

## INSTRUCTION & MAINTENANCE

### SE-3 60 HZ STEADY ENERGY PHASE SELECTIVE TRACK CIRCUIT

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VERSION C.2



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## DOCUMENT HISTORY

Version	Release Date	Details of Change
A		Initial release
B	July 2011	<ul style="list-style-type: none"> <li>• Grammatical and detail clarification changes throughout manual.</li> <li>• Updated SE-3 photos with and without Code Reset Circuitry.</li> <li>• Deleted ST-9 Track Feed Inductor references throughout.</li> <li>• Page 1-3 added note describing usage difference between ST-7 and ST-8 Inductors.</li> <li>• Section 2 and Figure 3-3 corrected applicable schematics: ST-200-1 is 1:10 step up track transformer.</li> <li>• Re-worded Warning on page 2-6 concerning installation of special equalizer across SE-3 track input terminals and downgraded it to Caution.</li> <li>• Page 3-1 added note that SE-3 must be mounted vertically.</li> <li>• Page 3-1 Upgraded Caution to Warning concerning track leads being fused in electric traction territory or areas with utility power line over-build.</li> <li>• Added paragraph on page 3-2 concerning verifying SE-3 operation after making any adjustments to the track circuit.</li> <li>• Modified heading 3.3 and subsequent paragraphs and tables to clarify track lead lengths and renamed express cable lengths.</li> <li>• Modified figure 3-2 to show track leads and optional insertion of matching transformer with express cable on one or both track lead circuits.</li> <li>• Added note after Table 3-3 concerning track circuit configurations involving long distances.</li> <li>• Page 4-1 upgraded Note to Caution concerning using an isolation transformer when using a dual-trace o'scope.</li> <li>• Page 4-1 added Warning concerning sufficient testing after any adjustment to the track circuit.</li> <li>• Page 4-2 added steps 7 – 9 to Equipment Check Procedure.</li> <li>• Page 4-2 added Warning concerning bypassing insulated joints in electrified territory.</li> <li>• Page 4-2 added Warning concerning when check procedure must be performed.</li> <li>• Section 4 added Track Circuit Post Installation Test procedure and test form.</li> <li>• Modified Table 5-1 Track Circuit Nominal Voltages Without a Shunt.</li> <li>• Expanded Table 5-2 Troubleshooting Chart.</li> <li>• Page 5-2 added Warning concerning changing any tap settings on the secondary side of the ST-400, ST-7 and/or variable track resistor.</li> </ul>
C	September 2011	<ul style="list-style-type: none"> <li>• Bumped manual to version C for consistency and uniformity with changes made to SE-3 83.3 Hz, 91.7 Hz, and 100 Hz manuals.</li> </ul>
C.1	April 2013	<ul style="list-style-type: none"> <li>• Added paragraph describing DC Blocking Unit in Figure 2-2.</li> </ul>
C.2	April 2014	<ul style="list-style-type: none"> <li>• Rebrand for Siemens</li> <li>• Added <math>\pm 10\%</math> to voltage specs on pg. 1-2 and pg. 5-1, Table 5-1</li> </ul>

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## **NOTES, CAUTIONS, AND WARNINGS**

Throughout this manual, notes, cautions, and warnings are frequently used to direct the reader's attention to specific information. Use of the three terms is defined as follows:

### **WARNING**

**INDICATES A POTENTIALLY HAZARDOUS SITUATION WHICH, IF NOT AVOIDED, COULD RESULT IN DEATH OR SERIOUS INJURY. WARNINGS ALWAYS TAKE PRECEDENCE OVER NOTES, CAUTIONS, AND ALL OTHER INFORMATION.**

### **CAUTION**

REFERS TO PROPER PROCEDURES OR PRACTICES WHICH IF NOT STRICTLY OBSERVED, COULD RESULT IN A POTENTIALLY HAZARDOUS SITUATION AND/OR POSSIBLE DAMAGE TO EQUIPMENT. CAUTIONS TAKE PRECEDENCE OVER NOTES AND ALL OTHER INFORMATION, EXCEPT WARNINGS.

### **NOTE**

Generally used to highlight certain information relating to the topic under discussion.

If there are any questions, contact Siemens Industry Inc., Rail Automation Application Engineering.

## ELECTROSTATIC DISCHARGE (ESD) PRECAUTIONS

Static electricity can damage electronic circuitry, particularly low voltage components such as the integrated circuits commonly used throughout the electronics industry. Therefore, procedures have been adopted industry-wide which make it possible to avoid the sometimes invisible damage caused by electrostatic discharge (ESD) during the handling, shipping, and storage of electronic modules and components. Siemens Industry, Inc., Rail Automation has instituted these practices at its manufacturing facility and encourages its customers to adopt them as well to lessen the likelihood of equipment damage in the field due to ESD. Some of the basic protective practices include the following:

- Ground yourself before touching card cages, assemblies, modules, or components.
- Remove power from card cages and assemblies before removing or installing modules.
- Remove circuit boards (modules) from card cages by the ejector lever only. If an ejector lever is not provided, grasp the edge of the circuit board but avoid touching circuit traces or components.
- Handle circuit boards by the edges only.
- Never physically touch circuit board or connector contact fingers or allow these fingers to come in contact with an insulator (e.g., plastic, rubber, etc.).
- When not in use, place circuit boards in approved static-shielding bags, contact fingers first. Remove circuit boards from static-shielding bags by grasping the ejector lever or the edge of the board only. Each bag should include a caution label on the outside indicating static-sensitive contents.
- Cover workbench surfaces used for repair of electronic equipment with static dissipative workbench matting.
- Use integrated circuit extractor/insertion tools designed to remove and install electrostatic-sensitive integrated circuit devices such as PROM's (OK Industries, Inc., Model EX-2 Extractor and Model MOS-40 Insertion (or equivalent) are highly recommended).
- Utilize only anti-static cushioning material in equipment shipping and storage containers.

For information concerning ESD material applications, please contact the Technical Support Staff at 1-800-793-7233. ESD Awareness Classes and additional ESD product information are also available through the Technical Support Staff.



## SECTION 1 INTRODUCTION

### 1.1 GENERAL DESCRIPTION

The SE-3 60 Hz Receiver (Figure 1-1) is a general purpose, vital, steady energy track circuit used for the detection of train presence and/or broken rail in electric traction territory, or where high levels of induced AC interference occur. It can be used with impedance bonds for traction current return or with either balanced or unbalanced (single rail) track circuits using insulated joints without impedance bonds. Recommended industry shunting sensitivity and excellent immunity to traction current interference, as well as EMI from "chopper" motor controls or AC traction motors, make it ideal for applications where other types of track circuits experience operational difficulty. It is mutually compatible with audio frequency track circuits.



**Figure 1-1. Model SE-3 60 Hz Receiver Without & With Code Reset**

In general, an SE-3 track circuit consists of a tapped feed step-down transformer and a series feed reactor at the transmit end (optional variable resistor for making small adjustments to the transmit voltage/current), with a track transformer, receiver and biased-neutral relay at the receive end. All required equipment utilizes AREMA binding posts for connections. The components making up the SE-3 system include the Receiver, Track Relay, Track Feed Inductor, Signal Transformer, and Receiver Track Transformer. (A Receiver with code reset option is also available). See paragraph 1.3 *ORDERING INFORMATION* for part numbers.

Local power supply common to both transmit and receive ends of the track circuit is required as interference rejection and track polarity are determined by phase comparison to this reference local power supply. Power for this may be supplied by a sine wave converter or modified sine wave inverter.

## 1.2 SPECIFICATIONS

<b>Track circuit length:</b>	500 to 6000 feet @ 3 ohms per 1000 feet minimum ballast resistance with two 1-ohm impedance bonds. Up to 10,000 feet for higher ballast resistance and/or higher resistance impedance bonds (see track circuit tables in section 3)
<b>Local reference voltage:</b>	105 to 125 VAC, 60 Hz $\pm$ 10%
<b>Local receiver current:</b>	75 mA maximum
<b>Phase angle relationship:</b>	40° $\pm$ 20°, track lagging local reference for optimum operation
<b>Shunting sensitivity:</b>	250 to 500 milliohms at any point
<b>Dielectric breakdown - circuit to chassis, circuit to circuit:</b>	3000 VAC, 60 Hz
<b>Traction environment:</b>	DC to 60 Hz
<b>Interference rejection:</b>	Normal operation with up to 140 volts 60 Hz or 25 Hz at receiver input terminals
<b>Receiver track fuses:</b>	10 amp, 600 volt recommended <b>Note:</b> Higher current fuses will not affect safety of operation, but may result in damage to the equipment
<b>Operating temperature range:</b>	-40 °C to 71 °C (-40 °F to 160 °F)
<b>Mounting:</b>	Relay rack (Safetran ST, ALSTOM B) or backboard

### **WARNING**

**FOR OPTIMUM SYSTEM PERFORMANCE THE LOCAL OR REFERENCE FREQUENCY MUST BE KEPT WITHIN PLUS OR MINUS 2 HZ OF THE DESIGNED OPERATING FREQUENCY.**

**Specifications continued:****Dimensions:**

<b>Equipment Description (See Note below)</b>	<b>W x H x D (In)</b>	<b>Weight (lb)</b>	<b>W x H x D (cm)</b>	<b>Weight (kg)</b>
ST-7 Inductor -	5.0 x 7.25 x 8.75	19	12.7 x 18.42 x 22.23	8.62
ST-8 Inductor -	5.0 x 7.25 x 8.75	13	12.7 x 18.42 x 22.23	5.90
ST-400-1 Feed Transformer -	5.0 x 7.25 x 8.75	20	12.7 x 18.42 x 22.23	9.07
SE-3 Receiver -	5.0 x 7.25 x 9.25	9	12.7 x 18.42 x 23.50	4.08
ST-200-1 Receiver Transformer -	5.0 x 7.25 x 6.25	12	12.7 x 18.42 x 15.88	5.44
400518 Track Relay -	2.5 x 6.25 x 8.25	7	6.35 x 15.88 x 20.96	3.18

**NOTES**

All units listed are similar in size to a double wide ST Relay mounting (ST-2) except #400518 Track Relay which is single ST Relay mounting (ST-1).

In determining when to use either an ST-7 or an ST-8 inductor, the main difference is in the amount of shift you want to see in the phase for a given track circuit. The ST-7 inductor provides for a much greater phase shift than the ST-8.

**1.3 ORDERING INFORMATION**

To order, specify description and part number.

<b>Description</b>	<b>Part Number</b>
Receiver Unit, 60 Hz	A44926-060X
Receiver Unit, 60 Hz with Code Reset	A44926-060RX
Track Relay (2 ohm bias neutral)	400518
Track Repeater Relay	400000 or 400004
Track Feed Inductor (ST-7)	A44903-X
Track Feed Inductor (ST-8)	A44909-X
Receiver Track Transformer (ST-200-1)	A44562-1X
Signal Transformer (ST-400-1)	A44560-21X

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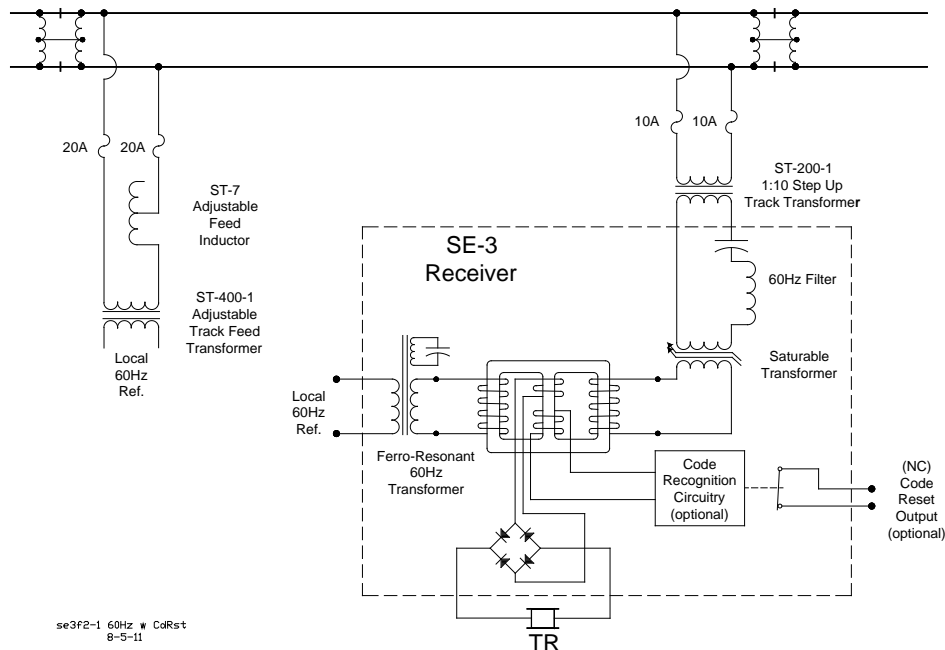
## SECTION 2 THEORY OF OPERATION

### 2.1 SE-3 SYSTEM

For the following discussion, refer to Figure 2-1 (typical double rail track circuit) and Figure 2-2 (typical single rail track circuit).

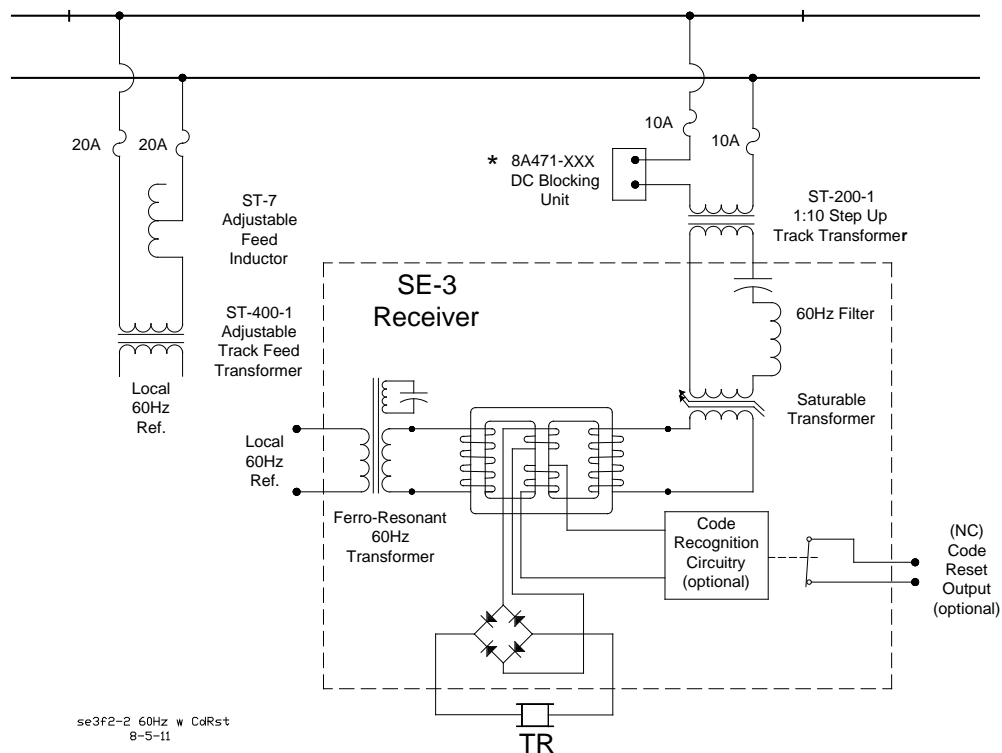
The track feed is applied through a tapped step-down track transformer. A series inductor and adjustable track resistor limits voltage/current and helps provide a lagging phase shift. This track feed is similar in voltage and shunt current to conventional rate-coded cab signals. Setup for entering and feed-end current for proper operation of cab signals is compatible with the requirements of the SE-3 receiver.

The SE-3 Receiver is connected to the track by means of a step-up transformer with a 1:10 ratio. The amplitude and phase of the SE-3 Receiver track voltage is compared with the local reference voltage on the reference line, which is common to the track circuit feed voltage. The SE-3 is a current sensing device, having a low input impedance of approximately 60 ohms when properly phased with the local voltage. This is reflected as an impedance of 0.6 ohms at the track by the 1:10 input transformer. Input impedance is higher for out-of-phase track voltages and is very high for frequencies other than the intended frequency. Consequently, phase and frequency discrimination is excellent, "foreign" frequencies are rejected and the receiver will not load down other audio frequency track circuit equipment which may be on the same track. Voltage at the SE-3 receiver TRACK INPUT terminals is typically 8.5 to 11.5 VAC (10 VAC nominal) with the track circuit not shunted to provide optimum receiver relay drive output voltage.



**Figure 2-1. SE-3 Track Circuit Double Rail Application**

## THEORY OF OPERATION



**Figure 2-2. SE-3 Track Circuit Single Rail DC Propulsion Application**

A DC relay output voltage is provided by the SE-3 to a 2-ohm ST biased neutral track relay (Safetran # 400518 or 400523). The SE-3 relay drive output voltage drops very rapidly as the track input voltage is lowered. Consequently, shunting sensitivity of the SE-3 is excellent. Track relay drop-away with 250-milliohm shunting of the track circuit is assured and 500-milliohm shunting is typical with adequate margin for lowered ballast resistance in adverse conditions.

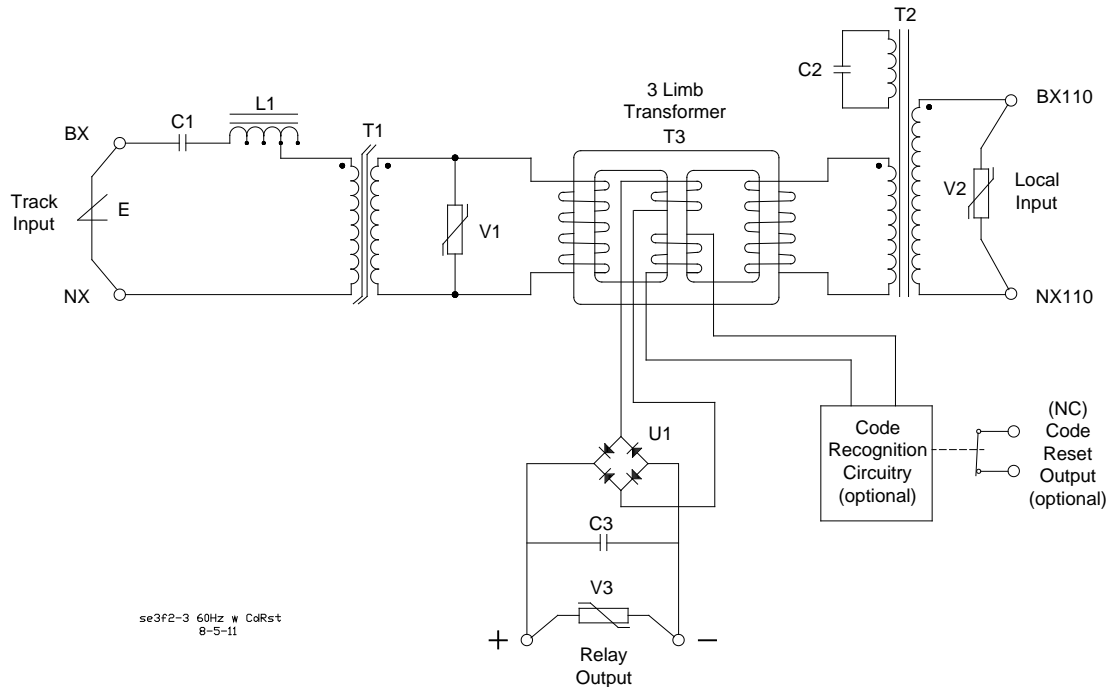
The SE-3 receiver with Code Reset option provides a reset output when used in conjunction with rate-coded cab signals. In a typical application, code is applied when the track relay drops, indicating train presence. When the train departs, the SE-3 receives rate-coded 60 Hz from the track circuit and signal energy. While the SE-3 output relay will not pick up on this code, the (optional) code reset circuitry senses rate codes from 50 to 420 per minute and opens an output relay contact to reset the circuit to steady track energy.

\* The use of an 8A471-XXX (XXX = operating frequency of the SE-3 Track Circuit) DC Blocking Unit in a single rail track circuit may be required where the I/R drop in the traction return rail is excessive. If this condition exists the SE-3 receiver output will typically de-energize or remain de-energized until such time that this blocking unit is installed.

## 2.2 RECEIVER

For the following discussion refer to Figure 2-3, Receiver Unit Schematic.

Track circuit voltage from the external 1:10 track transformer is applied to the TRACK INPUT terminals of the SE-3 Receiver. A series tuned filter passes the 60 Hz track circuit signal and rejects other frequencies. This assists in preventing traction frequencies and other EMI from affecting normal operation. Output from this filter goes to input transformer T1 which has a saturable core to reject high levels of track circuit energy which may occur in a fault situation.



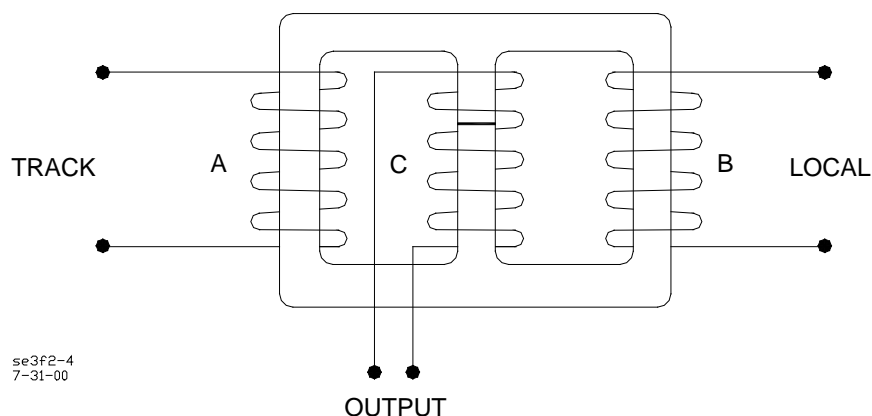
**Figure 2-3. Receiver Unit Schematic**

The local reference (LOCAL INPUT), which is a nominal 115 volts AC at 60 Hz, is applied to a ferroresonant transformer T2 which both regulates and limits the reference signal input in the event of exceptionally high fault voltages. Sine wave, square wave or modified sine wave from an inverter is suitable for the local reference voltage. Variations of + or – 10 volts AC in the nominal 115 volt AC local reference voltage will not have a significant effect on relay drive voltage or shunting sensitivity of the SE-3. Note, however, that track circuit and local reference voltage meter readings may be different from those shown for typical operation if other than a sine wave is used due to variations in averaging when metering non-sinusoidal waveforms.

## THEORY OF OPERATION

The voltages<sup>1</sup> from input transformer T1 and ferroresonant transformer T2 are compared in transformer T3. This is a specially designed three-limb device that acts as a vital "AND" gate; providing drive for relay pick-up from its center leg winding only when the track input voltage is of proper amplitude and phase. Figure 2-4 shows this three-limb transformer in detail.

<sup>1</sup>It is recognized that transformers and relays are current operated, but the term "voltage" is used throughout to simplify the functional explanations of unit operation.

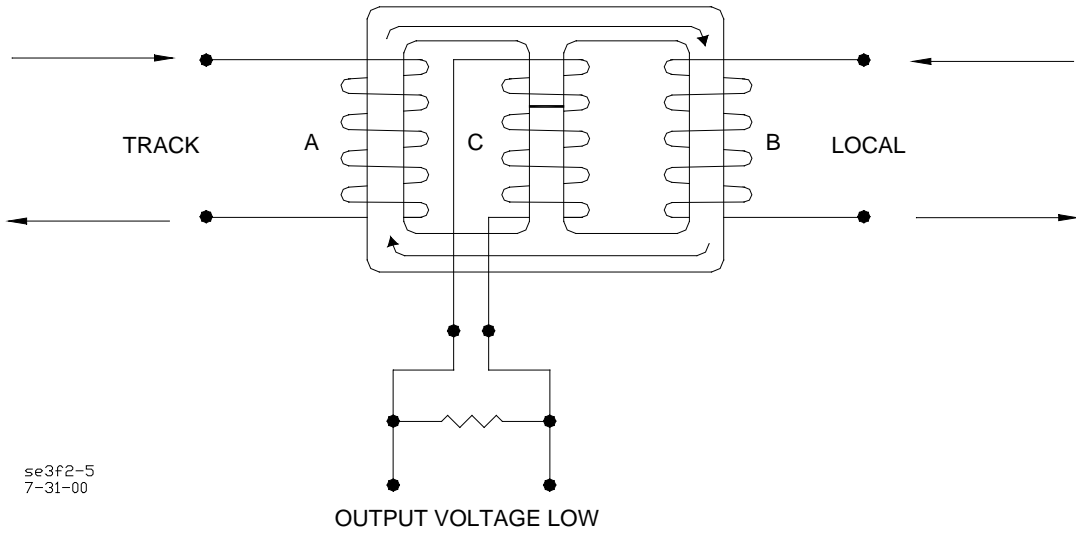


**Figure 2-4. Three-Limb Transformer**

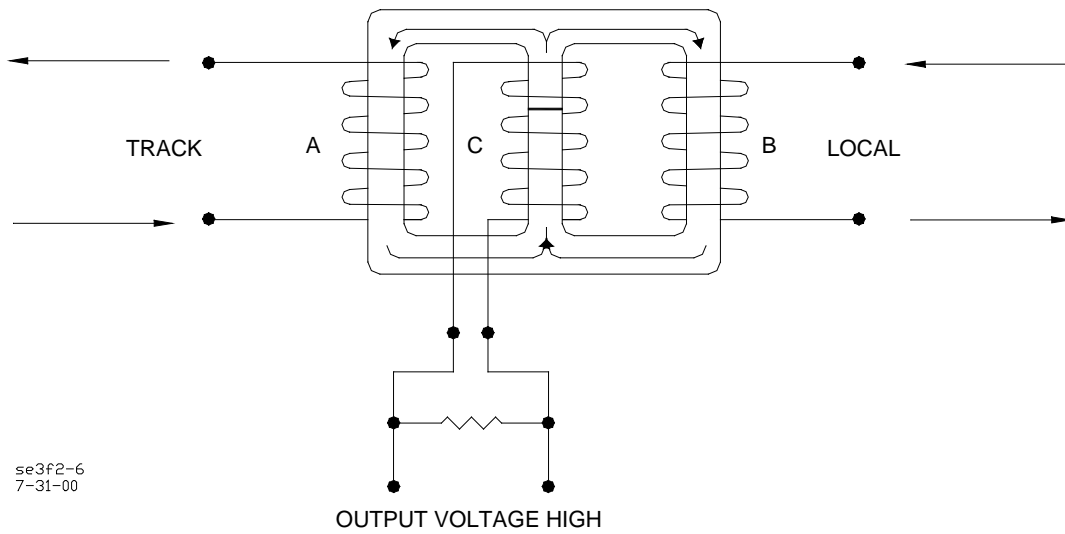
Track circuit voltage appears on winding "A" and local reference voltage on winding "B". Winding "C" on the center leg provides voltage for driving the output to the track relay. A non-magnetic gap is provided in the center leg of the transformer core so its reluctance is much higher than that of the other two legs.

When the voltages on windings A and B are in phase, as shown in Figure 2-5, they produce aiding magnetic flux which flows through the outer cores of the transformer. Therefore, virtually no flux flows in the center leg as its reluctance is much higher because of the non-magnetic gap and winding C output voltage is very low. However, when the voltages on windings A and B are out of phase and approximately equal in amplitude, as shown in Figure 2-6, their respective magnetic fluxes oppose each other and magnetic flux is forced through the center leg despite its higher reluctance. This results in voltage being induced in the center windings and thus relay drive output from winding C.





**Figure 2-5. Track Voltage And Local Reference Voltage In Phase**



**Figure 2-6. Track Voltage And Local Reference Voltage Out Of Phase**

Varistors V1, V2 and V3 provide additional protection against transients entering the receiver unit and causing damage. No fuses are used within the SE-3. No active components are used other than the diode bridge which is well protected from external surges and uses robust 1-amp diodes.

The SE-3 appears as a high impedance to off-frequency traction or power line voltages. The presence of such a high voltage on the TRACK INPUT terminals might affect SE-3 operation, but more importantly, could pose a threat to personal safety without affecting the normal operation of the receiver. For this reason, the SE-3 is supplied with a special equalizer installed across the TRACK INPUT terminals. The equalizer consists of two Safetran 700 equalizer elements in series and has a breakdown voltage rating of 175 to 190 Vrms.

### **CAUTION**

WHERE APPLICABLE DO NOT CONNECT THE SE-3 TRACK INPUT TERMINALS TO THE RAILS UNLESS THE SPECIAL EQUALIZER IS INSTALLED ACROSS THE SE-3 TRACK INPUT TERMINALS.

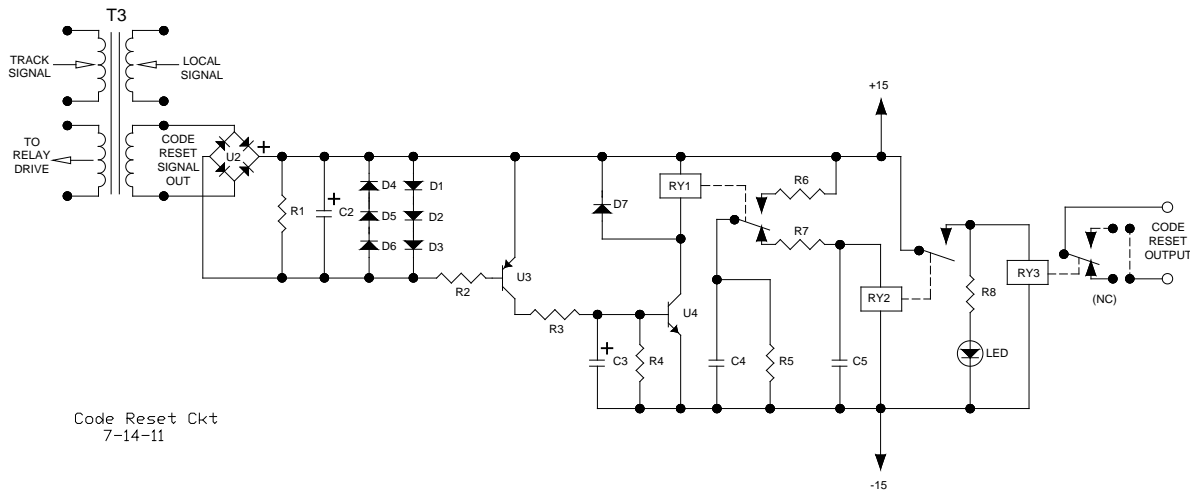
When the track circuit is opened, a low-level voltage that is 180 degrees out of phase with the actual track circuit voltage will appear on the TRACK INPUT terminals due to coupling of the reference voltage back through the three-limb transformer from winding B to winding A. A small voltage of less than 0.2 volts may also appear on the track circuit when the feed end of the circuit is opened. This is not detrimental to the operation of the SE-3 and will not affect another device connected to the track circuit. However, this small voltage may be noted during setup and test.

## **2.3 CODE RESET OPTION**

The optional Code Reset circuitry senses coded energy from the track circuit following departure of a train and provides a reset output to restore steady energy to the track circuit and energize the SE-3 Track Relay.

Code Reset has been integrated into the SE-3 Receiver to take advantage of the extensive signal processing provided in the receiver unit. Besides eliminating a redundant filter, the excellent phase, frequency and EMI discrimination of the SE-3 is utilized. Also, when the SE-3 is adjusted for proper relay drive with steady energy, the code reset level, which is factory adjusted to approximately 75% of relay pickup level, will be correct as well.

Figure 2-7 shows a schematic of the Code Reset circuitry. Coded 60 Hz energy is routed to transformer T3 which provides isolation. Diodes D1 through D6 clamp the voltage for higher than normal levels. This 60 Hz is applied to a diode bridge and the same thresholding occurs in the code reset circuitry as in the SE-3 TR relay drive circuitry. Thus excellent resolution is provided to reject noise. A two transistor DC amplifier provides drive to relay RY1 whenever the SE-3 TR relay output is above 85% of the track relay pickup voltage. Time constants are set so that RY1 will only follow rate codes from 50 to 420 per minute.



**Figure 2-7. Code Reset Circuit**

RY1 will pick up when the SE-3 track input voltage is higher than 75% of track relay pickup and will follow the code when the track is coded at this amplitude or greater. When RY1 follows code, it alternately charges capacitor C4 and then discharges it into capacitor C5 and the RY2 coil. After 3 to 5 code pulses, C5 becomes charged to the point that relay RY2 will pick up and in turn pick up RY3. If steady energy is present, RY1 will pick up and stay up as long as track circuit energy is present. However, RY2 and RY3 will not pick up as C5 will not be charged. An LED is provided on the front panel to indicate that RY2 is picked up and a reset is present. RY2 and RY3 will remain picked up for 3 to 4 seconds after coded energy stops because of the slugging by capacitor C5.

This provides adequate time for external relay operation to get the code turned off before RY3 drops and the reset circuit is closed. Code reset output is connected for normally closed (NC) unless otherwise specified. Optionally, a normally-open contact of RY3 may be internally wired to the CODE RESET output terminals.

While the code reset circuitry is designed to be reliable and rugged, it is not intended to be fail-safe. Failure of the circuitry can only result in cab signal failure which, though undesirable, is inherently safe. Reliability is enhanced by providing excellent isolation from external surges and transients for the transistor amplifier and miniature relays.

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## SECTION 3 INSTALLATION

### 3.1 INITIAL INSTALLATION AND SET-UP

- SE-3 receiver and associated components must be located in a clean, dry location.
- It is recommended that the track relay be mounted or installed in the same enclosure as the SE-3 receiver.
- Again it is recommended that relay contacts not be introduced between the SE-3 receiver and the track relay due to the low resistance of this circuit.
- Mount the units on a relay rack using standard mounting hardware, if mounted on a wood back-board, use suitable wood screws.
- For back-board mounting, a back-board mounting adapter for the track relay is available from Siemens Industry, Inc., Rail Automation. See relay section of Siemens Signal Catalog.

#### NOTE

The SE-3 unit must be installed with the orientation shown in the figure below.



#### WARNING

**IN ELECTRIC TRACTION TERRITORY OR AREAS WITH UTILITY POWER LINE OVER-BUILD, TRACK LEADS MUST BE FUSED TO PREVENT INCURSION OF VOLTAGE FROM SEVERE FAULTS. ONE FUSE MUST BE USED IN EACH TRACK LEAD. RECOMMENDED FUSES ARE 10 AMPS WITH MINIMUM 600 VOLT RATING.**

#### CAUTION

HIGHER CURRENT FUSES WILL NOT AFFECT SAFETY OF OPERATION, BUT MAY RESULT IN DAMAGE TO THE EQUIPMENT.

At the transmit end of the track circuit, a Safetran ST-400-1 (US&S WT-400 or ALSTOM UT) universal transformer can be used to obtain the recommended track drive voltage. This may be coded for cab signal applications.

**WARNING**

**LOCAL REFERENCE 110 VOLT AC TERMINALS (LOCAL INPUT) OF THE RECEIVER MUST BE EQUIPPED WITH THE INSULATED NUTS PROVIDED TO MINIMIZE SHOCK HAZARD. POWER MUST BE APPLIED ONLY AFTER THE UNIT IS INSTALLED AND INSULATED NUTS ARE IN PLACE TO AVOID PERSONAL INJURY.**

Initial track circuit setup and adjustment should be performed using the Track Circuit Adjustments in Table 3-4 through Table 3-9 as a guideline. It is recommended to start with the lowest track voltage setting of 1.0 VAC and gradually increase it to the final recommended voltage. There are no adjustments on the SE-3 receiver. All key adjustments are done at the transmit end of the track circuit. Adjustments per the Track Circuit Tables will aide in providing voltages close to the nominal operating levels.

Following any adjustments of the track circuit it is essential to verify the operation of the SE-3 track circuit by placing a test shunt adjusted to the recommended shunting sensitivity on the feed end of the track circuit and observe the track relay is in the de-energized position. Remove the shunt and observe the track relay energizes. Repeat this test at mid-point and relay ends of the track circuit. Perform additional track circuit tests per railroad/agencies standard practices and procedures. (Test shunt as defined by railroad and/or regulatory agency (0.06 ohm and/or 0.250 ohm)).

400518 Track Relay Operating Characteristics:

- Relay pick-up level is nominally 0.370 volts DC.
- Drop-away level is nominally 0.275 volts.
- Working voltage is normally 0.415 to 0.450 volts depending on track circuit ballast variations and requirements for cab signal current.

It may be necessary to modify the working voltage value to obtain proper cab signal current levels.

In some instances, it may be necessary to feed coded track energy and steady track energy into separate track feed transformer taps to attain proper operating levels for both coded cab current and SE-3 relay operation. However, the system is designed such that normally when the track feed is adjusted so that levels at the SE-3 are correct, cab signal levels will be proper as well.

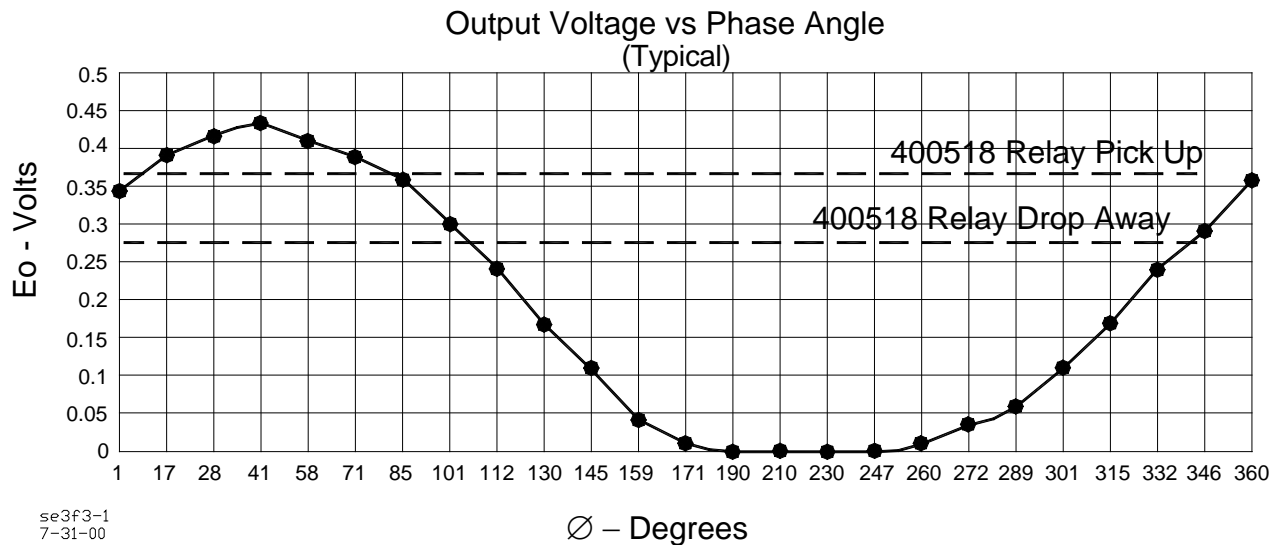
Either a digital voltmeter, TS-111 or Triplett Model 2000 - 2002 rate code meter may be used for measuring relay, track input and reference or local voltages. Therefore, if additional resistance appears in the circuit when a current measuring meter is inserted, readings will be lower with the meter in the circuit and higher when it is removed. Thus, a voltmeter should be used for determining relay operating levels when adjusting the SE-3.

The phase angle of the track voltage at the SE-3 receiver should lag the local reference voltage by approximately 20-60° under optimal conditions (refer to Figure 3-1). The combination of reactance of the series feed inductor together with the track circuit reactance and variable resistor will normally provide this phase shift when adjusted according to the Track Circuit Tables below. Increase feed inductance to increase phase angle and decrease feed inductance to decrease phase angle.

While the SE-3 is unaffected by audio frequency track circuits or foreign current from AC traction or power lines, these voltages may give erroneous meter readings at the track circuit and/or reference voltage terminals. If this is suspected, an oscilloscope or frequency selective voltmeter should be used to determine the presence of unintended or unknown frequencies.

If practical, unintended or unknown frequencies observed on the track circuit should be identified and if possible removed during or prior to track circuit setup. If this is not possible then ensure the track circuit operates as intended for the given conditions by ensuring these frequencies do not affect the operation of the track circuit.

Reverse the track circuit terminals at the receiver to determine the effect of a 180 degree phase reversal. Relay drive must be less than 0.10 volts with phase reversed. If the adjacent track circuits are also 60 Hz, but of reversed phase, jumper the insulated joints with the track feed for the SE-3 track circuit removed to assure that the relay drive is less than 0.10 volts.



**Figure 3-1. Phase and Output Voltage Relationship**

### 3.2 TYPICAL OPERATING LEVELS

**Table 3-1. Typical SE-3 60 Hz Operating Levels**

Reference or local voltage	105 to 125 volts AC
Frequency	60 Hz
SE-3 track input voltage	8.5 to 11.5 VAC (10 VAC nominal)
Relay pick-up	0.370 volts DC
Relay drop-away	0.275 volts DC
Normal relay working voltage	0.415 to 0.450 VDC (0.42 VDC nominal)
Track circuit shunting sensitivity	150 to 500 milliohms at any point

### 3.3 TRACK LEAD AND EXPRESS CABLE LENGTHS

Introduction of resistance in the track leads can have an adverse effect on SE-3 track circuit operation, including shunting sensitivity. Track lead resistance reduces the Q of the entire track circuit system, and this adversely affects the phase relationship between track and local inputs at the receiver.

The characteristic impedance of a typical track circuit without impedance bonds is 1 to 5 ohms, and is 0.25 to 1.0 ohms with impedance bonds. These values will vary with track length and ballast resistance. Since the allowable track lead resistance is proportional to the track circuit impedance, allowable track lead resistance and length will vary. Table 3-2 lists recommended maximum lead lengths, but can be longer depending upon the application.

**Table 3-2. Track Lead Wire Lengths With & Without Z Bonds**

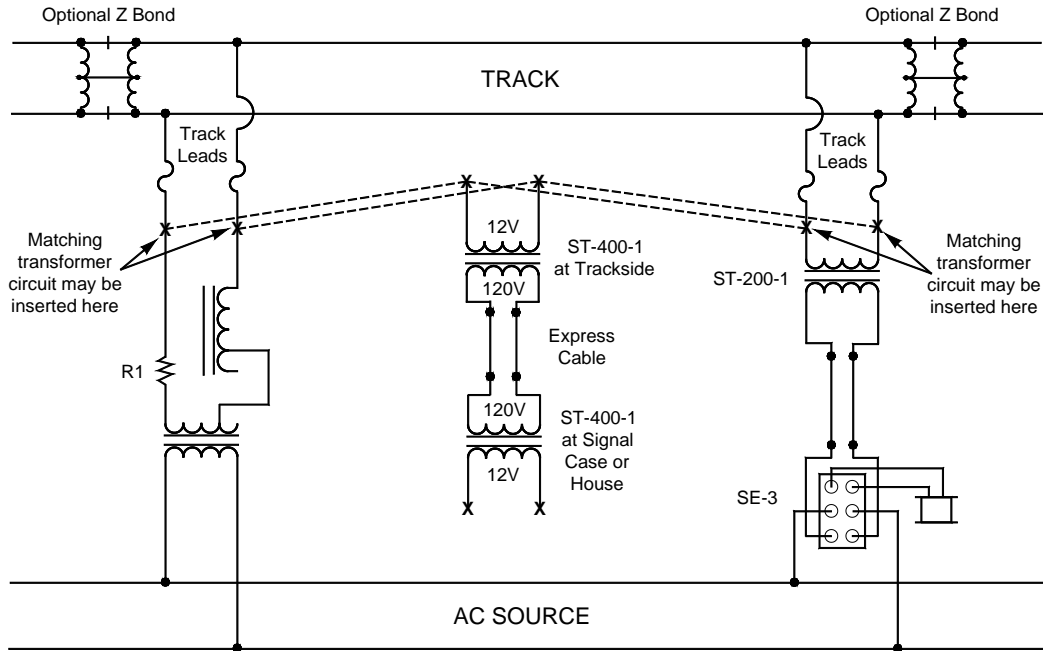
Track Circuit Length	Track Lead Gauge	Lead Length with 1-Ohm* Z Bond	Lead Length with 4-Ohm Z Bond	Lead Length without Z Bond
1000 – 3000'	#9	75'	100'	150'
3000 – 10,000'	#9	100'	150'	200'
1000 – 3000'	#6	150'	200'	300'
3000 – 10,000'	#6	200'	300'	400'

\* Impedance bonds 1 ohm @ 100 Hz, 0.6 ohm @ 60 Hz.

Track lead lengths in Table 3-2 are total length of transmit plus receive circuit length, from signal house or case to track connections.

If required, track lead lengths that exceed the values shown in Table 3-2 can be achieved by adding impedance matching transformer(s) and express cable(s). See Figure 3-2.





se3f3-2 Imped Match Xfms  
9-7-11

**Figure 3-2. Impedance Matching Transformers to Allow Longer Track Lead Lengths**

Since impedance is reflected as the square of the turns ratio in a transformer, the 1:10 ratios of the ST200-1 and ST400-1 transformers shown in Figure 3-2 will provide an apparent reduction of 100X in express cable length. Thus values in Table 3-2 may be increased significantly and smaller wire may be used for express cable circuits. See Table 3-3.

**Table 3-3. Express Cable Lengths With Impedance Matching Transformers & Z Bonds**

Track Circuit Length	Cable Wire Gauge	Cable Length with 1-Ohm* Z Bond	Cable Length with 4-Ohm Z Bond	Cable Length without Z Bond
1000 – 3000'	#14	750'	1000'	1500'
3000 – 10,000'	#14	1000'	1500'	2000'
1000 – 3000'	#10	1500'	2000'	3000'
3000 – 10,000'	#10	2000'	3000'	4000'

\* Impedance bonds 1 ohm @ 100 Hz, 0.6 ohm @ 60 Hz.

**NOTE**

Contact Siemens Industry, Inc., Rail Automation for other possible track circuit configurations involving long distances between the track and equipment.

The above values are based upon no more than 100' of #6 track lead length (transmit + receive) between track and trackside matching transformer(s).

### 3.4 TRACK CIRCUIT ADJUSTMENT TABLES

For initial track circuit setup and adjustment, refer to Track Circuit Adjustment Table 3-4 through Table 3-9 and the track circuit adjustment schematic in Figure 3-3. These values can be used as a starting point and feed voltage adjusted to obtain the optimum relay drive and shunting sensitivity. When in doubt, start at the lowest track setting possible and increase accordingly.

**Table 3-4. Trk Ckt: No Z Bond, 3 Ω / 1000' Ballast, 0.5 Ω Shunting Sensitivity**

Track Circuit Length (feet)	ST-400-1 Tap (Volts)	ST-8 Tap (tap numbers)	R1 (Ohms)
7000	8	2-7	0.2
6000	7	2-8	0.2
5000	6	1-2	0
4000	6	1-4	0
3500	6	1-5	0
3000	5	1-4	0
2500	5	1-6	0
2000	4	1-5	0
1500	4	1-5	0
1000	4	1-6	0
500	3	1-6	0

**Table 3-5. Trk Ckt: No Z Bond, 5 Ω / 1000' Ballast, 0.5 Ω Shunting Sensitivity**

Track Circuit Length (feet)	ST-400-1 Tap (Volts)	ST-8 Tap (tap numbers)	R1 (Ohms)
9000	7	2-6	0.2
8000	6	2-5	0.2
7000	6	2-7	0.2
6000	6	2-8	0.2
5000	5	1-2	0
4000	5	1-3	0
3500	5	1-4	0
3000	5	1-5	0
2500	4	1-4	0
2000	4	1-5	0
1500	4	1-6	0
1000	4	1-6	0
500	3	1-6	0

**Table 3-6. Trk Ckt: No Z Bond, 10  $\Omega$  / 1000' Ballast, 0.5  $\Omega$  Shunting Sensitivity**

Track Circuit Length (feet)	ST-400-1 Tap (Volts)	ST-8 Tap (tap numbers)	R1 (Ohms)
10000	7	2-7	0.2
9000	6	2-7	0.2
8000	6	2-8	0.2
7000	6	1-2	0
6000	6	1-4	0
5000	5	1-4	0
4000	5	1-5	0
3500	5	1-5	0
3000	5	1-6	0
2500	4	1-5	0
2000	4	1-6	0
1500	4	1-6	0
1000	4	1-7	0
500	3	1-6	0

**Table 3-7. Trk Ckt: 1  $\Omega$  Z Bond\*, 3  $\Omega$  / 1000' Ballast, 0.15  $\Omega$  Shunting Sensitivity**

Track Circuit Length (feet)	ST-400-1 Tap (Volts)	ST-7 Tap (tap numbers)	R1 (Ohms)
6000	8	2-4	0
5000	7	2-4	0
4000	7	2-6	0
3500	7	2-7	0
3000	7	2-7	0
2500	7	1-5	0
2000	7	1-6	0
1500	7	1-6	0
1000	7	1-7	0

\* Impedance bonds are 1 ohm @ 100 Hz, 0.6 ohm @ 60 Hz

**Table 3-8. Trk Ckt: 1 Ω Z Bond\*, 5 Ω / 1000' Ballast, 0.15 Ω Shunting Sensitivity**

Track Circuit Length (feet)	ST-400-1 Tap (Volts)	ST-7 Tap (tap numbers)	R1 (Ohms)
7000	8	4-6	0.2
6000	7	2-4	0
5000	7	2-5	0
4000	7	2-6	0
3500	7	2-7	0
3000	7	1-5	0
2500	7	1-5	0
2000	7	1-6	0
1500	7	1-6	0
1000	7	1-7	0

\* Impedance bonds are 1 ohm @ 100 Hz, 0.6 ohm @ 60 Hz

**Table 3-9. Trk Ckt: 1 Ω Z Bond\*, 10 Ω / 1000' Ballast, 0.15 Ω Shunting Sensitivity**

Track Circuit Length (feet)	ST-400-1 Tap (Volts)	ST-7 Tap (tap numbers)	R1 (Ohms)
8000	8	4-6	0.2
7000	8	3-5	0.2
6000	7	3-7	0
5000	7	2-5	0
4000	7	1-4	0
3500	7	2-7	0
3000	7	1-5	0
2500	7	1-6	0
2000	7	1-6	0
1500	7	1-7	0
1000	7	1-8	0

\* Impedance bonds are 1 ohm @ 100 Hz, 0.6 ohm @ 60 Hz

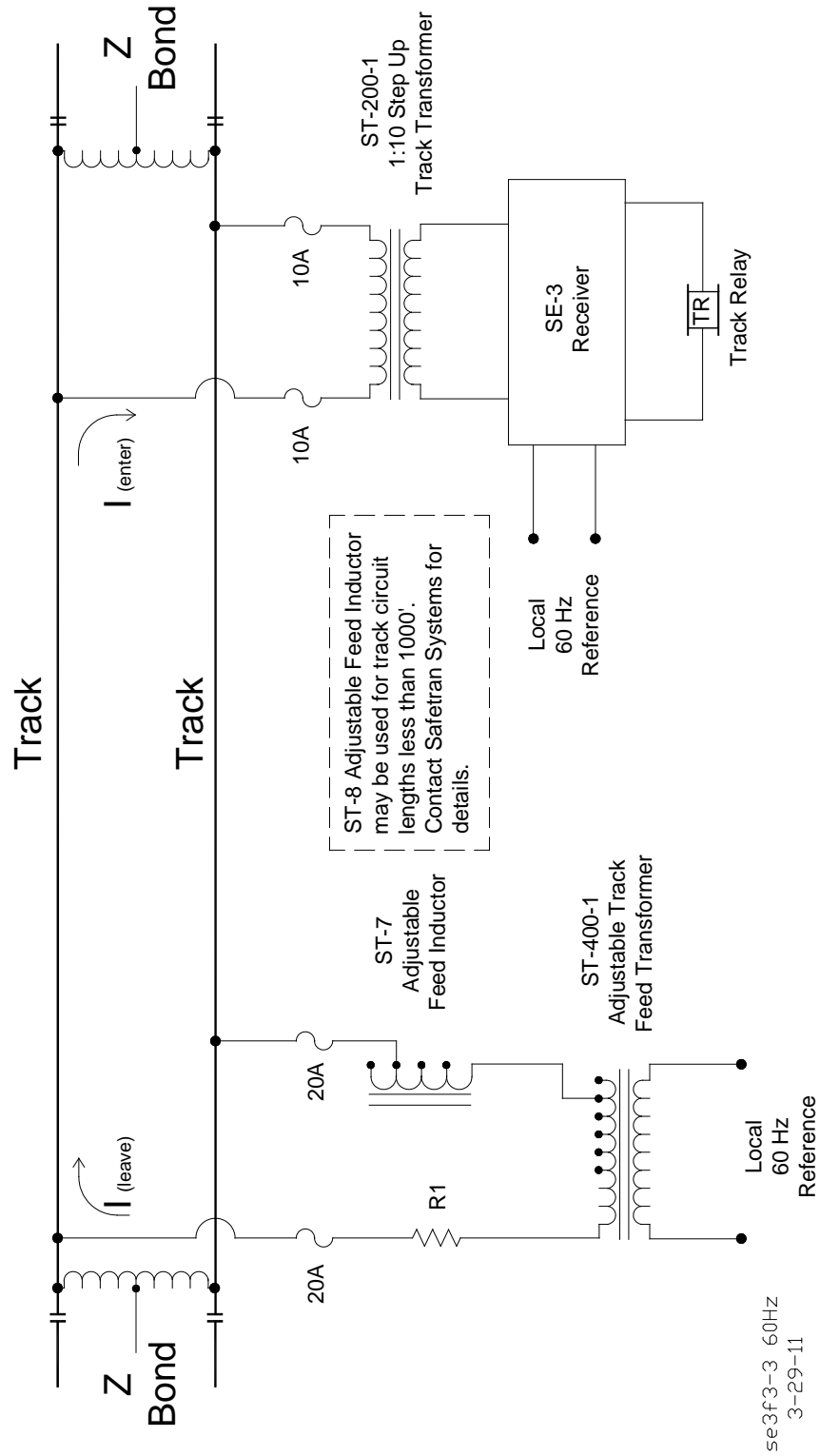


Figure 3-3. Track Circuit Adjustment Schematic

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## **SECTION 4 ADJUSTMENT & MAINTENANCE**

### **4.1 GENERAL**

The SE-3, like other vital safety devices, must be tested periodically to ensure safe operation. Testing should be performed at installation and subsequently thereafter according to railroad standard practices and procedures.

#### **WARNING**

**OBSERVE ALL SAFETY PRECAUTIONS WHEN WORKING WITH 110 VOLT AC REFERENCE OR LOCAL CIRCUITS, TRACK CIRCUITS IN ELECTRIC TRACTION TERRITORY, OR OTHER CIRCUITS WHICH MAY CARRY HIGH VOLTAGE.**

### **4.2 TEST EQUIPMENT RECOMMENDED**

- Portable digital voltmeter such as a Fluke Model 189 or equivalent, Simpson TS-111, Triplett Model 2000-2002.
- Dual-trace portable oscilloscope (can be effective in locating sources of interference or improper phase shift in the track circuit).

#### **CAUTION**

WHEN USING A DUAL-TRACE OSCILLOSCOPE, BE SURE TO USE AN ISOLATION TRANSFORMER ON BOTH THE TRACK AND LOCAL REFERENCE TERMINALS TO AVOID TYING THE TWO SOURCES TOGETHER WITH THE COMMONS OF THE TWO CHANNEL OSCILLOSCOPE LEADS.

### **4.3 EQUIPMENT CHECK PROCEDURE**

All key adjustments needed to obtain the required AC input voltage to the SE-3 receiver should be made at the feed end of the track circuit. If required, the receiver track circuit voltage can be adjusted by changing taps on the track feed transformer secondary (ST-400) and/or track reactor (ST-7 or 8). If the SE-3 track circuit input voltage is low, increase feed end track voltage; if high, decrease feed end track voltage.

#### **WARNING**

**FOLLOWING ANY ADJUSTMENT OF THE TRACK CIRCUIT SUFFICIENT TESTING MUST BE PERFORMED TO ENSURE THE TRACK CIRCUIT IS OPERATING AS INTENDED AND PER RAILROAD OR AGENCY REQUIREMENTS.**

1. Check to make sure all terminals on the track circuit equipment are tight.
2. Measure the voltage across the SE-3 LOCAL INPUT terminals (BX110 and NX110). Voltage should be 105 to 125 volts AC.

**NOTE**

If using a Fluke digital or other meter that provides a frequency readout, also measure the frequency which should be approximately 60 Hz.

3. Measure the voltage across the TRACK INPUT terminals (BX and NX). Level should typically be between 8.5 to 11.5 VAC (10 VAC nominal) when the track is not shunted.
4. Measure the voltage across the relay terminals. This should typically be between 0.415 to 0.450 volts DC with the track not shunted.
5. Shunt the track with a 250 milliohm shunt (or other value as specified by the railroad or agency). Verify that the voltage across the relay terminals drops below 0.275 volts and that the relay de-energizes. Remove the shunt and observe the relay energizes.
6. Reverse the phase of the track wires at the receiver. Verify that the relay voltage drops below 0.10 volts and that the track relay remains de-energized. Restore the track wires to proper phase and observe the track relay energizes.

**WARNING**

**CARE MUST BE USED WHEN BYPASSING  
INSULATED JOINTS IN ELECTRIFIED  
TERRITORY.**

7. With the SE-3 track circuit feed disconnected, jumper (bypass) both insulated joints at the relay end and observe the track relay stays de-energized. Verify that the relay voltage drops below 0.10 volts. This test will verify the phasing of the adjacent track feed to ensure it is reverse and that there is no foreign signal present. Remove the bypass jumpers and reconnect the feed end of the track circuit.
8. If the optional code reset receiver is used, code at all applicable code rates to assure that the unit resets. The reset LED indicator can be observed to determine if a reset has been achieved without resetting to steady energy.
9. Cab signal and/or coded track circuit current tests as prescribed by the railroad should also be performed at this time.

There are no adjustments in the SE-3 receiver. If a unit is suspected of being faulty, it should be replaced. No field repairs should be attempted.

No other periodic field maintenance is required.

**WARNING**

**THE ABOVE PROCEDURE MUST BE  
PERFORMED WHEN ANY COMPONENT /  
EQUIPMENT IN THE TRACK CIRCUIT IS  
CHANGED OR MODIFIED (E.G. ST-7, ST-200,  
ST-400, ETC.).**



#### 4.4 SE-3 TRACK CIRCUIT – POST INSTALLATION TEST PROCEDURE

##### Purpose:

The purpose of this test procedure is to verify the correct installation, adjustment, and operation of SE-3 track circuit. Performance of this test procedure will assure proper operation of the SE-3 60 Hz track circuit(s). These tests shall be performed during initial commissioning, and thereafter as required. The intent of these tests is to ensure that the SE-3 track circuits are properly installed per the location design, and to perform the required adjustments for their proper operation per railroad and/or manufacturer's specifications.

##### **NOTE**

The **SE-3 Track Circuit Test Form** located at the end of this section should be used to log the test results. It is suggested to make a copy of the test form prior to performing this test procedure.

##### Scope:

The track circuit under test must be installed and adjusted per this SE-3 I&M manual. Siemens Industry, Inc., Rail Automation recommends the use of two qualified employees in support of initial commissioning and setup of the SE-3 track circuit, with one employee located at the feed end and the other located at the relay end of the track circuit. Each must be equipped with a Fluke 189 multimeter or equivalent, an approved shunt, 0.06 or other recommended shunt sensitivity, and a current copy of this SE-3 I&M manual.

##### Test Prerequisites:

Before the track circuit post-installation test can be performed the following tasks must have been previously completed:

- The installer must have carried out the following tests and inspection:
  - Compliance installation with installation drawings.
  - Visual installation quality control.
  - Circuit wiring and wire tag verification.
  - Insulated joints testing.
  - Rail bonding resistance testing.
- SE-3 track circuit equipment in enclosure must be installed and enclosure power must be on.
- No train and/or vehicle must be parked on the track circuit(s).

##### Test Equipment Required:

- Fluke 189 Multimeter or equivalent (2 preferred)

Procedure:

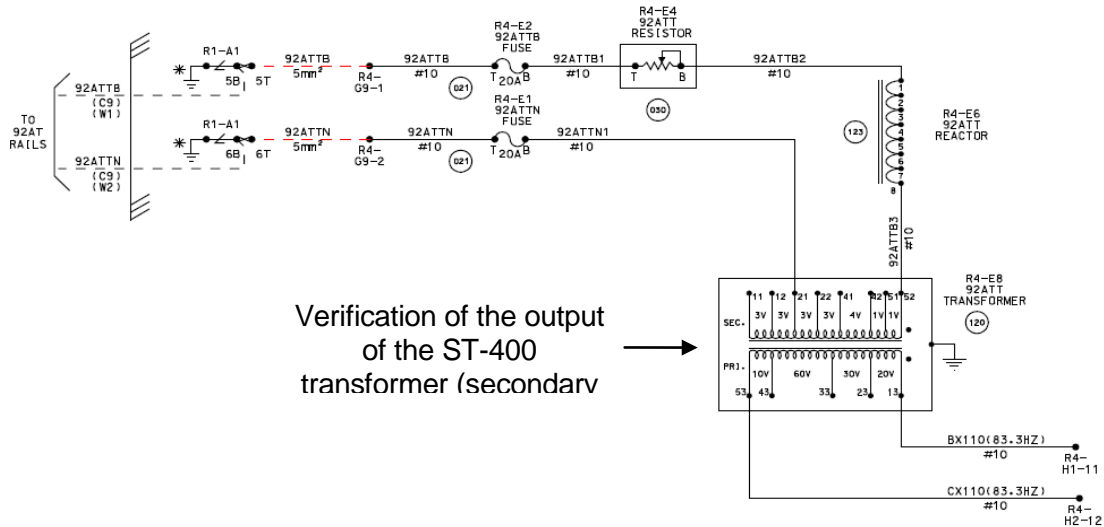
1. Installer checklist review.
  - a. The test engineer must verify on the installer checklist that all verifications have been performed on all items.
  - b. The test engineer must verify on the installer checklist that all discrepancies and punch items have been cleared. Note, some discrepancies can be cleared later, provided they do not affect the operational aspect of the track circuit.
2. The test engineer must visually inspect the workmanship to verify:

**WARNING**

**THE SE-3 TRACK CIRCUIT IS AN AC TRACK CIRCUIT THAT UTILIZES A 110 VAC 60 HZ LOCAL REFERENCE VOLTAGE, THEREFORE PRECAUTIONS MUST BE TAKEN TO AVOID OR MINIMIZE SHOCK HAZARDS.**

- a. Visually inspect all track wire connections, head bonds, and impedance bonds to ensure all connections are proper and in accordance with railroad standards and approved circuit plans/design for the location.
- b. Verify the track wires have been properly identified and installed per the location plan, including correct polarity. Ensure the adjoining track circuit(s) are 180° out of phase from the track circuit under test. To observe the effect of a 180° out of phase track circuit reverse the track wires to the Track Input terminals of the SE-3 receiver. Verify the DC Output relay voltage drops below 0.10 volts DC and the respective track relay de-energizes. Restore the track circuit under test to its original configuration and observe the track relay energizes. After observing this condition disconnect or open the SE-3 track circuit feed by opening the track wires at the feed end of the track circuit. With the use of 2 ea. jumpers, jump around or bypass both insulated joints at the relay end of the track circuit under test. If the polarity of the adjoining track circuit is staggered, 180° out of phase, then the SE-3 DC Output relay voltage for the track circuit under test should drop below 0.10 volts DC and the track relay de-energized. It is recommended to use hardwire #6 bond strand jumpers when performing this test. Remove the jumpers from around the insulated joints at the relay end of the track circuit and close or connect the feed end of the track circuit. Depending on the track circuit configuration and adjustment, i.e. feed/relay, feed/feed, and/or relay/relay, one or both relays may drop when bypassing insulated joints.

3. Track circuit adjustment – feed end. For the following test steps, refer to the typical SE-3 track circuit feed end shown here.



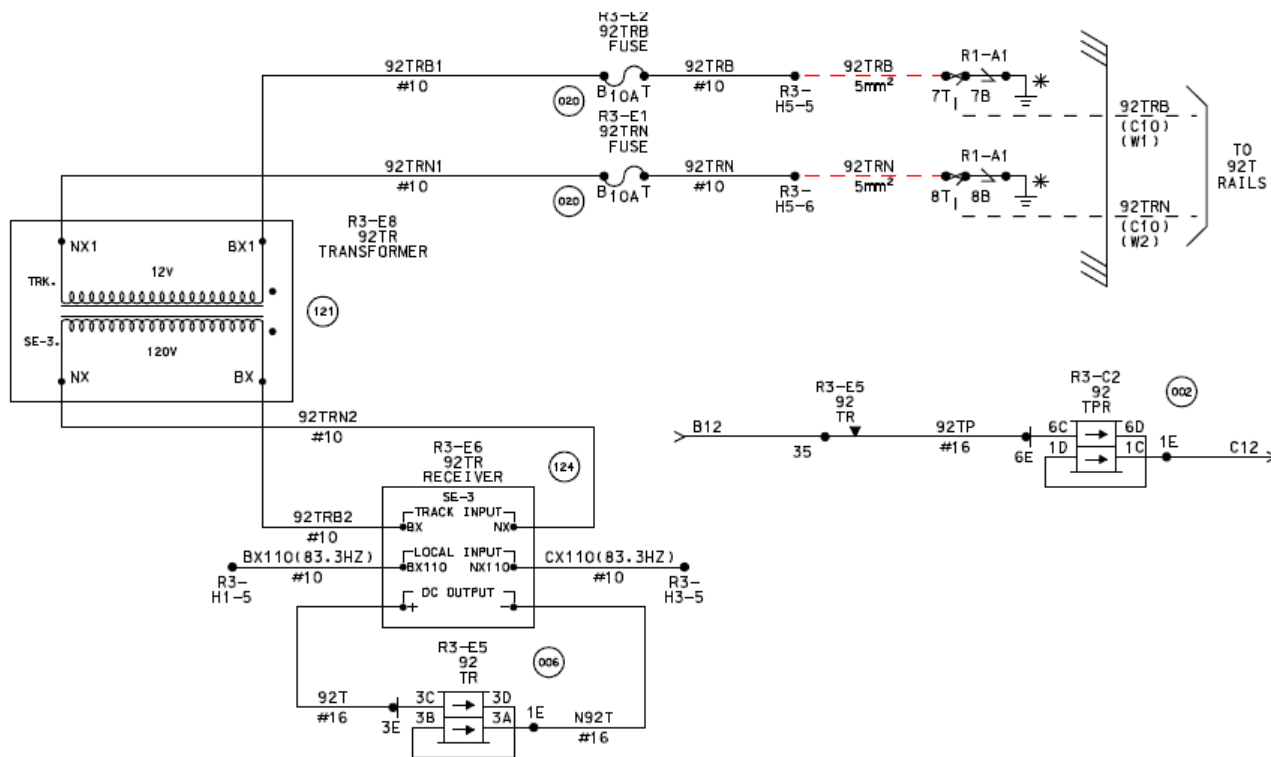
**Figure 4-1. Typical SE-3 Track Circuit – Feed End**

- With the use of a voltmeter (Fluke 189 or equivalent) measure the AC voltage and its frequency on the primary terminals of the ST-400 transformer. Record this reading on the track circuit form.
- During initial commissioning of the track circuit it is recommended that the secondary output voltage of the ST-400 transformer be adjusted to its minimum output voltage, TB wire connected to secondary tap 52 and TN wire connected to secondary tap 51.
- Verify the secondary output voltage of the ST-400 to the track is approx. 1.0 volt AC. Verify this secondary output voltage is also observed on the track.
- Using the track circuit tables provided in section 3.4 of the Instruction & Maintenance manual for the SE-3 60 Hz receiver as a guideline, adjust the reactor, ST-7, taps accordingly.
- Establish communication with the employee at the relay end of the track circuit and verify the track voltage similar in amplitude is also observed on the track at the relay end of the circuit and on the Track input terminals of the ST-200 transformer.

### **CAUTION**

THE ST-200 TRANSFORMER IS A 1:10 RATIO TRANSFORMER THEREFORE 1.0 VAC ON THE TRACK TERMINALS (INPUT FROM THE TRACK) WILL RESULT IN 10.0 VAC ON THE SE-3 TERMINALS (OUTPUT TO THE SE-3 RECEIVER).

4. Track circuit adjustment – relay end. For the following test steps, refer to the typical SE-3 track circuit relay end shown here.



**Figure 4-2. Typical SE-3 Track Circuit – Relay End**

- a. With the use of a voltmeter measure the Local Input voltage and its frequency to the SE-3 receiver. Record this reading on the track circuit form.
- b. With the use of a voltmeter measure the input (Track) and output (SE-3) voltage of the ST-200 transformer at the relay end of the track circuit.
- c. In communication with the employee at the feed end of the track circuit adjust the output voltage of the ST-400, ST-7 reactor, and variable track resistor (R1) in combination as necessary to obtain approximately 10.5 volts AC at  $-40^\circ$  phase angle (Track phase is lagging local phase) as measured at the SE-3 Track Input terminals on the receiver, relay end of the circuit.

**NOTE**

It is recommended to use a dual trace oscilloscope to measure the phase angle between the track and local sources of the SE-3 receiver.

The track relay should now be energized. Refer to the tables in the Section 3.4 of this manual as a guideline. Once you have obtained the desired input voltage, measure and record the AC voltage as observed on the track at both the feed and relay ends of the track circuit.

- d. With approximately 10.5 volts AC on the Track Input terminals of the SE-3 receiver measure and record the DC output voltage on the DC Output terminals of the SE-3 receiver. This reading should be approximately 0.415 - 0.450 VDC and again the track relay should be energized.

#### 5. Functional test

- a. With the use of 0.06 ohm shunt, apply a shunt across the rails at the feed end of the track circuit and observe the track circuit relay under test is de-energized. Measure and record the DC output voltage of the SE-3 receiver on the track circuit form.
- b. Remove the 0.06 ohm shunt from the feed end of the track circuit and observe the track relay under test energizes.
- c. Place a 0.06 ohm shunt across the rails at the relay end of the circuit and observe the track circuit relay under test is de-energized. Measure and record reading on the track circuit form. Remove the 0.06 ohm shunt from the relay end of the track circuit and observe the track relay under test energizes.
- d. Remove the 0.06 ohm shunt from the relay end of the track circuit and observe the track relay under test energizes.
- e. Open one of the track wires at the feed end of the track circuit and verify the track relay de-energizes. Close the track wire at the feed end of the track circuit and observe the track relay energizes. Repeat this step for the other track wire at the feed end of the track circuit.
- f. Open one of the track wires at the relay end of the track circuit and verify the track relay de-energizes. Close the track wire at the relay end of the track circuit and observe the track relay energizes. Repeat this step for the other track wire at the relay end of the track circuit.
- g. At each relay end of the track circuit turnoff or de-energize the 60 Hz 110 VAC power supply for the location and observe the track relay under test de-energizes. Restore power and observe the track relay under test energizes.

6. Record measurements for the track circuit under test.
  - a. For the feed end of the track circuit record:
    - i. AC voltage and frequency to the primary terminals of the ST-400 transformer
    - ii. Final AC output secondary voltage and tap settings of the ST-400 transformer
    - iii. Final tap settings of the ST-7 reactor
    - iv. Final tap setting of the variable track resistor
    - v. Final AC voltage and phase angle as measured on the rails
  - b. For the relay end of the track circuit record:
    - i. AC voltage and frequency to the Local Input terminals of the SE-3 receiver
    - ii. Final AC voltage and phase angle as measured on the rails
    - iii. Final AC input and output voltages of the ST-200 transformer
    - iv. Final Track Input AC voltage and phase on the SE-3 receiver
    - v. Final DC output voltage on the SE-3 receiver
  - c. During functional shunt test record the AC input and DC output voltage of the SE-3 receiver
    - i. SE-3 receiver AC input/DC output voltage with a shunt applied at the feed end of the circuit
    - ii. SE-3 receiver AC input/DC output voltage with a shunt applied at the relay end of the circuit

4.5 SE-3 TRACK CIRCUIT TEST FORM



LOCATION NAME & MP	TRACK CIRCUIT NOMENCLATURE

TRACK CONDITIONS	FEED END MEASUREMENTS AND SETTINGS							
Wet/Dry (W/D)	ST-400 Primary Voltage (VAC)	ST-400 Primary Freq. (Hz)	ST-400 Secondary Voltage (VAC)	ST-400 Tap Setting	ST-7 Tap Setting	Variable TK. Resist Tap Setting	Track Voltage (VAC)	Signature and Date of Person Performing Test

TRACK CONDITIONS	RELAY END MEASUREMENTS							
Wet/Dry (W/D)	Track Voltage (VAC)	Local Voltage (VAC)	Local Freq. (Hz)	ST-200 Input Voltage (VAC)	ST-200 Output Voltage (VAC)	SE-3 Receiver Output Voltage (VDC)	TK/Local Phase Shift Measured on the SE-3 Receiver (Hz)	Signature and Date of Person Performing Test

FEED END FUNCTIONAL TEST			RELAY END FUNCTIONAL TEST		
Track Polarity (√)	SE-3 Receiver Input/Output Voltage w/0.06 Ohm Shunt Applied (VAC/VDC)	Relay de-energized (√)	Track Polarity (√)	SE-3 Receiver Input/Output Voltage w/0.06 Ohm Shunt Applied (VAC/VDC)	Relay de-energized (√)

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## SECTION 5 TROUBLESHOOTING

### 5.1 TROUBLESHOOTING

A properly adjusted track circuit should have nominal voltages as listed in Table 5-1 without a shunt applied at various points in the circuit.

**Table 5-1. Track Circuit Nominal Voltages Without a Shunt**

Primary of feed transformer:	105 to 125 VAC, 60 Hz $\pm$ 10%
Secondary of track feed transformer:	This value will depend on several track circuit factors, length of track circuit, ballast resistance, type of impedance bond used, etc.
Feed end track leads:	3 to 6 VAC for short track circuits, 4 to 10 for long circuits
Receive end track leads:	This value will depend on several track circuit factors, length of track circuit, ballast resistance, type of impedance bond used, etc.
Track circuit receiver terminals:	8.5 to 11.5 VAC (10 VAC nominal)
Local reference receiver terminals:	105 to 125 VAC, 60 Hz $\pm$ 10%
Relay receiver terminals:	0.415 to 0.450 VDC (0.42 VDC nominal)

While it is possible to give an outline of troubleshooting techniques, it is impossible to cover every combination of problems that may occur in the system. Therefore, the methods described in Table 5-2 have been prepared as an outline for localizing faults, and not necessarily as a means of pin-pointing them.

**Table 5-2. Troubleshooting Chart**

<b>Problem</b>	<b>Possible Causes</b>	<b>Check or Try</b>
Low relay voltage, track voltage low	<ul style="list-style-type: none"> <li>• Low ballast resistance.</li> <li>• Excessive impedance bond loading.</li> <li>• Improperly adjusted track circuit.</li> </ul>	<ul style="list-style-type: none"> <li>• Use higher feed transformer tap.</li> <li>• Check both impedance bonds.</li> <li>• Verify track circuit adjustment.</li> </ul>
Zero relay drive voltage	High resistance or open track circuit.	Check track circuit, connections and look for possible broken rail.
Feed transformer voltage low	Improperly adjusted track circuit.	Use higher feed transformer tap and verify track.
Low relay voltage, track voltage OK	<ul style="list-style-type: none"> <li>• Phase reversed (if below 0.10 V).</li> <li>• Improper phase.</li> </ul>	<ul style="list-style-type: none"> <li>• Reverse phase of track or local.</li> <li>• Verify track circuit adjustment.</li> </ul>
Local voltage low or off-frequency	Questionable power supply or source.	Verify load and/or feed, replace inverter if necessary, check feed point connections and cable condition.
Phase angle incorrect	Incorrect reactor setting.	<ul style="list-style-type: none"> <li>• Change feed end reactor tap (see track circuit Table 3-4 thru Table 3-9) .</li> <li>• Verify track circuit adjustment.</li> </ul>
SE-3 receiver unit faulty		Replace receiver.
High interference voltage/foreign signal	Adjacent track circuit(s), bad insulated joints.	Locate source and eliminate or mitigate.
No code reset	<ul style="list-style-type: none"> <li>• Code duty cycle out of range.</li> <li>• SE-3 not seeing track code.</li> <li>• Code reset faulty.</li> </ul>	<ul style="list-style-type: none"> <li>• Adjust duty cycle to reach nominal 50%.</li> <li>• Check for code at track terminals.</li> <li>• Replace receiver unit.</li> </ul>
Equalizer fires often	Excessive voltage across track(s).	Check for shorted insulated joint or fault to rails.

**WARNING**

**CHANGING ANY OF THE TAP SETTINGS ON THE SECONDARY SIDE OF THE ST-400 TRANSFORMER AND/OR REACTOR, ST-7, AND/OR VARIABLE TRACK RESISTOR WILL AFFECT THE OPERATION OF THE SE-3 TRACK CIRCUIT.**

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## NOTES

## NOTES

## NOTES

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