Reference material

CSEE UM71 Track Circuit Test and Investigation Guideline

This legacy document is published as historical reference material. The content described might be of assistance to individuals and organisations performing work on Transport for NSW Rail Assets.

This document refers to organisational and positional roles and responsibilities in place prior to 1 July 2013 and may have been superseded by other documents.

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CSEE UM71 Track Circuit

Test and Investigation Guideline

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1. Introduction

The CSEE UM71 Track Circuit reliability team has produced this document to improve performance in fault finding. The team has representatives from each Region and Engineering.

This document details recommended practice for the testing and investigation of No Cause Found (NCF) failures for CSEE UM71 track circuits.

2. Test & Failure Investigation Strategy

Once the cause for a failure has not been able to be found then:

- All the investigations detailed on the I&T Form 1 must be completed. The tests associated with the form are listed as Level 1 in the section detailing the tests.
- If the R1/R2 voltage has changed by more than 35mV from the last full test of the track circuit, I&T Form 2 must completed in addition to I&T Form 1. The tests associated with the form are listed as Level 2 in the section detailing the tests.

Investigations of repeat No Cause Found failures (within 3 months of previous NCF failure) and significant incidents must complete I&T Form 3. The tests associated with the form are listed as Level 3 in the section detailing the tests.

Specific tests that are carried out during fault finding or when required by the Signal Engineer or tester are listed as “As Requested”.

The information recorded on the forms is to be analysed by the Signal Electrician, and Signal Engineer to determine further action required identifying and correcting the fault.

If no cause can be identified after 3 NCF failures with the same transmitter and receiver in place then the transmitter and receiver are to be replaced as a pair and returned to REC for a priority test to specifications. This is to determine that the modules are the cause of the repeated no cause found failures or not.

3. Typical Problems

3.1. Faults with no significant change in recorded values

Cause	Test
Loose or poor connection	Covered in Level 1, 2, and 3 tests.
Rx - internal connections	Covered in Level 1 test.
Rx - Internal Drift	Covered by elimination of other causes.
Track stick	Covered in Level 1, and 3 test.
Track repeat relay, CBI, or telemetry fault.	Not covered. External to track circuit.
Tx - faulty output stage	Covered in Level 1 test. Excessive Tx DC current draw.
Tx - Frequency drift	Covered in Level 3 test
Tx - not recovering after passage of train.	Covered in Tx as requested tests.
Tx - not recovering after power on.	Covered in Tx as requested tests.
Spark gap connection	Covered in Level 1 test.
Traction imbalance	Covered in Level 1 test.
Impedance bond or electrolysis bond	Covered in Level 1 test.
PSU - AC ripple	Covered in Level 3 test. PSU output ripple.
Track insulation defect	Covered in Level 1, 2, and 3 tests.

3.2. Faults with a significant change in recorded values

Cause	Test
MU - capacitors.	Covered in Level 2 tests.
TU - connection	Covered in Level 1 tests.
TU - impedance change	Covered in Level 2 tests.
PSU - low output	Covered in Level 1 tests.
Tx - low output	Covered in Level 1 test.
Tx - faulty output stage	Covered in Level 1 test. Tx DC current draw.
Ballast condition	Covered in Level 1 tests.
Broken rail	Covered in Level 1 tests.
SI - Connection	Covered in Level 1 tests.

3.3. Installation factors that can contribute to failures

Installation factors that can contribute to no cause found failures are:

Factor	Concern
Modules recently put into service.	Modules in service for less than 3 months may have a defect that was not found in production or repair.
Modules that have been in-service for more than 12 years.	Modules continually in service for more than 12 years may start to have components that have drifted or start to have internal connection problems.
Modules that are older than 20 years.	Older modules are more likely to have components that are subject to temperature and vibration effects.
Long term heat stress.	Modules that have been operated for long periods (>5 years) at high average temperatures will have components that have deteriorated which can cause intermittent faults or higher failure rate.
Large day night temperature swings.	Modules that have been operated for long periods (>5 years) with large (>20ºC) day night temperature swings will have components that have internal connection problems that can cause intermittent faults.
Type of rail connections.	Web welded connections are more stable and are less likely to deteriorate or be the cause of intermittent faults.
Stability of the track at or near rail connections.	Vertical rail movement near track connections can cause bolted connections to 'work loose'.
Track leads.	The leads from Tuning unit to rail should be held together from Tuning unit to near rail by non-metallic ties. A revised arrangement for securing track leads to reduce damage due to track work was issued during 2006.
DPU cabling	The use of non-twisted pair cables to DPUs allows the additional pick up of electrical noise. Cabling from DPUs should be twisted pair cable.
Spark Gap connections	Requirements for spark gap connections changed in the late 1990's. Spark gap connections are only required as per Electrical Specification EP 12 20 00 01 SP *Bonding of Overhead wiring structures to Rail*.
Vandal resistant covers.	Vandal resistant covers can reduce failures due to vandalism. However metallic covers are not permitted on SI units.
Power supply stability	Some areas have their normal power supply fed via the railway 33kV network. The 33kV railway supply is not regulated and this can affect pre year 2000 Store 93s and may have voltage swings beyond the limits for the tapping set on UM71 power supplies.
Surge protection	No surge protection, or poorly installed surge protection will accelerate the deterioration of modules and increase all types of module faults.
Ballast above the foot of the rail.	Excessive ballast height can increase the change in ballast resistance between day and night particularly with heavy dew. This mainly affects long track circuits.
Ballast condition and drainage	Poor ballast condition and drainage can cause failures in wet conditions, as the ballast resistance change between wet and dry is too large for the normal track adjustment to handle.

4. Typical Symptoms

Symptom	Likely Causes
Slow to pick up after a train or picked after 2nd train.	Tx - not recovering after passage of train, Tx - faulty output stage, Rx, rail connection, track stick, train stop, or PSU.
Dropped on the approach of a train.	Tu, Traction imbalance, Spark gap, connection or Rx.
Drop and pick intermittently without train present or nearby.	Mu, Tu, Ballast condition, Tx, Rx, Power supply AC, or DC, or un-intended rail connection (eg failed spark gap). R1/R2 may cycle high/low/high due to interference from a same frequency track via a leaky TU or external connection to the track.
Drop again after picking up after train had passed.	People working in area, or Traction imbalance.
Drop and pick within 30 seconds with no significant change in R1R2.	Tu, Traction imbalance, Spark gap, connection, Rx, or People working in area.
Drop and pick after 30 seconds.	Tu, connection, Tx or Rx.
DPU track not shunting for 1st bogie	Tx set for high power. Note that some Txs are internally bridged for high power. Rx adjustment, and wheel rail contact are also causes.
Track picks up shortly after location door opened or when meter applied.	Loose or poor connection at the back of the Rx.

5. CSEE Failure Investigation & Test Form 1

CSEE Failure Investigation & Test Form 1

Track Name:	Inspection Date:
Location:	Failure Date(s):
Inspection By:	Time of Failure:
Track Frequency: Hz	Failure Duration: (Approx.)
Track Length: Metres	Estimated temperature at time of failure:

TRANSMITTER END

- [ ] PSU & Tx Connections Checked
- [ ] Tx Locked in place
- [ ] PFC12 Block inspected OK

PSU Input Voltage (Bx120/Nx120)		Vac
PSU Output Voltage (B24/N24)		Vdc
Tx Input Voltage (A+/A-)		Vdc
Tx Input Current (A+ or A-)		mAdc
Tx Power Setting (High is M2-M4, M2-M5)		H or N
Tx Output Voltage (Loc. Track term.)		Vac
Rail to Rail Voltage (Tx end)		Vac
Vd Up Rail Conn. (Tx end)		mVac
Vd Dn Rail Conn. (Tx end)		mVac
Vd Up Rail Conn. (Tx end adj TU)		mVac
Vd Dn Rail Conn. (Tx end adj TU)		mVac
Vd Up Rail Conn. (SI)		mVac
Vd Dn Rail Conn. (SI)		mVac

- [ ] MU Connections checked OK
- [ ] TU Connections checked OK
- [ ] Record & Compare with details on Track History

RECEIVER END

- [ ] PSU & Rx Connections Checked
- [ ] Rx Locked in place
- [ ] PFC12 Block inspected OK

PSU Input Voltage (Bx120/Nx120)		Vac
PSU Output Voltage (B24/N24)		Vdc
Relay Output Voltage (L+/L-)		Vdc
Has Track Stick		Yes/No
Relay Voltage (Relay R1/R2)		Vdc
Drop Shunt		ohm
KRV Setting		
Last entry R1/R2 (Track History Card)		mVac
Rx R1/R2 (Track Unoccupied)		mVac
Rx Input Voltage (Loc. Track term.)		Vac
Rail to Rail Voltage (Rx end)		Vac
Vd Up Rail Conn. (Rx end)		mVac
Vd Dn Rail Conn. (Rx end)		mVac
Vd Up Rail Conn. (Rx end adj TU)		mVac
Vd Dn Rail Conn. (Rx end adj TU)		mVac
Vd Up Rail Conn. (SI)		mVac
Vd Dn Rail Conn. (SI)		mVac

- [ ] MU Connections checked OK
- [ ] TU Connections checked OK
- [ ] DPU Checked OK
- [ ] Record & Compare with details on Track History

FAILED WITH TRAIN

- [ ] Approaching
- [ ] Departing
- [ ] On Adjacent Line
- [ ] In Vicinity
- [ ] Not in Area
- [ ] Unknown

Train Type was:

ADDITIONAL CHECKS

- [ ] Repeat Relays
- [ ] Event Logs Reviewed
- [ ] Telemetry/CBI Reviewed
- [ ] Work group(s) in area

TRACK

Ballast Condition: ____________

- [ ] Track Inspected
- [ ] Spark Gaps Checked OK
- [ ] Impedance Bonds Checked
- [ ] Impedance Bonds resonated
- [ ] Traction Return Balanced (Note Differences)
- [ ] Electrolysis bond checked and balanced

Equipment replaced in last 3 months:	

6. CSEE Failure Investigation & Test Form 2

CSEE Failure Inspection & Test Form 2 (Rx R1/R2 changed by more than 35mV from last full test.)

CSEE *Failure Investigation & Test Form 1 must also be filled out with this form.*

Track Name:	Inspection Date:
Location:	Failure Date(s):
Inspection By:	CSEE Failure I. & T. Form 1 dated:

TRANSMITTER END

MU Input Voltage (E1/E2)		Vac	V1.V2 > $V_{5/7}$/10 - 0.7V
MU Transf'r Input V. (5/7)		Vac	
MU Output Voltage (V1/V2)		Vac	
MU C1 V.drop (C1+/-)		mVac	<100mV C1=C2
MU C2 V.drop (C2+/-)		mVac	

TUNING UNIT (Track Under Test)

TU IMPEDANCE TEST AT TRACK FREQUENCY

TU Voltage V1/V2		mVac	
TU Current (MU-TU)		Amps	
TU Impedance (Z Calculated)		mΩ	Z=TU(mV) / I(A)

TU IMPEDANCE AT ADJACENT TRACK FREQUENCY

TU Voltage V1/V2		mVac	
TU Current (Trk-TU)		Amps	
TU Impedance (Z Calculated)		mΩ	Z=TU(mV) / I(A)

TUNING UNIT (Adjacent Track)

TU IMPEDANCE TEST AT THIS TRACK FREQUENCY

TU Voltage V1/V2		mVac	
TU Current (Trk-TU)		Amps	
TU Impedance (Z Calculated)		mΩ	Z=TU(mV) / I(A)

TU IMPEDANCE AT ADJACENT TRACK FREQUENCY

TU Voltage V1/V2		mVac	
TU Current (See note.)		Amps	
TU Impedance (Z Calculated)		mΩ	Z=TU(mV) / I(A)

AIR CORE INDUCTOR (SI UNIT)

SI UNIT IMPEDANCE TEST (AT TRACK FREQ.)

SI Voltage V1/V2		mVac	
SI Current		Amps	
SI Impedance (Z Calculated)		mΩ	Z=TU(mV) / I(A)

Note: MU-TU if Tx, or Trk-TU if Rx.

RECEIVER END

MU Input Voltage (V1/V2)		Vac	V1.V2 = $V_{9/10}$ ±0.1V
MU Output Voltage (9/10)		Vac	
MU C1 V.drop (C1+/-)		mVac	C1=C2 Vd < 20mV
MU C2 V.drop (C2+/-)		mVac	

TUNING UNIT (Track Under Test)

TU IMPEDANCE TEST AT TRACK FREQUENCY

TU Voltage V1/V2		mVac	
TU Current (Trk-TU)		Amps	
TU Impedance (Z Calculated)		mΩ	Z=TU(mV) / I(A)

TU IMPEDANCE TEST AT ADJACENT TRACK FREQ.

TU Voltage V1/V2		mVac	
TU Current (Trk-TU)		Amps	
TU Impedance (Z Calculated)		mΩ	Z=TU(mV) / I(A)

TUNING UNIT (Adjacent Track)

TU IMPEDANCE TEST AT THIS TRACK FREQUENCY

TU Voltage V1/V2		mVac	
TU Current (Trk-TU)		Amps	
TU Impedance (Z Calculated)		mΩ	Z=TU(mV) / I(A)

TU IMPEDANCE AT ADJACENT TRACK FREQUENCY

TU Voltage V1/V2		mVac	
TU Current (See note.)		Amps	
TU Impedance (Z Calculated)		mΩ	Z=TU(mV) / I(A)

AIR CORE INDUCTOR (SI UNIT)

SI UNIT IMPEDANCE TEST (AT TRACK FREQ.)

SI Voltage V1/V2		mVac	
SI Current		Amps	
SI Impedance (Z Calculated)		mΩ	Z=TU(mV) / I(A)

7. CSEE Failure Investigation & Test Form 3

CSEE Failure Inspection & Test Form 3 (Repeat Failure follow up)

Track Name: ______ Inspection Date: ______

Location: ______ Failure Date(s): ______

Inspection By: ______ CSEE Failure I. & T. Forms 1/ 2 Dated ______

TRANSMITTER END

Vd Bx120v Fuse		mVac
Vd Nx120v Term.		mVac
Vd B24v Fuse		mVdc
Vd N24v Term.		mVdc
PSU Output ripple		Vac
TX Frequency		Hertz
Vd Loc. Track term.		mVac
Vd Loc. Track term.		mVac
Vd MU, E1 to 7		Vac
Vd MU, E2 to 5		Vac
Vd MU Bridge R1/R2		mVac
Vd MU Bridge L3/7		mVac
Vd MU Bridge L4/5		mVac

☐ Surge Protection Inspected

☐ 3Y20 Arrestors Tested

RECEIVER END

Vd Bx120v Fuse		mVac
Vd Nx120v Term.		mVac
Vd B24v Fuse		mVdc
Vd N24v Term.		mVdc
PSU Output ripple		Vac
Vd MU Bridge R1/R2		mVac
Zero feed test		mVac
Track Stick resistance		ohms
Shunt tested (0R15)		

☐ Surge Protection Inspected

☐ 3Y20 Arrestors Tested

Additional Tests	

8. Tests

8.1. Test Equipment Requirements

Test Equipment	General Requirements	Approved Test Equipment
DMM (Digital Multi-Meter) General	Must have true RMS to> 3kHz Frequency reading to 1 Hz. Min/Max is 100mS response time.	Fluke 8060, 179, 87, 187, 189 Continued use of Fluke 27 averaging meter with no freq, or fast min/max facility is permitted. Comparison testing is to be carried out.
DMM with fast min/max or peak min/max.	As per the general Multimeter. Fast Min/Max is faster than 5mS response time.	Fluke 187, 189. Fast min/max Fluke 87V Peak min/max
FSM (Frequency Selective Meter)	Centre frequencies of 1700hz, 2000Hz, 2300Hz, 2600Hz. Bandwidth < +/-0.5db at +/-30Hz, and > 60db rejection at +/-600Hz from centre frequency.	Selective Track Frequency Meter (STFM) or Track Circuit Filter Adaptor (TFA) and DMM. The TFA is not suitable for rejection ratio or TU impedance measurements.
DC Tong Meter for Traction current measurement	Accuracy of better than 1.5% of reading for traction return. 0 to 2000A DC. For conductor size 55mm diameter.	Kyoritsu 2003, 2003A, 2009
DC Tong Meter for general use	Resolution of better than 0.1A.	Kyoritsu AC/DC Digital Clamp meters. 2003, 2003A, 2004, 2033
AC Tong Meter for general use	Resolution of better than 0.1A.	Kyoritsu 2033
AC Current clamp	10Hz to 3kHz, 10mV/A, and 100mV/A.	Chauvin Arnoux 1000/1 A current clamp. AMEC AC current probe SD661

Test Equipment Requirements (Continued)

Test Equipment	General Requirements	Approved Test Equipment
Rail current meter	Indication of rail current. Resolution of 0.1A rail current at 1700Hz to 2600Hz.	**Clancy meter**: Calibrated at 50Hz. The Clancy meter tends to read high at audio track circuit frequencies but does provide an indication of comparative rail current. **RAS Coil**: Output 1mV/A at 50Hz and about 1mV/A at 1700 - 2600Hz. Reads about 10-20% low at audio frequencies. The readings are lower as the frequency increases. Used in conjunction with a DMM. Must use a Fluke 189 or equivalent meter. Using Hz button on multimeter can check the frequency of the dominant rail current if the output of the RAS coil is high enough for the meter. **Rail Current Meter**: Output 1mV/A or 10mV/A. Used in conjunction with a DMM.
CRO (Oscilloscope)		
Arrestor Tester		

8.2. Power Supply Investigation and Test

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
Visual and Physical Checks	Hand tools Visual	Inspect and check all terminations	Terminations effective and secure	PSU Unit locked in place	Correct as required		Level 1, 2 and 3
PSU Input Voltage	DMM on Vac	BX120 bus	AC voltage 110 – 132Vac	If voltage is <110V Check UM71 PSU voltage taping. Check Store 93 is an Exectronics brand with serial number. Unmarked units are not suitable.	Adjust input voltage taps on UM71 PSU or replace unsuitable Store 93 PSU.	Supply voltage less than 110Vac with wrong type of power supply.	Level 1, 2 and 3
PSU Output Voltage	DMM on Vdc	B24/N24	22.5Vdc – 28.8Vdc		Replace power supply.	<22.5Vdc >28.8Vdc	Level 1, 2 and 3 Track Circuit History Card
PSU Output ripple Voltage	DMM on Vac	B24/N24	< 100mVac	Power Supply Ripple Significant ripple also indicates the track circuit may drop out on Power supply changeover.	Replace power supply.	>1.0Vac	Level 3 – Detailed Investigation
Bx120v fuse Voltage Drop	DMM on Vac	Bx120v fuse	<30mVac	Connection and fuse.	Clean and Re-Secure or replace fuse.	>50mVac	Level 3 – Detailed Investigation
Nx120v Terminal Voltage Drop	DMM on Vac	Nx120v Terminals	<5mVac	Connection and pin.	Clean and Re-Secure	>5mVac	Level 3 – Detailed Investigation
B24 Terminal Voltage Drop	DMM on Vdc	B24v fuse	<30mVdc	Connection and fuse.	Clean and Re-Secure or replace fuse.	>50mVdc	Level 3 – Detailed Investigation
N24 Terminal Voltage Drop	DMM on Vdc	N24v Terminals	<5mVdc	Connection and pin.	Clean and Re-Secure	>5mVdc	Level 3 – Detailed Investigation
VA loss	DMM and AC, DC current tong.	Voltage at BX120, and B24, AC current input PSU, DC current out of PSU.	AC current times voltage to give VAinput DC current times by voltage to give VAoutput.	Va loss = VA input – VA output.	Replace power supply.	VA Loss more than 50VA.	As Requested

Power supply Investigation and Test (Continued)

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
PSU output voltage earth balance	DMM on Vdc with 20k shunt.	B24, N24, and earth bar.	< 0.5Volts from B24, or N24 to earth.	Earth fault inside modules or wiring insulation.	Test surge protectors. Test insulation resistance of wiring. Replace modules.	>2 Volts for either B24 or N24 to earth.	As Requested

8.3. Transmitter Investigation and Test

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
Visual and Physical Checks	Hand tools Visual	Inspect PFC12 Block as per Section 9.	Terminations effective and secure	Tx Unit locked in place. Faston crimps by **gently** pulling the wires.	Correct as required	Loss of tension on Faston crimps, defective fittings or connections.	Level 1, 2 and 3
Input Voltage	DMM on Vdc	A+ / A-	22.5Vdc to 28.8Vdc		Test Power Supply Unit and TX input current.	<22.5V or >28.8V	Level 1, 2 and 3
Output voltage	DMM on Vac	Location Track Terminals	T1 45-60Vac T2 50-80Vac.	1700Hz transmitters output voltage should be closer to 45Vac. 2600Hz transmitters output voltage should be closer to 60Vac.	Check Kem strapping. Change Transmitter or find and correct any fault loading the track.	T1 <40 or >65Vac T2 <50 or >80Vac	Level 1, 2 and 3 Track Circuit History Card
Input Current	DC Tong meter	Wire to A+ or A-	0.2 – 1.2Amps on low power. 0.2 – 2.2Amps on high power.	Increasing current means an increased load on track or faulty transmitter.	If >0.8A unit should be on High Power or have transmitter changed.	Change Transmitter If > 1.2Amps on low power, and >2.2Amps on high power. See **Note**.	Level 1
TX Output Terminal Voltage Drop	DMM on Vac	TX SAK Output Terminals	<5mVac		Clean and Re-Secure	>5mVac	Level 3 – Detailed Investigation
Transmitter Frequency	DMM on Vac, Hz (Fluke 8060, 87, 187, 189)	Location Track Terminals	Base Frequency ±2Hz Use Min/Max to get Average if unstable reading.	Indicates correct modulation.	Check mod. strap M1-M3. Change Transmitter	Change Transmitter >Base Frequency +6Hz <Base Frequency -6Hz	Level 3 – Detailed Investigation

Note: Since 1996 Transmitters that have been serviced by REC have had the high power bridges bridge applied internal to the transmitter.

Transmitter Investigation and Test (Continued)

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
TX Lower Frequency	DMM on Vac, Hz	Remove M1-M3. Bridge and release M1-M3 until lower frequency is observed. Measure at TX Output Terminals	1689, 1989, 2289, or 2589 Hz at +1.5Hz, -0.5Hz.	Use higher voltage scale if unexpected reading. See **Note**.	Change Transmitter	Change Transmitter at more than +/-6 Hz from lower freq.	As Requested
TX Upper Frequency	DMM on Vac, Hz	Remove M1-M3. Bridge and release M1-M3 until upper frequency is observed. Measure at TX Output Terminals.	1711, 2011, 2311, or 2611 Hz at +1.5Hz, -0.5Hz.	Use higher voltage scale if unexpected reading. See **Note**.	Change Transmitter	Change Transmitter at more than +/-6 Hz from upper freq.	As Requested
TX Output voltage earth balance	DMM on Vac	Location Track Terminals and earth bar.	About 50% of output voltage from each leg to earth.	Earth fault inside modules or wiring insulation.	Test surge protectors. Test insulation resistance of wiring. Replace modules.	One leg being more than 75% of output voltage to earth.	As Requested
Recovery after shunt.	Shunt box on short circuit.	Apply shunt at Tx Tu for 10 seconds.	Track relay drops and picks due to test.	Tx output voltage recovers after power limiting.	Replace Tx.	Track does not pick within 3 seconds.	As Requested
Start-up at power on.	-	Pull N24 pin for Tx, and restore after 10 seconds.	Track relay drops and picks due to test.	Tx starts working at power on.	Replace Tx.	Track does not pick within 3 seconds.	As Requested

Note: Since 1996 Transmitters that have been serviced by REC have had the M1-M3 bridge applied internal to the transmitter.

8.4. Transmitter End Matching Units Investigation and Test

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
Visual and Physical Checks	Hand tools Visual	Inspect and check all terminations	Terminations effective and secure		Correct as required		Level 1, 2 and 3
Input Voltage	DMM on Vac	E1/E2 on T1 1/2 on T2	40Vac– 60Vac range. Less than 5V drop from TX output.	Typically cable voltage drop should be less than 5V.	Check Transmitter and/or Cable	>10V lower than TX Output voltage.	Level 2 & 3 – Investigation
Transformer Input Voltage	DMM on Vac	5/7 on T1 5/10 on T2	35Vac – 60Vac	Typically 1 to 5V less than E1/E2.	Check Voltage Drop 1 and Voltage Drop 2	<25Vac	Level 2 & 3 – Investigation
Output Voltage	DMM on Vac	V1 / V2	Output should be more than the Transformer Input Voltage ÷ Ratio minus 0.7V.	Ratio is 10 for T1 and 13 for T2.	Check Bridge R1/R2 Terminals V1/V2 Capacitors C1 & C2 Bridges L3/7, L4/5	Condemn if unable to get Output voltage more than Transformer Input voltage ÷ Ratio minus 0.7V. **See Note 1.**	Level 2 & 3 – Investigation
Capacitor Voltage Drop C1	DMM on Vac	C1 +/-	Typical 10mV to 60mV	Readings up to 100mV acceptable. Degradation occurring if readings are significantly different between caps.	Note and monitor Significant differences (CSEE Failure Report)	>100mV Change Matching Unit. **See Note 2.**	Level 2 & 3– Investigation
Capacitor Voltage Drop C2	DMM on Vac	C2 +/-	Typical 10mV to 60mV		Note and monitor Significant differences (CSEE Failure Report)	>100mV Change Matching Unit. **See Note 2.**	Level 2 & 3– Investigation
Bridging R1-R2 Voltage Drop	DMM on Vac	R1/R2	Acceptable < 5mV		Check bridge and Termination	>5mV Change the bridge if still not compliant change the MU	Level 3 – Detailed Investigation
Bridging L3-7	DMM on Vac	L3/7 on T1 3/5 on T2	Acceptable < 5mV		Check bridge and Termination		Level 3 – Detailed Investigation
Bridging L4-5	DMM on Vac	L4/5 on T1 4/10, 7/8 on T2	Acceptable < 5mV		Check bridge and Termination		Level 3 – Detailed Investigation

Note 1: Output voltage ratio is not a suitable test when the Mu is connected to an impedance bond.

Note 2: Westinghouse Matching unit capacitors may have a higher voltage drop and use a condemning limit of 180mV.

Transmitter End Matching Unit Investigation and Test (Continued)

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
Voltage Drop 1	DMM on Vac	E1 / 7 on T1 1/5 on T2	Typical 5Vac – 45Vac	Vd1=Vd2 (± 10%)	<5v Check for HR in MU, TU or Connections >45v Check for S/C in MU, TU or Connections Unbalanced change MU.	If Vd1 varies from Vd2 by greater than 10% Change Out MU	Level 3 – Detailed Investigation
Voltage Drop 2	DMM on Vac	E2 / 5 on T1 2/10 on T2	Typical 5Vac – 45Vac	Vd1=Vd2 (± 10%)	<5v Check for HR in MU, TU or Connections >45v Check for S/C in MU, TU or Connections. Unbalanced change MU.	If Vd1 varies from Vd2 by greater than 10% Change Out MU	Level 3 – Detailed Investigation
Track voltage earth balance	DMM on Vac	V1, V2, and earth (or mounting post).	About 50% of track voltage (V1/V2) from each leg to earth.	Earth fault inside MU, TU, IB or on track.	Test Spark gaps. Inspect Track. Insulation test MU, TU, and IB.	One leg being more than 90% of track voltage to earth **and** the other leg being less than 10% of track voltage to earth.	As Requested
DC Voltage due to traction return	DMM on Vdc	V1 / V2	Typically between -0.1 and +0.1Vdc with trains nearby.	Traction imbalance exceeding MU rating	Investigate traction return imbalance and traction tie ins. Check SI unit and connections.	> +3Vdc or < -3Vdc.	As Requested

8.5. Tuning Unit Investigation and Test

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Requirement
Visual and Physical Checks	Hand tools Visual	Inspect and check all terminations	Terminations effective and secure		Correct as required		Level 1, 2 and 3
Short Circuit Test (Considered as a track shunt rather than Bridging or Releasing)	A registered jumper wire.	Apply jumper wire across V1/V2 of adjacent Tuning unit to confirm adjacent TU.	Track voltages on track circuit should return to track history card values or better.	Track relay picks up.	Perform TU impedance test.	Track picks up when adjacent tuning unit is short-circuited or Track V1/V2 voltage increases by more than 10% (~0.3v) for a Tx Tu, and 30% (~0.15v) for a Rx TU.	As Requested
Attenuation Ratio Test	FSM **Excluding TFA.**	VT1=Rail to Rail Voltage at adjacent tuning unit at frequency of that track VT2=Rail to Rail Voltage at t tuning unit under test, at frequency of the adjacent track	VT1/VT2>10	Brown encapsulated unit Ratio 15 to 20:1 Black encapsulated unit Ratio 10 to 25:1. Higher ratios may occur.	Perform TU impedance test.	VT1/VT2<10	As Requested
Impedance Test see Section 8.6 Tuning Unit Impedance Tests							

8.6. Tuning Unit Impedance Tests

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Requirement
Transmitter end Tuning Unit Impedance Test **AT TRACK FREQUENCY**	FSM (**Excluding TFA)** AC Current Clamp	Disc. 1 track lead at TU 1. TU Voltage mV V1/V2 2. Current between TU & MU	Use readings to calculate impedance and compare with Table	Z=TU(mV) / I(A)	Change out Tuning Unit	See Table	Level 2 and 3 TU Voltage: Track Circuit History Card
Transmitter end Tuning Unit Impedance Test **AT ADJACENT FREQUENCY**	FSM (**Excluding TFA)** AC Current Clamp	Disc. MU V1 or V2 1. TU Voltage mV V1/V2 2. Current in track cable to TU V1 or V2	Use readings to calculate impedance and compare with Table	Z=TU(mV) / I(A)	Change out Tuning Unit	See Table	Level 2 and 3
Receiver end Tuning Unit Impedance Test **AT TRACK FREQUENCY**	FSM (**Excluding TFA)** AC Current Clamp	Disc. MU V1 or V2 1. TU Voltage mV V1/V2 2. Current in track cable to TU V1 or V2	Use readings to calculate impedance and compare with Table	Z=TU(mV) / I(A)	Change out Tuning Unit	See Table	Level 2 and 3 TU Voltage: Track Circuit History Card
Receiver end Tuning Unit Impedance Test **AT ADJACENT FREQUENCY**	FSM (**Excluding TFA)** AC Current Clamp	Disc. MU V1 or V2 1. TU Voltage mV V1/V2 2. Current in track cable to TU V1 or V2	Use readings to calculate impedance and compare with Table	Z=TU(mV) / I(A)	Change out Tuning Unit	See Table	Level 2 and 3

TUNING UNIT IMPEDANCE RANGES	**Z at 1700Hz**	**Z at 2000Hz**	**Z at 2300Hz**	**Z at 2600Hz**
TU. 1700	340<Z<390 mΩ		Z<62 mΩ	
TU. 2000		395<Z<455 mΩ		Z<76 mΩ
TU. 2300	Z<66 mΩ		445<Z<521 mΩ	
TU. 2600		Z<80 mΩ		490<Z<592 mΩ

8.7. SI Tests

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Requirement
Impedance at GIVEN FREQUENCY	FSM (**Excluding TFA)** AC Current Clamp	SI Voltage mV V1/V2 Current Using Current Clamp and FSM	Use readings to calculate impedance and compare with Table	$Z = \frac{TU(mV)}{I(A)}$	Check that the vandal resistant cover is not the cause of the error. **See note**. Change out SI Unit	See Table	Level 2 and 3
DC current through SI	DC Tong for Traction current.	One SI rail connection.	Typically less than 20A.	Traction arrangements.	Investigate traction return imbalance and traction tie ins. Check SI impedance.	>100A	As Requested
DC Voltage due to traction return	DMM on Vdc	V1 / V2	Typically between -0.05 and +0.05Vdc with trains nearby.	Traction imbalance exceeding SI rating	Investigate traction return imbalance and traction tie ins.	> +0.5Vdc or < -0.5Vdc.	As Requested

Z at 1700Hz	Z at 2000Hz	Z at 2300Hz	Z at 2600Hz
331<Z<385 mΩ	389<Z<453 mΩ	448<Z<520 mΩ	506<Z<588 mΩ

Note: Metallic vandal resistant covers (particularly made from Aluminium) can reduce the impedance of SI units.

8.8. Track Investigation and Test

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
Track Voltage	FSM	Rail to Rail		Reference: Track Circuit History Card & Record			Level 1, 2 and 3
Voltage drops on all Track Connections. This includes both TU and SI for TX and RX tuned loops.	DMM on Vac	Test point depends on the type of connection. **See Note 1**	<5mV drop for bolted connections. <10mV for welded connections.	Rail connections. Target for rail connections is less than 1 mOhm.	Repair/replace connection and make good. **See Note 2.** Advise Civil of any track movement.	>10mV drop for bolted connections. >20mV for welded connections. One rail connection > twice the other connection.	Level 1, 2 and 3
Shunt Test	0.15Ω Fixed Shunt	3 metres either side of the TU at both Tx and Rx end of the track as well as mid point of the track length.	Relay front contacts should be observed to open.		Report findings to DSE and Signal Engineering		Level 3 – Detailed Investigation
General Inspection	Visual	Track Connections Trackside Equipment (Incl. Impedance bonds and spark gaps) Ballast Condition, Ballast height, Rails, Bonding, Bridge Structures etc. Insulation on spark gap connections that pass under the other rail. No long pieces of rail scale or conductive material.	Installed to standards, free of defects, damage, and contamination	Track Insulation Plan Standards No cause of rail to rail short circuits or rail to earth short circuits.	Report, record and if possible, rectify.		Level 1, 2 and 3

Note 1: Test points for track connection.

First meter lead is held on the palm of the crimp for tapered bolt and welded stud connections.

First meter lead is held on the bi-metallic inline crimp for direct welded connections.

The other meter lead should be held on the wheel/rail contact band on the head of the rail.

Note 2: Welded connection tests include more than just the rail connection. Condemn at >5mOhms per complete connection.

Track Investigation Test (continued)

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
Rail voltage drop profile	FSM	Rail to rail voltages at regular intervals. (~100m) From Tx to Rx.	Voltage drop should range from 1.5 to 0.3V per 100m.	The voltage drop per 100m should reduce along the track. The rate of reduction should decrease. The reduction can be constant for good ballast.	Look for a rail to rail connection across the track.	**Note 1**.	As Requested
Rail current profile	Rail Current meter.	Up rail, or Down Rail currents at regular intervals. (~100m) from Tx to Rx. This test does not include measurements in the tuned loop.	Initial rail currents of 1.5 to 0.4A are typical. Shorter track circuits tend to have higher rail currents.	**Note 2**.	Look for a rail to rail connection across the track.	**Note 3**.	As Requested
Rail current balance	Rail Current meter.	Up rail, and Down Rail currents at regular intervals. (~100m)	Equal readings for Up and Down rails.	Unbalanced leakage and external currents.	Look for: external connection to rail, faulty spark gap, or a common mode external current.	Clearly detectable difference of at least 0.2A.	As Requested

Note 1: A higher rate of voltage drop occurs on the shorter higher frequency tracks. A higher rate of voltage drop occurs between a transmitter and a mid-track impedance bond. The voltage drop per 100m for each successive 100m should decrease when measured from transmitter to receiver end. The decrease should reduce for each 100m segment. An increase in the rate of reduction indicates an extra load across the track in the previous 100m.

Note 2: The rail current should gradually decrease from transmitter to receiver. The rail current at the receiver end should be at least 0.1A.

Note 3: Tracks without impedance bonds or electrolysis bonds should have a decreasing reduction in rail current for every 100m when the rail current is measured once every 100m from transmitter to receiver end. An increase in the current reduction indicates an extra load across the track in the previous 100m.

Tracks with impedance bonds or electrolysis bonds should have a decreasing reduction in rail current for every 100m when the rail current is measured once every 100m from transmitter to receiver end except for the 100m segment with the impedance bond or electrolysis bond. An increase in the current reduction indicates an extra load across the track in the previous 100m.

8.9. DPU Investigation and Test

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
Visual and Physical Checks				DPU is secure, parallel to the rail and correct spacing from the rail.	Correct mounting	Visible defect.	Level 1
Output voltage with no or low load. (Either input to DPU Amp or with Matching Unit disconnected.)	FSM	Location Input terminals with DPU Amp. Or DPU cable disconnected from MU.	AC output voltage.	DPU is producing sufficient output voltage with no or low load.	Check connections or replace DPU. Check and ensure sufficient rail current. Insufficient rail current can be due to connection or RX Tuned loop problems.	Output Voltage less than 40mV.	As Requested
Output voltage (Load on DPU)	FSM	Voltage at MU input.	AC voltage Typically >20mV.	DPU is producing sufficient output voltage when loaded.	Check connections and adjustment or replace DPU.	Unable to achieve R1/R2 voltage of >320mV	As Requested
DPU Matching unit adjustment	FSM	Voltage at input and output of MU.	MU output voltage divided by MU input voltage gives transformer ratio.	Voltage ratio from input to output is approximately equal to transformer ratio.	Check or readjust matching unit.	Voltage ratio is < 2/3 of transformer ratio.	As Requested
DPU Amp	FSM	Voltage at R1/R2 of Rx		Sufficient output voltage from DPU and Amp.		Unable to achieve R1/R2 voltage of >320mV	As Requested

DPU Investigation and Test (Continued)

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
DPU Amp High gain setting effectiveness.	DMM on Vac	DPU Amp Output A5/A6 With D1/D2 bridge (High gain) and without.	Output Voltage on high gain should be twice voltage on low gain.	High gain strap effectiveness.	Replace DPU Amp.	High gain output voltage > 1.8 times low gain voltage.	As Requested
DPU Amp power	DMM on Vdc	DPU Amp R1/R3	22.5 to 28.8Vdc	Power supply to DPU Amp.	Test Power supply unit, fuses and connections.	<22.5V or >28.8V	As Requested
Over-energisation	FSM and short circuit shunt 1m on Rx side of DPU.	Voltage at R1/R2 of Rx	R1/R2 voltage should increase but not exceed the condemning limit given.	Over-energisation of receiver.	Re-adjust track circuit. The track may need to be set on Normal power.	>800mV on R1/R2.	As Requested
Rail current past DPU	FSM (**Excluding TFA)** AC Current Clamp RAS coil for rail current.	Track lead at Rx TU or other location if available	CSEE DPU requires rail current >: 570mA at 1700Hz 520mA at 2000Hz 485mA at 2300Hz 470mA at 2600Hz	Sufficient rail current for DPU. Affected by Impedance bonds, and ballast. A DPU Amp will allow operation at lower rail currents.	Refer to Engineering.	Values less than that given.	As Requested
Voltage balance to earth	DMM on Vac	Each DPU cable wire to earth connection.	About 50% of output voltage from each leg to earth.	Earth fault on wiring insulation.	Test insulation resistance of wiring.	One leg being more than 75% of output voltage to earth.	As Requested

8.10. Compensating Capacitors Investigation and Test

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
Impedance	AC Current Clamp and FSM	Voltage across the capacitor, and current through the capacitor at the track frequency.	Impedance is Voltage divided by the current. (Z=V/I)	The 33uF cap. for 1700Hz, and 2000Hz tracks impedance should be in the range of 1.9 to 3.4 ohms. The 22uF cap. for 2300Hz, and 2600Hz tracks impedance should be in the range of 2.2 to 3.8 ohms.	Check connections or replace capacitor.	Impedance outside the range.	As Requested

8.11. Spark Gap Investigation and Test

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
DC Volts	DMM on Vdc	Stanchion or Structure to Rail Connection	Range: >3Vdc & <115Vdc	Voltage should vary with electric train movements. Voltages < 3Vdc may occur if no electric trains are in the area.	Report to Electrical Discipline any spark gap outside the condemning limits	<3Vdc or >115Vdc	Level 1, 2 and 3 **See note.**
DC Current	DC Tong Meter	Connection from rail to structure or stanchion	Not greater than minimum sensitivity of tong meter	Should be zero current	Report to Electrical Discipline any spark gap outside the condemning limits	Measurable current	Level 1, 2 and 3 **See note.**
AC Current	AC Tong Meter	Connection from rail to structure or stanchion	Not greater than minimum sensitivity of tong meter	Should be zero current	Report to Electrical Discipline any spark gap outside the condemning limits	Measurable current	Level 1, 2 and 3 **See note.**

CAUTION: Electrical safety issues exist relating to Over Head Wiring structures. Refer to Signalling Maintenance Procedure TMG J042 *Safety Issues for Signalling Personnel* for more details.

Note: Only one of these three tests is required to test a spark gap.

8.12. Electrolysis bond Investigation and test

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
Visual and Physical Checks				Inspect connections and Store 54.			Level 1
Store 54 Balance	DMM on Vac	Measure voltage from centre to each rail connection.	Voltages approximately same	Each half of choke should be the same.	Check connections and Store 54.	> 10% difference.	Level 1
Store 54 Impedance	AC current clamp and FSM	Voltage across Store 54 and current.		Impedance of Store 54 not loading the track.	Replace Store 54	<30 ohms at track frequency. **See Note.**	As requested.
Leakage current	AC current clamp and FSM	Measure track circuit current in electrolysis connection		No track circuit current should be leaving or entering the track via the electrolysis bond.	Find and correct leakage path.	> 0.1A	As requested

Note: Impedance across Store 54 should be 30 ohms at 50Hz, 1020 ohms at 1700Hz, and 1560 ohms at 2600Hz.

DC resistance of each leg of Store 54 to centre tap is 20 milliohms.

8.13. Impedance Bond Investigation and Test

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
Inspect bond for signs of damage	Visual			Connections secure. Side leads are equal lengths. Bond okay.	Repair/Replace		Level 1, 2 and 3
2000R/AF Inspect resonating capacitor box (when fitted).	Visual		See **Note 1**, and **Note 2**.	Capacitor links securely open, or closed. Transzorb not fitted across capacitors. MOV (B32K385) fitted.	Repair/Replace		Level 1, 2 and 3
Check for Traction Return balance	2 off DC Tong for traction	Impedance bond side leads.	DC Rail currents are similar with variance <10%		Check connections, bond, side leads	Variance >33%	Level 1, 2 and 3
2000R/AF Resonating winding Test	FSM	(V1) Rail to Rail Voltage (V2) Resonating winding Voltage	The Resonating winding Voltage (V2) should be >60 times the rail to rail voltage (V1)	Turns ratio of resonating winding.	Try to re-resonate bond and if unable to achieve acceptable value then do impedance test.	< 40 times	As Requested
Voltage Comparison Up and Down Rails to Neutral Lead	FSM	(V1).Up Rail to Imp. bond 4 way. (V2).Dn Rail to Imp. bond 4 way.	V1 ≈ V2		Check connections and possible rail faults to earth. Replace impedance bond if no other cause found.	+/-20% difference.	As Requested
Side Lead Current	AC Current Clamp FSM	Each individual side lead	All individual measurements should be equal	Can have errors due to large changes in DC currents.	Check connections and possible rail faults to earth. Replace impedance bond if no other cause found.	+/-10% difference.	As Requested

Note 1: If the 2000R/AF Impedance bond is resonated then typically the resonating capacitors should be about 9nF for 1700Hz, 5.7nF for 2000Hz, 4.7nF for 2300Hz, or 3.2nF for 2600Hz. During the 1990's higher capacitor values were used, which are no longer recommended.

Note 2: The 2000R/AF Impedance bond resonation is affected by capacitance of the MOV (~1.5nF) protecting the capacitors.

Impedance Bond Investigation and Test (Continued)

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
MJS, MJX, Macolo Impedance Bond Impedance	AC Current Clamp FSM	(V)=Rail to Rail (I)=Sum of side lead currents Z=V/I	17 to 26 Ω	Impedance bond loading the track.	Replace bond.	<8 Ω	As Requested
2000R/AF Impedance bond impedance	AC Current Clamp FSM	(V)=Rail to Rail (I)=Sum of side lead currents Z=V/I	Not Resonated: 2 to 3 Ω. Resonated. 10 to 30Ω.	Impedance bond loading the track.	Not Resonated: Replace bond. Resonated: Re-resonate bond. If unable to re-resonate, check coil.	Not Resonated: < 1.5 Ω Resonated: <8 or >40 Ω	As Requested
CIT1400 Impedance bond impedance	AC Current Clamp FSM	(V)=Rail to Rail (I)=Sum of side lead currents Z=V/I	Not Resonated: 9 to 15 Ω. Resonated. 1 to 4 Ω	Impedance bond loading the track. **See Notes 1 and 2.**	Not Resonated: Replace bond. Resonated: Check capacitor, and coil.	Not Resonated: < 4 Ω Resonated: > 9 Ω	As Requested
2000R/AF Secondary coil resistance.	DMM ohms scale	Across winding	1.5 to 2 ohms.		Replace bond.	<1 ohm or >3 ohms	As Requested.
Vac Case to Resonating Coil Leads	DMM on Vac 20K Shunt	(V1) Coil Lead (1) to Case. (V2) Coil Lead (2) to Case	V1 <0.5Vac V2 < 0.5Vac		Find and correct resonating coil or capacitor fault to case or replace impedance bond.	V1 >0.5Vac or V2 > 0.5Vac	As Requested
Vdc across impedance bond	Precision DMM on Vdc. Eg Fluke 187 or 189.	Rail connection bus bar to Rail connection bus bar. Can be from palm to palm of side lead connections.	< 10mV DC Value will vary with train movement. Ignore readings with train on track circuit. **See Note 3.**	Traction current balance.	Further investigation as to reason for traction imbalance.	> 200mV for 2000R. > 300 mV for Macolo > 350mV for other bonds.	As Requested

Note 1: CIT1400 bonds should only be resonated for tracks longer than 600m or when two bonds are installed on the track.
Note 2: CIT1400 bonds have been incorrectly resonated for 2300Hz. Capacitor is on F and M, strap on G to L.
Note 3: If using Min/Max then a suitable scale (eg 500mV) must be manually set before Min/Max is selected.

8.14. Receiver End Matching Unit Investigation and Test

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Requirement
Visual and Physical Checks	Hand tools Visual DMM on Vac	Inspect and check all terminations	Terminations effective and secure Connections Vd<10mVac		Correct as required		Level 1, 2 and 3
Input Voltage	FSM	V1 / V2	Range is 0.25Vac – 2Vac. Should have no more than 100mV drop from the rail to rail voltage.	Should approximate rail to rail voltage.	Check Connections, Track cables, rails, bonding, bridge structures, Transmitter MU	More than 100mV drop from rail to rail voltage.	Level 2 & 3– Investigation
T1 Output Voltage	FSM	9 / 10	Approximately the same as the Input Voltage	Should approximate rail to rail voltage.	Check Bridge R1/R2 Capacitors C1 & C2 Terminations	If variance between V1/V2 and 9/10 is greater than 0.1V Change out MU. **See Note 1.**	Level 2 & 3– Investigation
T2 Output Voltage	FSM	1/2	18 to 23Vac	Sufficient voltage to Rx.	Adjust MU. Perform other MU tests.	< 16v	Level 2 & 3– Investigation
Capacitor Voltage Drop C1	DMM on Vac	C1 +/-	Typical 1mV to 5mV	Readings up to 20mV acceptable. Degradation occurring if readings are significantly different	Note and monitor Significant differences (3 times C2)	>20mV Change Matching Unit	Level 2 & 3– Investigation
Capacitor Voltage Drop C2	DMM on Vac	C2 +/-	Typical 1mV to 5mV		Note and monitor Significant differences (3 times C1)	>20mV Change Matching Unit	Level 2 & 3– Investigation
Bridging R1-R2 Voltage Drop	DMM on Vac	R1/R2	Acceptable Reading < 5mV	Connections	Check bridge and Termination	>5mV Change the bridge. If still not compliant change the MU.	Level 3 – Detailed Investigation

Note 1: Output voltage ratio is not a suitable test when the Mu is connected to an impedance bond.

Receiver End Matching Unit Investigation and Test (Continued)

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Requirement
T2 Bridging	DMM on Vac	Across each bridge	Acceptable Reading < 5mV	Connections	Check bridge and Termination	>5mV Change the bridge. If still not compliant change the MU.	Level 3 – Detailed Investigation
T2 Common mode choke	DMM on Vac	1/3 and 2/4	Voltage 1/3 = Voltage 2/4	Common mode choke	Change out MU.	More than 10% difference.	As requested
T2 MU ratio	FSM	3/4 as output 15/16 as input.	Output voltage divided by input voltage gives transformer ratio.	Voltage ratio from input to output is approximately equal to transformer ratio.	Check or readjust matching unit.	Voltage ratio is < 2/3 of transformer ratio.	As Requested
DC Voltage due to traction return	DMM on Vdc	V1 / V2	Typically between -0.1 and +0.1Vdc with trains nearby.	Traction imbalance exceeding MU rating	Investigate traction return imbalance and traction tie ins. Check SI unit and connections.	> +3Vdc or < -3Vdc.	As Requested.

8.15. Receiver Unit Investigation and Test

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
Visual and Physical Checks	Hand tools Visual	Inspect PFC12 Block as per Section 9.	Terminations effective and secure	Rx Unit locked in place. Faston crimps by **gently** pulling the wires.	Correct as required	Loss of tension on Faston crimps, defective fittings or connections.	Level 1, 2 and 3
Relay Output Voltage T1	DMM on Vdc	L+ / L-	Typical values are 25Vdc to 27Vdc		Change Receiver	<18.5Vdc or >28Vdc	Level 1, 2 and 3
Relay Output Voltage T2	DMM on Vdc	TR+/ TR-	Acceptable Range 42Vdc to 58Vdc		Change Receiver	<42Vdc or >58Vdc	Level 1, 2 and 3
Track Receiver Input Voltage T1	FSM	Location Track Terminals	Acceptable Range 0.25Vac to 1.5Vac		If < 0.25Vac Check Cables, Connections MU, TU, Track. If >2.5Vac Refer to DSE		Level 1, 2 and 3 <u>Track Circuit History Card</u>
Receiver R1/R2 Voltage Track Unoccupied	FSM	R1/R2 on T1 M1/M2 on T2	Acceptable Range <35mV change from last full test.		Find fault and re-adjust track as per Maintenance procedures.	>35mV change from last full test	Level 1, 2 and 3 <u>Track Circuit History Card</u>
Drop Shunt Test	Variable Shunt Box / DMM	Rail to Rail at RX TU	Between 0.5 and 1.5 Ω		Refer to Maintenance Signal Engineer	< 0.5 ohm or > 1.5 ohm.	Level 1, 2 and 3
Track Stick contacts resistance	DMM on ohms	Track Relay A1/A2 (stick finger)	Typically less than 2 ohms per contact.	Measure resistance with receiver de-energised.	Replace relays with faulty contacts.	>10 ohms	Level 3 – Detailed Investigation
Zero Feed Receiver Voltage	FSM	R1 / R2 on T1 M1/M2 on T2 Take readings with Tx feed disconnected	Up to 45mV can be expected depending on site configuration.	Interference from same freq. tracks.	Investigate source of supply.	>45mV	Level 3 – Detailed Investigation <u>Track Circuit History Card</u>
Beating	FSM	R1/R2 on T1 M1/M2 on T2	The measured value should not change by more than 50mV.	Beating with other track circuits.	Isolate and find source of interfering signal.	Changes of more than 100mV when observed for 10 seconds.	As Requested

Receiver Unit Investigation and Test (Continued)

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
Receiver R1/R2 Voltage Track Shunted	FSM Fixed 0.15Ω Shunt	R1/R2 on T1 M1/M2 on T2	Typically < 45mV. **See Note 1.**	Use of a perfect shunt unit is critical.	Investigate and correct.	T1 > 90mV T2 > 55mV	<u>Track Circuit History Card</u>
Adjacent Frequency	FSM	R1/R2 on T1 M1/M2 on T2	Adjacent frequency should be less than 400mV.	Less than 1/10th of adjacent freq. rail voltage.	Investigate RX tuned loop.	> 500mV	As Requested
Track Stick Voltage Drop during pick up.	DMM Vdc set for fast or peak min/max	Track Relay A1/A2 (stick finger) (Meter set up with relay de-energised.)	Maximum between 0V and 2Vdc (Once relay energised)	Voltage drop on track stick contacts during pickup.	Test pick-up and holding path for HR contact/s.	>3V drop across contacts.	As requested.
Receiver DC Input Current with relay up.	DC Tong Meter	N24	0.15Amps to 0.4Amps		Change Receiver	<0.15Amps or >0.4 Amps	As Requested
Wideband Track Receiver input voltage	DMM on Vac	R1/R2 on T1 M1/M2 on T2	300-800mVac	Wideband voltage saturating receiver input.	Find and correct source of other voltage.	> 800mV.	As Requested
Modulation and receiver operation. (This is not a normal test.)	DMM on Vdc	Measure T/A- on T1 or T/F- on T2. Use 5 or 6VDC scale. Hz, and Fast Min Max.	13.3 Hz -1700Hz track 15.6 Hz -2000Hz track 18.0 Hz -2300Hz track 20.3 Hz -2600Hz track Min and Max voltage.	Modulation frequency and Rx level. Use lowest freq. Reading.	Analysis by Engineer and confirmation by Engineering.	At more than +/- 3 Hz from nominal Modulation freq. Min > 1Vdc. Max < 2.5Vdc Difference < 2Vdc Determination by Engineer.	As Requested
Modulation and receiver operation. This is not a normal test.	CRO	T/A- on T1 T/F- on T2	13.3 Hz -1700Hz track 15.6 Hz -2000Hz track 18.0 Hz -2300Hz track 20.3 Hz -2600Hz track Min and max voltage.	Waveshape analysis incl. Minimum voltage and maximum voltage.	Analysis by Engineer.	Min >0.5Vdc, Max <2.5Vdc Determination by Engineer.	As Requested

Note 1: T1 Receiver R1/R2 has a pick up/drop away value of 180mV. T2 Receiver M1/M2 has a pick up of 265mV, and a drop away value of 105mV.

Receiver Unit Investigation and Test (Continued)

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
Receiver, Input Current at R1/R2.	DMM on Iac	In series with R1 or R2	0.5mA AC to 15mA AC	Rx R1/R2 input Z approx. 300Ω	Analysis by Engineer.	Determination by Engineer.	As Requested
Receiver, Input Current at track terminals.	DMM on Iac	In series with track cable terminals into V1 or V2	5mA AC to 120mA AC	Rx V1/V2 input Z is from 36 to 55Ω	Analysis by Engineer.	Determination by Engineer.	As Requested
RX Input voltage earth balance	DMM on Vac	Location Track Terminals and earth bar.	About 50% of input voltage from each leg to earth.	Earth fault inside modules or wiring insulation.	Test surge protectors. Test insulation resistance of wiring. Replace modules.	One leg being more than 90% of track voltage to earth **and** the other leg being less than 10% of track voltage to earth.	As Requested

8.16. Surge Protection Investigation and Tests

Test	Test Equipment	Test Point Terminals	Readings	Checks	Action If Not Compliant	Condemning	Test Required
3Y20 Gas Arrestor Visual Inspection	Visual			No visible cracking, splitting, burn marks or blackening of the case.	Replace arrestor	Visible defects	Level 3 – Detailed Investigation
3Y20 Gas Arrestor Test	Arrestor Tester	Unplug unit and plug into arrestor tester.	Approximately 290Vdc for Line to earth.	Break down voltage	Replace arrestor	<220Vdc >360Vdc	Level 3 – Detailed Investigation
Elsafe 216680 Series voltage drop	DMM on mVac	Terminal 1 to 4, and Terminal 2 to 3.	<5mV	Connections.	Replace Elsafe module	>10mV	As Requested
Elsafe 216680 Break down voltage	Arrestor Tester	Unplug unit and connect to arrestor tester.	Approximately 290Vdc for Line to earth. 450Vdc for Line to Line.	Break down voltage	Replace Elsafe module	<220Vdc or >360Vdc for Line to earth. <300Vdc or >600Vdc for line to line.	As Requested
MOV on 24V bus Visual Inspection	Visual			No visible cracking, splitting, or burn marks.	Replace MOV	Visible defects	As Requested
MOV on 24V bus	DMM on Ohmmeter, and diode test.	Disconnect one leg and measure across the MOV	Ohmmeter should read >10 meg ohm. Diode test should read OL in both directions.		Replace MOV	Ohmmeter reading of <10 meg ohm or Diode test of less than OL.	As Requested
MOV on 24V bus Arrestor Test	Arrestor Tester	Disconnect one leg and measure across the MOV	Approximately 40Vdc.	Maximum operating voltage	Replace MOV	<36Vdc >45Vdc	As Requested
MOV on 120V bus Visual Inspection	Visual			No visible cracking, splitting, or burn marks.	Replace MOV	Visible defects	As Requested
MOV on 120V bus Arrestor Test	Arrestor Tester	Disconnect one leg and measure across the MOV	Approximately 210Vdc.	Maximum operating voltage	Replace MOV	<190Vdc >230Vdc	As Requested

9. PFC12 Block

9.1. Front Inspection

Inspect the top surface of the front contacts for discolouration or corrosion. If the tops of the contacts are mostly black then they may require cleaning.

Inspect the front contacts for even height and position. A contact may have lost spring tension or been bent. This may require replacement of the PFC12 block.

9.2. Rear Inspection

Check security of the Faston crimps by gently pulling and wriggling the wire. The crimp should be secure and not loose or move relative the blade that it is pushed onto. Replace any crimps that do not securely grip the blade they are pushed onto.

The Faston crimps gradually loose grip on the blade they are pushed onto with repeated use.

9.3. Tx/Rx Inspection

Inspect the under side contacts in the receiver or transmitter to see that they are not damaged, corroded or blackened.

9.4. Cleaning

Contact cleaning can be done using CRC 2354 Contact 60, which removes carbon, and sulphides (the cause of the blackening), and CRC Contact WL which is the washer for Contact 60.

Read the MSDS before use. The MSDS recommends the use of gloves and a Type A respirator. A Type A respirator is not a Dust mask. It is a filter for organic vapours.