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Module

Design of Schemes, Chapter D: Signalling Schemes

Endorsement and Authorisation

For endorsement, authorisation and issue record of this document, please refer to the SSI Applications Manual Contents, NR/L2/SIG/17002

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User information

This Network Rail standard contains colour-coding according to the following Red–Amber–Green classification.

Red requirements – *No variations, could stop the railway*

- **Red requirements shall** always be complied with and achieved.
- Red requirements shall be presented in a red box **with the word “shall” or expressed as a direct instruction**.
- Accountability for the efficacy of red requirements lies with the Professional Head/Standard Owner.
- Red requirements are monitored for compliance.
- Corrective actions shall be enforced if deviations are discovered through functional checks (e.g. engineering verification visits, audit or Operations Self-Assurance).

Amber requirements – *Controlled variations, approved risk analysis and mitigation*

- **Amber requirements shall** be complied with unless variation has been approved in advance.
- Amber requirements shall be presented with an amber sidebar **and with the word “shall” or expressed as a direct instruction**.
- Accountability for the efficacy of these requirements lies with the Professional Head/Standard Owner, or their nominated Delegated Authority.
- Amber requirements are monitored for compliance.
- Variations **may** be permitted. Variations are approved by the Standard Owner or through existing Delegated Authority arrangements.
- Corrective actions shall be enforced if **non-approved** variations are discovered through functional checks (e.g. engineering verification visits, audit or Operations Self-Assurance).

Green – *Guidance*

- Guidance is based on good practice. Guidance represents supporting information to help achieve **Red** and **Amber** requirements.
- Guidance shall be presented with a dotted green sidebar **and with the word “should” (usually in notes) or as a direct instruction**.
- Guidance is **not mandatory** and is not monitored for compliance.
- Alternative solutions may be used. Alternative solutions do not need to be formally approved.
- Decisions made by a competent person to use alternative solutions should be backed up by appropriate evidence or documentation.

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1 Introduction

For an SSI scheme, signalling plans and Control Tables shall be produced and approval obtained as normal practice. Minor Control Table differences required for SSI are explained in Section 2. It is then necessary to produce a Location Plan showing the boundaries between each location and where necessary, between each CI. At the same time, a set of TFM Schedules, described in Sections 3 and 4 and showing the allocation of signalling functions to PMs and SMs shall be completed. The Schedules are then entered into the scheme database held in the SSI DWS (see [SSI8300](#) - "SSI Design Workstation Users' Guide").

Following finalisation of the Control Tables and allocation of the TFMs and Interlocking boundaries the geographic data shall then be produced as described in [SSI8003](#) "SSI Data Preparation" and entered into and compiled on the DWS. The data procedures in "SSI Data Procedures" ([SSI8505](#)) shall be followed, and documentation produced and issued in accordance with Chapter J of this document.

The capacity of each CI is limited and, for most schemes, the limiting factor will be the number of TFMs each CI is allowed to address. TFMs shall therefore be allocated carefully. Not all outputs and inputs to TFMs will be used but additional outputs and inputs shall not be left unallocated for future use, such outputs and inputs are likely to be in the wrong place and will be too limited in quantity for any practical future expansion. It is more advantageous to retain spare TFM addresses within each Interlocking which may then be allocated to any site at a future date, the quantity to remain unallocated is discussed in Section 6 of this specification. Signalling functions should be allocated to TFMs which can then be grouped into location areas to maximise the number of TFMs connected to each pair of DLMS. Some interchange of feed and relay ends of track circuits may also need to be considered to obtain the best arrangement of TFMs. However, other factors may be more important in determining the design of track sections and siting of locations.

Where information on a TFM input is required in more than one CI, then it shall be input via one TFM to one of the CIs and then passed onto the other CI(s) via the IDL.

Where automatic and semi-automatic signals are controlled from an SSI, they shall be treated in the same way as controlled signals for Module allocation. They will act in the same manner as if they were controlled by relays.

Where controls are provided via SSI for automatic level crossings and other items where strike in points are time dependent then two seconds shall be allowed for system reaction time.

Where One Train Working using track section/treadle sequential operations is required, consideration shall be given to the effects of power failure on its operation. To provide full battery/UPS back up requires the logic to be carried out in relays at the trackside, rather than using SSI data, as the latter method cannot achieve the required reliability. Further details are given in [SSI8003-80](#).

The remainder of this Chapter describes the constraints in the allocation of TFMs and the division of the scheme into separate CIs. Figure D1 summarises the output, return current path and input data requirements of the TFMs for various signalling functions and Figure D4 shows typical circuits.

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2 Control Tables

Control tables for SSIs are prepared as for free wired Interlockings but with the minor changes listed below. The area covered by a set of Control Tables does not have to coincide with an individual SSI i.e. a set may cover one or several SSIs or just a part of an SSI. The area may be chosen for data preparation or testing convenience.

2.1 Operation of Adjacent Track Section

It is a requirement, as trains correctly pass from one track section to another, that any functions in the Interlocking relying on this track section operation also operate correctly. It is also a requirement that the Interlocking then passes these changes in track section states onto Signalman's indication systems and other associated systems in the correct order. Measures taken to achieve this in design application may need to be reflected back into control table changes so that these measures are adequately recorded.

Various factors may introduce significant changes in the relative delays in passing the states of track sections going clear or occupied from the point of rail/wheel contact through to where these states are used in the Interlocking or in systems linked to the Interlocking via the PPMs. The standard measures contained in [SSI8500](#) & [SSI8003](#) are adequate to cover normal factors. Such factors include variable delays in track sections inputs changing state being reported by TFM's once per major cycle to the Interlocking, the rare possibility of a missing/unreadable TFM message to the Interlocking and variable delays in the Interlocking transferring information to its PPMs. The standard measures include the additional delay in the Interlocking registering a track section clear over registering it occupied. This delay is approx. one major cycle at the TFM input and a further two major cycles in the Interlocking.

The changes in states of adjacent track sections are brought closer together time-wise by fast and/or short trains. These changes in state can be brought even closer together or even have their order reversed by the time they reach the Interlocking or PPMs when additional factors are present. These additional factors include certain track section operating characteristics and short track sections. Alternatively the order may be maintained, but the required states of adjacent track sections may coexist in the Interlocking for less than the one major cycle needed to guarantee that the required data tests are successfully processed.

Required sequences of events involving two adjacent track sections that may be affected in the presence of fast trains are:

Continuity of track section occupation

a track section remaining registered as occupied until after the next track section is registered as occupied

Rear of train monitoring

a track section being registered as clear before the next track section is registered as clear

Front of train monitoring

a track section being registered as occupied before the next track section is registered as occupied

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Another situation where such measures may apply is when an interface between two CIs is accomplished by TFMs and relays rather than the use of the IDL (such as might occur at the boundary between CIs in different control centres, or where enforced by IDL capacity limitations).

The following sections apply only to SSI. At the boundary of SSI and relay controlled areas, differences in the times taken to react to changes in track section states can also cause problems. These are covered in Section 5.2, but the application of any resulting special controls, such as Tollerton control, shall be specified in the Control Tables. Explanatory notes shall be provided for such controls.

2.1.1 Continuity of Track Section Occupation

The requirement that a track section remains registered as occupied until after the next track section is registered as occupied confirms that a train is always registered as present by the Interlocking as it passes from one track section to the next (track circuit bobbing protection is a different matter). Various Interlocking functions such as signal aspect controls and sectional route locking release rely on this either wholly or in part. Additionally, PPM supplied systems such as Signaller's indications and any other associated systems such as TD & ARS can be perturbed by this requirement not being met.

In the presence of short fast trains this requirement can be affected by either of the track circuits having characteristics such that the pick-up time is greater than the drop-away time. Such track circuits are HVI or reed and the requirement can still be met by delaying for a further major cycle the registering in the Interlocking of the track sections becoming clear. The options for achieving this are given in Section 3.3.5.

As the measures specified assume the very worst case situation, including the very rare occurrence of a single missing message on both TDLs at the critical moment, this does in effect almost guarantee both track sections will be occupied for at least one major cycle. This can be assumed so long as a failure to achieve this does not lead to an unsafe situation, otherwise the registering of the first track section clearing will need to be delayed by a further major cycle. Both track sections being registered as occupied for at least one major cycle also confirms that order reversal does not occur when the changes of track section states are transferred to the PPMs for use by the Signaller's indication systems and/or other associated systems.

2.1.2 Rear of Train Monitoring

The first requirement is that in the PPMs a track section is registered as clear before the next track section is registered as clear. This is needed by the Signaller's indication systems and other associated systems, such as TD & ARS, linked to the PPMs. Additionally, there may be a second requirement that in the Interlocking a track section is registered as clear for at least one major cycle before the next track section is registered as clear. Functions such as TORR & TISP that use sequential operation of track sections will require the latter.

These requirements can be affected if the second track section is short. For the purposes of this Section, a "short" track section is defined as one that can be traversed by the rear of a train in less than two seconds at line speed. If both track sections in the sequence are input into the same TFM then this defining time is reduced by one second. If the first track section has a significantly slower pick-up

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time than the second (e.g. a TI21 track circuit followed by a HVI track circuit) then this defining time is increased by the difference (e.g. by approximately two seconds). Boundaries between Interlockings can also worsen this factor due to delays in transmitting information - see below.

If only the first requirement has to be met and no order reversal takes place between the Interlocking and its PPMs then the defining time of a short track section can be reduced by a further second. Order reversal depends on the TFM addresses and track section identity order- this order can be changed to avoid reversal. Order reversal will occur if events [2nd TC IPT] [1st TC IPT] [1st TC sent to PPM] [2nd TC sent to PPM] can occur in this order within a period of any 64 consecutive minor cycles. (As advised in [SSI8003-20B](#), at the beginning of any minor cycle "N", the states of track sections with identity numbers from " $N \times 4$ " to " $(N \times 4) + 3$ " are transferred from the Interlocking to the PPM.)

If either requirement is not met then the second track section has to be delayed in being registered as clear in the Interlocking by "Z" additional major cycles where Z equals the deficit between the defining time and actual time of the short track section. This delay is additional to any delay already required purely for the short track section being an HVI or reed type track circuit. The methods of doing this are shown in Section 3.3.5 and [SSI8003-10E](#) Section 1.5. Generally Z should not exceed the value of two, and an assessment should be carried on the implications of using a higher figure, including the disadvantage of increasing headways.

On bi-directional lines, this delaying of the second track section being registered clear also has a beneficial effect on movements in the opposite direction.

An option to counteract the second requirement not being met is to combine the following track section with the short track section just for the purposes of the sequence, and this is illustrated in Section 2.2. However, this does not allow the first requirement to be met and thus may not be acceptable.

Another factor to be taken into account for the second requirement is the proximity of Interlocking boundaries. States of track sections passed between SSIs, whether via IDL or Signal Modules with a relay interface, can be delayed by up to three seconds, this depending on a number of factors such as data position and Interlocking number range. Thus if the two track sections are in different Interlockings, the situation will be worsened if the required sequence is tested for in the second Interlocking. It will not be worsened if tested for in the first Interlocking. (Normally sequences such as those for TISP & TORR are tested for in the first Interlocking.) Such situations shall be avoided wherever possible.

If a pair of adjacent track sections are both short, measures taken for one may worsen the situation for the other, and this has to be taken into account.

2.1.3 Front of Train Monitoring

The first requirement is that in the PPMs a track section is registered as occupied before the next track section is registered as occupied. This is needed by the Signaller's indication systems and other associated systems, such as TD & ARS, linked to the PPMs. Additionally, there may be a second requirement that in the Interlocking a track section is registered as occupied for at least one major cycle before the next track section is registered as occupied. Functions such as TORR that use sequential operation of track sections may require the latter.

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These requirements can be affected if the first track section is short. For the purposes of this Section, a "short" track section is defined as one that can be traversed by the front of a train in less than two seconds at line speed. If both track sections in the sequence are input into the same TFM then this defining time is reduced by one second. If the first track section has a significantly slower drop-away time than the second then this defining time is increased by the difference. As most track section types do not have markedly different drop-away times this will rarely be a factor. Boundaries between Interlockings can also worsen this factor due to delays in transmitting information - see below.

If only the first requirement has to be met and no order reversal takes place between the Interlocking and its PPMs then the defining time of a short track section can be reduced by a further second. Order reversal depends on the TFM addresses and track section identity order - this order can be changed to avoid reversal. Order reversal will occur if events [2nd TC IPT] [1st TC IPT] [1st TC sent to PPM] [2nd TC sent to PPM] can occur in this order within a period of any 64 consecutive minor cycles. (As advised in [SSI8003-20B](#), at the beginning of any minor cycle "N", the states of track sections with identity numbers from "N x 4" to "(N x 4) + 3" are transferred from the Interlocking to the PPM.)

On bi-directional lines, this delaying of the second track section being registered occupied in the PPMs neither addresses nor worsens any problems arising from the short track section for movements in the opposite direction.

Delaying the registering of a track section going occupied in the Interlocking is not permitted, thus if the second requirement is not met then this has to be counteracted by combining the previous track section with the short track section just for the purposes of the sequence, and this is illustrated in Section 2.2. If the first requirement is not met then the second track section can be delayed in being registered as clear between the Interlocking and the PPM by one major cycle only (see [SSI8003-10E](#) Section 1.5). If the deficit in seconds between the defining time and actual time of the short track section exceeds this then other measures such as changing TFM addresses or track section identity numbers or lengthening the short track section shall be considered.

Another factor to be taken into account for the second requirement is the proximity of Interlocking boundaries. States of track sections passed between SSIs, whether via IDL or Signal Modules with a relay interface, can be delayed by up to three seconds, this depending on a number of factors such as data position and Interlocking number range. Thus if the two track sections are in different Interlockings, the situation will be worsened if the required sequence is tested for in the second Interlocking. It will not be worsened if tested for in the first Interlocking. (Normally sequences such as those for TORR are tested for in the first Interlocking.) Such situations shall be avoided wherever possible.

If a pair of adjacent track sections are both short, measures taken for one may worsen the situation for the other, and this has to be taken into account.

2.2 Short Track s Section Combining for TISP (for Approach Locking Release) and TORR

Sections 2.1.2 & 2.1.3 above have advised of the difficulties that "short" track sections may cause to sequences that monitor the progress of a train from one track

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section to the next. Where either of these track sections is "short" (as defined above), difficulty may arise from the changes of state of these track sections being reported too close together for the Interlocking to separately process each step of the sequence. Which of the two track sections will give difficulty through being short depends on whether the front or the rear of the train is being monitored.

If it is the first track section in a sequence that is too short, then any control monitoring the front of the train moving from this track section to the next will be affected, as the Interlocking may receive the successive occupation of the two track sections at less than the required one major cycle apart. The test on the train having occupied the short first track section with the second track section clear has to be changed to "preceding or first track section occupied and the second track section clear". If the first track section is proved clear at anytime during the sequence then the preceding track section should also be proved clear at the same time.

If it is the second track section in a sequence that is too short, then any control monitoring the rear of the train clearing the first track section will be affected, as the Interlocking may receive the successive clearance of the two track circuits at less than the required major cycle apart. The test on the train having cleared the first track section with the short second track section occupied has to be changed to "first track section clear and the second or following track section occupied". If the second track section is proved clear at anytime during the sequence then the following track section should also be proved clear at the same time.

As explained in Section 2.1.2 above, an alternative (and preferred) method, when the rear of the train is monitored, is to additionally delay the second track section from being registered by the Interlocking as clear.

Examples follow of the application of these rules for combining track sections to Control Tables. 'TC' and 'TD' are the first and second track sections in the sequence with 'TB' and 'TE' being respectively the track sections preceding and following the sequence track sections.

The most common train-in-section-proving control for freeing approach locking will be affected by the second track section in the sequence being too short. This control will become:

"TC occd., TD occd. followed by TC clear, (TD or TE occd.)."

The most common train-operated-route-release control will be affected by either track section in the sequence being too short. If the first track section in the sequence is too short this control will become:

"(TB or TC occd.), TD clear followed by TB clear, TC clear, TD occd."

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If the second track section in the sequence is too short this control will become:

"TC occd., TD clear, TE clear followed by TC clear, (TD or TE occd.)"

2.3 TORR—Delayed Signal Clearance

Where TORR requires the condition that no train is approaching the signal, the clearance of the signal in rear for a subsequent movement may have to be delayed to allow TORR to be effective. When this is required, the Control Tables for the signal in rear should require either:

- the last track section in the route to be clear for two seconds or preferably:
- the signal in question "on", or having been "on" since the previous train, e.g. as per [GK/RT0060](#) [1] Section C8.2.2 and as detailed in [SSI8003-79](#) Section 2.

2.4 Search for Approaching Trains (1)

When this is done in SSI (for releasing comprehensive approach locking or Train Operated Route Release), no account is taken of the state of the search area prior to the search taking place, whereas in a relay Interlocking the stick feature on Train Approach Relays means that any previous incursions into the search area will be remembered and thus the search will find a train. Control table standard headings for columns or sections may need to be changed to reflect this. This also means that approach locking will be released if a signalled train has cleared the berth track section of a signal with comprehensive approach locking when the entrance button is pulled.

Normally this "stick" feature omission is acceptable because of the level of track circuit bobbing protection provided by the SSI system (see Section 3.3.5). If rail-to-vehicle contact is such that this protection is considered inadequate then other measures should be taken, e.g. track section sequencing, in order to address the root cause, as poor track section operation raises associated hazards such as wrong signal aspects.

In complex track areas, because of potentially high data processing times and high data testing costs, the use of searches for approaching trains for approach locking release and TORR should be minimised to where it is operationally expedient.

2.5 Search for Approaching Trains (2)

The search is done geographically, starting at the relevant signal and proceeding in the opposite direction to that of a potential approaching train. Where it is required for the search to branch, i.e. at a set of points in the trailing direction for trains, the search tests point detection (including correspondence) and then continues only in that detected direction. If the points are undetected then the search is declared "failed", i.e. the search area not clear of approaching trains. Control table preparers are recommended to add this detection selection to the search areas for comprehensive approach locking release and Train Operated Route Release. The format is typically --- (211N.--- or 211R. ---) to cover the situation where detection has failed. Selection in the facing direction uses the normal format, typically --- (--- or 212N). This point detection also includes correspondence.

Where the search is used continuously, typically for automatic level crossings, barrow crossings, staff warning systems etc., then point controls are substituted for

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point controls and detection at points in the trailing direction for trains to avoid triggering caused by moving points.

2.6 Approach Lock Release Times

Advantage can be taken of a different set of data being provided for each route of a signal and thus different approach lock release times being possible for each class of route, in addition to less approach locking time provided where the berth track section is occupied by a stationary train. Thus for example the approach lock release timer may be 240 seconds for a main class route whilst that for a shunt or call-on class route from the same signal may be 30 seconds.

2.7 Sectioned Track Circuits

Apart from where single sections have to be used, such as for approach control and the replacement of distant signals, [SSI8003](#) expects the use of combined track circuits wherever possible in Control Tables. Combined track circuits shall be used in the releasing of route locking.

2.8 Approach Control of AWS

Such a control may be required for high power AWS electro-magnets applying to automatic signals (or controlled signals working automatically) in order to avoid such magnets being energised for long periods. The switching on of such magnets are often likely to trigger the Signal Module's hourly power-disable tests. As the switching on will not coincide with an aspect change of the signal, then the resulting blink in the green aspect of the signal will potentially be visible to the Driver of the approaching train. To avoid alarming the Driver, the approach control point is to be such that the Driver at this point either cannot see the signal, or is in rear of the previous signal.

2.9 Miscellaneous

It is not necessary to specify the equivalent of down proving of relays within the Interlocking, unless this is required to check that the proper sequence of operation is followed.

The SSI equivalents of timing relays have an accuracy of ± 2 seconds.

Distant signals or banner repeating signals shall not be proved on in the repeated signal's approach locking release unless mechanically or electromechanically operated.

Where the energisation of a trackside function is delayed until a train is approaching (e.g. for some AWS suppressors), the "strike-in" point shall be at least two seconds (at line speed) ahead of the position of the function.

For further details of the above see the relevant sections of [SSI8003](#) "SSI Data preparation".

Where treadles are cut into track circuits (whether direct or via data in the Interlocking), the treadle damping will delay the clearing of the track section. In situations where sequencing of track sections includes detecting the rear of a train clearing a track section, such sequencing may be upset by this delayed clearance. This delay in clearance can be further increased by reduced treadle performance and cross-boundary delays.

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The term “Location” is used within [SSI8500](#) to denote a location site; this may be:

- A single location case
- A suite of immediately adjacent location cases not separated by tracks or other infrastructure.
- A REB or Equipment Room

3 Signal Module

The Signal Module is intended to handle all trackside functions with the exception of point drives and detection, e.g. signal aspects and route and junction indicators, AWS, ground frames, track circuits, plungers etc., and can interface to adjacent signalling schemes. In many instances, a transformer, transformer rectifier or relay interface will be necessary.

Each Signal Module has a fixed number of input and output connections, two or more Modules may therefore be necessary at a location.

Aspects of automatic and semi-automatic signals shall be allocated to Signal Module outputs in the same way as controlled signals.

In 4 aspect automatic signalled sections, as each signal requires five outputs (aspects and AWS), two signals will require more than one Signal Module. In 2 or 3 aspect 2 line territory, one Module per automatic signal will be required unless up and down line signals are regularly adjacent; in this instance, the availability of sufficient inputs shall be confirmed. When allocating Signal Module inputs and outputs the effect of a failure of a single Module shall be considered to see if the failure can be confined to one line. Whether this can be done at the expense of extra Modules will depend on the customer's specification.

To assist in the allocation of outputs and inputs and for use in subsequent Data Preparation, a Signal Module Data Entry Form (Figure D2) shall be completed for each Module. The output & input numbers 7-0 correspond with bit numbers in the command telegram from the Interlocking and the reply telegram to the Interlocking. Some information on form completion is given below. Further information is contained in Part 3 of [SSI8300](#) “SSI Design Workstation User’s Guide” which shall be read before attempting to fill in the forms. All TFM Data Entry Forms shall be filled in before deciding on CI boundaries and TFM addresses.

3.1 Signal Module Outputs - Sources

3.1.1 General

Each Signal Module provides 8 independently switched outputs, each output can be allocated only to a single function, e.g. one aspect and shall be fused at not more than 2 amps. It is not necessary to allocate all outputs.

Outputs shall not be paralleled except as specified to produce flashing aspects or the red retaining feature.

3.1.2 Rating

Each output is rated at 110 V 50 Hz 150 VA. Where voltage differences and/or current limitations preclude a direct connection to a Module output, an interface relay

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(BRB Specification [966](#), Appendix F7), and/or a transformer or transformer rectifier shall be provided. Note that any 966F7 relay driven by the module shall be housed in the same location as the module. Any relay connected to an output via a transformer rectifier shall be of the slow release type capable of maintaining its front contacts closed during a 120 ms interruption of Module output voltage. The total load of all outputs which can be energised simultaneously by a Signal Module shall not exceed 240 VA.

3.1.3 Module shall not exceed 240 VA.Red Retaining

Outputs 7 and 3 can be configured to provide a "Red Retaining" feature. In this mode, the Module can maintain the most restrictive aspect during certain types of Module or Data Link failure. Red, or the most restrictive aspect if this is other than Red, shall be allocated to these outputs and the Signal Module Data Entry Form Figure D2, Mode column, marked "RR".

This feature may also be used when driving other types of equipment where the Module output is desired to default to the energised condition in the event of link failure (e.g. Closed Circuit Television camera controls).

If not required for Red Retaining, these outputs can be allocated to other functions and the feature not used. When red retaining is not used or the output is not allocated, the Mode column shall be marked "PS" (Protected Source).

3.1.4 Signal Aspects

All aspects of a signal, including on a main aspect signal any associated position lights, shall be allocated to the same Module. AWS and route and junction indicators may be allocated to a different Module, with preference being given to retaining the AWS on the same Module. Route or junction indicators that are proved alight in a signal's aspect shall not be allocated to a Module with a number one less than that of the Module controlling the signal, nor to a Module with a number two less than that of the Module controlling the signal if a LLL is employed. This rule shall also apply to the relative allocation of route and junction indicators to TFMs for aspects with two of these indicators where one indicator has to be proved alight before the second indicator can be lit.

NOTE Careful allocation of Signal Module outputs is important because of Power Disable Tests (PDTs). PDTs are triggered by a change of state of any output of a Signal Module if the time since its last PDT exceeds one hour. If a signal aspect is controlled by a Signal Module that also controls a function, such as AWS suppression, that is regularly triggered as a train is approaching that signal, the chances of a PDT occurring with a train approaching the signal is greatly increased. This has been made particularly important with the introduction of LED signals, since the momentary loss of output caused by the PDT causes a blink of the aspect that is readily visible to the approaching driver.

When allocating outputs to the aspects of a signal, the most restrictive aspect shall be allocated to output 7 (or 3) and the least restrictive aspect to the lowest numbered output in sequence, e.g. for a 4 aspect signal, the red aspect would be allocated to output 7, the bottom yellow to output 6, the top yellow to output 5 and the green aspect to output 4. When two signals are to be allocated to a Signal Module, output 3 shall be allocated to the most restrictive aspect of the second signal, e.g. the second signal shall be connected red - output 3, bottom yellow - output 2, top yellow - output 1 and green - output 0. Where a signal displaying a most restrictive aspect of double yellow is involved then rules above shall be followed except that both

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yellows shall be connected to the HGE output 7 or 3 (note: an additional dummy HHGE output is still required for the second yellow for diagnostic purposes).

It is permissible to add an ECR relay coil in series with a signal red lamp circuit driven by a Signal Module output. A typical application for this is to allow the proving of an SSI controlled protecting signal at red in level crossing circuitry, independently of SSI failures.

3.1.5 Fixed Source

An item allocated to "Fixed Source" is supplied with BX110 from the same fuse that supplies the Signal Module, and the NX110 leg is taken via the Modules NX110 current return paths (see Section 3.2), utilising current proving if required. Thus the item is disconnected if the Module is powered down or unplugged. The "Fixed Source" shall therefore be allocated to those items associated with the Module's switched outputs that shall themselves be continuously lit, e.g. pivot lamps of position light shunting signals, or those items that need to be continuously lit and current proved, e.g. Limit Of Shunt signals and searchlight signal lamps.

An alternative arrangement not using the Fixed Source is shown in Typical Circuit [T28301](#).

3.1.6 Junction and Route Indicators

All lamps of each junction indicator arm shall be supplied from the same output. Where diverging routes require more than one junction indicator arm, the pivot lamp shall also be allocated to a separate output.

If a signal is equipped with both Standard and Miniature alphanumeric route indicators, the following illustrates the form of output and input naming convention which should be adopted:

Indicator Type	Output Name	Input Name
Junction Indicator	S1010 (1) UGE	S1010 UEC
Standard Indicator	S1010 (R) UGE-S	S1010 UEC-S
Miniature Indicator	S1010 (UP) UGE-M	S1010 UEC-M

The use of the above notation is necessary for the correct operation of the diagnostic system.

If a signal has two route indicators on different TFMs that shall be lit together, it may be necessary to include a check on the red retaining status (status bit 2) of the module controlling the retained output in the controls to the other related modules, so as to prevent a partial clearance of the route indication if one of the related modules is red retained. See [SSI8003-10G](#) section 1.2.6.

3.1.7 Output De-energisation and Protection from back EMF

To prevent damage to the Module it is important that an output load is de-energised only by the Module, thus relay contacts which de-energise loads shall not be added to Module output circuits. To avoid using such contacts the control shall be achieved either by inputting that control to the SSI and including it in the data controlling the output, or by providing an output relay and including the control in a circuit isolated from the TFM.

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To prevent damage or output disabling, highly inductive loads such as high power AWS magnets shall have a 5.6 Ohm 25 W resistor between the relevant Module output and transformer rectifiers (see Chapter G Figure G14). The external diode used on AWS circuits as shown in Chapter G Figure G5 is not a specific SSI requirement.

Where a hydraulically powered train stop is controlled via a relay interface by a Signal Module, a diode (rating 1 A, 1000 V) shall be provided for back EMF suppression across the outgoing links of the solenoid valve circuit.

Where relay coils (e.g. for ECR functions) are connected in series with module outputs, this connection shall be in the BX leg of the output.

TPWS interfaces do not generate significant back EMF and no special provision needs to be made.

3.1.8 Double/Single Cutting

Signal Module outputs are not double cut by the Module, i.e. only the BX110 leg is switched by the Module, and thus vital outputs that are taken outside the location (other than normally single cut circuits such as signal aspects) shall have an interface in the location, either an interface relay or transformer rectifier to provide the equivalent of double cutting.

3.1.9 Circuit Length Restrictions and the Use of Pull Down Resistors

Where more than one output circuit is provided in a multicore cable, fed from the same Module, and these circuits, if open circuited, may go unnoticed for sometime, or if the output is driving a high impedance load, then these circuits shall be limited in length to 400 metres, and any of these circuits over 150 metres in length shall have a 10 kOhm 2.5 W resistor connected across the circuit where it leaves the Module's location.

Examples of such circuits include:

- Non lamp proved direct fed 110 V lamps in position lights or route indicators
- TPWS equipment, if a module output drives a dedicated TPWS load.
- Non-vital circuits.

This is done to avoid capacitive coupling presenting voltages across Module outputs which are not energised and thus causing the Module to shut down its output interface. The Module regularly checks all outputs so that switched off outputs have no voltage across them, and any loaded outputs will have cable capacitive induced voltages squelched by the loads.

Generally, all output circuits shall be limited in length to 700 metres.

When driving AWS magnets refer to lineside and on track equipment typical circuit 'AWS, SSI – Inductor Circuits Standard (Yellow) and Extra (Green) Strength Magnets' [T02005](#).

See also the immunisation requirements in Section 10.

3.1.10 Flashing Aspects

These can be driven by the Signal Module which has to be configured by a modifier (see Chapter G Section 3.7 and Figures G9 and G14 for typical circuit and

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connections). The Mode column for outputs 6, 5, 1 and 0 in Figure D2 shall be marked FL accordingly. Thus outputs 6 and 5 are capable of flashing and outputs 1 and 0 are not available for other purposes.

For a four aspect signal, the aspects are allocated to outputs 7, 6, 5 and 4 thus allowing both yellows to flash. Outputs 3 and 2 may be allocated to other functions. For a 3 aspect signal the aspects are allocated to outputs 7, 6 and 5 thus allowing the yellow to flash. Outputs 4, 3 and 2 may be allocated to other functions.

Outputs 1 and 0 are used as follows. Considering the example of Chapter G Figure G14, to obtain a flashing bottom yellow aspect requires bits 6 and 1 set in the command telegram from the CI. This will cause output 6 to switch on and off at the flashing rate (60 ± 10 flashes per minute at a 2:1 light/dark ratio) and output 1 to be switched on continuously. The value (680 Ohm 10 W) of resistor R1 is chosen to make the lamp appear dim without allowing the filament changeover relay to drop. To obtain a steady bottom yellow aspect requires bit 6 set and bit 1 clear in the command telegram. This will cause both outputs 6 and 1 to be switched on continuously. A flashable top yellow is produced similarly by command telegrams and outputs 5 and 0 in conjunction with resistor R2.

3.1.11 Flashing Signal Without Red

If it is required to have a flashing signal without a red aspect then the problem arises of a yellow aspect that is flashed and requires the red retaining feature, and the Signal Module cannot directly provide this. This can be done by configuring output 7 as "protected source" and driving a 110 V a.c. BR 966F7 relay from this output called <Signal id> (RET)R. Interlocking data will be provided so that this output is normally energised, and thus it will only be de-energised whilst the Module is in red-retaining mode or if the fuse or wiring to the relay fail. Contacts of this relay are used to isolate the retained signal aspects from the Module's protected source supply and connect the most restrictive aspect instead to the fixed source. Where the most restrictive aspect is double yellow then both yellows shall be switched thus.

A front contact of this yellow retaining relay is connected to one of the module's general purpose inputs with text in the TFM entry form for a non-critical alarm 'S<nnn> YELLOW RETAINING'. This contact sets a Latch in data to hold the signal at its most restrictive aspect if the relay drops.

3.1.12 Co-acting Signals, Banner Repeating Signals and Splitting Distant

Co-acting signals should be treated as separate signals for TFM allocation purposes with their own TFM outputs and inputs, and own signal identity (suffix CA) used in the identity field. The TFM controlling the co-acting signal also requires an output and input allocated for diagnostics purposes (see [SSI8003-72](#) for details). Where a double yellow aspect is used, extra lamp proving inputs are required for the second yellow lamp of both signals.

Fibre-optic banner repeating signals use two TFM outputs, one for the "on" indication and one for the "off" indication, irrespective of whether one or two lamps are provided for each indication. BR941 relays with a parallel resistor (value dependent on relay manufacturer) are used for lamp proving, one per lamp situated in the feed from the TFM output to the lamp, i.e. in the BX110 leg. Two separate NX110 returns shall be provided from the banner head to the location, one for the "on" indication

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lamp(s) and one for the “off” indication lamp(s). Return current path 0 is used (see Section 3.2). See Standard Circuit [T28382](#) for details.

Two TFM inputs are required (see Section 3.3), that are cut by the relevant combination of ECR contacts to achieve the following. One input (“EC”) indicates to the CI when made that at least one lamp is alight in the required “on” or “off” indication. The other input (“EK”) indicates that where two lamps are provided for a lit indication, they are both alight.

Where fibre-optic splitting banner signals are provided, for TFM output and input allocation, each banner head should be treated separately as above but both heads are to be controlled by the same TFM. See Standard Circuit [T28388](#) for details.

Inner splitting distant signals should have each head treated as a separate signal for TFM allocation purposes, but both heads on an outer splitting distant should be controlled by the same TFM. An offset head does not have a red aspect, and thus no outputs for this head are red-retained. For inner splitting distant signal heads one or two lamp proving inputs may be required, and two additional outputs and one additional input have to be provided for diagnostic purposes. One of these additional outputs is a dummy output, i.e. it has no output load, but a 10 kohm 2.5 W resistor has to be connected across the output in lieu of a load. A 110 V a.c. relay is connected to the other output, and a front contact of this relay is used to control the input. Further details on completing TFM allocation tables are provided in [SSI8003-69C](#).

3.1.13 Relay Controlled Signals and Interfaced SSI

Where its is required to control an SSI signal via relays, as may occur for example if the signal is on a viaduct or in a tunnel, the application details and principles are given in [SSI8003-84](#) “Relay Interfaced Signals”.

Where SSI is being used to replace an existing relay interlocking, with interfaces to the existing trackside infrastructure via relays, see [SSI8507](#) “Relay Interfaced SSI”.

3.2 Signal Module Outputs - Return Current Paths

3.2.1 General

All current outputs shall be returned to the originating Module by one of the five return current paths which are provided with differing current (lamp) proving options. With reference to the Signal Module Data Entry Form (Figure D2), the return current path shall be indicated by number in the return path column for each output selected. Figure D1 summarises the return current path requirements for common items of signalling equipment.

Return Current Path 0 provides no current proving and shall be used to return signalling functions which are not normally provided with proving, e.g. AWS and position lights associated with a main aspect.

Return Current Path 1 (which corresponds to bit 7 in the reply telegram) provides current proving suitable for a 24/24 watt lamp or other equivalent loads - see Section 3.2.3 for actual current values. All signal aspects which are required to be on the same current proving function shall be connected (e.g. all aspects of a 3 aspect signal).

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Return Current Paths 2, 3 and 4 (which correspond to bit 6 in the reply telegram) are capable of detecting currents of different value and only one may be used on any one Module, as follows:

- Return Current Path 2 is suitable for the detection of a two lamp stencil-type miniature route indicator where it is necessary to detect one lamp out.
- Return Current Path 3 is suitable for a 5 lamp junction indicator (5 x 24/24 W, 3 lamps detected as "lit", 2 lamps detected as "out").
- Current Path 4 is similar to return Current Path 1 and may be allocated to an additional set of signal lamps (24/24 W). Where more than one signal requiring current proving is allocated to the Signal Module, the current from the second signal shall be returned via return Current Path 4.

Where it is necessary to prove a single lamp is lit in a stenciltype miniature route indicator, return Current Paths 1 or 4 may be used.

The top yellow of a signal that can show double yellow shall be returned via return Current Path 0.

Where insufficient return current paths are available, or if the load does not conform to the above specifications, the following measures may be adopted:

- A lamp proving relay, situated between the Signal Module output and the load, may be used instead, with contacts of this relay controlling a Signal Module input (see Section 3.3). The coil of the relay shall be in the BX leg of the output. The output(s) used for controlling the function being lamp proved shall be on the same Signal Module as this input.
- External resistor circuits may be used to modify the sensitivity of the module, as described in [SSI8500G](#) Section 3.8 and Figure G15.

Where the voltage drop in the return leg of the tail cable exceeds 2 volts (including surges associated with transformer inrush currents), or in areas of high electrical noise, separate return conductors shall be provided for each aspect/indication.

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3.2.2 Current Values

Values of current detected by return current paths are:-

Return Current Paths 1 and 4	Current detect above 190 mA No current detect below 150 mA (between 150 mA & 190 mA, indeterminate)
Return Current Path 2	Current detect above 760 mA No current detect below 630 mA
Return Current Path 3	Current detect above 630 mA No current detect below 510 mA

Detailed calculations shall allow for the loading of lamp transformers, etc.

Where current proving for non-standard loads is required, this may be accomplished using an external resistor connected as described in Chapter G Section 3.8 and Figure G15.

3.2.3 Position Light Shunting Signals

Where it is required to lamp prove the red lamp in a position light shunting signal then the return of both the red "on" and white "off" lamps shall be connected to return Current Path 1 or 4, and the return of the pivot lamp taken separately to return Current Path 0. The current proving of the "off" lamp is done to cover the changeover time, when a position light shunting signal is button replaced, between the signal replacement being originated in the Interlocking, and the red lamp being registered as lit in the Interlocking. Otherwise the signal in rear, which proves "red lamp alight or signal off" would be momentarily replaced during the changeover.

Where a position light shunting signal is used as a Limit Of Shunt, i.e. with two fixed red lamps, then an ECR relay shall be provided for each lamp. A front contact of each relay in parallel then provides an EC input and in series an EK input.

3.2.4 Flashing Aspects

Whenever one of **more** outputs are flashing the current of one flashing output only has to be detected on return Current Path 1. This is required to allow the Module to check that the current does in fact drop below the threshold during the "dim" period. For a standard 4 aspect signal, output 6 (bottom yellow) shall be returned on path 1 and output 5 (top yellow) on path 0.

Thus a flashable output on return Current Path 0 cannot be flashed independently of the flashable output on return Current Path 1, and if both flashable outputs are returned on path 1, then whilst one output is being flashed the other shall be out.

For details of the design of flashing aspects see [SSI8500G Section 3.7](#).

3.2.5 LED Signals

For interfacing to LED main signals see typical circuits.

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3.2.6 Impact of Power Disable Test

The Signal Module periodically performs a test, known as the Power Disable Test, to check its ability to disable its outputs in the event of malfunction. The interval between tests is as follows:

- On the next change of module output state when the time from the last test exceeds 1 hour.
- Every 5 hours since the last test (irrespective of whether a change of aspect is taking place).

For retained outputs (see Section 3.1.3), the effect of the Power Disable Test is invisible; for other outputs it results in a brief interruption of the module output.

In most instances, tests will occur as a result of aspect change, and the effect will be imperceptible. However, a test may sometimes occur such as to systematically result in a change of a non aspect output as a train approaches the signal. This may cause an aspect blip as a train approaches the signal. Examples known to cause problems include:

- High power AWS magnets which are approach energised.
- Banner repeaters fed from the same module as the signal, and which are replaced by the occupation of (say) the berth track circuit.

Similar effects may also occur if some module outputs are used for purposes unrelated to the signal concerned but which change state frequently (e.g. An AWS magnet on the opposite direction track).

3.3 Signal Module Inputs

3.3.1 General

Each Signal Module has 6 inputs (numbered 5-0). Each input will respond only to the correct pseudo random binary coded signal of the correct polarity generated within that Signal Module and output via the BXI/NXI and BXE/NXE supply connections of the Module.

3.3.2 Double/Single Cutting

These two supplies BXI/NXI and BXE/NXE are identically coded but are electrically isolated from each other. Recommended practice is to use BXI/NXI for input circuits internal to the location and BXE/NXE for input circuits external to the location. This segregation of supplies allows vital internal inputs to be single cut. Any input will respond to either supply. This is in accordance with [NR/L2/SIG/11201/Mod B3](#)[2] Section 4.2, which does not require safety critical inputs to be double cut so long as they are "internal".

As each input has BX and NX terminals then each can be either single or double cut. Where single cutting is used, the BX circuit is taken via the relay or other contact to be input and the NX terminal is linked to the appropriate NXI or NXE supply.

Normal rules for double or single cutting apply, viz. all vital external circuits shall be double cut with all other circuits single cut, so long as the above segregation of supplies is observed e.g. non-vital single cut external circuits use the same