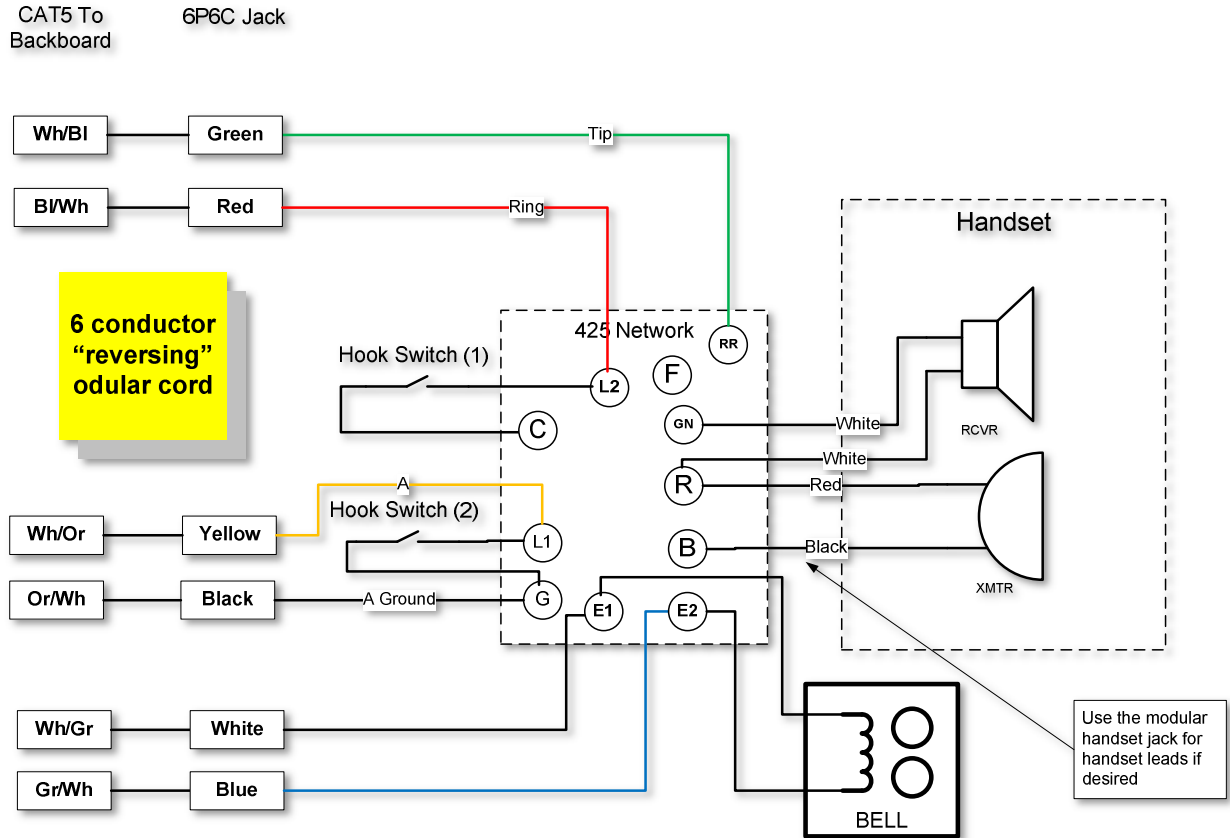
While this note discusses removing the housing and dial, you can use the wall set with the housing and you can leave the dial in place, although you may need more tie points.

<http://www.modelrailroadcontrolsystems.com/content/Basic%20554%20application%20note%2020170705.pdf>

Desk Sets:

These are electrically the same as the wall and cup hook sets, but here are the connections:

Dave wanted to use a desk set, so I modified a 2500 type desk set. Since the application was a hot line there was no need for a dial. All leads to the DTMF ("Touch Tone") dial were removed from the network and stored. The circuit requires 6 wires (actually 5, but the functions are traditionally paired, so we used 3 pairs, 6 wires) by replacing the mounting cord jack with a 6P6C panel mount jack. (see table 3 above).



Notes:

- 1 – Hook switch has 2 contacts, (1) takes the phone off hook, (2) part of the latch circuit when phone goes off-hook
- 2 – Note that network terminals have been moved for clarity
- 3 – Some Networks have extra tie points, E1,E2 which can be used to make connections to parts of the latch circuits. Also A and K can be used for miscellaneous connections (they are 2 sides of a capacitor normally part of the ringer circuit which we're not using, use this for the A, A Ground pair if used)

Figure 3 - Desk Set Wiring Diagram

5. Test Your Hot Line

Go to each phone and go off hook:

1. Gently blow into or tap on the mouthpiece. You should hear yourself in the receiver of the phone (this is called "battery" by phone people as in "do you hear battery?")
2. You should hear the other phone ringing
3. Have a helper answer the other phone, it should stop ringing
4. Ensure that you can converse in both directions

5. Theory of Operation

Normally both phones are on-hook, so no current flows through tip to ring from the EBF31A. When either station goes off hook (refer to figure 2 above), talk current is drawn through the EBF31A and the relay on the EBF31A at the bottom of the diagram operates. The right-hand contact provides a ground to the ringing generator module, causing ringing to appear on the blue wire. The left-hand contact provides a holding path for the two phone relays K1, and K2. [These can all be on one contact if you are using a single 12V supply as I did, I separated the grounds to allow for easier substitution of different ringing arrangements].

Let's assume Phone 1 has gone off hook: the second hook switch contact (shown on the diagram, the first one is for tip and ring and isn't shown for clarity) closes and provides an operate path to K1. As K1 operates contact 1 (K1 1 on the diagram) opens, cutting off ringing to Phone 1, so it doesn't ring itself. Contact K1 2 closes providing a path to keep K1 latched up until both phones go back on hook, preventing an unwanted re-ring if Phone were to hang up first. The diode across K1's winding is back biased to short out the inductive spike caused when the relay is released. Phone 2 and K2 are arranged similarly so the circuit is symmetrical. Note that a single ground is shown on Phone 2, this is OK as all the grounds are tied together. This may not work with all ringing generators. If you are substituting ringing supplies, you should contact the author.

When the first phone to hang up goes on hook, the phone relays are both kept operated (and ringing cut off) through the respective contact 2 and the ground from the EBF31A. When the second phone goes on hook, the relay on the EBF31A releases, the ringing generator loses its ground and stops generating the ringing signal (20 Hz @ 75V) and the holding ground to the Phone relays is released. All is ready for the next call.

7. Other Ringing Options

Ringing can be as simple as DC buzzers in or at the telephones, in which case no ringing generator is used and a suitable supply (most likely the existing 12VDC supply) is applied where ringing is shown. You can use the normally closed side of the relay contact used in this diagram to switch +12 to the buzzers which helps control re-rings.

You can also use our Morse Code Buzzer Controller <http://www.modelrailroadcontrolsystems.com/morse-code-buzzer-board/> in which case you don't need the phone relays. The MCBC has 7 "circuits." Use 1 for each of the phones, connect the START leads to a normally open contact on the EBF31A relay and connect the hook switch contact in each phone to one of the STOP leads. You can code each station with a unique telegraph call code or just use something like "- - -" for ringing.

The Power Components ringing generators appear to be surplus from some telecom manufacturer and may not always be available (we've acquired a small stock to support our customers) but there are similar modules around. Check the specs and input and output power ratings and connections before wiring them up. You may also come across ringing generators from larger telephone switch boards or special service assemblies (however if you know what they are and how to use them, you probably don't need this note). Contact the author if you have questions about how to apply them to this circuit.

Other than the MCBC option above, all these circuits ring or buzz continuously. If you want to apply a ringing “cadence,” the Ringing Generator has an “inhibit” lead, (the yellow wire) and if pulled up to (I believe) 5 volts, it cuts ringing off. You could build a timer out of a 555 or a small Arduino to create a ringing pattern that meets your needs. For a simple on/off pattern the 555 might be cheaper, but an Arduino allows great control of the ringing pattern. Many system ringing supplies have a “motor start” input (goes back to when the ringing generator was a magneto with a timing chain driving an interrupter to make both ringing and a ringing cadence) that can be used for this purpose.

8. Any Questions:

Contact Seth Neumann at Model Railroad Control Systems
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