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Track Circuits – Set-Up, Test and Certification

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1.0	May 2025		Consolidated SES 01 to SES 08 into this document. Minor editorial changes.

Table of Contents

1 Introduction

1.1 Purpose

The purpose of this document is to provide testing and certification procedures for the various type of track circuits on the ARTC network.

1.2 Scope

This document covers DC, AC Immune DC, Jeumont, AC Single Rail, AC Double Rail, CSEE UM71, FS2500 and ML TI21 track circuits.

This document applies to the entire ARTC network.

1.3 Document Owner

The Manager Engineering Services is the Document Owner. Queries should be directed to standards@artc.com.au in the first instance.

1.4 Responsibilities

Signalling staff performing the work on the track circuits are responsible for following this procedure.

1.5 Reference Documents

The following documents support this procedure:

- ESM-07-02 – Track Circuit and Train Detection Devices
- ESM-07-04 – Unreliable Track Circuit due to Infrequent Operation
- AS7715 – Train Detection

1.6 Definitions

The following terms and acronyms are used within this document:

Term or acronym	Description
AC	Alternating Current
BRB	British Railways Board
DC	Direct Current
HVI	High Voltage Impulse

2 DC Track Circuits

This section describes the procedures for the putting into operation, testing and certification of standard DC track circuits.

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.

2.1 Initial Set-Up

Initial set-up covers the removal of any old track circuit equipment and the connection and powering up of the new equipment.

2.1.1 Clear Old Track Connections

Where an existing signalling system is being renewed, the first step is to remove all old, redundant track circuit connections. This includes old feed and relay connections.

2.1.2 Bonding and New Connections

Bond out all redundant insulated joints, remove any temporary bonds around new insulated joints and connect any new parallel and series bonds. Check that all mechanical joints are bonded out.

Make all new rail connections and close up all terminal links. Check that track feed and relay cables are correctly terminated.

2.1.3 Check Bonding and Connections

Walk the length of the track circuit, checking the track against the new track insulation plans.

2.1.4 Equipment Check

Check that the track feed set is correctly installed, surge protection is installed, the correct arrestors are fitted and that all screw terminals on fuses and links are properly tightened.

Check that the feed resistor is adjusted to mid-range. On the TR17 feed set, check that the output adjustment is set for the low output.

2.1.5 Power Up – Feed End

Close outgoing cable links and track feed set 110/120 volt supply fuse and link.

Check that track polarity is the reverse of the previous DC track. If not, reverse the connections between the feed set and the track connections.

2.1.6 Rail Connections Check

Check that all rail connections are securely tightened.

2.1.7 Power Up – Relay End

Check that surge protection is wired and the correct arrestor is fitted. Close the incoming relay fuse and link.

Observe that the relay energises. If the relay does not pick up, or picks up weakly, increase the relay voltage by decreasing the feed resistor or increasing the feed set output.

2.1.8 Shunt and Correspondence Check

Check that the track shunts correctly by applying a fixed shunt at the relay end and observing 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.

2.2 Final Adjustment

Final adjustment covers the adjustment of the track feed set to achieve the specified relay operating values.

2.2.1 Initial Relay Check

Measure that the relay control voltage is above 150 per cent of the compression voltage recorded on the relay test label. If it is less than this, increase the track feed as required.

If a TR17 style feed set is used, the relay voltage should be above 150 per cent. If it is less than this, set the feed set output to the High output setting.

2.2.2 Drop Shunt Check and Final Adjustment

Measure and note the relay control volts.

Check the drop shunt at the relay end of the track, connected two metres outside the relay end track connections.

A final drop shunt value between 150 and 200 per cent of the minimum is acceptable. If necessary, adjust the feed voltage using the feed resistance to obtain the necessary drop shunt.

Notes:

- *The relay is de-energised when all front contacts can be seen open.*
- *There is no provision for adjustment of TR17 style track circuits other than the High/Low output tappings. The track circuit is designed to operate effectively over a wide range of length and ballast conditions.*

2.3 Certification

Certification covers the proving of correct operation of the track circuit and the completion of all documentation activities.

2.3.1 Zero Feed Relay Voltage

With all adjacent tracks operating, disconnect the feed from the track under test and record the DC voltage on the relay control coil.

If the remaining voltage exceeds 30 per cent of the relay release value, this shall be reported as a track circuit fault and the cause of the excessive voltage located and rectified.

Note: *With DC track circuits of all types, it is possible to encounter the phenomenon of 'battery effect'. A voltage is generated between the rails by chemical/electrolytic interaction between the rails and the ballast. If a residual voltage is found, prove that it is not a false feed by observing that it remains when all adjacent DC track feeds are disconnected. Battery effect voltages are also seen to drop gradually to zero after the track feed is disconnected and the shunt is applied across the tracks.*

2.3.2 Polarity Reversal

Check that correct polarity reversal occurs at each block joint where another DC track circuit abuts.

2.3.3 Test Shunt

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

- two metres from the feed end rail connections
- mid-track
- at both ends of any parallel-bonded section of track (where points are involved) two metres from the relay end rail connections.

2.3.4 History Cards

When all track work is finished, complete the ESI0703F-02 DC Track Circuit History Card for all tracks. The cards shall be signed by the responsible signal maintenance staff.

2.4 Appendix 1 – Explanatory Notes

Note 1: Track Circuit Polarity Check

With DC track circuits, it is critical that at any interface between a pair of tracks, the polarity of one track is opposite to the polarity of the other. This requirement exists to ensure that if the block joints at the interface fail, the relay of one track cannot be held falsely energised by the feed of the other. This requirement can be relaxed if unavoidable, at an interface where two feed ends abut.

Note 2: Track Connection Resistance

It is critical that the rail terminations of track connection cables are as low resistance as possible. As a guide, the voltages to be expected on good, new connections should be less than 2 mV.

Measure the voltage drop at each connection between the connecting cable conductors and the head of the rail near the termination. If the cable cores are not accessible, measure from a point on the connection lug, as close as possible to the insulation.

Note: Where duplicated leads are fitted, a low millivolt reading will be measured on both, so long as at least one is making good contact.

Any reading over 5 mV should be taken to indicate a suspect connection. Check the tightness of the securing nuts and, if this does not work, dismantle the connection, clean all mating surfaces with abrasive or solvent as required, then reassemble and tighten carefully.

3 AC Immune DC Track Circuits

This section describes the procedures for the putting into operation, testing and certification of an AC Immune DC track circuit equipped with a 9 ohm BRB 966F2 DC track relay.

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.

3.1 Initial Set-Up

Initial set-up covers the removal of any old track circuit equipment and the connection and powering up of the new equipment.

3.1.1 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.

3.1.2 Bonding and New Connections

Bond out all redundant insulated joints, remove any temporary bonds around new insulated joints and connect any new parallel and series bonds. Check that all mechanical joints are bonded out.

Make all new rail connections and close up all terminal links. Check that the track feed and relay cables are correctly terminated.

3.1.3 Check Bonding and Connections

Walk the length of the track circuit, checking the track against the new track insulation plans.

3.1.4 Equipment Check

Check that the track feed set is correctly installed, with the output range jumper set to low output, that surge protection is installed and the correct arrestors are fitted, and that all screw terminals on fuses and links are properly tightened.

3.1.5 Power Up – Feed End

Close outgoing cable links and track feed set 110/120 volt supply fuse and link.

Check that track polarity is the reverse of the previous DC track. If not, then reverse the connections between the feed set and track connections.

3.1.6 Rail Connections Check

Using a suitable digital meter, measure the DC 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.

3.1.7 Power Up – Relay End

Check that surge protection is wired and the correct arrestor is fitted.

Close the incoming relay fuse and link.

Observe that the relay energises. If the relay does not pick up, or picks up only weakly, increase the feed set output.

Note: The upper limit to the permissible relay energisation is the 3 watt coil dissipation limit. (This is equivalent to about 5.2 volts on the 9 ohm relay.)

3.1.8 Shunt and Correspondence Check

Using a fixed shunt 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.

3.2 Final Adjustment and Measurement

Final adjustment covers the adjustment of the track feed set to achieve the specified relay operating values.

3.2.1 Initial Relay Check

Measure that the relay control voltage is above 150 per cent of the compression voltage recorded on the relay test label. If it is less than this, set the feed set output to the High output setting.

3.2.2 Drop Shunt Check and Final Adjustment

Measure and note the relay control volts.

Check the drop shunt of the track using a variable shunt unit at the relay end of the track, connected two metres outside the relay end track connections.

A final drop shunt value between 150 per cent and 200 per cent of the minimum is acceptable.

Notes:

- *The relay is de-energised when all front contacts can be seen open.*
- *There is no provision for the adjustment of AC Immune DC track circuits, other than the High/Low output tappings. The track circuit is designed to operate effectively over a wide range of length and ballast conditions.*

3.3 Certification

Certification covers the proving of correct operation of the track circuit and the completion of all documentation activities.

3.3.1 Zero Feed Relay Voltage

With all adjacent tracks operating, disconnect the feed from the track under test and record the DC voltage on the relay control coil.

If the remaining voltage exceeds 30 per cent of the relay release value, this shall be reported as a track circuit fault and the cause of the excessive voltage located and rectified.

Note: With DC track circuits of all types, it is possible to encounter the phenomenon of 'battery effect'. A voltage is generated between the rails by chemical/electrolytic interaction between the rails and the ballast. If a residual voltage is found, prove that it is not a false feed by observing that it remains when all adjacent DC track feeds are disconnected. Battery effect voltages are also seen to drop gradually to zero after the track feed is disconnected, and the shunt is applied across the tracks.

3.3.2 Check Polarity Reversal

Check that correct polarity reversal occurs at each block joint where another DC track circuit abuts.

3.3.3 Test Shunt

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

- two metres from the feed end rail connections
- mid-track
- at both ends of any parallel-bonded section of track (where points are involved) two metres from the relay end rail connections.

3.3.4 History Cards

When all track work is finished, complete individual history cards for all tracks tested by the team. The cards shall be signed by the responsible signal maintenance staff.

3.4 Appendix 2: Explanatory Notes

Note 1: Track Circuit Polarity Check

With DC track circuits, it is critical that at any interface between a pair of tracks, the polarity of one track is opposite to the polarity of the other. This requirement exists to ensure that if the block joints at the interface fail, the relay of one track cannot be held falsely energised by the feed of the other. This requirement can be relaxed if unavoidable, at an interface where two feed ends abut.

Note 2: Track Connection Resistance

It is critical that the rail terminations of track connection cables are as low resistance as possible. As a guide, the voltages to be expected on good new connections should be less than 2 mV.

Measure the voltage drop at each connection between the connecting cable conductors and the head of the rail near the termination. If the cable cores are not accessible, measure from a point on the connection lug, as close as possible to the insulation.

Note: Where duplicated leads are fitted, a low millivolt reading will be measured on both, so long as at least one is making good contact.

Any reading over 5 mV should be taken to indicate a suspect connection. Check the tightness of the securing nuts and, if this does not work, dismantle the connection, clean all mating surfaces with abrasive or solvent as required, then reassemble and tighten carefully.

4 Jeumont-Schneider Impulse Track Circuits

This section describes the activities involved in commissioning and certifying GEC-Alstom / Jeumont-Schneider HVI track circuits.

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.

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

Track Insulation	Electrified	Matching Device	RX Type	Track Length		Tx Loop Res	Min Drop Shunt
				Min	Max	Ω	Ω
Single Rail	Yes	TV-TH1	2-wire	18	500	20	0.5
Single Rail	Yes	TV-TH1	2-wire, double RX	18	300	20	0.5
Single Rail	Yes	TV-THD2	2-wire	18	400	(multi feed)	0.25
Single Rail	No	TV-THD2	2-wire	50	1500	20	0.25
Double Rail	Yes	CIT-1400 or 2000P	4-wire	50	1000	10	0.25
Double Rail	Yes	CIT-1400 or 2000P	2-wire	50	600	20	0.25
Double Rail	Yes	CIT-1400 or 2000P	2-wire, double RX	50	300	20	0.25
Double Rail	No	TV-LV	4-wire	50	3000	10	0.25

Table 1 - Applicable Track Circuit Arrangements

4.1 Set to Work

This section covers removal of any old track circuit equipment and the connection and powering-up of the new equipment.

4.1.1 Bonding and Track Connections

Where an existing signalling system is being renewed, ensure that all old, redundant track circuit connections, including old feed and relay connections, impedance bonds, and spark-gap connections, are removed.

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

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

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

4.1.2 Check Auxiliary Track Equipment

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

4.1.3 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.

4.1.4 Loop Resistance

20 Ohm Loop		10 Ohm Loop	
Measured Loop Resistance	**Bridges to Set**	**Measured Loop Resistance**	**Bridges to Set**
0 to 2	C+ to 6	0 to 0.5	C+ to 4, 2 to 3
2 to 4	C+ to 5	0.5 to 1.5	C+ to 6, 3 to 5
4 to 5.5	C+ to 5, 2 to 3	1.5 to 2.5	C+ to 4, 2 to 3, 3 to 6
5.5 to 7	C+ to 6, 3 to 4	2.5 to 3.5	C+ to 3
7 to 9	C+ to 4	3.5 to 4.5	C+ to 5, 2 to 6, 3 to 5
9 to 10.5	C+ to 4, 2 to 3	4.5 to 5.5	C+ to 2
10.5 to 12	C+ to 6, 3 to 5	5.5 to 6.5	C+ to 6, 1 to 2, 3 to 5
12 to 14	C+ to 3	6.5 to 7.5	C+ to 3, 1 to 4
14 to 16	C+ to 2	7.5 to 8.5	C+ to 6, 1 to 5
16 to 17	C+ to 6, 1 to 3, 3 to 5	8.5 to 9.5	C+ to 5, 1 to 2, 3 to 5, 2 to 6
17 to 19	C+ to 6, 1 to 5	9.5 to 10	C+ to 1
19 to 20	C+ to 1		

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 3, according to the loop resistance specified in Table 1.

4.1.5 Terminations

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

4.1.6 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 in 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 operates, and that the relay energises cleanly.

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.

4.1.7 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 side leads 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 suitable digital 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 achieved the low millivolt drop.

4.1.8 Shunt and Correspondence Check

Using a fixed shunt (in accordance with the Table 1), 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.

4.2 Final Adjustment

With Jeumont-Schneider high-voltage impulse track circuit equipment, there is almost nothing that is adjustable in the field. 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.

4.2.1 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.

4.3 Certification

Certification covers the proving of correct operation of the track circuit, and the completion of all documentation activities.

4.3.1 Equipment for Test and Certification

A suitable Pulse integrator (See Appendix 3) is required for all measurements of impulse track circuit operating levels. Note, that the integrator shall be correctly polarised, for correct measurement and recording of track circuit polarities

4.3.2 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 shall be reported as a track circuit fault, and the cause of the excessive voltage located and rectified.

4.3.3 Polarity Reversal

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

4.3.4 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 shunt. Measure and record all equipment serial numbers and voltages listed on the history card (a sample history card 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.

4.3.5 History Cards

When all track work is complete fill in an individual history card for each track tested by the team. The cards shall be signed by the responsible signal maintenance staff.

4.4 Appendix 3 - Technical Notes

Note 1: 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.

Figure A1.1 - 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.

Note 2 : 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.

The integrator shall be polarised such that a positive-going pulse applied to the positive (red) input terminal will be integrated with the polarity switch in the ‘+ve’ position.

Note 3 : Track Connection Resistance

It is critical that the rail terminations of track connection cables are as low-resistance as possible, in view of the high DC and AC currents flowing through them, and especially in view of the need to keep traction return currents balanced. As a guide, the voltages to be expected on good new connections should be less than 2mV.

Measure the AC voltage drop at each connection between the connecting cable conductors and the head of the rail near the termination. If the cable cores are not accessible, measure from a point on the connection lug, as close as possible to the insulation.

Note that, where duplicated leads are fitted, a low millivolt reading will be measured on both, so long as at least one is making good contact.

Any reading over 5mV should be taken to indicate a suspect connection. Check the tightness of the securing nuts and, if this does not work, dismantle the connection, clean all mating surfaces with abrasive or solvent as required, reassemble and tighten carefully.

5 AC Single Rail Track Circuits

This section describes the procedures for the putting into operation, testing and certification of an AC single rail track circuit equipped with a double-element vane relay.

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.

Care shall be taken to ensure that none of the necessary checks and tests specified in this document are omitted.

This document applies to all forms of single rail AC track circuit listed in table 3.

Table 3: Single Rail AC Track Circuit Arrangements

Track Cct Type	Track Feed Set	Feed Res Value	Feed Trans Volts(typ)	Relay Prot'n	Min Drop Shunt	Test Shunt
Sig Bch (standard)	St 47	1.0	6	Shield'g Imp	0.25	0.25
Sig Bch (high voltage)	St 51	6	30	25 ohm	0.25	0.25
WB&S	WB&S	16.5	20	'501' Rectifier	0.5	0.5

5.1 Initial Set-Up

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

5.1.1 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.

5.1.2 Bonding and New Connections

Bond out all redundant insulated joints, remove any temporary bonds around new insulated joints and connect any new parallel and series bonds. Check that all mechanical joints are bonded out.

Make all new rail connections and close up all terminal links.

Check that impedance bond sideleads are all of equal length and securely terminated to bond and rails, that neutral connection is secure and track feed and relay cables are correctly terminated.

5.1.3 Check Bonding and Connections

Walk the length of the track circuit, checking the track against the new track insulation plans.

5.1.4 Check Auxiliary Track Equipment

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

Check that any traction tie-in cables are terminated.

5.1.5 Equipment Check

Check that the track transformer and feed resistance are correctly installed, with the feed resistance unit of correct value.

Check that surge protection is installed, the correct arrestors are fitted and earthing is installed and correctly terminated.

5.1.6 Check Auxiliary Track Equipment

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

Check that any traction tie-in cables are terminated.

5.1.7 Equipment Check

Check that the track transformer and feed resistance are correctly installed, with the feed resistance unit of correct value.

Check that surge protection is installed, the correct arrestors are fitted and earthing is installed and correctly terminated.

5.1.8 Power Up – Feed End

Connect the track feed 110/120 volt supply and close outgoing cable links. Adjust the feed resistance to about 1.0 ohms.

Set the feed transformer connection to the correct output tap.

Measure feed end rail volts.

Check that track polarity is the reverse of the previous AC track. (Refer to Appendix 4: Technical Notes.) If not, then reverse the connections between the feed set and the feed end impedance bond.

5.1.9 Power Up – Relay End

Check that surge protection is installed, the correct arrestors are fitted and earthing is installed and correctly terminated.

Close incoming relay fuse and link, and relay local coil Bx110/120 fuse and link. Observe that the relay energises. The relay should pick up strongly, but not violently.

If the relay drives down, reverse the connections between the relay and relay end impedance bond.

Impedance Bond Resonation

If the track circuit uses 2000 amp/rail resonated impedance bonds, these should now be adjusted.

If the relay does not pick up, or picks up only weakly, it may be necessary to increase the feed transformer secondary volts.

If the relay picks up too strongly, it may be necessary to decrease the feed voltage by increasing the feed resistance (to a maximum of approximately 0.75 ohms) or decreasing the transformer secondary volts.

5.1.10 Shunt and Correspondence Check

Using a fixed shunt (in accordance with Table 3) 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.

5.2 Final Adjustment and Measurement

Final adjustment involves the adjustment of the track feed set to achieve the specified relay operating values.

5.2.1 Initial Adjustment

Measure that the relay control voltage is between 120 percent and 200 percent of the compression voltage recorded on the relay test label. If it is outside this range, adjust the track feed voltage correspondingly.

Feed voltage adjustments should, as far as possible, be made by adjusting the feed transformer tappings. This will ensure that the feed resistance value is maintained suitably high to provide a good operating phase angle.

5.2.2 Drop Shunt Check and Final Adjustment

Measure the relay control coil volts (without the shunt applied); this should be about 1 volt, or 50 per cent above the compression voltage recorded on the relay test label, whichever is greater.

Check the drop shunt of the track using a variable shunt unit at the relay end of the track, connected two metres outside the sidelead connections.

The drop shunt measured should be greater than the minimum specified in Table 3. A final drop shunt value between 150 per cent and 200 per cent of the minimum is acceptable. If the initial value is outside this range, an attempt should be made to adjust the track feed for a better drop shunt.

Note: *While the final setting may involve some compromise, it should be possible to achieve a suitable control voltage while retaining a drop shunt value below the 200 per cent value and certainly above the minimum.*

The relay is de-energised when all front contacts can be seen open.

5.3 Certification

Certification covers the proving of correct operation of the track circuit and the completion of all documentation activities.

5.3.1 Zero Feed Relay Voltage

With all adjacent tracks operating, disconnect the feed from the track under test and record the AC voltage on the relay control coil.

If the remaining voltage exceeds 30 per cent of the relay release value, this shall be reported as a track circuit fault and the cause of the excessive voltage located and rectified.

5.3.2 Test Shunt

Test shunt the track using a fixed shunt of the value stated in Table 3. Sets of three shunts should be made at the following points, at least:

- two metres from the feed end rail connections
- mid-track
- at both ends of any parallel-bonded section of track (where points are involved) two metres from the relay end rail connections.

5.3.3 History Cards

When all track work is finished, complete individual history cards for all tracks tested by the team. The cards shall be signed by the responsible signal maintenance staff.

5.4 Appendix 4: Technical Notes

Track Circuit Polarity (Phasing) Check

With AC track circuits, it is critical that at any interface between a pair of tracks that the phasing of one track is opposite to the phasing of the other. This requirement exists to ensure that if the block joints at the interface fail, the relay of one track cannot be held falsely energised by the feed of the other. This requirement can be relaxed at an interface where two feed ends abut.

To check track phasing between two single rail track circuits, measure the voltages on the signalling rail from either side of the block joint to the common traction rail, and the voltage directly across the block joint on the same rail. If the tracks are correctly phased, the sum of the two track circuit voltages will equal the voltage across the joint. If the sum of the voltages is significantly different from the measured value, then the tracks are not correctly phased and corrective action shall be taken.

At the interface between single and double rail track circuits, the ‘half-bond’ voltage on the double rail track takes the place of one ‘rail to common’ voltage.

Track Connection Resistance

It is critical that the rail terminations of track connection cables are as low resistance as possible, in view of the high DC and AC currents flowing through them, and especially in view of the need to keep traction return currents balanced. As a guide, the voltages to be expected on good new connections should be less than 2 mV.

Measure the AC voltage drop at each connection between the connecting cable conductors and the head of the rail near the termination. If the cable cores are not accessible, measure from a point on the connection lug, as close as possible to the insulation.

Note: Where duplicated sideleads are fitted, a low millivolt reading will be measured on both, so long as at least one is making good contact.

Any reading over 5 mV should be taken to indicate a suspect connection. Check the tightness of the securing nuts and, if this does not work, dismantle the connection, clean all mating surfaces with abrasive or solvent as required, then reassemble and tighten carefully.

6 AC Double Rail Track Circuits

This section describes the procedures for the setting to work, testing and certification of an AC double rail track circuit, equipped with a double element vane relay and non-resonated impedance bonds.

The procedures for the adjustment of 50 Hz resonated impedance bonds are available as a separate document.

6.1 Initial Set-Up

Initial set-up includes the activities generally carried out by the initial set-to-work team. It covers the removal of any old track circuit equipment and the connection and powering up of the new equipment. Where a track is equipped with resonated impedance bonds, the adjustment of these is part of the initial setting to work.

6.1.1 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.

6.1.2 Bonding and New Connections

Bond out all redundant insulated joints, remove any temporary bonds around new insulated joints and connect any new parallel and series bonds. Check that all mechanical joints are bonded out.

Make all new rail connections and close up all terminal links.

Check that impedance bond sideleads are all of equal length and securely terminated to bond and rails, that neutral connection is secure and track feed and relay cables are correctly terminated.

6.1.3 Check Bonding and Connections

Walk the length of the track circuit, checking the track against the new track insulation plans.

6.1.4 Check Auxiliary Track Equipment

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

Check that any traction tie-in cables are terminated.

6.1.5 Equipment Check

Check that the track transformer and feed resistance are correctly installed, with the feed resistance unit of correct value.

Check that surge protection is installed, the correct arrestors are fitted and earthing is installed and correctly terminated.

6.1.6 Power Up – Feed End

Connect the track feed 110/120 volt supply and close outgoing cable links.

Adjust the feed resistance to approximately 0.5 ohms.

Set the feed transformer connection to 6 volt tap. Measure the feed end rail volts.

Check that track polarity is the reverse of the previous AC track. (Refer to Appendix 5: Technical Notes.) If not, then reverse the connections between the feed set and feed end impedance bond.

6.1.7 Rail Connections Check

Using a suitable digital 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 cleaned and retightened.

6.1.8 Power Up – Relay End

Check that surge protection is installed, the correct arrestors are fitted and earthing is installed and correctly terminated.

Close incoming relay fuse and link, and relay local coil Bx110/120 fuse and link. Observe that the relay energises. The relay should pick up strongly, but not violently.

If the relay drives down, reverse the connections between the relay and relay-end impedance bond.

Impedance Bond Resonation

If the track circuit uses 2000 amp/rail resonated impedance bonds, these should now be adjusted.

If the relay does not pick up, or picks up only weakly, it may be necessary to increase the feed transformer secondary volts.

If the relay picks up too strongly, it may be necessary to decrease the feed voltage by increasing the feed resistance (to a maximum of approximately 0.75 ohms) or decreasing the transformer secondary volts.

6.1.9 Shunt Check

Check shunting of the track by applying a 0.1 ohm fixed shunt at the relay end and observe that the relay de-energises.

6.2 Final Adjustment

Final adjustment involves the adjustment activities carried out by the test-and-certify team. It covers the adjustment of the track feed set to achieve the specified relay operating values.

6.2.1 Initial Adjustment

Measure that the relay control voltage is between 120 per cent and 200 per cent of the compression voltage recorded on the relay test label. If it is outside this range, adjust the track feed voltage correspondingly.

Feed voltage adjustments should, as far as possible, be made by adjusting the feed transformer tappings. This will ensure that the feed resistance value is maintained suitably high to provide a good operating phase angle.

6.2.2 Drop Shunt Check and Final Adjustment

Measure the relay control coil volts (without the shunt applied). This should be about 1 volt, or 50 per cent above the compression voltage recorded on the relay test label, whichever is greater.

Check the drop shunt of the track using a variable shunt unit at the relay end of the track, connected two metres outside the sidelead connections. The drop shunt measured should be greater than

0.06 ohms. A final drop shunt value between 0.09 ohms and 0.15 ohms is acceptable. If the initial value is outside this range, an attempt should be made to adjust the track feed for a better drop shunt.

Note: *While the final setting may involve some compromise, it should be possible to achieve a suitable control voltage while retaining a drop shunt value below 0.2 ohms and certainly above 0.06 ohms.*

6.3 Certification

Certification covers the proving of correct operation of the track circuit and the completion of all documentation activities.

6.3.1 Zero Feed Relay Voltage

With all adjacent tracks operating, disconnect the feed from the track under test and record the AC voltage on the relay control coil.

If the remaining voltage exceeds 30 per cent of the relay release value, this shall be reported as a track circuit fault and the cause of the excessive voltage located and rectified.

6.3.2 Test Shunt

Test shunt the track using the 0.1 ohm fixed shunt. Sets of three shunts should be made at the following points, at least:

- two metres from the feed end rail connections
- mid-track
- at both ends of any parallel-bonded section of track (where points are involved)
- two metres from the relay end rail connections

6.3.3 History Cards

When all track work is finished, use the details recorded on the commissioning master sheet to complete individual history cards for all tracks tested by the team. The cards shall be signed by the responsible signal maintenance staff.

6.4 Appendix 5: Technical Notes

Track Circuit Polarity (Phasing) Check

With AC track circuits, it is critical at the interface between any pair of tracks that the phasing of one track is opposite to the phasing of the other. This requirement exists to ensure that if the block joints at the interface fail, the relay of one track cannot be falsely held energised by the feed of the other. The requirement can be relaxed only at any interface where two feed ends are adjacent.

To check track phasing, measure the voltages on one rail from either side of the block joint to the impedance bond neutral, and the voltage directly across the block joint on the same rail. If the tracks are correctly phased, the voltage across the joint will equal the sum of two 'halfbond' voltages, or at least be greater than both of them. If the voltage across the joint is less than either one of the ‘halfbond’ voltages, then the tracks are not correctly phased and corrective action needs to be taken.

Track Connection Resistance

It is critical that the rail terminations of track connection cables are as low resistance as possible, in view of the high DC and AC currents flowing through them, and especially in view of the need to keep traction return currents balanced. As a guide, the voltages to be expected on good new connections should be less than 2 mV.

Measure the AC voltage drop at each connection between the connecting cable conductors and the head of the rail near the termination. If the cable cores are not accessible, measure from a point on the connection lug, as close as possible to the insulation.

Note: Where duplicated sideleads are fitted, a low millivolt reading will be measured on both, so long as at least one is making good contact.

Any reading over 5 mV should be taken to indicate a suspect connection. Check the tightness of the securing nuts and, if this does not work, dismantle the connection, clean all mating surfaces with abrasive or solvent as required, then reassemble and tighten carefully.

7 CSEE UM71 AF Jointless Track Circuits

This section describes the activities involved in commissioning and certifying CSEE UM71 (Type T1) audio-frequency jointless track circuits.

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.

7.1 Set to Work

This section covers removal of any old track circuit equipment and the connection and powering-up of the new equipment.

7.1.1 Bonding and Track Connections

Where an existing signalling system is being renewed, ensure that all old, redundant track circuit connections, including old feed and relay connections, impedance bonds, and sparkgap connections, are removed.

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

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

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

7.1.2 Check Auxiliary Track Equipment

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

7.1.3 Equipment Check

Check that all tuning units, transmitters and receivers are of the correct frequency and type.

Check that matching unit strapping is correct for transmitter or receiver, and that SI units are correctly installed. Where the track circuit terminates on an impedance bond, check that cables from the matching unit are correctly terminated

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

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

Check that any resonated impedance bonds are preset to the required initial value, listed in Appendix 6, Note 1.

7.1.4 Transmitter & Receiver Settings

Check that the transmitter output level (Kem) is set correctly for the transmitter frequency, and that the modulation strap M 1/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

7.1.5 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.

7.1.6 Check Rail Connections

Using a suitable digital 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 achieved the low millivolt drop.

7.1.7 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.

7.1.8 Shunt and Correspondence check

Using a fixed 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.

7.2 Final Adjustment

Final adjustment covers the adjustment of impedance bonds and the setting of receiver gain to achieve the specified drop-shunt value.

7.2.1 Equipment

A frequency-selective voltmeter (ML, VS19, or frequency-selective adapter use with digital multimeter) is necessary for all track and receiver voltage measurements.

7.2.2 Resonated Impedance bonds

Identify any resonated impedance bond installed on the track circuit.

With Jeumont Schneider bonds, set the resonating capacitor connections as shown in the CSEE manual.

On WB&S and Macolo resonated bonds, set the resonating capacitor initially to the values shown in Appendix 6, Note 1. If necessary, adjust the resonating capacitance to achieve a maximum voltage across the capacitor, but not exceeding 400 volts.. Capacitor voltage can range from 35 volts up to over 400 volts, depending on track length and the position of the bond.

On tracks less than 400 metres in length, it is normally satisfactory and preferable to leave the bond unresonated, with the capacitor terminals left open.

7.2.3 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 6, Note 2)

7.2.4 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.

7.3 Certification

Certification covers the proving of correct operation of the track circuit, and the completion of all documentation activities.

7.3.1 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 shall be reported as a track circuit fault, and the cause of the excessive voltage located and rectified.

7.3.2 Drop-Shunt check

Measure and record the drop-shunt of the track, using a variable shunt unit at the relay end of the track, connected outside the tuned loop at the receiver end rail connections.

7.3.3 Test Shunt

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

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

7.3.4 History cards

When all track work is complete, fill in individual history cards for all tracks tested by the team. The cards should be signed by the responsible signal maintenance staff.

7.4 Appendix 6 - Technical Notes

Note 1: Resonated Impedance Bonds- Initial capacitor settings (WB&S 2000R/AF)

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
1700	26.8
2000	22.5
2300	20.0
2600	17.8

Note 2: 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 range the 320 - 350 mV then the adjustment is correct, and the relay should be up.

If R1/R2 volts are outside this range:

a) -check Krv setting by inspecting the existing gain strapping and referring to Krv tables
b) -if R1/R2 volts are high, select and set a lower Krv setting; vice versa if R1/R2 volts are low
c) -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 shall advise maintenance staff of the need 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.

Note 3: Track Connection Resistance

It is critical that the rail terminations of track connection cables are as low-resistance as possible, in view of the high DC and AC currents flowing through them, and especially in view of the need to keep traction return currents balanced. As a guide, the voltages to be expected on good new connections should be less than 2mV.

Measure the AC voltage drop at each connection between the connecting cable conductors and the head of the rail near the termination. If the cable cores are not accessible, measure from a point on the connection lug, as close as possible to the insulation.

Note that, where duplicated sideleads are fitted, a low millivolt reading will be measured on both, so long as at least one is making good contact.

Any reading over 5mV should be taken to indicate a suspect connection. Check the tightness of the securing nuts and, if this does not work, dismantle the connection, clean all mating surfaces with abrasive or solvent as required, reassemble and tighten carefully.

8 FS2500 AF Jointless Track Circuits

This section describes the activities required for commissioning and certifying FS2500 audio frequency jointless track circuits.

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.

8.1 Set to Work

This section covers the removal of any old track circuit equipment and the connection and powering up of the new equipment.

8.1.1 Bonding and Track Connections

Where an existing signalling system is being renewed, ensure that all old, redundant track circuit connections, including old feed and relay connections, impedance bonds and spark gap connections, are removed.

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

Make all new rail connections and close up all location terminal links.

Walk the length of the track circuit, checking the track against the new track insulation plans. Check that all bonding and connections are complete, that spark gap connections are to the correct rails, that no extra rail connections are left and that there are no spark gap or auxiliary equipment connections within the tuned loops.

8.1.2 Check Auxiliary Track Equipment

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

8.1.3 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 transmitter or receiver, as appropriate.

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

Where the track circuit terminates on an impedance bond, check that cables from the end tuning unit are correctly terminated.

Check that the transmitter output tapping is correctly set for the track length in accordance with the Table 4 below.

Table 4: Track length and transmitter output

Track Length (metres)	Output (%)
50-250	20
250-450	40
450-600	60
600-750	80
750-900	100

Check that the receiver sensitivity straps are set for an initial value of 1.00.

If the track includes an intermediate receiver (DPU), check that the IRx amplifier gain straps are set to High (bridge D1/D2).

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

Check that any resonated impedance bonds are preset to the required initial value, listed in Appendix 7: Technical Notes, Note 1.

8.1.4 Power Up

Insert fuses and links to power up the transmitter and receiver. Observe that transmitter B24 and the O/P lights are illuminated, that the receiver lights are correctly illuminated (B24, 'Input Valid' and 'Output' on steady, 'Processor Running' flashing) and that the relay energises.

If the receiver 'Input valid' and 'output' lights fail to illuminate, check the receiver monitor voltage. If this is below 1 volt, increase the transmitter output tapping.

Measure the transmitter and receiver B24 supply voltages. Set the power supply output to between 24 and 28 volts DC.

8.1.5 Check Rail Connections

Using a suitable digital 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.

8.1.6 Shunt and Correspondence Check

Using a fixed 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.

8.2 Final Adjustment

Final adjustment covers the adjustment of impedance bonds and the setting of receiver gain to achieve the specified drop shunt value.

8.2.1 Equipment

A frequency selective voltmeter (ML, VS19 or frequency selective adapter use with digital multimeter) is necessary for all track and receiver voltage measurements.

8.2.2 Resonated Impedance Bonds

Identify any resonated impedance bond installed on the track circuit.

With Jeumont Schneider bonds, set the resonating capacitor connections as shown in the CSEE manual.

On WB&S and Macolo resonated bonds, set the resonating capacitor initially to the values shown in Appendix 7: Technical Notes, Note 1. If necessary, adjust the resonating capacitance to achieve a maximum voltage across the capacitor, but not exceeding 400 volts. Capacitor voltage can range from 35 volts up to over 400 volts, depending on track length and the position of the bond.

On tracks less than 400 metres in length, it is normally satisfactory and preferable to leave the bond unresonated, with the capacitor terminals left open.

8.2.3 Initial Receiver Adjustment

Check that the receiver input level voltage measured at the monitor terminals is between 1.15 and 1.20 volts.

If necessary, adjust the receiver sensitivity to give this value.

8.2.4 Drop Shunt Measurement and Receiver Adjustment

Measure and record the drop shunt of the track using a variable shunt unit at the relay end of the track, connected outside the tuned loop at the receiver end rail connections.

The drop shunt should be as close as possible to 1 w. Adjust the receiver gain to obtain a final drop shunt value between 0.8 and 1.2. Leave the gain set at the value which results in a drop shunt nearest to 1. Record the final gain and drop shunt values.

8.2.5 Intermediate Receiver (DPU)

Each intermediate receiver should be treated as a separate track circuit, sharing a common transmitter end with its parent track. A separate history card should be completed for each intermediate receiver.

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 7: Technical Notes.

Note: *If it is necessary to adjust the transmitter level to obtain correct adjustment of the intermediate receiver, then it will be necessary also to readjust the parent track receiver.*

8.3 Certification

Certification covers the proving of correct operation of the track circuit and the completion of all documentation activities.

8.3.1 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 250 mV (i.e. 30 per cent of the receiver release value), this shall be reported as a track circuit fault and the cause of the excessive voltage located and rectified.

8.3.2 Test Shunt

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

- three metres inside the Tx tuned loop two metres outside the Tx tuned loop
- mid-track
- at both ends of any parallel bonded section of track (where points are involved)
- two metres outside the Rx tuned loop three metres inside the Rx tuned loop.

8.3.3 History Cards

When all track work is finished, complete individual history cards for all tracks tested by the team. The cards shall be signed by the responsible signal maintenance staff.

8.4 Appendix 7: Technical Notes

Note 1: Resonated Impedance Bonds – Initial Capacitor Settings (WB&S 2000R/AF)

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

Note 2: Intermediate Receiver (IRx) Adjustment Sequence

The final adjustment of the intermediate receiver should be carried out after the parent track is finally adjusted.

IRx Amplifier Adjustment

Check that the receiver input current from the intermediate receiver selective amplifier is between 28 mA and 60 mA. If necessary, adjust the amplifier to Low gain by removing the bridge on terminals D1/D2. If the resulting input current is still too high, reduce the transmitter output power

Note: If it is necessary to adjust the transmitter level to obtain correct adjustment of the intermediate receiver, then it will be necessary also to readjust the parent track receiver.

IRx Drop Shunt and Final Adjustment

Measure the IRx drop shunt at a point one metre on the transmitter side of the IRx pickup units. Adjust the IRx receiver gain (and amplifier attenuator, if necessary) to obtain a drop shunt between 0.8 and 1.

Note 3: Track Connection Resistance

It is critical that the rail terminations of track connection cables are as low resistance as possible, in view of the high DC and AC currents flowing through them, and especially in view of the need to keep traction return currents balanced. As a guide, the voltages to be expected on good new connections should be less than 2 mV.

Measure the AC voltage drop at each connection between the connecting cable conductors and the head of the rail near the termination. If the cable cores are not accessible, measure from a point on the connection lug, as close as possible to the insulation.

Note: *Where duplicated sideleads are fitted, a low millivolt reading will be measured on both, so long as at least one is making good contact.*

Any reading over 5 mV should be taken to indicate a suspect connection. Check the tightness of the securing nuts and, if this does not work, dismantle the connection, then clean all mating surfaces with abrasive or solvent as required, reassemble and tighten carefully.

9 ML TI21 AF Jointless Track Circuits

This section describes the activities required for commissioning and certifying ABB/ML type TI21 audio frequency jointless track circuits.

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.

9.1 Set to Work

This section covers the removal of any old track circuit equipment and the connection and powering up of the new equipment.

9.1.1 Bonding and Track Connections

Where an existing signalling system is being renewed, ensure that all old, redundant track circuit connections, including old feed and relay connections, impedance bonds and spark gap connections are removed.

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

Make all new rail connections and close up all location terminal links.

Walk the length of the track circuit, checking the track against the new track insulation plans. Check that all bonding and connections are complete, that spark gap connections are to the correct rails, that no extra rail connections are left and that there are no spark gap or auxiliary equipment connections within the tuned loops.

9.1.2 Check Auxiliary Track Equipment

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

9.1.3 Equipment Check

Check that all tuning units, transmitters and receivers are of the correct frequency and type.

Check that matching unit strapping is correct for the transmitter or receiver and that SI units are correctly installed. Where the track circuit terminates on an impedance bond, check that cables from the matching unit are correctly terminated

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

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

Check that any resonated impedance bonds are preset to the required initial value, listed in Appendix 8: Technical Notes, Note 1.

9.1.4 Transmitter and Receiver Initial Settings

Check that the transmitter power output is set correctly for the length of track circuit by selecting the appropriate transmitter tuning unit input terminals.

Tracks up to 250 metres: Low power

Tracks over 400 metres: High power

Check that the receiver gain straps are preset

Tracks up to 400 metres: Gain = 7

Tracks over 400 metres: Gain = 13

9.1.5 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.

9.1.6 Check Rail Connections

Using a suitable digital 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.

9.1.7 Compensated Tracks

Check that capacitors are evenly spaced at 200 metre intervals (estimated), that capacitors are of the correct value (see below), that all capacitor connections are tight, that 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.

9.1.8 Shunt and Correspondence Check

Using a fixed 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.

9.2 Final Adjustment

Final adjustment covers the adjustment of impedance bonds and the setting of receiver gain to achieve the specified drop shunt value.

9.2.1 Equipment

A frequency selective voltmeter (ML, VS19 or frequency selective adapter used with a digital multimeter) is necessary for all track and receiver voltage measurements.

9.2.2 Resonated Impedance Bonds

Identify any resonated impedance bond installed on the track circuit.

With Jeumont Schneider bonds, set the resonating capacitor connections as shown in the CSEE manual.

On WB&S and Macolo resonated bonds, set the resonating capacitor initially to the values shown in Appendix 8: Technical Notes, Note 1. If necessary, adjust the resonating capacitance to achieve a maximum voltage across the capacitor, but not exceeding 400 volts. Capacitor voltage can range from 35 volts up to over 400 volts, depending on track length and the position of the bond.

On tracks less than 400 metres in length, it is normally satisfactory and preferable to leave the bond unresonated, with the capacitor terminals left open.

9.2.3 Drop Shunt Measurement and Receiver Adjustment

Measure and record the drop shunt of the track using a variable shunt unit at the relay end of the track, connected outside the tuned loop at the receiver end rail connections.

The drop shunt should be as close as possible to 1 w. Adjust the receiver gain to obtain a final drop shunt value between 0.8 and 1.2. Leave the gain set at the value which results in a drop shunt nearest to 1. Record the final gain and drop shunt values.

For tracks with low range gains, each gain step will produce a large change in drop shunt and it may not be possible to achieve a drop shunt value closer than 0.7 or 1.3. In that case choose the upper value.

9.2.4 Intermediate Receiver (DPU)

Each intermediate receiver should be treated as a separate track circuit; sharing a common transmitter end with its parent track. A separate history card should be completed for each intermediate receiver.

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 8: Technical Notes.

Note: If it is necessary to adjust the transmitter level to obtain correct adjustment of the intermediate receiver, then it will be necessary also to readjust the parent track receiver.

9.3 Certification

Certification covers the proving of correct operation of the track circuit and the completion of all documentation activities.

9.3.1 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 30 per cent of the receiver release value, this shall be reported as a track circuit fault and the cause of the excessive voltage located and rectified.

9.3.2 Test Shunt

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

- three metres inside the Tx tuned loop two metres outside the Tx tuned loop
- mid track
- at both ends of any parallel bonded section of track (where points are involved)
- two metres outside the Rx tuned loop three metres inside the Rx tuned loop

9.3.3 History Cards

When all track work is finished, complete individual history cards for all tracks tested by the team. The cards shall be signed by the responsible signal maintenance staff.

9.4 Appendix 8: Technical Notes

Note 1: Resonated Impedance Bonds – Initial Capacitor Settings (WB&S 2000R/AF)

The following table provides 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

Note 2: Intermediate Receiver (IRx) Adjustment Sequence

The final adjustment of the intermediate receiver should be carried out after the parent track is finally adjusted.

Note: If it is necessary to adjust the transmitter level to obtain correct adjustment of the intermediate receiver, then it will be necessary also to readjust the parent track receiver.

IRx Amplifier Adjustment

Measure the receiver input current from the intermediate receiver selective amplifier. If necessary, adjust the amplifier attenuator until the receiver input current is between 30 mA and 50 mA.

IRx Drop Shunt and Final Adjustment

Measure the IRx drop shunt at a point one metre on the transmitter side of the IRx pickup units. Adjust the IRx receiver gain (and amplifier attenuator, if necessary) to obtain a drop shunt between 0.8 and 1.

Note 3: Track Connection Resistance

It is critical that the rail terminations of track connection cables are as low resistance as possible, in view of the high DC and AC currents flowing through them, and especially in view of the need to keep traction return currents balanced. As a guide, the voltages to be expected on good new connections should be less than 2 mV.

Measure the AC voltage drop at each connection between the connecting cable conductors and the head of the rail near the termination. If the cable cores are not accessible, measure from a point on the connection lug, as close as possible to the insulation.

Any reading over 5 mV should be taken to indicate a suspect connection. Check the tightness of the securing nuts and, if this does not work, dismantle the connection, then clean all mating surfaces with abrasive or solvent as required, reassemble and tighten carefully.