
Issued date: 22 December 2016
Effective date: 22 December 2016
Subject: Withdrawal of legacy RailCorp signalling set to work manuals

This technical note is issued by the Asset Standards Authority (ASA) to notify that the following legacy RailCorp signalling set to work manuals have been withdrawn:

- TMG 1350 DC Track Circuits – Set Up, Test and Certification, version 1.1
- TMG 1351 AC Immune DC Track Circuits – Set Up, Test and Certification, version 1.1
- TMG 1352 Jeumont-Schneider Impulse Track Circuits – Set Up and Adjustment Procedure, version 1.2
- TMG 1353 AC Single Rail Track Circuits – Set Up, Test and Certification, version 1.1
- TMG 1354 AC Double Rail Track Circuits – Set Up, Test and Certification, version 1.1
- TMG 1355 CSEE UM71 AF Jointless Track Circuits – Set Up, Test and Certification, version 1.1
- TMG 1356 WBS FS2500 AF Jointless Track Circuits – Set Up, Test and Certification, version 1.1
- TMG 1357 ML TI21 AF Jointless Track Circuits - Set Up, Test and Certification, version 1.1

Note: All enquiries regarding the technical content of the manuals listed in this technical note should be directed to SydneyTrainsstandards@transport.nsw.gov.au.
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TMG 1352

JEUMONT SCHNEIDER IMPULSE TRACK CIRCUITS SET UP AND ADJUSTMENT PROCEDURE

Version 1.2

Issued May 2013

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Signals & Control Systems

Signal Research & Development

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# Document control

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Summary of change</th>
</tr>
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<tr>
<td>1.0</td>
<td>21/08/2007</td>
<td>Replaced SC 07 42 00 00 WI Jeumont Schneider Impulse Track Circuits – Set-Up, Test and Certification – v 2.0 of 1 November 2001. New RailCorp format</td>
</tr>
<tr>
<td>1.1</td>
<td>March 2013</td>
<td>Application of TMA 400 format</td>
</tr>
<tr>
<td>1.2</td>
<td>16 May 2013</td>
<td>Fixed error in table 2 for the 16 to 17 Ohm range it shows C+ to 6, 1 to 3, 3 to 5. Source document TMG E1360 correctly shows C+ to 6, 1 to 2, 3 to 5. Updated accordingly.</td>
</tr>
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1 Introduction

This procedure describes the activities involved in commissioning and certifying Jeumont-Schneider high-voltage impulse track circuits, in a typical RailCorp installation.

Commissioning a new track circuit consists of removing any old equipment, connecting the new equipment and any new bonding, powering-up the new equipment, then carrying out the final adjustments and certification checks.

The commissioning procedure is described in two stages. Firstly, there are the set-to-work activities, by which the new track circuit is made operational. This is followed by the test and certification phase, when finally adjustments and checks are carried out to ensure that the track circuit is operating correctly and safely. When there are only a few track circuits to be commissioned, the duties can be carried out by a combined team. All care must be taken then, that none of the necessary checks and tests specified in this document are omitted.

Before proceeding with the testing and commissioning of Jeumont-Schneider high-voltage impulse Track Circuits, persons not familiar with their operation are advised to read Appendix B, which gives a concise description of the equipment operating principles and hardware.

This procedure applies to all forms of Jeumont-Schneider track circuit listed in Table 1, below.

<table>
<thead>
<tr>
<th>Type</th>
<th>Track Insulation</th>
<th>Electrified</th>
<th>Matching Device</th>
<th>Rx Conns</th>
<th>Track Length</th>
<th>Tx Loop Res</th>
<th>Min Drop Shunt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Single-rail</td>
<td>Yes</td>
<td>TV-TH1</td>
<td>2-wire</td>
<td>18</td>
<td>500</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Single-rail</td>
<td>Yes</td>
<td>TV-THD2</td>
<td>2-wire</td>
<td>18</td>
<td>400</td>
<td>multifeed</td>
</tr>
<tr>
<td>3</td>
<td>Single-rail</td>
<td>No</td>
<td>TV-THD2</td>
<td>2-wire</td>
<td>50</td>
<td>1500</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Double-rail</td>
<td>Yes</td>
<td>CIT-1400 2000P</td>
<td>4-wire</td>
<td>50</td>
<td>1000</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Double-rail</td>
<td>No</td>
<td>TV-LV</td>
<td>4-wire</td>
<td>50</td>
<td>3000</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 1 - Applicable Track Circuit Arrangements

2 Set to Work

This section describes the activities generally carried out by the set-to-work team. It covers removal of any old track circuit equipment and the connection and powering-up of the new equipment.

2.1 Equipment for Set-to-Work

The following is the minimum equipment required by the set-to-work team:

- Cable cutter, to remove old rail connections,
- Hammer,
- Spanners:
  - 17mm ring or deep socket (bond rail connections)
  - 12 mm tube, insulated (CIT 1400 terminals)
- Terminal Screwdriver, 3mm parallel-blade,
- Multimeter (high-impedance Fluke 27, 8026, 87, or equivalent). Used for AC and DC measurements,
- Switchable shunt box, with 0.25 and 0.5 ohm settings, complete with track clips,
- J/S track circuit manual,
• Track circuit Set-to-Work master sheet, clipboard and pens.

2.2 Staffing for Set-to-Work
The recommended staffing for set-to-work is two competent electricians or equivalent, plus one assistant/lookout. Where bonding and track connections are not 100% prepared, then a bonder and mate with full equipment should be available.

The allocation of set-to-work teams for the commissioning will depend on the level of readiness on commissioning day. Where all connections and bonding are in place, ready for final connection, the allocation should be made on the basis of 1/2 hour per track circuit, for complete set-to-work by a two-man team.

2.3 Clear Old Track Connections
Where an existing signalling system is being renewed, the first step is the removal of all old, redundant track circuit connections. This includes old feed and relay connections, impedance bonds, and spark-gap connections.

2.4 Make New Connections
Make all new rail connections, and close up all location terminal links.

2.5 Bonding
Bond out all redundant insulated joints, remove any temporary bonds around new insulated joints, connect any new parallel and series bonds.

2.6 Rail Connections Check
Walk length of track circuit, checking track against the new track insulation plans. Check that all bonding and connections are complete, that spark-gaps connections are to the correct rails, and that no extra rail connections are left.

2.7 Check Auxiliary Track Equipment
Check that any auxiliary track circuit equipment, such as traction tie-ins and electrolysis bonds has been reconnected.

2.8 Equipment Check
Check that all relays, transmitters and receivers are of the correct type, and that they are correctly positioned on the equipment rack.

Check that all lightning protection and earthing at locations and matching units is installed and correctly terminated.

2.9 Loop Resistance Check
Open the outgoing cable links at the transmitter, temporarily short-circuit the trackside end of the feed cable, and measure the cable loop resistance. Close the outgoing cable links.
### Measured Loop Resistance Bridges to Set

<table>
<thead>
<tr>
<th>Measured Loop Resistance</th>
<th>Bridges to Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>0  to  2</td>
<td>C+  to  6</td>
</tr>
<tr>
<td>2  to  4</td>
<td>C+  to  5</td>
</tr>
<tr>
<td>4  to  5.5</td>
<td>C+  to  5, 2  to  3</td>
</tr>
<tr>
<td>5.5 to  7</td>
<td>C+  to  6, 3  to  4</td>
</tr>
<tr>
<td>7  to  9</td>
<td>C+  to  4</td>
</tr>
<tr>
<td>9  to 10.5</td>
<td>C+  to  4, 2  to  3</td>
</tr>
<tr>
<td>10.5 to 12</td>
<td>C+  to  6, 3  to  5</td>
</tr>
<tr>
<td>12 to 14</td>
<td>C+  to  3</td>
</tr>
<tr>
<td>14 to 16</td>
<td>C+  to  2</td>
</tr>
<tr>
<td>16 to 17</td>
<td>C+  to  6, 1  to  2, 3  to  5</td>
</tr>
<tr>
<td>17 to 19</td>
<td>C+  to  6, 1  to  5</td>
</tr>
<tr>
<td>19 to 20</td>
<td>C+  to  1</td>
</tr>
</tbody>
</table>

**Table 2 - Transmitter loop resistance adjustment - 20 ohm Loop**

Adjust the transmitter loop resistance tapping to suit the measured loop resistance, using Table 2 or Table 3, according to the loop resistance specified in Table 1.

<table>
<thead>
<tr>
<th>Measured Loop Resistance</th>
<th>Bridges to Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>0  to  0.5</td>
<td>C+  to  4, 2  to  3</td>
</tr>
<tr>
<td>0.5 to  1.5</td>
<td>C+  to  6, 3  to  5</td>
</tr>
<tr>
<td>1.5 to  2.5</td>
<td>C+  to  4, 2  to  3, 3  to  6</td>
</tr>
<tr>
<td>2.5 to  3.5</td>
<td>C+  to  3</td>
</tr>
<tr>
<td>3.5 to  4.5</td>
<td>C+  to  5, 2  to  6, 3  to  5</td>
</tr>
<tr>
<td>4.5 to  5.5</td>
<td>C+  to  2</td>
</tr>
<tr>
<td>5.5 to  6.5</td>
<td>C+  to  6, 1  to  2, 3  to  5</td>
</tr>
<tr>
<td>6.5 to  7.5</td>
<td>C+  to  3, 1  to  4</td>
</tr>
<tr>
<td>7.5 to  8.5</td>
<td>C+  to  6, 1  to  5</td>
</tr>
<tr>
<td>8.5 to  9.5</td>
<td>C+  to  5, 1  to  2, 3  to  5, 2  to  6</td>
</tr>
<tr>
<td>9.5 to 10</td>
<td>C+  to  1</td>
</tr>
</tbody>
</table>

**Table 3 - Transmitter loop resistance adjustment - 10 ohm Loop**

### 2.10 Terminations

Check that all rail connections and location terminal connections are made and properly tightened.

### 2.11 Power- Up

**CAUTION**

Exercise care when working on this equipment. Potentially hazardous voltages are present between the transmitter and matching unit (or impedance bond), and receiver, matching unit, and relay.

Note also that at no time should the transmitter or power supply be plugged or unplugged nor bridging changed while the power is on.

A Jeumont-Schneider transmitter should not be left feeding into an open circuit as this may cause it to be damaged. It should not be operated with the track terminals open for an extended period.
Insert fuses and links to power up the transmitter. Observe that the transmitter makes a soft "zonk, zonk, zonk" sound, and that the relay energises.

Check the track polarity, and check that there is correct polarity reversal between it and adjacent track circuits. If the track polarity needs to be changed, reverse the feed cable connections.

If the relay picks up momentarily, then drops away, it means that the transmitter and receiver ends have been set up opposite in polarity. Reverse the track connections at the receiver end, to obtain matching polarity between receiver and transmitter.

2.12 Check Rail Connections

Inspect and physically check that all rail connections are secure, with securing nuts done up tight, and locknuts installed where applicable.

Where impedance bond sideleads are terminated to rail, the contact voltage drop check will be useful, but only if traction return currents are flowing in the area.

Using a Fluke meter, measure the AC millivolts drop on each track connection, between the cable core (or the crimp lug, if the core is not accessible), and the rail head. Each connection should read 1 millivolt or less. If any connection is over 5 millivolts it should be retightened. If this is not successful, the connection should be removed, cleaned and reconnected to achieve the low millivolt drop. If the set-to-work team is unable to carry out this task, then the problem should be reported to the commissioning control to be logged for cleaning and reconnection.

2.13 Shunt and Correspondence Check

Using a fixed shunt (in accordance with the Table 3 below), applied at the relay end of the track, shunt the track and observe that the relay de-energises.

Where the track circuit is indicated on a signal box diagram, check the correspondence of the track circuit to the diagram indication as part of this shunt check.

<table>
<thead>
<tr>
<th>Track Type</th>
<th>Test Shunt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 S/R TV-TH1</td>
<td>0.5</td>
</tr>
<tr>
<td>2 S/R TV-THD2</td>
<td>0.25</td>
</tr>
<tr>
<td>3 S/R TV-THD2</td>
<td>0.25</td>
</tr>
<tr>
<td>4 D/R CIT-1400</td>
<td>0.25</td>
</tr>
<tr>
<td>5 D/R TV-LV</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Table 4 - Value of Fixed Test Shunt Resistance

2.14 Documentation Check

Check that all set to work activities on the commissioning master sheet have been completed satisfactorily, and all test values measured and recorded.

2.15 Notification to Control

As soon as possible after each track is completed, advise the commissioning control centre so that the commissioning log can be updated.
3 Final Adjustment

This section details the adjustment activities carried out by the test-and-certify team.

With Jeumont-Schneider high-voltage impulse track circuit equipment, there is almost nothing that is adjustable in the field. All operating levels are fixed, and no means are provided to vary the shunt sensitivity. On double-rail tracks there is limited adjustment available of the receiver input levels.

The test-and-certify team is responsible for the preparation of track history cards for all tracks commissioned. These should be completed at the end of the day, using the data recorded on the commissioning master sheets prepared by the set-to-work and test-and-certify teams.

3.1 Equipment for Test and Certification

The following is the minimum equipment required by the set-to-work team:

- Spanners: 12mm tube, insulated, for impedance bond connections.
- Terminal Screwdriver: 3mm parallel-blade
- Pliers: Long-nose insulated, for adjusting taps
- J/S Pulse integrator: (See Appendix 1)
- Multimeter: High-impedance Fluke 27, 8026, 87, or equivalent. Used for AC and DC measurements.
- Switchable shunt box: With 0.25 and 0.5 ohm settings, complete with track clips.
- J/S track circuit manual
- Track circuit Set-to-Work master sheet, clipboard and pens.

3.2 Staffing for Test and Certification

The recommended staffing for test and certification is two; one engineer accredited to test and certify J/S tracks, and the second with some experience in track circuit testing.

For optimum efficiency, the second person should be competent to recognise a Jeumont-Schneider track relay, and to report whether it is energised or de-energised when requested to do so.

The allocation of teams for the commissioning should be made on the basis of allowing a total time of 1/4 hour for final adjustment and certification, per track circuit.

3.3 Receiver Adjustment

There is no adjustment possible on single-rail Jeumont-Schneider tracks.

With double-rail tracks, the matching transformer or impedance bond output can be adjusted to suit a range of track lengths. The relay may pick up weakly, either due to the condition of the track, or excessive cable resistance. The pick up may then be improved by adjusting the tappings to a setting corresponding to a longer track length.

3.4 Standard Values Check

Measure and record all equipment serial numbers and voltages listed on the commissioning master sheet (a typical master sheet is reproduced below)

The ‘receiver volts when shunted’ value is taken either while the track is shunted with the correct value of test shunt resistance at the receiver end, or while the track is actually occupied by a train.
4 Certification

Certification details the final activities carried out by the test-and-certify team. It covers the proving of correct operation of the track circuit, and the completion of all documentation activities.

4.1 Zero-Feed Receiver Voltage

With all adjacent tracks operating, disconnect the feed from the track under test, and measure the track voltage at the receiver end.

If the remaining voltage exceeds 5 volts on the ‘high’ side of the pulse, this must be reported as a track circuit fault, and the cause of the excessive voltage located and rectified.

4.2 Polarity Reversal

Check that correct polarity reversal occurs at each blockjoint where another impulse track circuit abuts.

4.3 Test Shunt

Test shunt the track, using the correct value of fixed shunt. Sets of three shunts should be made at the following points, at least:

- At the Tx end
- Mid-track
- At both ends of any parallel-bonded section of track (where points are involved)
- At the Rx end

Note the successful completion of all test shunts, on the commissioning master sheet.

4.4 Communicating Results

As soon as possible after each track is completed, advise the commissioning control centre so that the log can be updated.

If any problem is found with the track, notify the commissioning control centre as soon as possible. If the problem does not interfere with completion of track testing, continue. If the problem does preclude immediate completion of testing, notify control and then proceed to the next track and return when corrections have been carried out.

4.5 History Cards

When all track work is complete, use the details recorded on the master sheets, to fill in an individual history card for each track tested by the team. The responsible RailCorp member of the test-and-certify team signs the cards.

4.6 Final Documentation

Where separate documentation is provided for the recording of commissioning activities, ensure that the track testing records are completed and signed for all tracks tested by the team.

Ensure that all defects or problems encountered are recorded in the commissioning log.
Ensure that the numbers of all tracks completed, and of all tracks allocated to the team but not completed by the team, for whatever reason, are recorded either in the test records or the commissioning log.

Ensure that the handing-over of completed commissioning master sheets and track history cards is recorded in the commissioning log.

5  Sign Off and Leave Site

End of Procedure
Appendix A  Use of Pulse Integrator for J/S Measurements

The Jeumont-Schneider pulse is intermittent in nature and asymmetrical in waveform. This makes it impossible to measure with any normal measuring instrument. For this reason, pulse measurements are made using a Pulse Integrator, such as shown in the diagram below.

![Diagram of J/S Pulse Integrator]

The integrator consists of a capacitor/resistor network, with a long time-constant, which is charged up via a diode to the peak pulse voltage by successive pulses. A normal high-impedance multimeter can read the peak pulse voltage, held on the capacitor. The peak value measured can be 550 volts or over.

The integrator shown has switching to select a different diode polarity, to measure positive- and negative-going pulses respectively. The intermediate position on the polarity switch provides rapid discharge of the capacitor between measurements. The bypass switch is provided, to permit measurements of AC and DC values without having to dismount the integrator from the meter.

Polarity Checks

The polarity switch on the integrator is arranged to point towards the input terminal on which the positive half-wave is being measured. The meter reading then shows whether this is the ‘high’ or ‘low’ pulse.
Appendix B  Operating Principles and Hardware

Description of Track Circuit

Jeumont Schneider Impulse Track Circuits are used on sections of line where the correct shunting of the track circuit can be at risk due to rust, scale, coal dust or sand etc on the rail surface.

With Jeumont Schneider Track Circuit the voltage on the rails consists of a series of high voltage pulses of short duration separated by relatively long intervals, the purpose being to breakdown semi-insulating surfaces on the rail when the track is occupied. At the same time, because the pulses occur at intervals, the average power drawn from the supply by the transmitter, which produces the pulses, is much lower than the instantaneous energy fed to the track circuit.

The voltage across the rails can be felt but is not dangerous.

Each track circuit is insulated from the adjacent one by insulated block joints in the normal way.

The pulse type track circuit is suitable for use on electrified lines using either single or double rail traction return as well as on non-electrified lines. In all cases the transmitting and receiving equipment is basically similar, the difference in layout being mainly confined to the matching (coupling) arrangements between the transmitter and the track, and between the receiver and the track.

On non-electrified lines and on electrified lines using single rail traction return, matching is achieved by using two track transformers, one at the transmitting (feed) end and one at the receiving (relay) end.

On electrified lines using double rail traction return, matching is achieved by using a special impedance bond incorporating a secondary winding, at each end of the track circuit.

The track circuits are usually installed with a power supply and transmitter suitable for operation from the 120 Volts AC signalling busbar. However, where no reliable 120 Volts AC supply is available a self-contained transmitter/power supply suitable for operation from a 12V D.C. battery is available.

Operation

The transmitter produces the high voltage bipolar pulses, and these are fed to the track by either a track transformer or by an impedance bond incorporating a secondary winding. The pulses then pass along the track and are fed to the receiver which in turn operates a special relay.

The output pulse is produced in the transmitter by the charging of a capacitor to a high voltage. This charge is discharged as a sharp high pulse through an output transformer approximately three times per second via a thyristor (SCR) triggered by an oscillator. After each discharge pulse the magnetic energy stored in the transformer core collapses inducing a lower but longer negative voltage pulse which is delivered to the track. Refer to the figure shown below.
The transmitter output has a peak voltage in the order of 500 volts. This has to be transformed down to a level more suitable for connection to the rails to prevent variations in ballast resistance causing excessive changes in track voltage.

This is achieved by using matching transformers or impedance bonds with track and input windings, and by selecting transformation ratio connections appropriate to the situation.

At the relay end the reverse situation occurs where the track voltage is stepped up through the matching transformer or impedance bond to a level suitable for the receiver.

The voltage pulses as received from the track are unsuitable for the operation of a relay. The bipolar pulses are of short duration (about 10 milliseconds) with long pauses (approximately 300 milliseconds) between them, so the relay would drop away after each pulse.

The receiver modifies and stores the energy from the track and this is connected to the relay as two separate D.C. voltages. The energy from the high positive and low negative pulses is smoothed and stored separately in capacitors. The discrimination between positive and negative pulse is achieved by diodes.

The relay is specially constructed with two separate operating windings. Only when the magnetic fields produced by these windings are substantially the same will the relay pick-up. Since the energy available from the positive and the negative pulses is different the number of turns on each winding must be different for them to produce a similar ampere turns value.

Any appreciable interference with the balance between the magnetic fields produced by the windings will cause the relay to de-energise. For this reason the relay will not energise with the track polarity reversed.
Track circuits should be installed with reverse polarities on adjacent track circuits so that in the event of the insulated joint breaking down the reversed voltage pulses reaching the receiver from the adjacent track circuit will upset the balance of the magnetic field and the relay will de-energise.

**Track Circuit Configuration With Various Types of Modules**

Different combinations of module are available as per requirement. Each track circuit are made of a number of modular plug-in units and fixed mounted track side equipment as follows:

### Single Rail D.C. Electrified

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Quantity per Track</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply NCO EAT 115CA</td>
<td>1</td>
</tr>
<tr>
<td>Transmitter NCO EGT 600</td>
<td>1</td>
</tr>
<tr>
<td>Receiver NCO RVT 600</td>
<td>1</td>
</tr>
<tr>
<td>Relay NCO CV:TH 2.404</td>
<td>1</td>
</tr>
<tr>
<td>Matching Transformer TV.TH1</td>
<td>2</td>
</tr>
<tr>
<td>Regulating Resistance Set (2 per set) ER 2.2</td>
<td>1 Set</td>
</tr>
</tbody>
</table>

### Double Rail D.C. Electrified

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Quantity per Track</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply NCO EAT 115CA</td>
<td>1</td>
</tr>
<tr>
<td>Transmitter NCO EGT 600</td>
<td>1</td>
</tr>
<tr>
<td>Receiver NCO BRT CA2</td>
<td>1</td>
</tr>
<tr>
<td>Relay  NCO CV:TH 2.404</td>
<td>1</td>
</tr>
<tr>
<td>Limitation Device NCO VDR</td>
<td>1</td>
</tr>
<tr>
<td>Impedance Bond CIT 1400CT1 or WB&amp;S type 2000P</td>
<td>2</td>
</tr>
</tbody>
</table>

### Non-electrified Track Circuit - up to 1500 metres in Length.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Quantity per Track</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply  NCO EAT 115CA</td>
<td>1</td>
</tr>
<tr>
<td>Transmitter NCO EGT 600</td>
<td>1</td>
</tr>
<tr>
<td>Receiver NCO RVT 600</td>
<td>1</td>
</tr>
<tr>
<td>Relay NCO CV:TH 2.404</td>
<td>1</td>
</tr>
<tr>
<td>Matching Transformer TV.TH.D2</td>
<td>2</td>
</tr>
<tr>
<td>Adjustable Resistor RK40.0.0.74</td>
<td>1</td>
</tr>
</tbody>
</table>

### Non-electrified Track Circuits - up to 3000 metres

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Quantity per Track</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply NCO EAT 115CA</td>
<td>1</td>
</tr>
<tr>
<td>Transmitter NCO EGT 600</td>
<td>1</td>
</tr>
<tr>
<td>Receiver NCO BRT CA2</td>
<td>1</td>
</tr>
<tr>
<td>Relay NCO CV:TH 2.404</td>
<td>1</td>
</tr>
<tr>
<td>Matching Transformer TV-LV</td>
<td>2</td>
</tr>
</tbody>
</table>
In any of the above arrangements, Power Supply NCO EAT 115CA and Transmitter NCO EAT 600 can be replaced with a transmitter designed for operation from a DC supply (NCO BET 24CC, or N BET SC2-12).

**Equipment**

**Transmitter type NCO EGT 600, and Power Supply Unit Type NCO EAT 115CA**

The transmitter (NCO EGT 600) and AC power supply unit (NCO EAT 115CA) must always be used as a pair, operating from a 120 V, 50 Hz supply. Neither unit can operate independently of the other. The power supply unit produces two regulated DC power supplies, one low voltage to feed the thyristor switching circuit and one high voltage to charge the capacitor which delivers the output pulse. The transmitter output consists of the non-symmetrical pulses described earlier.

![Figure 3 - Terminal Details of Transmitter and Power Supply Unit](image)

**Transmitter Type NCO BET 24CC and N BET SC2-12**

For use where a reliable AC supply is unavailable, these transmitters incorporate DC to DC converters to produce the high and low voltage DC capacitor charging and switching thyristor supplies.

NCO BET 24CC operates directly from a 24 Volt DC battery busbar. Its operating voltage range is 22.5 Volts to 28.8 Volts DC. The power consumption is approximately 50 Watts.

N BET SC2-12 is designed to operate from either 120 volts AC or 12 volts DC, and incorporates an internal changeover to switch between supplies. Its operating voltage range is 103 to 127 volts AC, or 11 to 14.5 volts DC. The power consumption is 45 VA on AC, and 60 watts on DC.
Receiver type NCO RVT 600

This is the 'two-wire' receiver, used for single rail track circuits, DC electrified up to 500 metres with TV-THD2 and TV-TH1 matching transformers, and non-electrified up to 1500 metres, with TV-THD2 transformers. It requires no power source other than the track circuit itself.

Figure 5 - Terminal details of the receiver type NCO RVT 600.
Receiver Type NCO BRT CA2

This is the 'four-wire' receiver, used for double rail track circuits, DC electrified up to 1500 metres with impedance bonds or long non-electrified up 3000 metres with TV-LV matching transformers. It requires no power source other than the track circuit itself.

Figure 6 - Terminal details of the receiver type NCO BRT CA2