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Guidance Note

SSI Program and Data Problems

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Issue record

Issue	Date	Comments
1	February 1998	Original Issue
2	April 1998	Figs 1, 2, 3 & 4 amended to show contact of 31HR instead of 31 DR in series with 31DR coil. Other minor amendments.
3	April 2001	Updated following issue of additional Technical Investigations
4	December 2004	Updated following issue of additional Technical Investigations
5	March 2009	TT D6/D7 and issue of investigation reports

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1 INTRODUCTION

1.1 Purpose

This Guidance Note summarises significant SSI program and data problems identified on Network Rail's Signalling Infrastructure, and adopted solutions, to assist Engineers in identifying and avoiding them wherever possible.

1.2 Scope

This Guidance Note provides an insight into significant SSI program and data problems that have been found on Network Rail's Signalling Infrastructure, together with their effect, their history and how they have been addressed; further detail and guidance is contained in SSI8000 "SSI Applications Manual", the contents of which are detailed in NR/L2/SIG/17002. Guidance on whether any solutions should be applied retrospectively is outside the scope of this Guidance Note.

1.3 Reference Documentation

SSI8003	SSI Data Preparation
SSI8150	SSI Software Record
SSI8151	Retrospective and Other Amendments
SSI8500	Design of SSI Schemes
SSI8505	SSI Data Procedures

(For a list of the constituent parts of the above five documents and their issues, please refer to NR/L2/SIG/17002, "SSI Applications Manual Contents".)

SSISPG DIS54 Issue 4	SSISPG Approved Discussion Paper - Introduction of Program Issues SSI4303-D3 & -D4
SSISPG DIS62 Issue 5	SSISPG Approved Discussion Paper - SN109 Incident at Paddington 8/6/96
Newton accident report	HSE Report - A report of an Inquiry into the collision that occurred on 21 July 1991 at Newton Junction
BRR STG-D-PDS(SSS)-RP-17 Issue 1	BR Research Report - Investigation into an Incident at Watford Junction SSI on 3rd October 1995
TI Report 95074	Technical Investigation Report - Saltley SSI Signal SY25 : Incorrect Aspect Sequence
TI Report 95026	Technical Investigation Report - Wembley SSI : Control Table and Data Investigation Following the Movement of Points Ahead of a Train
TI Report 96802	Technical Investigation Report - Ely SSI : Interlocking Undergoing Reset Whilst in Service

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TI Report 97118	Technical Investigation Report - SN109 Incident at Paddington 08/06/96
TI Report 97146	Investigative Services Report - Loss of Overlap Locking for Willesden Route 9A(M)
TI Report 98807	Investigative Services Report - Slough New Signalling Centre : Route Setting Failure
TI Report 99803	Investigative Services Report - Kelvedon Church Street AHBC : Failure of Signal Regulation
Bellgrove incident report	Signalling Control UK Report - Investigation into Irregular Aspect Sequence on YF216 on January 20 1997
TI Report 00184	Investigative Services Report - WSF of SSI Signal Module Current Proving Indications : Proof House Junction August 25 2000
AEAT Report SAO-SSI-RP-6 Issue 2	Technician's Terminal SSI 4301-D5 Problems – Investigation Report
AEAT Report SAO-SSI-RP-4 Issue 1	Shenfield L487 Allegation 17/03/2000 – Investigation Report
AEAT Report SAO-SSP-RP-12 Issue 1	Unexpected Shutdown When Commissioning SSI 4304-D4 27/03/1998
TI Report 04801	Investigative Services Report – Woking: Geographical Data Error in WOKSTNDN Affecting Signal 167 23/5/04

1.4 Definitions

ARS	Automatic Routesetting Subsystem
AEAT	AEA Technology Rail (now DeltaRail Group Ltd)
CCTV	Closed Circuit Television
DeltaRail	DeltaRail Group Ltd
HPSA	High Performance Switch Actuator
IECC	Integrated Electronic Control Centre
MPM	Multi Processor Module
N	Normal
PMUX	Panel Multiplexer
PPM	Panel Processor Module
R	Reverse
RRI	Route Relay Interlocking
SSI	Solid State Interlocking
SSISPG	SSI Signalling Principles Group
TFM	Trackside Functional Module
TI	Technical Investigation
TT	Technicians Terminal
TORR	Train Operated Route Release
TPR	Track Repeating Relay

1.5 Safety

All persons are reminded that all appropriate safety precautions shall be observed when undertaking the work covered by this Guidance Note.

2 CROSS BOUNDARY TRACK ISSUES

2.1 Relay Controlled Signals Approaching SSI Areas

2.1.1 Original Incident Summary

During April 1991 an incident was reported at Tollerton. This involved a short fast train passing from a relay controlled area into a SSI controlled area. The signal in rear of the train momentarily displayed an aspect less restrictive than the required single yellow. This in turn affected the displayed aspect of the signal in rear, this being observed by the driver of a following train (A similar incident also occurred at Watford in late 1992.)

The problem occurred whilst the train was crossing the boundary between relay and SSI controlled areas. This is illustrated by Figure 1 below, but using three aspect signals (note that the circuits are shown in schematic form, e.g. double cutting is not shown). Consider the train just clearing track circuit AD. This track circuit registers clear in circuit 31 HR of the relay controlled signal 31 in rear before the following track circuit AE, input via the SSI, can be registered as occupied in SSI controlled signal 33. As signal 31 clears, it momentarily displays a green, until relay 33 HPR is de-energised when this signal then changes to the required yellow.

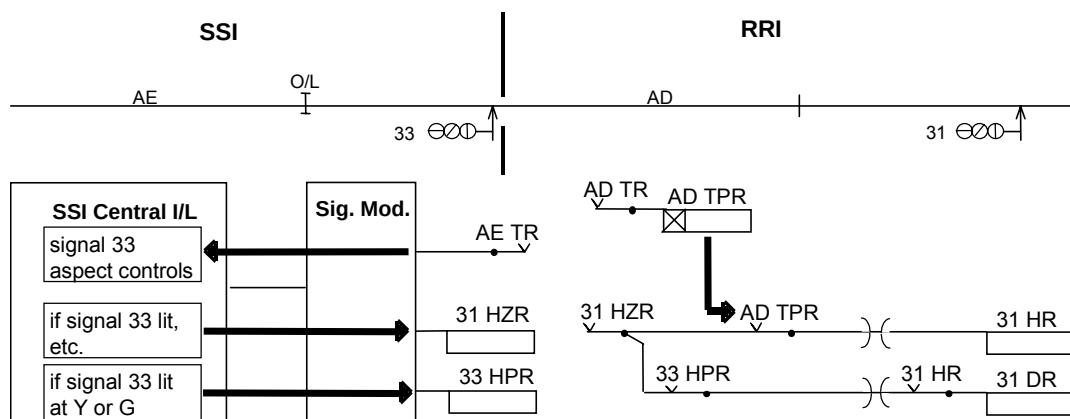


Figure 1

This problem was accentuated at both Tollerton and Watford by the first SSI signal being controlled by Signal Module output relays rather than being driven direct by the module.

The basic cause of this problem can give rise to two other problems of incorrect signal behaviour. The circumstances in which all three of these problems can occur are as follows, and are detailed below:

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- wrong aspect sequence
- wrongly cleared signal
- Approach Control track circuit failure.

2.1.2 Wrong Aspect Sequence Problem

As in the original incident, a relay controlled signal has its last (or only) track circuit in its aspect controls proved clear via a TPR contact direct into the relay circuit. The next track circuit is the first (or only) track circuit proved clear in the SSI controlled signal ahead. It is input into the SSI and proved clear in the SSI controlled signal via the SSI.

As the train passes between these track circuits, the first mentioned track circuit can pick and be proved clear in the relay controlled signal via the TPR, before the following track circuit dropping replaces the signal ahead, which can result in the aspect sequencing briefly allowing the relay controlled signal to display an aspect less restrictive than single yellow.

This problem will not arise where a track circuit is proved clear in both signals, i.e. the signal ahead has a separate overlap track circuit. It will also not arise if the relay controlled signal does not have both yellow and higher aspects.

2.1.3 Wrongly Cleared Signal Problem

Figure 2 shows a typical arrangement. A relay controlled signal (31) has two or more track circuits in its aspect controls. One of these track circuits (AD) is proved clear via a TPR contact direct into the relay circuit (31 HR), whereas the next track circuit (AE) in the direction of travel, is input into the SSI and is proved clear in the relay circuit via the contact of a Signal Module output relay (31 HZR).

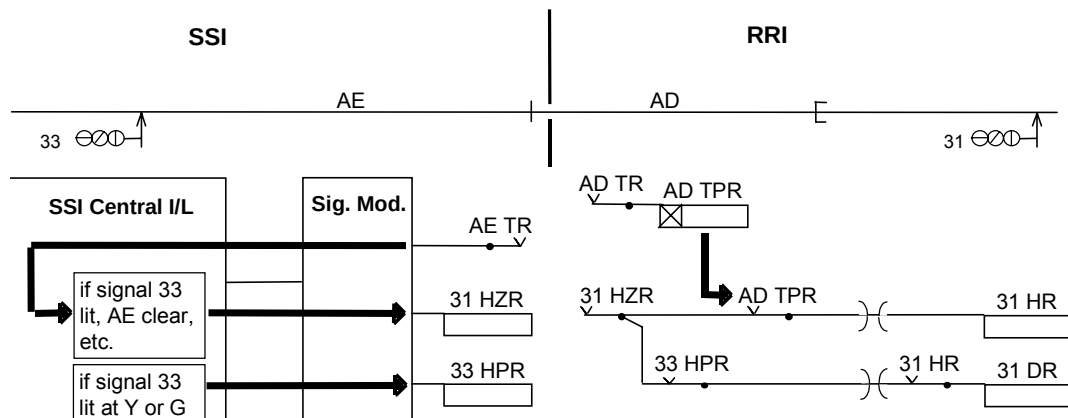


Figure 2

As the train passes between these track circuits, track circuit AD can pick and be proved clear in signal 31 via the TPR, before track circuit AE dropping can be registered by the breaking of the front contact of the Signal Module output relay 31 HZR. This allows signal 31 to momentarily clear from red.

This problem can arise if the relay controlled signal is automatic or semi-automatic, or if it is controlled and the signal is waiting to re-clear because of automatic working or oversetting.

2.1.4 Approach Control Track Circuit Failure Problem

Figure 3 shows a typical arrangement. The first SSI controlled signal (33) has its berth track circuit (AD) input into the SSI for approach control (temporary or permanent). The relay controlled signal in rear (31) has this track circuit in its aspect controls proved clear via a TPR contact direct into the relay circuit (31HR).

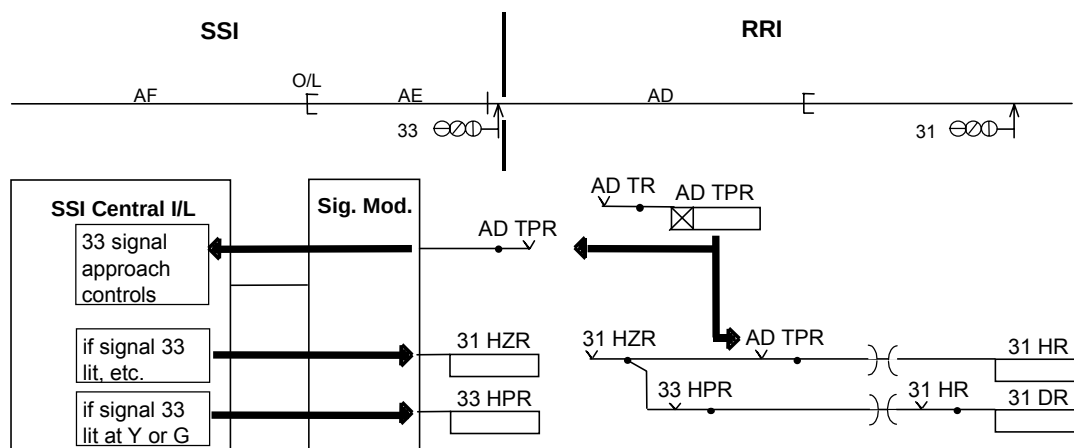


Figure 3

With signal 33 ready to clear except for approach controls, track circuit AD fails and this signal clears. The failure now disappears, but signal 31 clears before signal 33 is replaced. This can result in the aspect sequencing briefly allowing signal 33 to display an aspect less restrictive than the required single yellow.

This problem will not arise if the relay controlled signal does not have both yellow and higher aspects. (This problem can also arise where both signals are SSI controlled - see Section 2.3.)

Note: For each instance of a relay controlled signal leading up to a SSI controlled signal, one or two of the above problems may be present.

A similar problem involving the transition of trains across Interlocking boundaries is contained within Section 2.2 of this Guidance Note.

2.1.5 Solution

Both SSI8003 and SSI8500 have been changed to include the requirement that the relay controlled signal shall have the appropriate track circuit at the boundary proved clear twice in its aspect controls (i.e. in its HR or DR circuit), once direct via a TPR front contact and once via the SSI and a Signal Module output relay front contact. Figure 4 illustrates this for the problem detailed in Section 2.1.2. The other two problems are similarly dealt with.

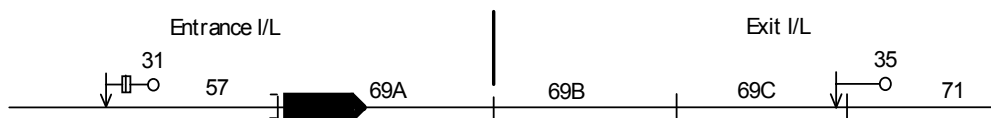


Figure 8

Signal 31 was the signal in rear of the first train that had briefly cleared whilst this train was in section. The inclusion of the various track circuits in the aspect controls of signal 31 was arranged in the data as follows.

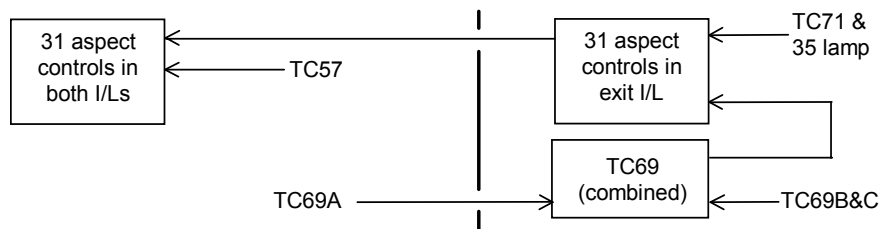


Figure 9

The state of track circuit section 69A was passed across the Interlocking boundary before being combined with the other two sections 69B & 69C. The combined track circuit was then added to 31 aspect controls in the Exit Interlocking and these aspect controls then passed across the boundary to the Entrance Interlocking. Track circuit 57, just cleared by the train, was passed directly into the aspect controls in the Entrance Interlocking.

This resulted in there being a difference in time of two boundary crossings between track circuits 57 and 69A being included in the aspect controls. This, depending on data position, can overcome the built-in allowance in SSI where a track circuit is only declared clear after two (or three) major cycles have elapsed since the track circuit was first reported clear. With the clear state of track circuit 57 reaching the aspect controls in the Entrance Interlocking before the occupied state of track circuit 69, signal 31 was commanded to clear. Then when one or two major cycles later the latter state was received, signal was replaced.

This problem is similar to that described in Section 2.1 of this document, i.e. it involves the transition of trains across Interlocking boundaries.

2.2.2 Solution

As discussed, the passing of aspect control or track circuit information across Interlocking boundaries delays that information in reaching its destination. For adjacent track circuits it is essential that the difference in such delays in proving the two track circuits clear in the signal is limited to a maximum of one more crossing of the boundary for the later occupied track circuit. Otherwise a short fast train passing between the track circuits may be momentarily lost in the track circuit proving in the signal. Putting this rule more simply, a track circuit shall be proved in the aspect

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controls of a signal either in the track circuit's own Interlocking (without crossing a boundary) or in the signal's entrance Interlocking.

With this solution applied, the new arrangement is as follows:

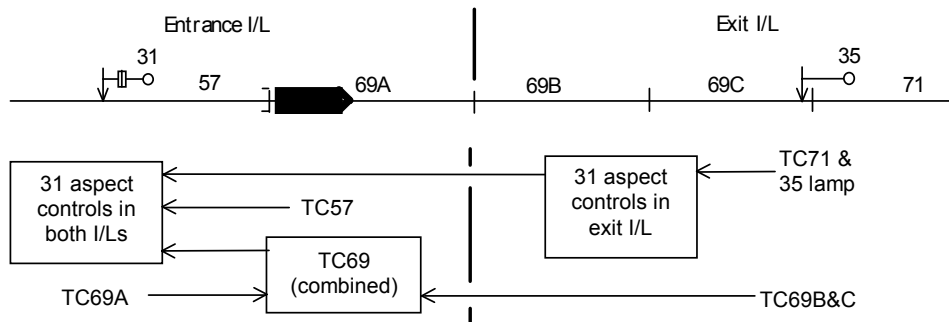


Figure 10

The only difference in delays, is at 69A/69B where 69B incurs one extra boundary crossing over 69A in being proved clear in signal 31.

2.2.3 Associated Documentation

TI Report 95074 was produced following investigations into the incident. The current issue of SSI8003-51C includes the above data changes.

2.3 Track Circuits at Interlocking Boundaries (2)

2.3.1 Problem Summary

In January 1997, at Bellgrove in the Yoker control area, the double block working was removed and SPAD indicators added. Accordingly the warning class route for signal YF216 was reinstated and an addition made to the data to enable the green aspect for this route. On the day after these changes were commissioned, with this route set, a driver observed YF216 signal clearing from red to green for about a second before the aspect dropped back to yellow.

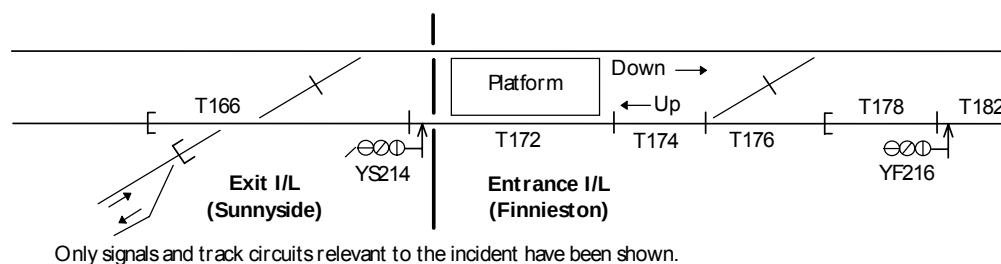


Figure 16

The aspect controls for route 216(W) only extend up to signal YS214, i.e. track circuit T166 is not proved clear. Signal YS214 is last-wheel replaced, thus with route 216(W) already set for a following train standing on track circuit T182, signal YS216 will clear

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at the same time as signal YF214 is replaced by the previous train. There is potentially a 50% chance (depending on data order) that, on track circuit T172 being cleared, the data for signal YF216 will be processed before that for signal YS214. If so the aspect sequencing will lead to YF216 briefly displaying a green before adopting the correct yellow aspect.

This problem has long been recognised in SSI8003, thus the aspect controls for route 216(W) required track circuit T172 clear for two seconds - this guarantees at least a one major cycle delay, thus normally ensuring YS214 is replaced before YF216 clears. (Where Interlocking MPM main processor program issue SSI4303-D4 (or later issue) is installed, this data method is superseded by the program automatically delaying signals clearing direct to higher aspects by holding them at single yellow for one major cycle.) Uniquely, although intending to achieve the same objective, this data method does not strictly comply with the relevant SSP. Subsequently issued SSP62 section 2.2.4 requires, in these circumstances, the forward signal to have been proved replaced before the signal in question is allowed to clear.

(A similar problem can occur where routes from signal YS214 are approach controlled by the occupation of berth track circuit T172. With this signal ready to clear except for approach controls, track circuit T172 fails and this signal clears. The failure now disappears but signal in rear YF216 clears before signal YS214 is replaced, which can result in the aspect sequencing briefly allowing signal YF216 to display an aspect less restrictive than single yellow. This is also addressed by the program change above.)

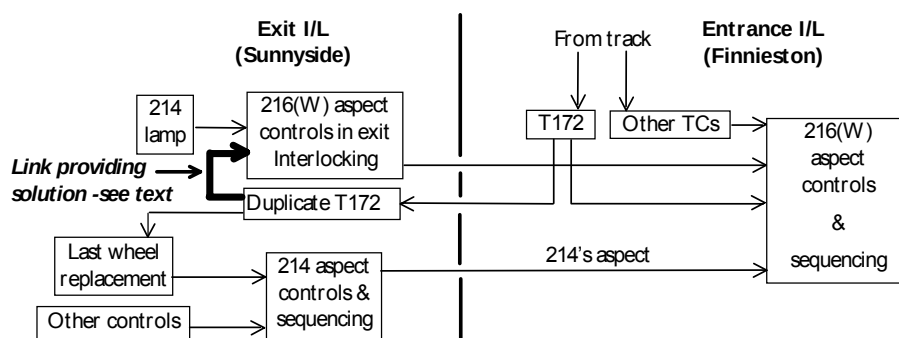


Figure 17

At Bellgrove, the problem was exacerbated by the delays introduced by the Interlocking boundary. The routes from signal YF216 crossed this boundary. Track circuit T172 was input into the Entrance Interlocking, this being directly proved clear for two seconds in the aspect controls for route 216(W). The state of this track circuit was copied across to the Exit Interlocking where it was used in the last-wheel controls (and any approach controls) of signal YS214. Information about the aspect of YS214 was then passed back to the Entrance Interlocking for use in the aspect sequencing of signal YF216. This is illustrated (less the bold item) in Figure 17 above.

2.3.2 Solution

The delays in passing information across the boundary more than equalled the induced delay in clearing signal YF216, thus this signal cleared before the information

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that signal YS214 had been replaced could reach the Entrance Interlocking. The initial solution, shown in **bold** in Figure 17, was to apply what is sometimes called Raynes Park control. Thus track circuit T172 is also proved clear (also for two seconds) in the aspect controls of route 216(W) (and in route 216(M)) **in the Exit Interlocking**. This is so that the cross-boundary delay is also applied to the clearing of signal YF216.

SSI8003 has required such additional proving since 1991, with additional emphasis added in 1996 for where a signal and its berth track circuit are in different Interlockings. However, as a result of this incident, SSISPG considered that SSP62 section 2.2.4 should be strictly complied with. This requires that the clearing signal prove that the signal ahead is replaced. The method for achieving this has been added to SSI8003.

2.3.3 Associated Documentation

For information on how to avoid and correct this problem, reference should be made to the current issues of SSI8003-51B & C and SSI8003-79 (section entitled "Proving of Signal Ahead Replaced"). Signalling Control U.K. document "Signalling Control UK Investigation into Irregular Aspect Sequence on YF216 on January 20 1997" reports on the incident.

3 OTHER CROSS-BOUNDARY ISSUES

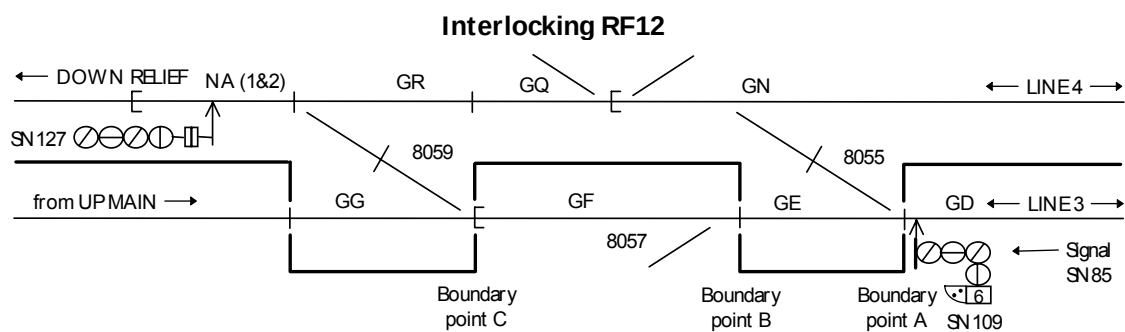
3.1 Lack of Route Locking for Cross-Boundary Route

3.1.1 Problem Summary

Just outside Paddington during June 1996, route 109C-1 was set by a Signaller at Slough Control Centre. Signal SN109 duly cleared, and when the train occupied track circuit GG, it was realised, because of the flooding of the track circuit indications, that the route locking was missing from track circuit GG onwards.

Note: the causes of this incident were complex, the following sections being merely a simplified account of the incident. For further, more detailed information, reference should be made to TI Report 97118.

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Interlocking MN02

All track circuits have prefix "(P)", but these have been omitted for clarity. Any non-relevant signals have also been omitted for clarity. The relevant routes are:

- From signal SN85 to SN109: 85A(M)
- From signal SN109 to SN127: 109C-1(M) via 8059R (preferred alternative)
- 109C-2(M) via 8055R (non-preferred alternative)

Figure 11

The signalling in the area is under the control of Slough IECC via two Solid State Interlockings, PADDMN02 & PADDRF12 (henceforth referred to as "MN02" & "RF12"). As shown in Figure 11, there are two alternative routes from signal SN109 to signal SN127. When the Signaller (but not ARS) sets a route between these signals, preference is given to the first alternative, the Interlocking being expected to attempt to set this one first. If this fails to be set, the Interlocking then attempts to set the second alternative. These are thus known as "chained" alternative routes. Chaining does not apply when ARS sets these routes - it simply selects which alternative it requires to be set. The preferred alternative route 109C-1(M) crosses thrice between the same two Interlockings at boundary points A, B & C (a "castellated" boundary). Note that 109C-2(M) and 85A(M) are also cross-boundary routes, the latter because its overlap crosses the boundary.

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3.1.2 Summary of Cross-boundary Methods

The causes of the incident are complex - to understand them requires knowledge of how cross-boundary functions are carried out - these are now summarised.

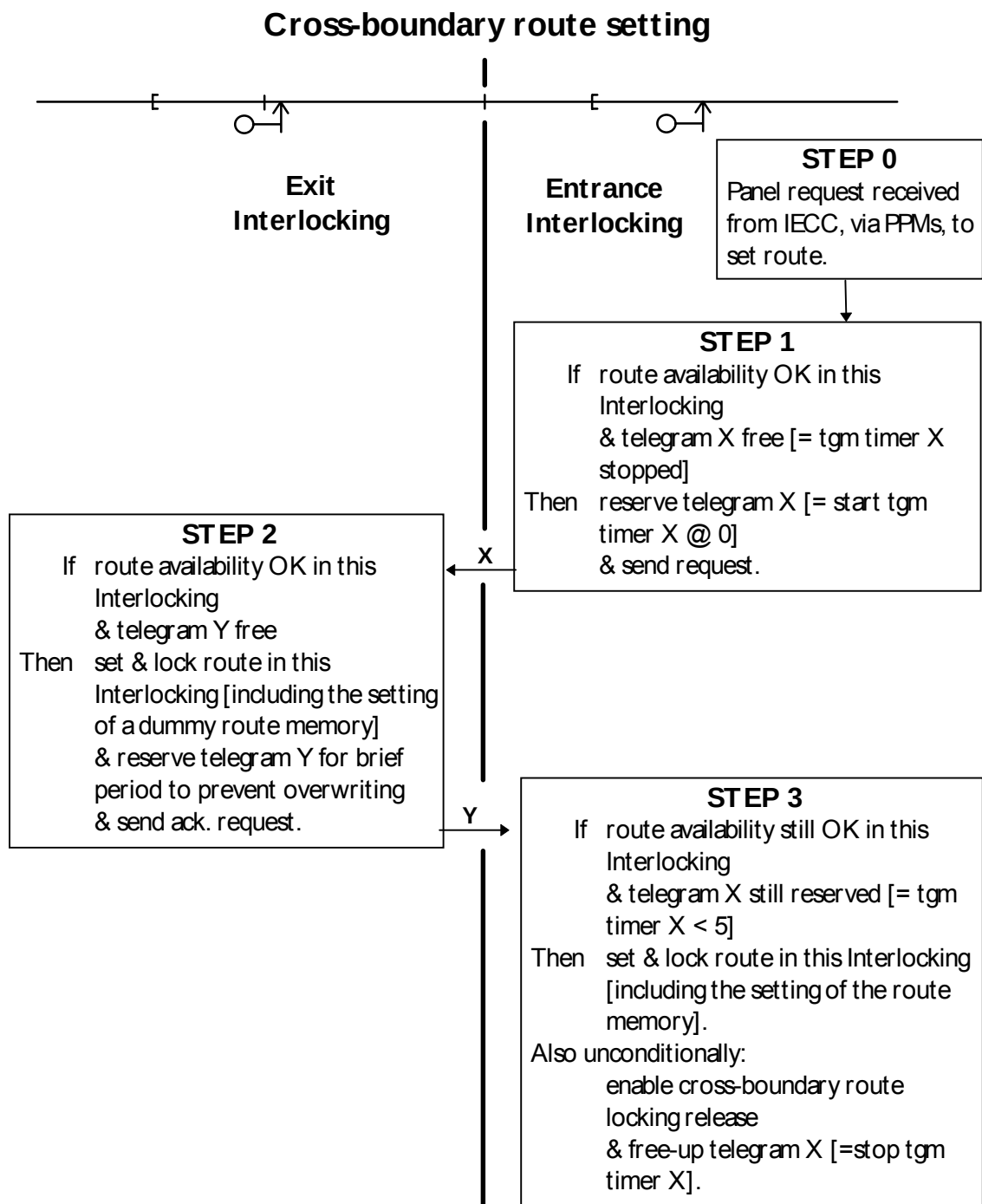


Figure 12

Once the Entrance Interlocking has received a panel request to set a cross-boundary route, then a three step hand-shaking process takes place, as shown in Figure 12. A

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telegram is allocated in each direction between adjacent Interlockings for the transmitting of all cross-boundary requests and acknowledgements, both for route setting and for other functions such as sectional route locking release. "One-shot" functions such as route setting need to reserve the telegram from the Entrance Interlocking whilst the hand-shaking takes place to avoid other route-setting or route locking release occurring simultaneously. They also need to avoid their requests and acknowledgements being overwritten by other requests or acknowledgements whilst awaiting transmission.

A dedicated telegram timer provides this facility. The telegram is considered "reserved" when the timer is running, and "free" when it is stopped. The timer is returned to this "stopped", i.e. parked, state once the hand-shaking process is complete or when the timer reaches five seconds, thus limiting the reservation period.

In Step 3 of the route setting process, the cross-boundary route locking release is unconditionally enabled. If the route is successfully set at this point then the release of the route locking in the Exit Interlocking is inhibited until the sectional route locking in the Entrance Interlocking is released up to the boundary (see Figure 13). If the route fails to be set in the Entrance Interlocking at Step 3 (e.g. because route availability in the Entrance Interlocking has changed between Steps 1 & 3) then route locking release is initiated in the Exit Interlocking in order to cancel the route setting that took place at Step 2.

In the case of castellated boundaries, route setting uses the same Steps as in Figure 2. Route availability tests and route setting and locking are done simultaneously for both parts of the route in the Interlocking concerned. Enabling of cross-boundary route release at boundary points A & C is done in Step 3 and that for B in Step 2.

Chained alternative routes are expected to be implemented such that if the route availability tests for the preferred alternative fail at either Steps 1 or 2 (but not at 3) then Steps 1 to 3 are repeated for the second alternative.

Because the two Interlockings' major cycle times will usually be different, a "transmit-twice" feature is employed by each sending Interlocking such that each cross-boundary request or acknowledgement is sent twice. This is so that each receiving Interlocking receives each request or acknowledgement at least once, however, this also means it is usually received (and processed) twice. If the receiving Interlocking is running faster (i.e. it has a smaller major cycle time) than the sending Interlocking, then requests/acknowledgements will occasionally be received (and processed) thrice. Any second or third acknowledgements received, although processed, are expected to have no effect because of failure of the "telegram still reserved" test in Step 3, as the telegram timer has already been stopped by the first acknowledgement.

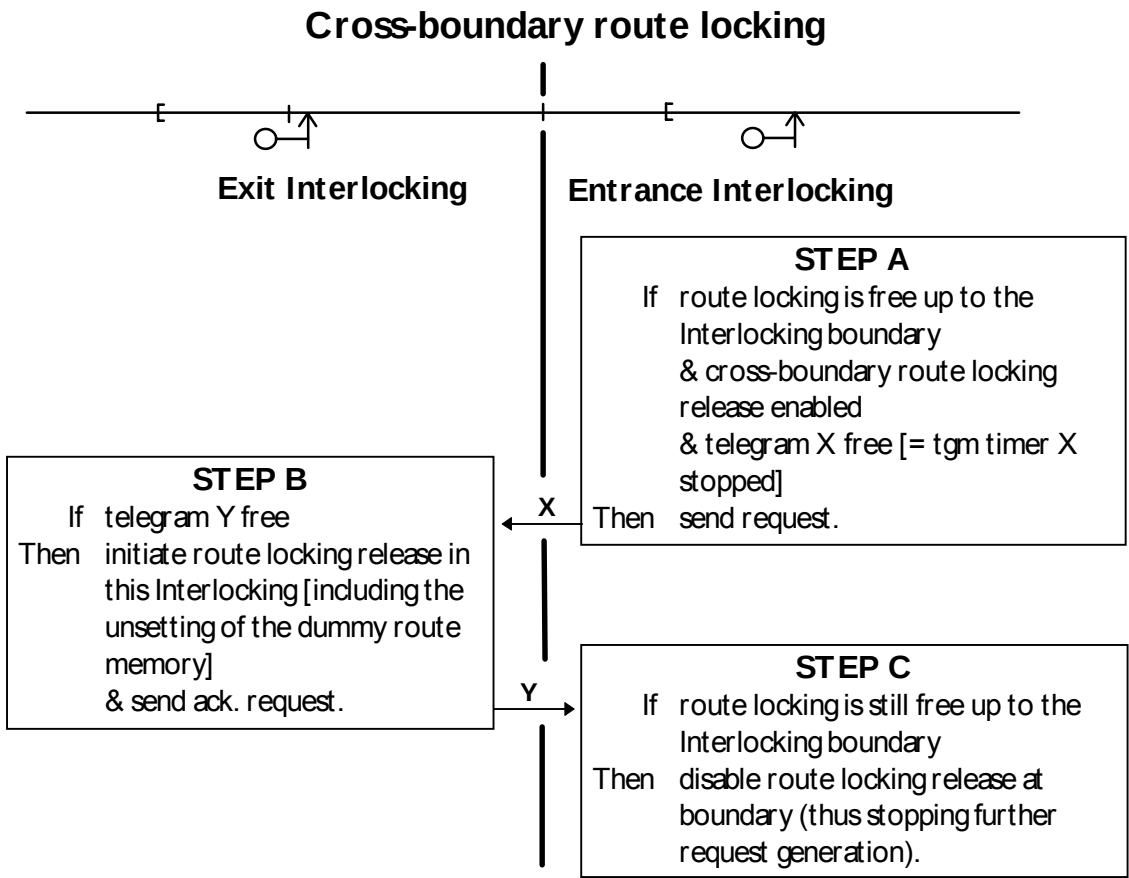


Figure 13

The releasing of sectional route locking across boundaries is done by a similar handshaking method, as shown in Figure 13. The data for Step A is regularly cycled with the resulting cross-boundary request continuing to be generated (i.e. not a "one-shot" request) until the acknowledgement is received in Step C. Because of this it can be treated as a lower priority request and does not need to reserve the telegram as the above higher priority route setting requests do.

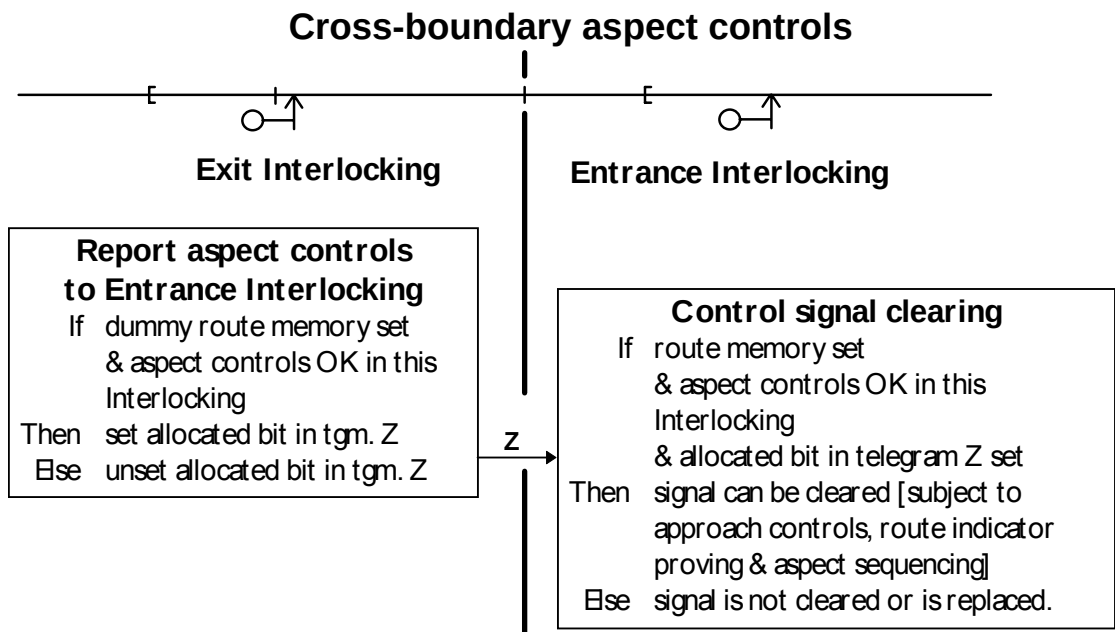


Figure 14

The method of transferring the aspect controls from the Exit Interlocking to the Entrance Interlocking is shown in Figure 14. Unlike in telegrams X & Y above, which are only used to transfer one request at a time in the form of an eight-bit code, up to eight bits of steady state information are transferred by telegram Z. As well as aspect controls, other information such as aspect sequencing and track circuit states may be transferred. Dummy route memories are allocated for each combination of route class and destination, these being used to select which aspect controls are to be transferred. The included dummy route memory test in the Exit Interlocking is also a check that the route locking in the Exit Interlocking is present. A similar arrangement applies to a route crossing a castellated boundary, the aspect controls tested in the Exit Interlocking including those for both parts of the route in this Interlocking.

3.1.3 Deduced Sequence of Events

The incident arose out of the close proximity of several events. The Signaller initiated the setting of routes from signal SN85 to SN109, and from signal SN109 to SN127, in close succession. During this route setting, the previous train cleared boundary point C in route 109C-1(M). The following table shows what was deduced to have happened from the TT and ARS tapes. The “Steps” refer to those shown in Figures 12 & 13.