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Technical Note - TN 083: 2016

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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Asset Standards Authority (ASA) to notify that the following legacy RailCorp signalling set to work manuals have been withdrawn: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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Engineering Manual

TMG 1355

CSEE UM71 AF JOINTLESS TRACK CIRCUITS – SET UP, TEST AND CERTIFICATION

Version 1.1

Issued March 2013

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Document control

Version	Date	Summary of change
1.0	21/08/2007	Replaced *SC 07 44 01 00 WI CSEE UM71 Jointless Track Circuits – Set-Up, Test and Certification – v2.0* of 1 November 2001. New RailCorp format
1.1	March 2013	Application of *TMA 400* format

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1 Introduction

This procedure describes the activities involved in commissioning and certifying CSEE UM71 audio-frequency jointless track circuits, in a typical State Rail 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.

Before proceeding with testing and commissioning, persons not familiar with the operation of CSEE Audio Frequency Track Circuits are advised to read Appendix C, which gives a concise description of the equipment operating principles and hardware.

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.

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
- Bond punches, 3-stage punch, hammer
- Spanners:
  - 17 mm ring or deep socket (rail connections)
  - 15 ring (Tuning unit connections)
  - 12 mm socket (TU mounting bolts)
- 2BA tube, insulated, for capacitor connections.
- Pliers, long-nose insulated, for adjusting capacitors on resonated bonds
- Multimeter (high-impedance, true-RMS, with frequency response to 3 kHz or better. (Fluke 8026, 87, or equivalent). Used for AC and DC measurements.
- Switchable shunt box, with 0.15 ohm setting, complete with track clips.
- CSEE UM71 track circuit manual
- Track circuit Set-to-Work master sheet, clipboard and pens.

2.2 Staffing for Set-to-Work

The normal requirement 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 3/4 hour per track circuit, for complete set-to-work by a two-man team.

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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.

Check that there are no spark-gap or auxiliary equipment connections within the tuned loops.

2.7 Check Auxiliary Track Equipment

Check that any auxiliary track circuit equipment, such as traction tie-in bonds and electrolysis bonds have been reconnected.

2.8 Equipment Check

Check that all tuning units, transmitters and receivers are of the correct frequency and type, and that the tuning unit connections are correct for the track end and track length.

Check that matching unit strapping is correct for transmitter or receiver, and that SI units are correctly installed.

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

Where the track circuit terminates on an impedance bond, check that cables from the matching unit are correctly terminated, either

- twin 7/0.85 to each side of bond, or
- twin shielded wire to terminals F/G on Jeumont bond internal winding.

Check that any resonated impedance bonds are preset to the required initial value, listed in Appendix A, Note 1.

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

2.9 Terminations

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

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Check that the transmitter output level (Kem) is set correctly for the transmitter frequency, and that the modulation strap M1/M3 is fitted.

Check that the receiver Krv straps are pre-set:

- Tracks up to 400 metres: Krv = 20
- Tracks over 400 metres : Krv = 30

2.10 Power-Up

Insert fuses and links to power up the transmitter and receiver. Observe that the transmitter makes the correct warbling tone, and that the relay energises.

Measure the transmitter and receiver B24 supply voltages.

2.11 Check Rail Connections

Using a Fluke meter, measure the 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.

2.12 Compensated Tracks

Check that capacitors are evenly spaced at 100 metre intervals (estimated), that capacitors are of correct value (see below), that all capacitor connections are tight, capacitor cables are clipped to the foot of the rail, and that each capacitor is secured to a sleeper, flush with the sleeper top.

Capacitor values:

- "HF" (or 22uF) for track frequencies 2600 and 2300,
- "LF" (or 33uF) for track frequencies 2000 and 1700.

2.13 Shunt and Correspondence Check

Using a fixed 0.15 ohm shunt, applied outside the tuned loop 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, observe the correspondence of the diagram indication to the track circuit as part of this shunt check.

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.

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3 Final Adjustment

Final adjustment details the adjustment activities carried out by the test-and-certify team. It covers the adjustment of impedance bonds and the setting of receiver gain to achieve the specified drop-shunt value.

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

The following is the minimum equipment required by the test-and-certify team:

- Frequency-selective voltmeter (ML, VS19 or W&G), or frequency-selective adapter for use with Fluke meter. This is necessary for all track voltage measurements.
- High-impedance true-RMS voltmeter with frequency response to 3 kHz or better. (Fluke 8060 or 87 recommended, otherwise Fluke 8026 or equivalent). Used for DC measurements, AC measurement over 10 volts, and frequency measurement if necessary.
- Switchable shunt box, with 0.15 ohm setting, complete with track clips.
- Portable two-way radios (2) for shunt-testing.
- CSEE track circuit manual
- Track circuit commissioning master sheet, clipboard and pens.
- 10mm metric ring or socket spanner
- 8 inch shifting spanner
- Terminal screwdrivers – 5 mm and 3 mm
- Track Insulation Plan

3.2 Staffing

The normal staff requirement is two engineers, one an engineer fully competent to test and certify CSEE tracks, and the second with some experience in track circuit testing, and some familiarity with CSEE equipment.

For optimum efficiency, the team should have two fully competent members, each with equipped with a selective voltmeter.

With less-experienced staff, a three-man team equipped with two selective meters and three radios has been found to be the most time-efficient.

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

3.3 Resonated Impedance Bonds

Identify any resonated impedance bond installed on the track circuit.

With J/S bonds, set the resonating capacitor connections as shown in the CSEE manual.

On WB&S resonated bonds, adjust the resonating capacitance to achieve a maximum voltage across the capacitor. The maximum voltage achievable depends on a number of factors, the main one being the track length. It can range from 35 volts up to over 400 volts. In practice, in cases where the bond can be resonated to higher values, it is recommended that it be set to a value not exceeding 400 volts. This gives an adequate bond impedance, while avoiding undue electrical stress on the resonating capacitance.

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3.4 Receiver Adjustment

Measure the receiver input reference voltage on receiver terminals R1/R2.

Adjust the Krv ratio (receiver gain) straps if necessary, to obtain a voltage across R1/R2 between 320 and 350 mV. (For adjustment method, see Appendix A, Note 2)

3.5 Intermediate Receiver (DPU)

Each intermediate receiver should be treated as a separate 'track circuit', sharing a common transmitter end with its 'parent' track. It should be recorded individually on the commissioning master sheets, and have a separate history card completed for it.

Final adjustment of the intermediate receiver should be carried out after the 'parent' track is finally adjusted. The procedure for this is described in Appendix B.

3.6 Standard values check

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

The 'volts on R1-R2 at Rx occupied' value is taken either while the track is shunted with a 0.15 ohm shunt outside the tuned loop 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 with the selective voltmeter measure the voltage on the receiver input terminals (R1/R2).

If the remaining voltage exceeds 60 mV (30% of the receiver release value), this must be reported as a track circuit fault, and the cause of the excessive voltage located and rectified.

4.2 Test Shunt

Test shunt the track, using the 0.15 ohm fixed shunt. Sets of three shunts should be made at the following points, at least:

- 6 m inside the Tx tuned loop (if a 23 m loop)
- 3 m inside the Tx tuned loop
- 2 m outside the Tx tuned loop
- Mid-track
- At both ends of any parallel-bonded section of track (where points are involved)
- 2 m outside the Rx tuned loop
- 3 m inside the Rx tuned loop
- 6 m inside the Rx tuned loop (if a 23 m loop)

Note the successful completion of all test shunts, on the master history card.

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4.3 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.

4.4 History Cards

When all track work is complete, use the details recorded on the 'master sheets' to fill in individual history cards for all tracks tested by the team. The cards should be signed by the responsible RailCorp member of the team.

4.5 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

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Appendix A Technical Notes

Resonated Impedance Bonds (WB&S 2000R/AF)

Initial capacitor settings

This table gives initial values to which a WB&S 2000R/AF resonated impedance bond should be preset to ensure operation of the track circuit when initially powered-up. The final resonation of the bond should be done as part of the final adjustment of the track circuit.

Track Frequency	Capacitor (nF)
1700	26.8
2000	22.5
2300	20.0
2600	17.8

Adjustment of Krv ratio

This adjustment sets the input sensitivity of the receiver. It is critical that it is not set higher than necessary – at extreme settings it may be possible to set the receiver so that the track will not shunt when occupied.

Begin by measuring the voltage on receiver terminal R1/R2. If this is in the range 320 to 350 mV then the adjustment is correct, and the relay should be up.

If R1/R2 volts are outside this range:

- check Krv setting by inspecting the existing gain strapping and referring to Krv tables
- if R1/R2 volts are high, select and set a lower Krv setting; vice versa if R1/R2 volts are low
- measure R1/R2 volts, and repeat step 'b' until it lies within range (if track is wet, aim for the lower end of the range; if very dry, aim for the upper limit)

If the track has been commissioned during wet weather or soon after, commissioning staff must record on the commissioning 'log', the need to direct maintenance staff to retest the track regularly as conditions dry out, and to adjust the Krv downwards as necessary to maintain the R1/R2 voltage within the required limits.

Transmitter Modulation Check

It is a feature of the operation of the CSEE track circuit that the transmitter's frequency modulation makes the output frequency alternate between two frequencies 12 to 20 Hz above and below the nominal frequency, about 15 times per second. Because a frequency counter functions by counting cycles over a set counting period, a frequency measurement on a normally functioning CSEE track will return a reading equal to the average output frequency – the nominal value.

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If the modulation fails, the receiver output will drop to zero even though all operating voltages on the track measure completely normal. There are two possible ways to check whether modulation is present:

- Possible only at the transmitter end:
  - Listen to the transmitter. A properly functioning transmitter emits a 'warbling' tone; a failed unit emits a steady tone, or none at all.
  - This check is not absolutely effective, as it may be difficult to hear the warbling in some circumstances.
- At any point on the entire track circuit: Measure the track circuit frequency. (The Fluke 8060 or 87 multimeter is ideal for this test.)

If the frequency measured equals the nominal frequency +/- 2 Hz , then the transmitter modulation is operating normally; failed modulation is indicated by a reading about 10 Hz above or below the nominal.

- e.g. for a 1700 Hz track,
  - 1698 to 1702 means transmitter OK, and
  - 1690 or 1710 means no modulation.

If modulation is not working, first check to see whether the transmitter modulation strap (terminals M1/M3 on the plugboard) is fitted and effective. If the strap is in place, then the transmitter is probably faulty.

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Appendix B Adjustment of Intermediate Receiver (DPU)

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Appendix C Operating Principles and Hardware

Description of CSEE UM71 Track Circuit

The CSEE UM71 Audio Frequency Track Circuit equipment is used generally in jointless track circuits, however it can also be conveniently used in insulated joint tracks by installing Impedance Bonds.

The track circuit employs four base frequencies, 1700 Hz, 2000 Hz, 2300 Hz and 2600 Hz. These frequencies are modulated at between 12 Hz to 20 Hz to minimise the possibility of false operation due to the presence of traction harmonics or other extraneous voltages close to the base frequencies. Both the base and the modulating frequency must be present for the track circuit to operate. To ensure maximum frequency separation for correct function of the tuned separation joint, track circuits with base frequencies of 1700 Hz and 2300 Hz are generally allocated to the `DOWN' track, and 2000 Hz and 2600 Hz to the `UP' track.

Where a track with insulated joints is installed between two CSEE track circuits the track frequencies should still be alternated. This prevents the possibility of false operation of the adjacent receiver in the event of a block joint failure.

The length of a CSEE track circuit is measured from the centre of the tuned loop to the centre of the next tuned loop (from one SI unit to the next SI unit) or from one impedance bond to the next impedance bond. The maximum length of an end fed circuit is 600 metres with a tolerance of +25 metres. The length may be increased to maximum 650 metres so as to overcome installation problems. These maximum lengths only apply when there is no additional loading on the track circuit such as impedance bonds, electrolysis bonds or bad ballast conditions. The minimum length of track circuit is 50 metres.

Basic Operation

A jointless track circuit consists of an audio frequency transmitter and a receiver operating at the same frequency whose output is fed to a signalling relay (track relay). Connection to the track is by means of a matching unit which provides impedance matching and DC isolation and a tuning unit of the same frequency. Adjacent tracks are separated either by insulated joints or by tuned loops consisting of the tuning units of the adjacent tracks. An Air Cored inductor (SI) unit is installed at the centre of the tuned loop. (SI unit is not required for the 19 metre tuned loop).

Transmitters and receivers require 24 V DC supply for their operation.

The tuned loop consists of a pair of tuning units with 600 Hz frequency separation, a specific length of track (19 or 23 metres), and an SI unit if a 23 metre tuned loop is used.

The tuning unit of a particular track having one frequency offers high impedance whereas it presents low impedance to the adjacent track having different frequency.

The high impedance presented on the tuning unit makes an optimum point for the connection of a transmitter or a receiver. At the other end of the tuned loop, the rail to rail voltage of this track is shunted by the low impedance presented at its frequency by the tuning unit of the adjacent track circuit, leaving only a small amount of signal to appear on the adjacent track transmitter or receiver. Thus the action of the tuned loop limits the propagation of the track circuit voltage past the adjacent track circuit tuning unit, simulating an insulated joint of tracks.

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If the distance between the tuning units is 23 metres an SI unit is connected at the midpoint of the tuned loop.

The purpose of the SI unit in the tuned loop is to balance the traction current in each rail and stabilise the inductance in the tuned loop. It also improves the definition of the cut-off point between the two adjacent track circuits. The centre tap of the SI unit is also an ideal point for the connection of electrolysis bonds and for traction tie-ins in AC-electrified areas.

The transmitter output is approximately 45 V to 60 V AC depending on the frequency. The transformation ratio of the transmitter matching unit is approximately 10 to 1. The matching unit feeds 2 V to 5 V AC to the track. A voltage drop of approximately 0.5 V occurs in the leads from the tuning unit to the rails.

Along the track the voltage decreases to a value of between 0.2 V to 1.5 V AC at the tuning unit on the receiver end, depending on the track length and ballast conditions. At the receiver tuning unit the voltage is applied to a matching unit which feeds the track voltage to the receiver with a transformation ratio of approximately 1 to 1. If the voltage is of sufficient magnitude and of correct frequency and modulation the track relay is energised by the receiver.

The track circuit is adjusted by varying the transformation ratio of the receiver input transformer, referred to as the Krv, to obtain a suitable value between terminals R1 and R2. The value is normally set to 350 mV AC for normal dry track conditions but may vary depending on weather and ballast conditions from 250 mV to 350 mV AC.

Whenever measuring voltage levels on CSEE track circuit equipment (with the exception of transmitter output voltages), it is important that a frequency selective voltmeter be used. (A Fluke meter, without selective filter adapter, is not frequency selective).

If such a meter is not available, then the transmitter of any adjacent CSEE or other jointless track circuit should be disabled by opening the outgoing terminals while the measurements are being taken. Failure to follow this rule could result in misleading readings, with possible incorrect adjustments and compromised track circuit safety.

Equipment

Transmitter

(refer to Figure 1)

24 volt DC supply is connected to A+ and A−. The average consumption is 1.1 ampere and maximum 2.2 amperes when a train is shunting the transmitter end of the track circuit. The transmitter output voltage is in the order of 45 V to 60 V AC at one of the four base frequencies 1700 Hz, 2000 Hz, 2300 Hz and 2600 Hz. These base frequencies are modulated as follows:

- F1 : 1700 Hz with 13.3 Hz modulation.
- F2 : 2300 Hz with 18.0 Hz modulation.
- F1': 2000 Hz with 15.6 Hz modulation.
- F2': 2600 Hz with 20.3 Hz modulation.

The output voltage of the transmitter is transformed down through the matching unit to between 2 to 5 V for connection to the track.

The transmitter output voltage is set by bridging on the base of the transmitter during installation. This bridging determines the transmitter output transformer ratio (Kem) which is different for each frequency. This ratio is set during installation of the track circuit and

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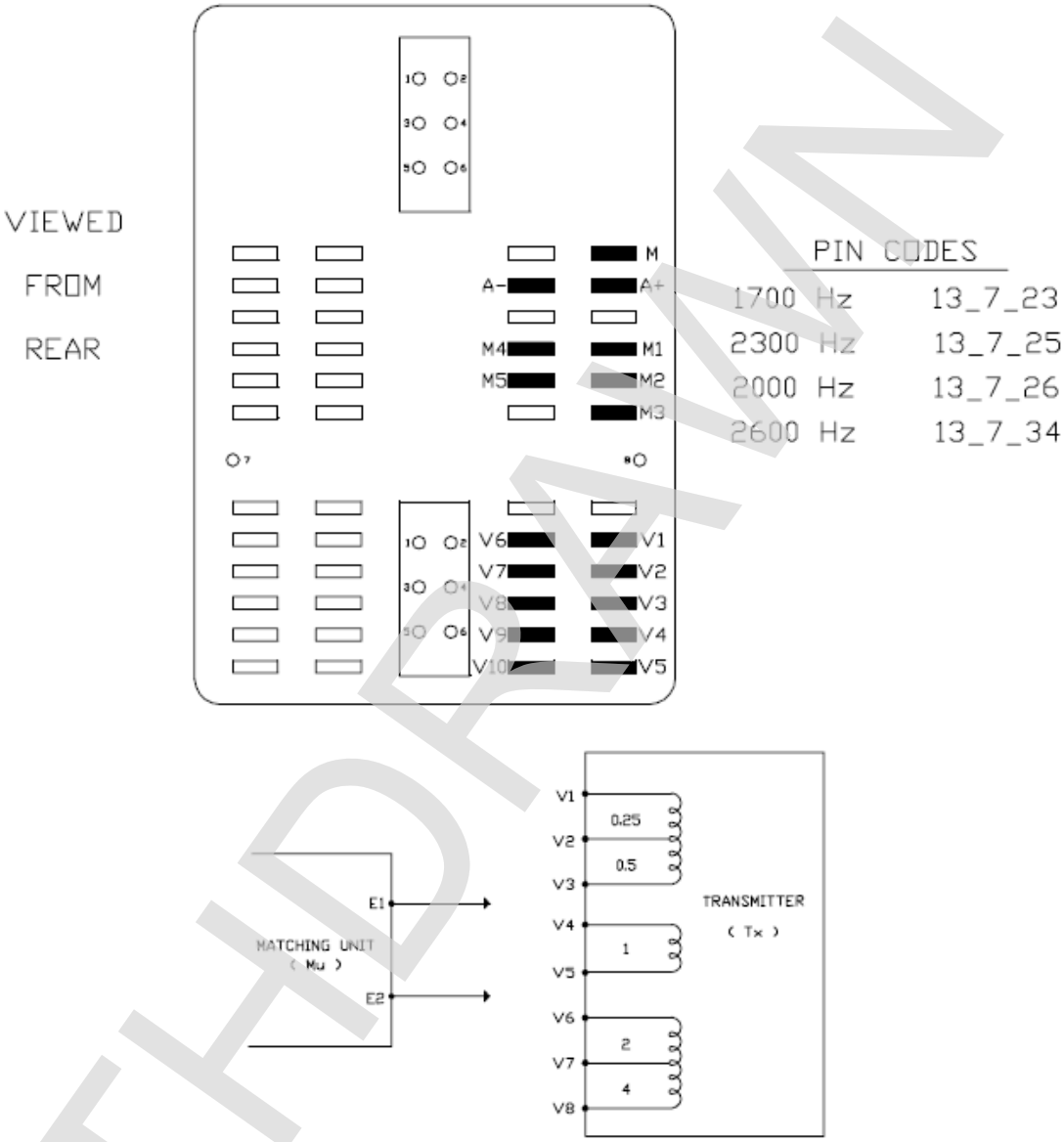
should never be altered. Details of the Kem ratio for each frequency are shown in Figure 1.



FREQ	KEM	CONNECT 1 on Mu to	2 on Mu to	BRIDGE
1700 Hz	3.5	V2	V7	V3-V4 V5-V6
2300 Hz	4	V7	V8	NIL
2000 Hz	3.75	V1	V7	V3-V4 V5-V6
2600 Hz	4.25	V1	V8	V2-V7

Figure 1 - CSEE UM71 Transmitter Connections

The transmitter may be located up to 500 metres from the matching unit.

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Matching Unit

(refer to Figure 2 below)

Transmitters and receivers are always connected through matching units to tuning units, impedance bonds or the track. A matching unit is used to match the impedance of the track to the characteristic impedance of the connecting cable and the equipment connected to the other end of the cable, irrespective of the frequency of the track circuit. It provides a voltage transformation ratio approximately 10 to 1 between transmitter and track, and approximately 1 to 1 between track and receiver. Matching units also provide DC isolation between the track and the transmitter and receiver.

Matching unit bridging varies, as described below, depending on whether it is connected to the transmitter or to the receiver.

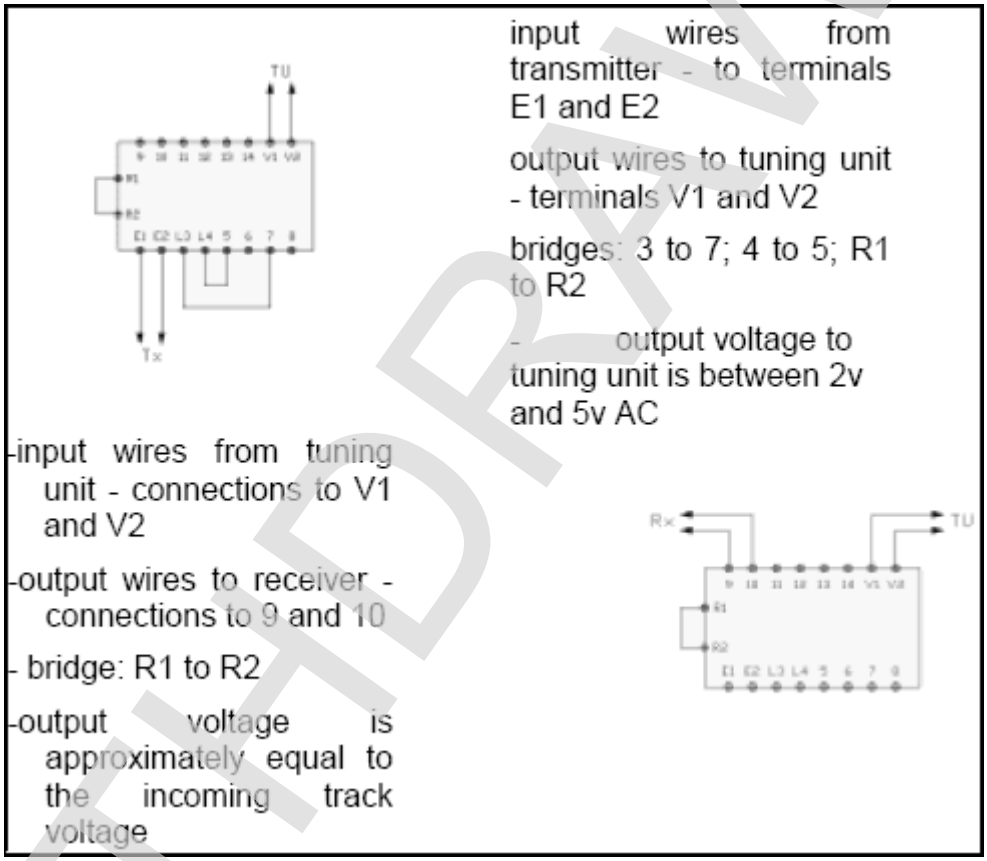

Figure 2 - CSEE UM71 Matching Unit Connections

Transmitter End Matching Unit

Input: from the transmitter to the terminals E1 and E2.

Output: to the tuning unit are from terminals V1 and V2.

Bridges: L3 to 7; L4 to 5 and R1 to R2.

Receiver End Matching Unit

Input: from tuning unit connections to V1 and V2.

Output: to receiver connections from terminals 9 and 10.

Bridge: R1 to R2.

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Tuning Unit

There are four different types of tuning units, one for each of the four frequencies. The tuning unit at the transmitter end is identical to the tuning unit at the receiver end. Tuning units consist of capacitors and inductors which act as resonant filters. The contents of all tuning units are fully encapsulated and inaccessible except for the terminals.

A tuning unit of a particular frequency appears as a high impedance to its own frequency and a low impedance to the frequency of the adjacent track. Because of this, the adjacent track voltage is prevented from being impressed onto the track circuit while its correct frequency is not attenuated.

The track connection is to the extended external lugs V1 and V2. Receiver and transmitter are connected to the tuning unit terminals 1 and 4 via the matching unit.

Air-core Inductor (SI unit)

This unit is connected midway between two tuning units in a 23 metre tuned loop. Where distances between points and signals need to be minimised the air-core inductor can be eliminated permitting a 19 metre tuned loop to be used.

The purpose of the air-cored inductor is to eliminate DC potential between rails and stabilise the inductance in the tuned loop. It is usually referred to as an SI (Self Inductor) unit and consists of an air core winding with a centre tap connection. The centre tap can provide convenient connections for electrolysis bond and spark gap connections.

Receiver

(see Figure 3)

The track voltage entering the receiver from the track side matching unit is fed into a variable ratio transformer before being applied to the filter and detection circuits of the receiver. The receiver will energise the track relay when a voltage of the correct base frequency and modulation and a minimum voltage of approximately 180 mV AC is applied at terminals R1 and R2. When the voltage falls to approximately 180 mV AC the receiver de-energises the relay.

The track voltage from the receiver matching unit, which ranges from 0.3 to 1.5 volts AC, is applied to receiver terminals V1 and V2. The track circuit is adjusted by varying the receiver sensitivity; the receiver input transformer ratio (Krv) connections and bridges are altered to obtain the correct voltage between R1 and R2. (This procedure is described in Appendix A). The normal range of values at terminals R1 and R2 is from 250 mV to 350 mV AC, with tracks typically set to 320 mV AC in dry weather conditions. All receiver voltage readings must be taken with a special tuned meter (Selective Level Meter) or if taken with a Fluke meter the transmitter of the adjacent track must be disconnected.

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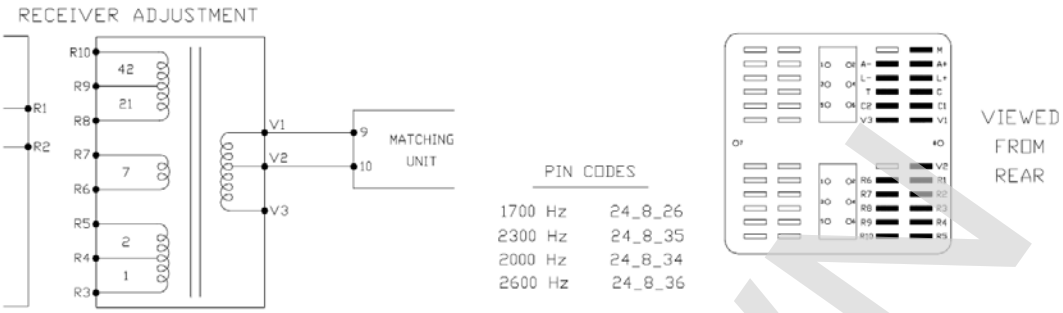

K_{RV}	CONNECT R1 to	R2 to	BRIDGE
1	R3	R4	
2	R5	R4	
3	R3	R5	
4	R5	R7	R3-R6
5	R5	R7	R4-R6
6	R4	R7	R3-R6
7	R6	R7	
8	R3	R7	R4-R6
9	R4	R7	R5-R6
10	R3	R7	R5-R6
11	R9	R7	R3-R8 R5-R6
12	R9	R7	R4-R8 R5-R6
13	R9	R7	R3-R8 R4-R6
14	R9	R7	R6-R8
15	R9	R3	R4-R7 R6-R8
16	R9	R4	R5-R7 R6-R8
17	R9	R3	R5-R7 R6-R8
18	R9	R5	R3-R8
19	R9	R5	R4-R8
20	R9	R4	R3-R8

K_{RV}	CONNECT R1 to	R2 to	BRIDGE
21	R9	R8	
22	R9	R3	R4-R8
23	R9	R4	R5-R8
24	R9	R3	R5-R8
25	R9	R5	R3-R6 R7-R8
26	R9	R5	R4-R6 R7-R8
27	R9	R4	R3-R6 R7-R8
28	R9	R6	R7-R8
29	R9	R3	R4-R6 R7-R8
30	R9	R4	R5-R6 R7-R8
31	R9	R3	R5-R6 R7-R8
32	R10	R7	R5-R6 R3-R9
33	R10	R7	R5-R6 R4-R9
34	R10	R7	R4-R6 R3-R9
35	R10	R7	R6-R9
36	R10	R7	R3-R6 R4-R9
37	R10	R7	R4-R6 R5-R9
38	R10	R7	R3-R6 R5-R9
39	R10	R5	R3-R9
40	R10	R5	R4-R9

K_{RV}	CONNECT R1 to	R2 to	BRIDGE
41	R10	R4	R3-R9
42	R10	R9	
43	R10	R3	R4-R9
44	R10	R4	R5-R9
45	R10	R3	R5-R9
46	R10	R5	R3-R6 R7-R9
47	R10	R5	R4-R6 R7-R9
48	R10	R4	R3-R6 R7-R9
49	R10	R6	R7-R9
50	R10	R3	R4-R6 R7-R9
51	R10	R4	R5-R6 R7-R9
52	R10	R3	R5-R6 R7-R9
53	R10	R7	R5-R6 R3-R8
54	R10	R7	R5-R6 R4-R8
55	R10	R7	R4-R6 R3-R8
56	R10	R7	R6-R8
57	R10	R7	R3-R6 R4-R8
58	R10	R7	R4-R6 R5-R8
59	R10	R7	R3-R6 R5-R8
60	R10	R5	R3-R8

K_{RV}	CONNECT R1 to	R2 to	BRIDGE
61	R10	R5	R4-R8
62	R10	R4	R3-R8
63	R10	R8	
64	R10	R3	R4-R8
65	R10	R4	R5-R8
66	R10	R3	R5-R8
67	R10	R5	R3-R6 R7-R8
68	R10	R5	R4-R6 R7-R8
69	R10	R4	R3-R6 R7-R8
70	R10	R6	R7-R8
71	R10	R3	R4-R6 R7-R8
72	R10	R4	R5-R6 R7-R8
73	R10	R3	R5-R6 R7-R8

Figure 3 - CSEE UM71 Receiver Connections

The table of connections and bridges for various Krv ratios is shown in the Figure 3.

The bridge C to C2 sets the relay pick-up delay time to 2 seconds. The track relay is connected to terminals L+ and L− and the 24 V DC supply is connected to terminals A+ and A−. The receiver requires a DC supply within the range of 22.5 volts to 28.8 volts.

Power Supply Unit

The 24 volt power supply may be obtained from a CSEE supply module, a RailCorp supply unit. The Store 93 filter can supply regulated 24 V DC normally either to two transmitters, four receivers or a combination of both to a maximum current load of 4 amperes. The input to the power supply unit is generally set to 120 V AC, normal signalling supply. The output is 24 volts +/− 0.5 volts. It is factory set, and no adjustment of output voltage is available.

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