Transport for NSW

Reference material

Advanced train control Migration System (AMS) Specifications – AMS Circuit Design Standard

This document is published as reference material to support the implementation of Automatic Train Protection as part of the roll out of the Advanced Train Control Migration System project.

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Authorised by: Chief Engineer, Asset Standards Authority
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AMS PROJECT SPECIFICATIONS

AMS CIRCUIT DESIGN STANDARD

DeskSite Reference: 4915414

Standard – Applicable to Transport Projects AMS Program

Quality Management System

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Process owner:	Project Director

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Document Approval:

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Reviewed and Accepted by: (Manager Safety Assurance)	**Michael Little**	**Date:** 11-5-2017
Reviewed and Accepted by: (Principal Engineering Manager Systems)	**Frederic Tricoche**	**Date:** 11/05/17
Approved for Release by: (Project Director)	**Craig Southward**	**Date:** 19/5/17

Document History

Version	Date of Issue	Author	Summary of change
0.1	12/02/2016	S.S. De	This version was created in MS Visio
0.2	26/04/2016	S.S. De	First issue of this document using AMS Project specific template Standard Circuits populated from Visio and the corresponding Layout and LEU Tables from Appendix C – AMS-TIP-009 Updated to stakeholders' review comments
0.3	16/05/2016	S.S. De	Updated to further review comments
0.4	23/05/2016	S.S. De	Updated to further review comments
0.5	17/05/2016	C.W.Oxborrow	Simplification of contact sensing arrangements.
0.6	26/05/2016	C.W.Oxborrow	Updated to review comments.
0.7	26/05/2016	C.W.Oxborrow	Amalgamation.
0.8	30/05/2016	C.W.Oxborrow	Consistency added to contact sensing arrangements to allow proper linking with junction signal clear.
0.9	02/06/2016	S.S. De	Updated to review comments

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1.0	02/06/2016	C.W.Oxborrow	Issued for approval
1.1	11/07/2016	C.W.Oxborrow	Clarification of inputs required for high risk turnouts.
1.2	12/07/2016	C.W.Oxborrow	Clarification on how shunt routes are treated.
1.3	13/07/2016	C.W.Oxborrow	Updated to review comments
1.4	13/07/2016	C.W.Oxborrow	Updated to review comments
1.5	13/07/2016	C.W.Oxborrow	Updated to review comments
2.0	13/07/2016	C.W.Oxborrow	Issued for approval
2.1	05/05/2017	S. S. De	Minor corrections and updated to CR 486: i) additional configuration included for Look-ahead using LEU Networking in Contact Sensing Area; and ii) modified configuration for double light junction signal
3.0	11/05/2017	S. S. De	Issued for approval

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Foreword

The Circuit Design Standard forms part of the TfNSW suite of railway signalling documents (Standards, Principles and Guidelines) which detail the requirements for the implementation of ATP / AMS on the TfNSW heavy rail network. This document specifically covers the Circuit Design Standard for AMS.

To gain a complete overview of ATP / AMS signalling design requirements, this document should be read in conjunction with the AMS suite of signalling design principles and guideline document.

Note

The following Circuit Design Standard is to be used by the AEOs engaged by the ATP program for the AMS concept design. This is to ensure that consistent methodologies are applied.

This has been produced during the development of the AMS Project Specifications and subsequent modification may be required as the specifications evolve.

This is an interim document until the ASA standard is published.

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1. Background

Transport for New South Wales (TfNSW) is using the European Train Control System (ETCS) to provide Automatic Train Protection (ATP) functionality on the TfNSW heavy rail network.

In ETCS, trackside equipment transmits information (track gradients, speed limits, signalled proceed authorities, and other related data) to on-board equipment. The on-board equipment uses this information and pre-programmed rolling stock parameters to calculate brake interventions to the train within safe speed and distance limits.

ETCS operates in numerous levels (defined mainly by the type of communication between trackside and on-board equipment). It is intended that the TfNSW network will eventually use a mixture of Level 1 and Level 2, dependent on operational characteristics of given areas, operating primarily in Full Supervision (FS) mode, to enforce speed and distance limits. This combined with intelligent rail traffic management systems, will be known as Advanced Train Control System (ATCS).

Due to the operational complexities of the TfNSW network and services (size of network, and size and deployment of rolling stock fleet and train crewing workforce), the path to FS is long and complicated. As a transitional arrangement, the 'Advanced train control Migration System' (AMS) has been devised. Using Limited Supervision (LS) mode in Level 1, AMS is designed primarily for rapid deployment to manage risks which are not already protected by other engineered systems, and enable personnel to become familiar with the equipment before more complex functionality is introduced.

2. Purpose

This document intends to present the circuitry arrangements required for each of the AMS functionalities where an LEU-Signalling interface is involved. The circuits are based on various signalling layouts that may be found within the proposed AMS fitment area. Each circuit has an accompanying LEU Table that lists all the intended AMS responses corresponding to the possible aspects of the signal to which the LEU is connected.

There are various circuits from ATP Full Supervision that are still valid for AMS. The latest version of these circuits, included under Section 9 (screen shots only) of this document, are from an unpublished issue of SDG 003 (version 1.4, dated 12/05/2014) and some of these drawings were hand marked and Approved for 'Trial Installations' only.

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2.1 Scope

This document covers both contact and current sensing arrangements for individual AMS functions only. Cascaded cases, i.e. where multiple AMS functions need to be provided from a single Balise Group, may require additional inputs from the signalling system and modifications to the LEU Tables.

For the examples in this document, the following should be noted:

1. Aspect sequence charts are only provided where there is a particular need to highlight this information to assist in the understanding of the individual case and the corresponding circuit.

2. For a junction involving multiple high risk turnouts, the turnout/crossover speeds may not be the only factor in deciding the "most restrictive speed" for the junction. The distances between the TSM initiating Balise Group and the toes of the turnout points also need to be taken into account. The turnout speed applicable to the most restrictive braking curve (i.e. requiring the earliest braking point) should be considered as the most restrictive speed for that junction. This speed will also be applied when any of the signals between (and including) the junction signal and the TSM initiating Balise Group is at stop. In some cases, the most restrictive speed profile may include more than one target speed with more than one target point.

   Inputting each route associated with a high risk turnout allows the appropriate post turnout speed (i.e. the applicable speed in advance of the turnout) to be sent as the final speed iteration. This is the reason for two similar masks in the contact sensing arrangements, where both have the AMS response of the most restrictive speed monitoring. When the signal is at stop, no post turnout speed is sent.

3. Target Speed Monitoring is not required for low risk turnouts and hence Line Speed is used as the AMS response for the routes leading over them.

   Where low risk turnouts are part of the same junction as high risk turnouts, the turnout speed related to the low risk turnout does not need to be considered for the purpose of calculating the 'most restrictive speed' for the junction. TSM will be revoked for routes through the low risk turnouts.

4. Where a signal (connected to an LEU) protects a low risk turnout, plus leads to a high risk turnout, it is possible that the applied TSM will not impose an unacceptable operational restriction for a train taking the low risk turnout, as the train speed will be updated from the repositioning balise group provided past the low risk turnout. The examples shown assume there is an unacceptable operational impact imposed for a train turning out through this low risk turnout when using a main aspect.

   Where there is an intermediate signal protecting a low risk turnout, look-ahead may be required if there is an unacceptable operational restriction for trains taking the low risk turnout.

   A case-by-case analysis may be required to determine whether there is an unacceptable operational impact, and the decision may be affected by the location of such repositioning balise groups.

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5. Refer to the AMS Look-ahead Design Guideline to assess look-ahead requirements. For simplicity, the look-ahead examples in this document show a maximum difference of one signal block between the signalling braking requirement and the AMS braking requirement. For situations where the AMS braking requirement is greater than this, a more complicated look-ahead design will be required.

6. Where look-ahead inputs are required, the hardwired copper cable method has been used for the contact sensing arrangements while Ethernet communications (LEU networking) has generally been used for the current sensing arrangements. However, there is one example layout under both 'contact sensing' and 'current sensing' configurations that has considered two different options; hardwired copper cable and Ethernet communications method for contact sensing and Ethernet communications and CBI data change (TFM interface) method for current sensing configurations. Refer to the AMS Look-ahead Design Guideline for more information on these options.

   Where a new relay function is created for look-ahead purposes, the new relay must be proved operated in a signal aspect control function, i.e. the design should avoid any situation where the only front contacts in use of a relay are for LEU inputs, as a failure of this relay to pick may go undetected for a period of time. The design of the new relay function needs to be arranged such that the relay drops with the local signal at stop, which then allows the relay to be back-proved in the local track stick circuit. Circuit schematics reflecting this requirement are shown in the examples to aid in the design.

   Where LEU networking method is used within a contact sensing area for Look-ahead purposes, at least one local function (where available) capable of sending linespeed independent of look-ahead inputs needs to be provided to the LEU. This will help avoid unwanted application of TSMs during any failure related to the look-ahead arrangement and thereby improve operations.

7. In most cases, subsidiary shunt inputs will not be required. Where these inputs are not provided, the LEU will consider the signal to be at stop when the shunt routes are clear. Accordingly, the necessary speed monitoring will apply, related to a high risk hazard or EBI due to an ETCS Trainstop (e.g. the train will be required to trip past a shunt aspect).

   For an ETCS Trainstop, shunt routes will only inhibit a brake intervention upon a special request from operations.

   For a high risk turnout, if the most restrictive turnout speed is less than 25km/h, it is possible that applying this most restrictive turnout speed could impose an operational restriction for a particular shunt route. If there is an LEU / balise group connected to the junction signal, and the operational restriction is identified as unacceptable, then the shunt route should be input to avoid this operational restriction.

   For an overlap deficiency, it may be assumed that there is an unacceptable operational restriction if the protecting signal is displaying shunt, and:

   - the deficient overlap speed is <25km/h, and
   - the shunt route drives the conventional trainstop, and

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- there is an LEU / balise group connected to the protecting signal.

If there is doubt on the acceptability of an operational restriction, then guidance should be sought from the AMS Project System Integrator.

This document has presented some examples (under both Contact and Current sensing arrangements) for signals protecting a hazard where shunt inputs are required. The corresponding LEU Tables show how to deal with these inputs.

8. There are various differences in the application of Low Speed and Close Up aspects across the network. The examples presented within this document have Low Speed aspects with approach clearing, hence all aspect sequences show a Caution aspect leading directly to a Stop aspect.

   This document has presented some cases of a Low Speed aspect where a Stencil Route Indicator is present at the signal. The examples used cover the situation where the Low Speed only applies to the straight route, and hence the associated SRI current sensing input is ignored for the Low Speed mask.

   The decision whether to input the Low Speed and/or Close Up will be on a case-by-case basis, taking into account the application of the Low Speed or Close Up aspect, the existing conventional trainstop functionality, its approach clearing speed, and whether there would be an unacceptable operational restriction if the input was omitted.

9. The term 'Overlap Deficiency' where used in this document, includes high risk deficient overlaps and high risk catch points or level crossings within the overlap.

10. Where relay driven Multi-lamp (Theatre type) Route Indicators are available, it is preferred to use contact sensing inputs from the relays that drive them. This allows the inputs to be received even in a lamp failure situation.

11. In the LEU Tables, a two-bit code (11, 10, 01, 00) is used to identify each input as on, off, pulsating/flashing or has a fault. This code is utilized by the data preparation tool.

12. Under current sensing arrangements for double-light signals capable of displaying medium and/or medium turnout aspects, a 'Dummy proceed' mask is required. This mask caters for the below mentioned failure situations:

    i) Top Green lamp failure during "Medium" aspect;

    ii) Top Yellow lamp failure during "Medium Turnout" aspect.

    This gives the flexibility to revoke TSM (if it is safe to do so) or inhibit EBI under these partial indications situations (which may be treated as proceed), which is consistent with contact sensing arrangements.

13. Under current sensing arrangements, the LEU Tables have assumed that in-built protection is provided into the existing installations where the interlocking restricts a signal to a more restrictive aspect in the event of its Turnout Repeater lamp failure. This also includes failure of the same input into the LEU due to loose crimp, broken wire etc. Under such a failure, conditions for a different mask commensurate the signal aspects get satisfied and the most restrictive speed for the junction ahead is enforced.

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14. Within the current sensing area there might be cases where the Turnout Repeaters are driven from an SSI module via a relay interface. In order to maintain the fail-safe outcome, as presented in the LEU tables for current sensing examples, it is mandatory to provide the turnout repeater lamp monitoring inputs to the LEU as opposed to inputs from the relay driving the turnout repeater. Additional protection is required to cater for certain failures if current sensing configuration is not maintained for these inputs.
15. Under current sensing arrangements where Shunt inputs are provided, the LEU Tables have included an additional Mask to cater for Stencil Route Indicator lamp failure (Shunt SRI Fail). This partial indication situation is considered an illegal indication by AMS, even though it is to be treated as proceed (Ref NSG 606). This achieves a fail-safe outcome when there is more than one shunt route from the signal.

    The conditions for this mask are also satisfied when any shunt route from the signal, other than the shunt route inputted into the LEU, is clear.

    An SRI alight with the shunt aspect failed is to be treated as stop (Ref NSG 606). Thus in a current sensing situation, if an AMS response requires an SRI alight, then the shunt aspect must also be proved alight.
16. For high risk turnout examples, where a balise group is shown at the junction signal as an approach balise group, it could possibly be positioned anywhere in the signal block in rear of the junction signal.

2.2 Application

This standard applies to the AEOs engaged to carry out the signalling design for new works and describes the requirements for signalling inputs to the LEU, their associated allocation and wiring arrangements under AMS context.

3. Reference Documents

The following documents should be read in conjunction with this guideline. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

i) AMS Signal Design Principles

ii) AMS Look-ahead Design Guideline

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4. Terms and definitions

The following terms and definitions apply in this document:

AEO Authorised Engineering Organisation; means a legal entity (which may include a Transport Agency as applicable) to whom the ASA has issued an ASA Authorisation

AMS Advanced train control Migration System

ASA Asset Standards Authority

ATP Automatic Train Protection; a system which supervises train speed and target speed, alerts the driver of the braking requirement, and enforces braking when necessary. The system may be intermittent, semi-continuous or continuous according to its track-to-train transmission updating characteristics.

BOL Band of Lights (Turnout Indicator) of a single-light signal

BTM G Green lamp from the lower head of a double-light signal

BTM R Red lamp from the lower head of a double-light signal

BTM Y Yellow lamp from the lower head of a double-light signal

C Caution aspect

CBI Computer Based Interlocking

Contact Sensing LEU inputs are from contacts of the relays driving the signal aspects

Ct Caution Turnout aspect

Current Sensing LEU inputs are directly from the signal lamps

(CU)HR Close-Up Relay

D1/D2 Main Line Route Indicators

DR Full Clear Relay

EBI Emergency Brake Intervention

ETCS European Train Control System; a three level, unified, modular automatic train protection specification to enhance interoperability across Europe

FC Full Clear aspect

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HR Caution Relay

HDR Medium Relay

I/P Input

JP Turnout Repeater aspect

JPHDR Turnout Repeater Relay

LEU Lineside Electronic Unit; equipment that controls the balise output based on the state of the signalling inputs

LEU Table A Table that records the intended AMS outputs in relation to the possible states of the LEU inputs associated to the valid aspects of the connected signal

LH Left Hand

LSpR Low Speed Relay

M Medium aspect

MK LT Marker Light of single-light signal

Mt Medium Turnout aspect

PHDR Preliminary Medium Relay

PM Preliminary Medium aspect

RH Right Hand

S Stop aspect

(S)HR Shunt Relay

SRI Stencil Route Indicator used for shunt and Low Speed routes

TFM Trackside Functional Module

TfNSW Transport for New South Wales

TOP G Green lamp from the upper head of a double-light signal

TOP R Red lamp from the upper head of a double-light signal

TOP Y Yellow lamp from the upper head of a double-light signal

TSM Target Speed Monitoring

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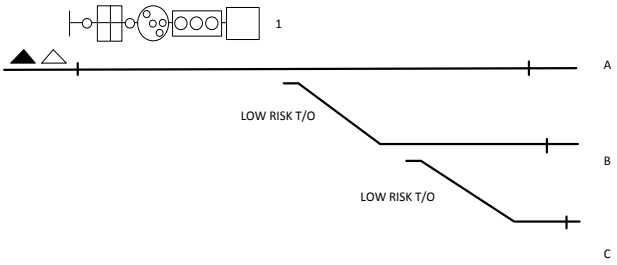
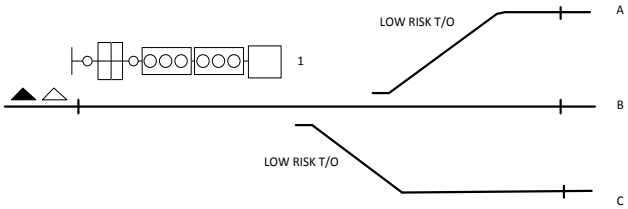
5. ETCS Trainstop

5.1 Contact sensing arrangements (Standard Circuits 1 & 2)

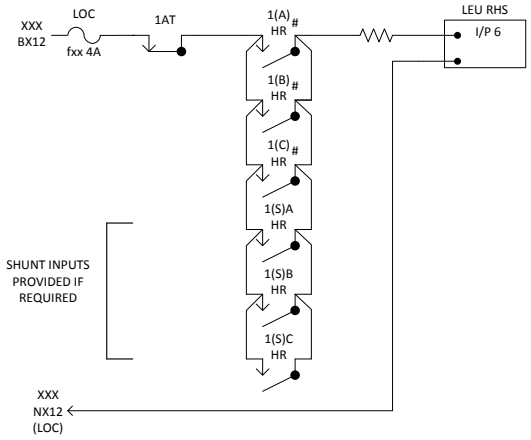


APPLICABLE TO STANDARD CIRCUITS 1, 2 & 3



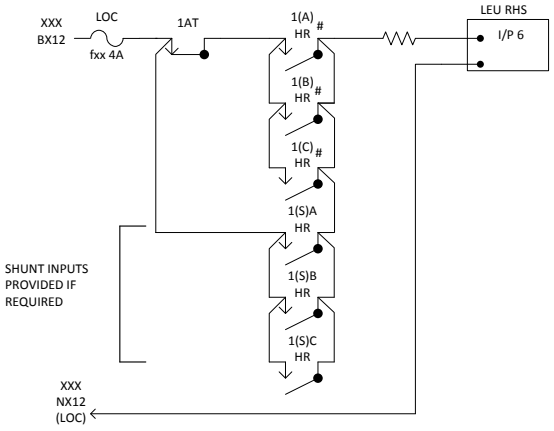
APPLICABLE TO STANDARD CIRCUITS 1, 2 & 4

SHUNT WITH REPLACEMENT TRACK
(STANDARD CIRCUIT 1)



- First proceed aspect control relay contact only - (M)HR, LSpR or (CU)HR

SHUNT WITH ESF/ NO REPLACEMENT TRACK
(STANDARD CIRCUIT 2)



- First proceed aspect control relay contact only - (M)HR, LSpR or (CU)HR

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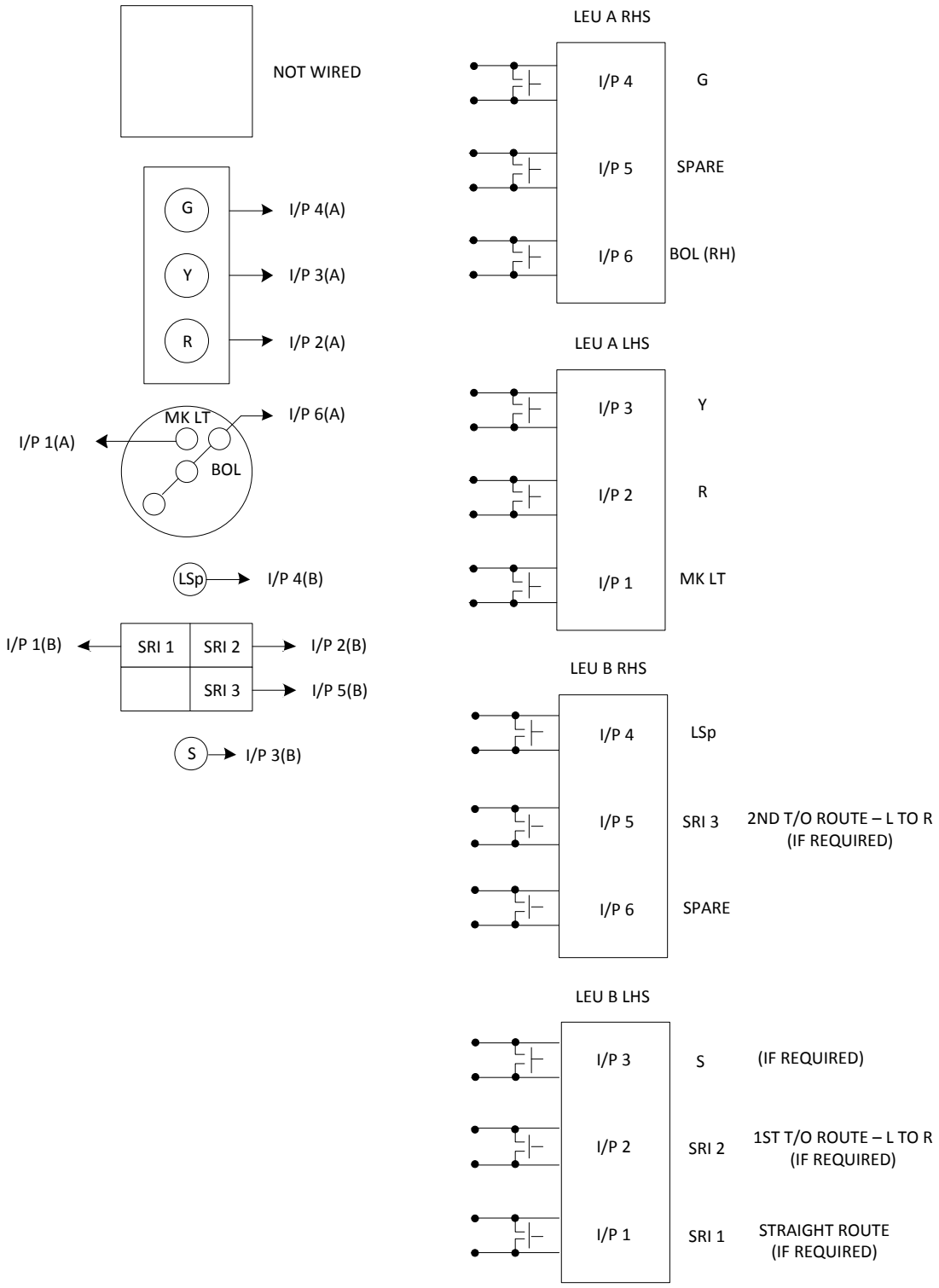
5.2 Current sensing arrangements:

5.2.1 SINGLE LIGHT SIGNALS (STANDARD CIRCUIT 3)



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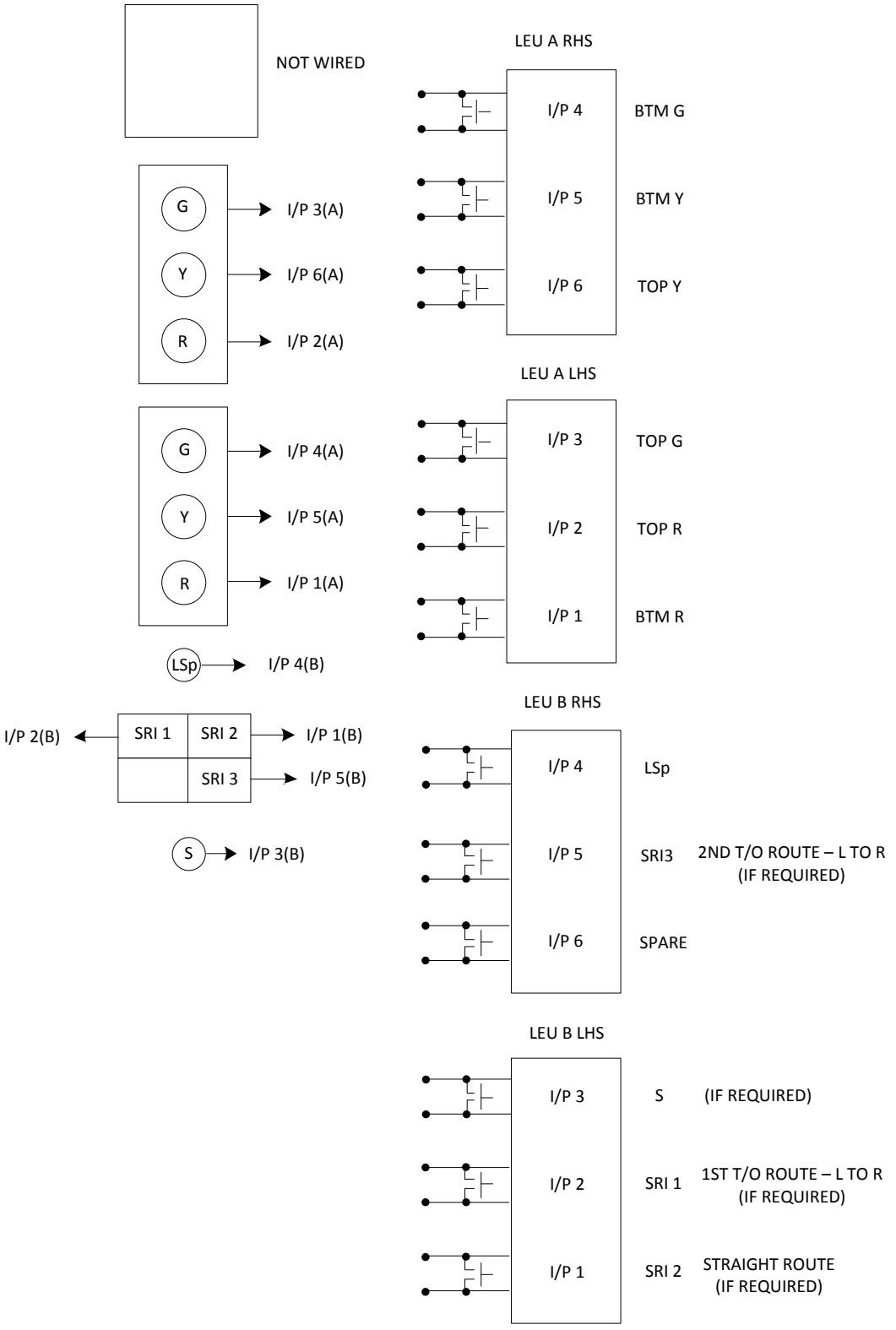
5.2.2 DOUBLE LIGHT SIGNALS (STANDARD CIRCUIT 4)



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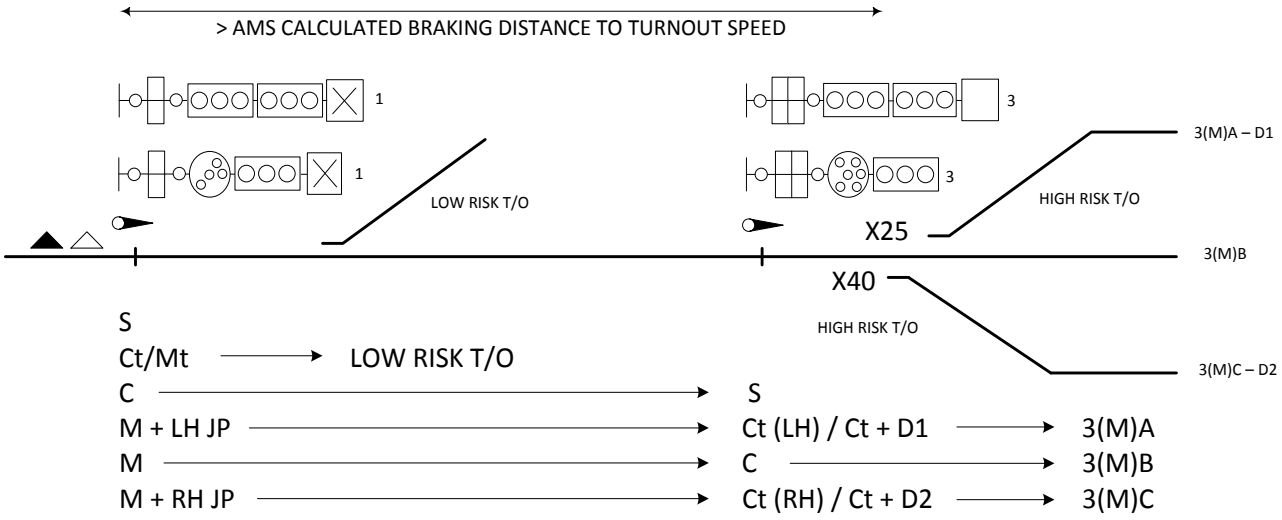
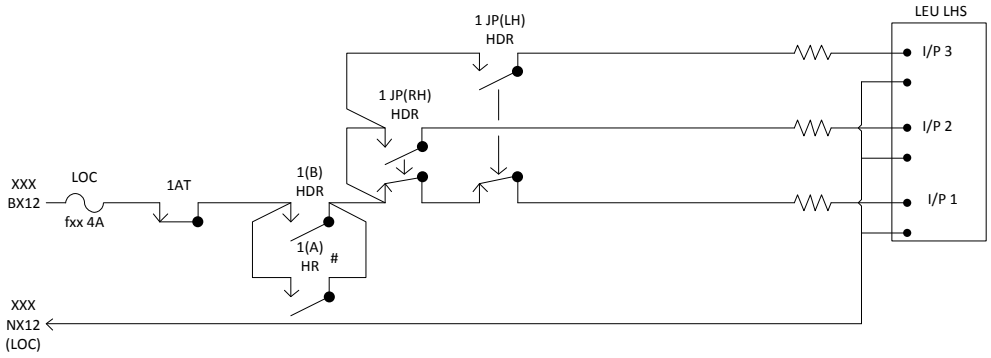
6. High Risk Turnout

6.1 Contact sensing arrangements

6.1.1 TURNOUT REPEATERS AVAILABLE (STANDARD CIRCUIT 5)





- First proceed aspect control relay contact only - (M)HR, LSpR or (CU)HR

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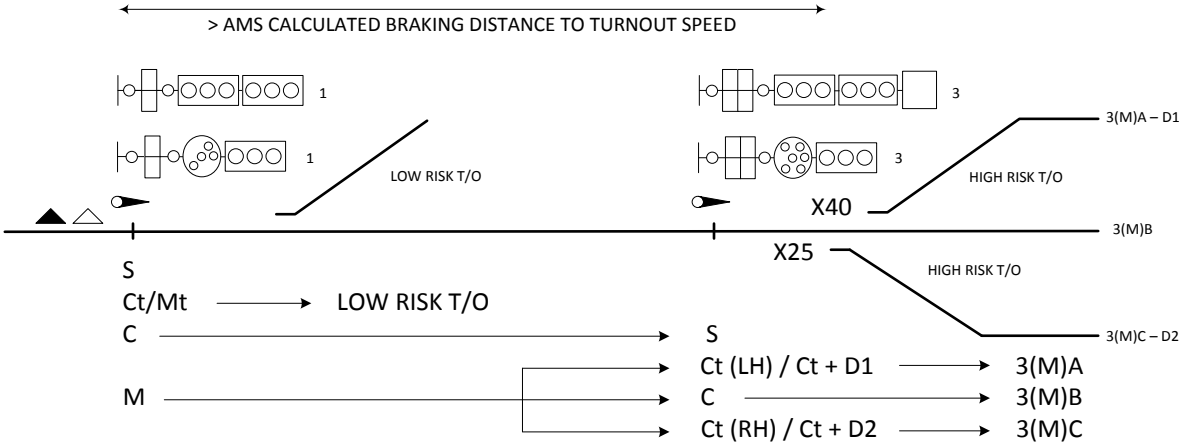
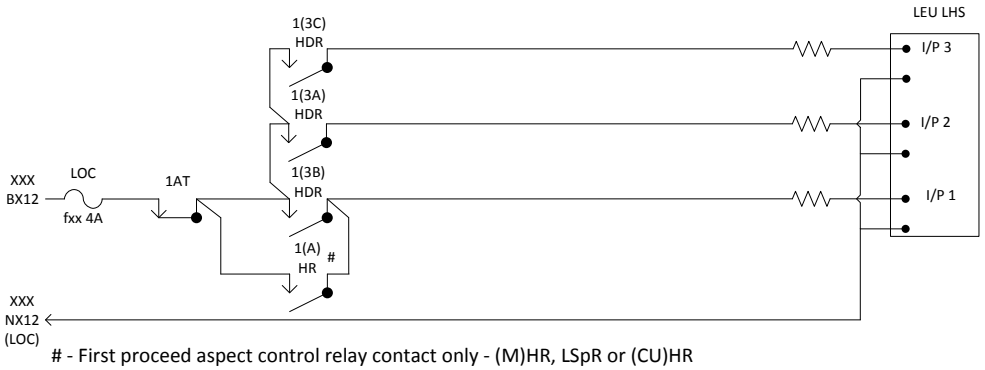
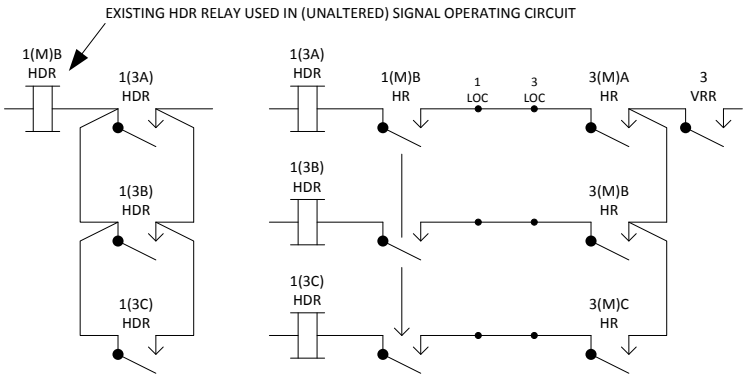
6.1.2 TURNOUT REPEATERS NOT AVAILABLE (STANDARD CIRCUIT 6A AND 6B)



STANDARD CIRCUIT 6A – LOOK-AHEAD USING HARDWIRED COPPER CABLE METHOD



- First proceed aspect control relay contact only - (M)HR, LSpR or (CU)HR



- ALL FOUR HDR RELAYS BACK-PROVED IN 1AT TRACK STICK CIRCUIT.
- SCHEMATIC ONLY. FULL CIRCUIT AND DOUBLE CUTTING NOT SHOWN.
- MULTIPLE ROUTES MAY BE COMBINED INTO THE ONE RELAY FUNCTION, PROVIDED EACH ROUTE HAS THE SAME AMS RESPONSE REGARDING:
  - TURNOUT SPEEDS AND TARGET POINTS;
  - POST TURNOUT SPEED.

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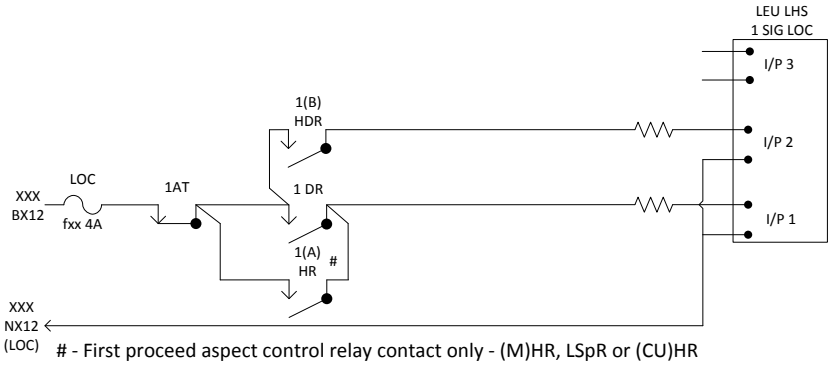
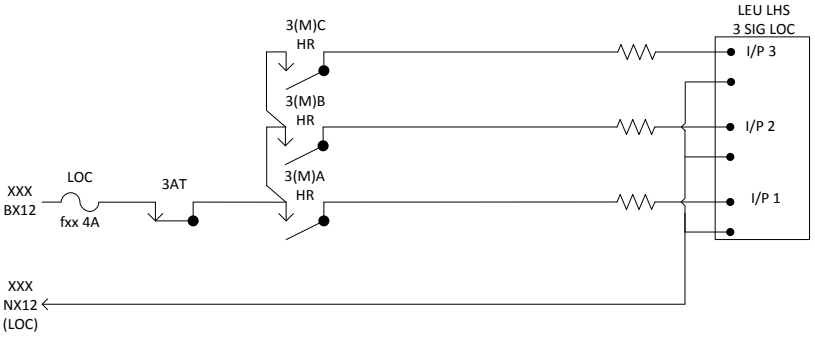
STANDARD CIRCUIT 6B – LOOK-AHEAD USING ETHERNET COMMUNICATIONS METHOD





Allocation of the Look-ahead inputs into the LEU is based on 'Left to Right' orientation of their corresponding routes.

The LEU provided at 3 Signal location for 'Look-ahead' purposes needs to be networked with the LEU at 1 Signal location via RS900. For detailed LEU Network connection, refer to Section 9.4.

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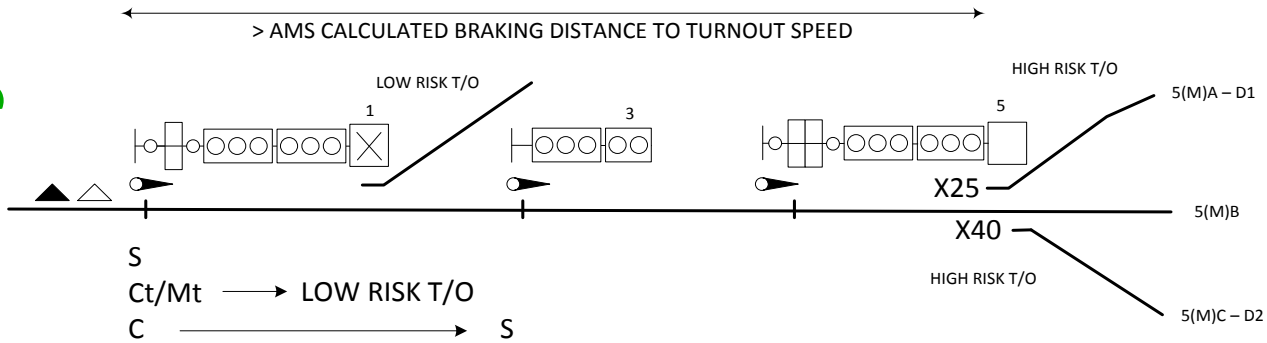
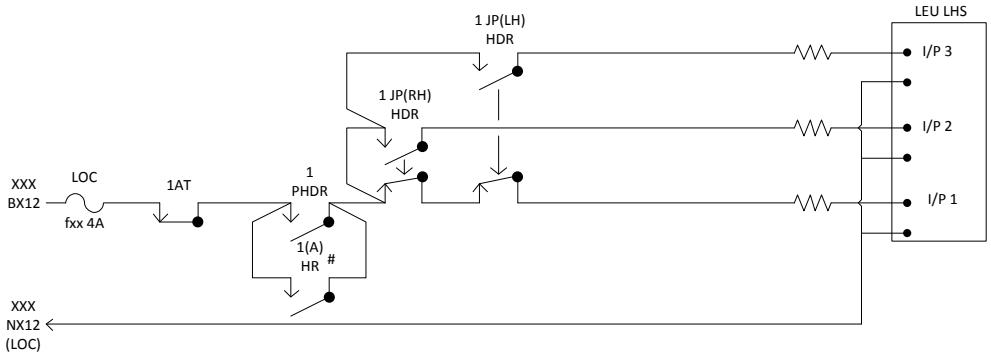
6.1.3 WITH PRELIMINARY MEDIUM ASPECT (STANDARD CIRCUIT 7)



S
Ct/Mt → LOW RISK T/O

C →	S		
M →	C →	S	
PM + LH JP →	M →	Ct + D1 →	5(M)A
PM →	M →	C →	5(M)B
PM + RH JP →	M →	Ct + D2 →	5(M)C



- First proceed aspect control relay contact only - (M)HR, LSpR or (CU)HR

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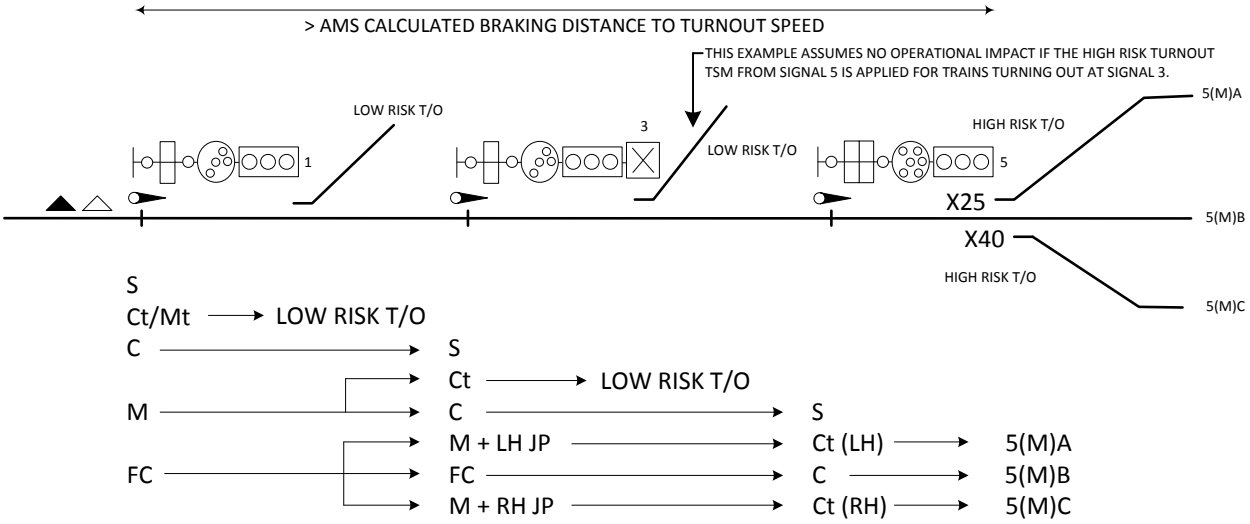
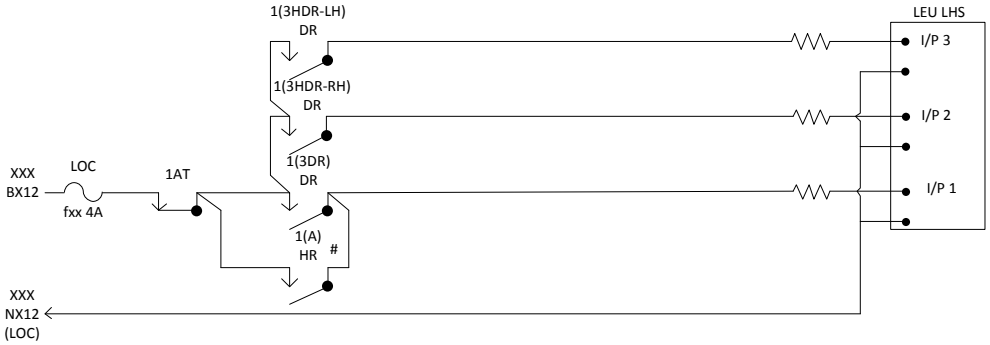
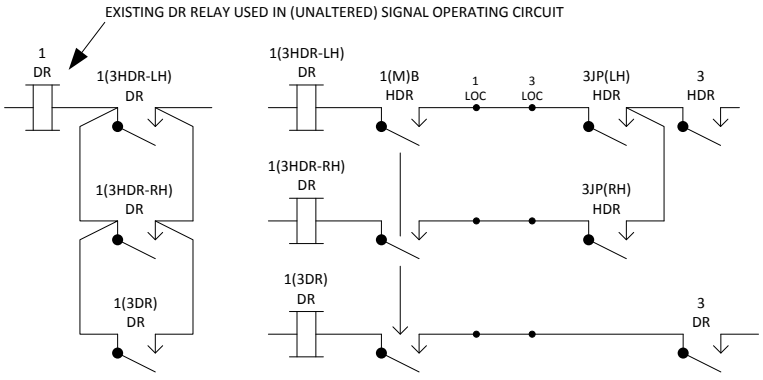
6.1.4 BRAKING POINT BEFORE FIRST WARNING SIGNAL – SINGLE LIGHT (STANDARD CIRCUIT 8)





- First proceed aspect control relay contact only - (M)HR, LSpR or (CU)HR



- ALL FOUR DR RELAYS BACK-PROVED IN 1AT TRACK STICK CIRCUIT.
- SCHEMATIC ONLY. FULL CIRCUIT AND DOUBLE CUTTING NOT SHOWN.
- MULTIPLE ROUTES MAY BE COMBINED INTO THE ONE RELAY FUNCTION, PROVIDED EACH ROUTE HAS THE SAME AMS RESPONSE REGARDING:
  - TURNOUT SPEEDS AND TARGET POINTS;
  - POST TURNOUT SPEED.

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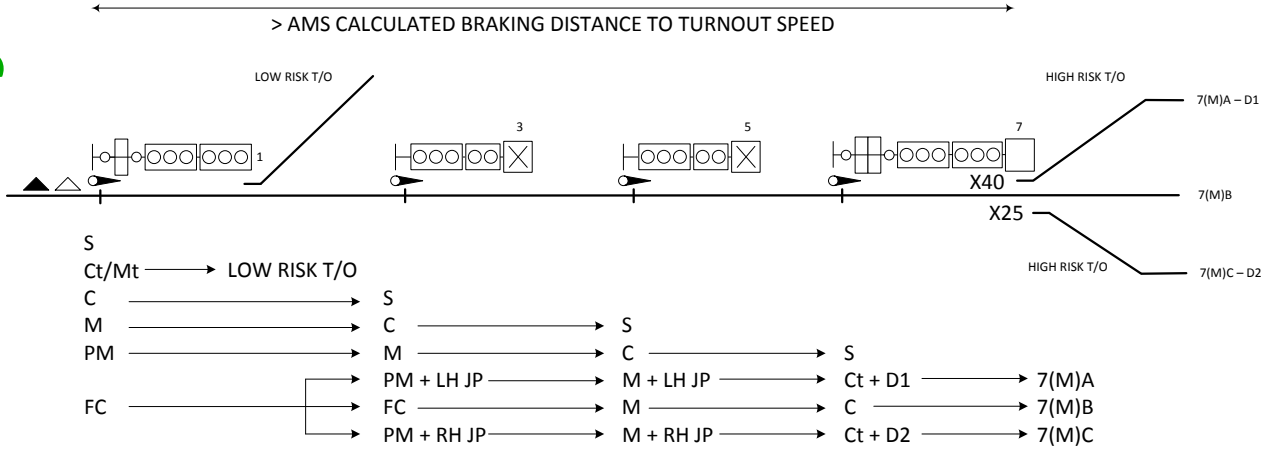
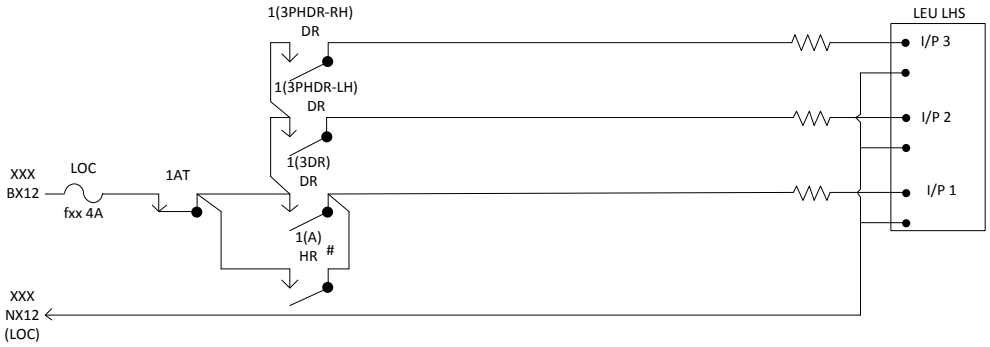
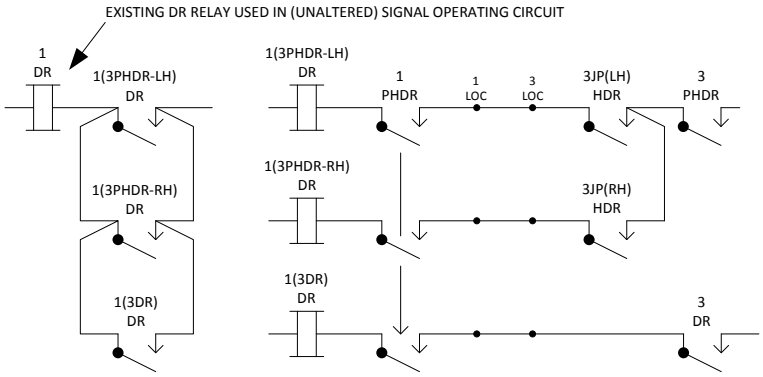
6.1.5 BRAKING POINT BEFORE FIRST WARNING SIGNAL – DOUBLE LIGHT (STANDARD CIRCUIT 9)





- First proceed aspect control relay contact only - (M)HR, LSpR or (CU)HR



- ALL FOUR DR RELAYS BACK-PROVED IN 1AT TRACK STICK CIRCUIT.
- SCHEMATIC ONLY. FULL CIRCUIT AND DOUBLE CUTTING NOT SHOWN.
- MULTIPLE ROUTES MAY BE COMBINED INTO THE ONE RELAY FUNCTION, PROVIDED EACH ROUTE HAS THE SAME AMS RESPONSE REGARDING:
  - TURNOUT SPEEDS AND TARGET POINTS;
  - POST TURNOUT SPEED.

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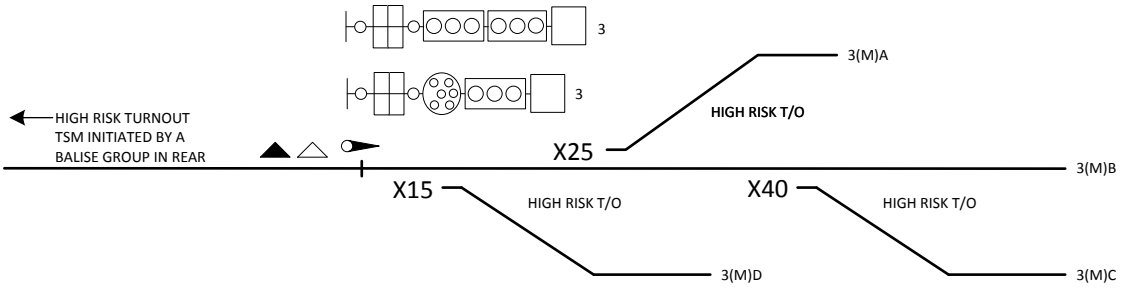
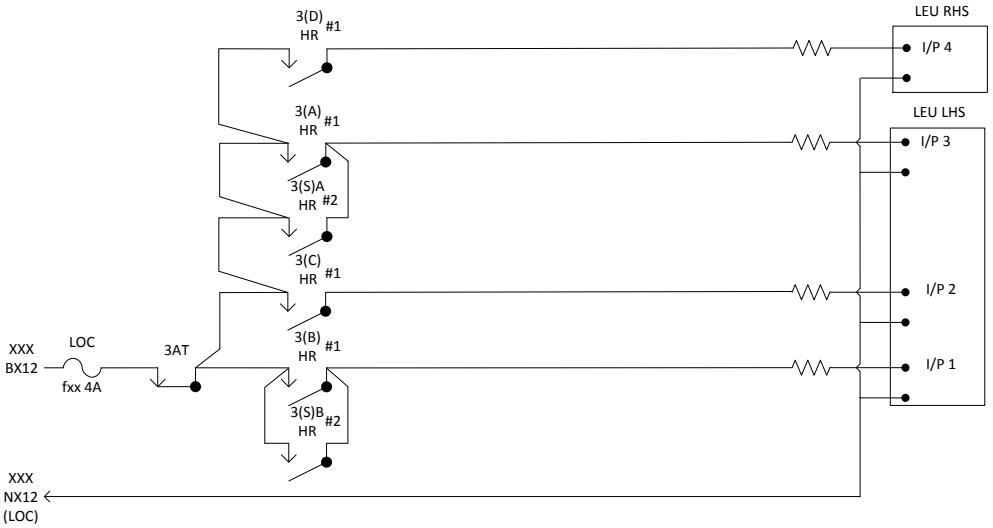
6.1.6 JUNCTION SIGNAL – SINGLE AND DOUBLE LIGHT (STANDARD CIRCUITS 10 & 11)



SHUNT WITH REPLACEMENT TRACK (STANDARD CIRCUIT 10)



#1 – First proceed aspect control relay contact only – (M)HR, LSpR or (CU)HR

#2 – Shunt routes to revoke or relax TSM provided to avoid an identified operational restriction.

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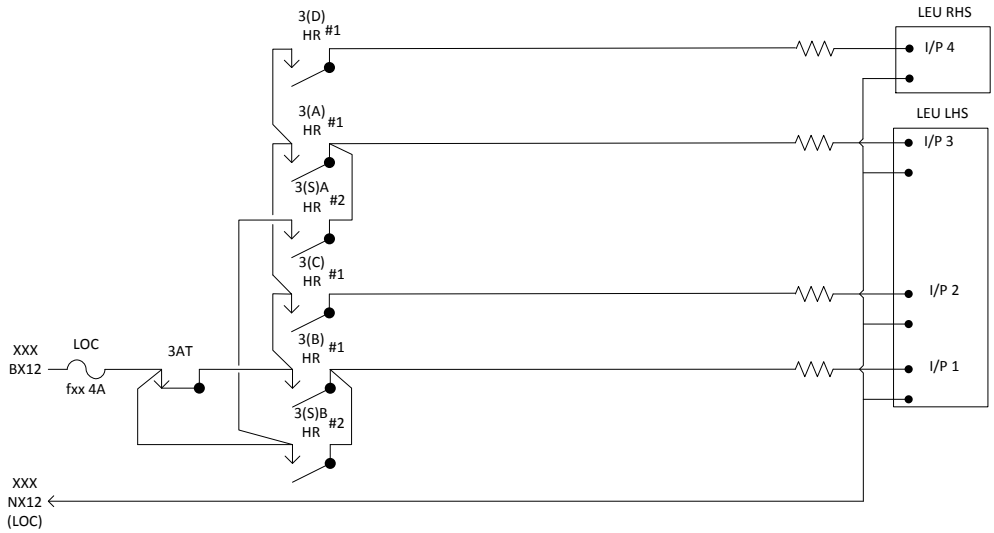
SHUNT WITH ESF / NO REPLACEMENT TRACK (STANDARD CIRCUIT 11)



#1 – First proceed aspect control relay contact only – (M)HR, LSpR or (CU)HR

#2 – Shunt routes to revoke or relax TSM provided to avoid an identified operational restriction.

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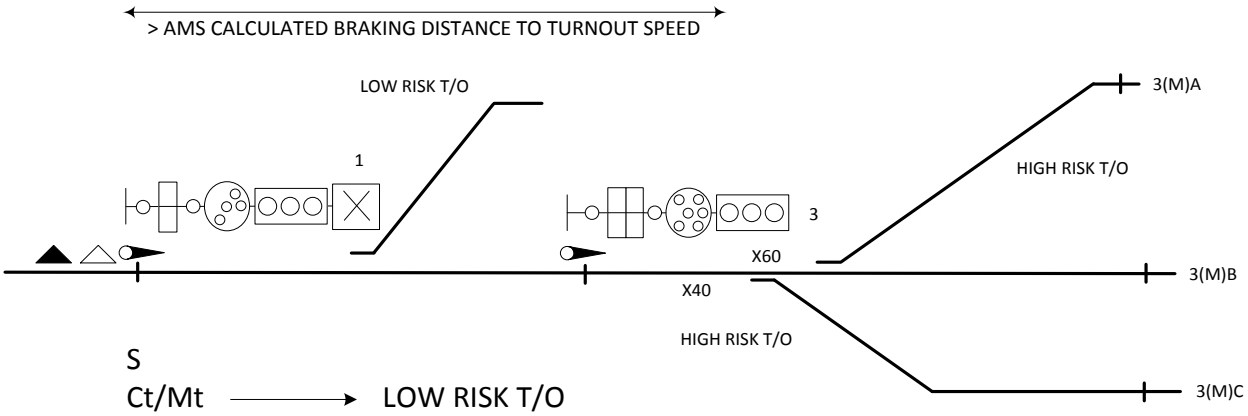
6.2 Current sensing arrangements

6.2.1 MULTIPLE DIVERGENCES – SINGLE LIGHT SIGNALS (STANDARD CIRCUIT 12)



S

Ct/Mt → LOW RISK T/O

C → S

M + LH JP → Ct (LH) → 3(M)A

M → C → 3(M)B

M + RH JP → Ct (RH) → 3(M)C

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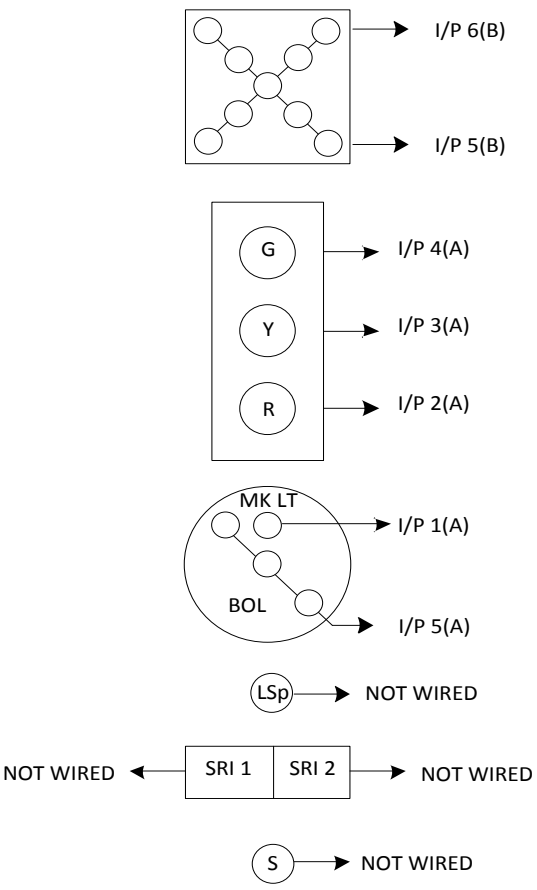
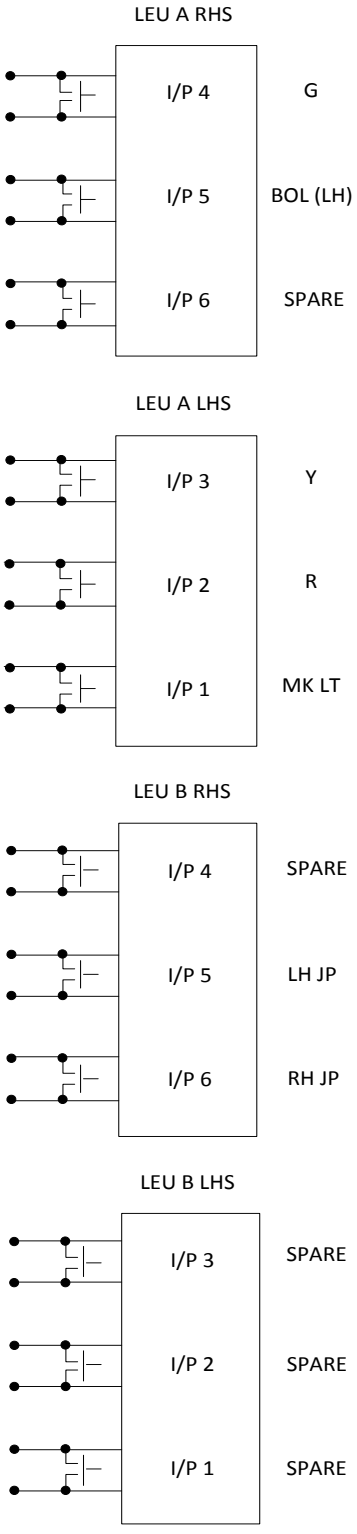


SIGNAL 1



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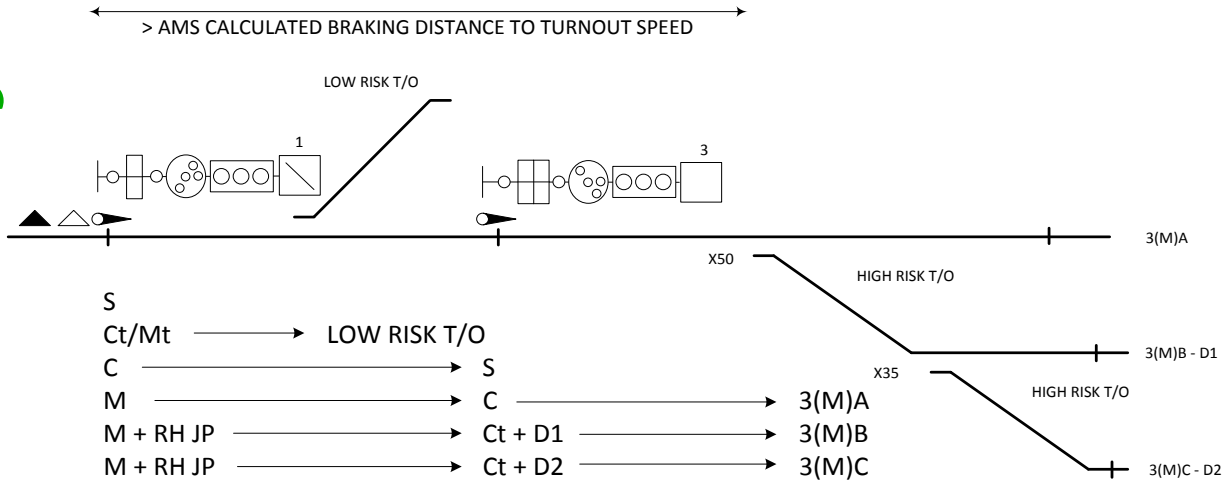
6.2.2 CONSECUTIVE DIVERGENCES – SINGLE LIGHT SIGNALS (STANDARD CIRCUIT 13)



Reference material only

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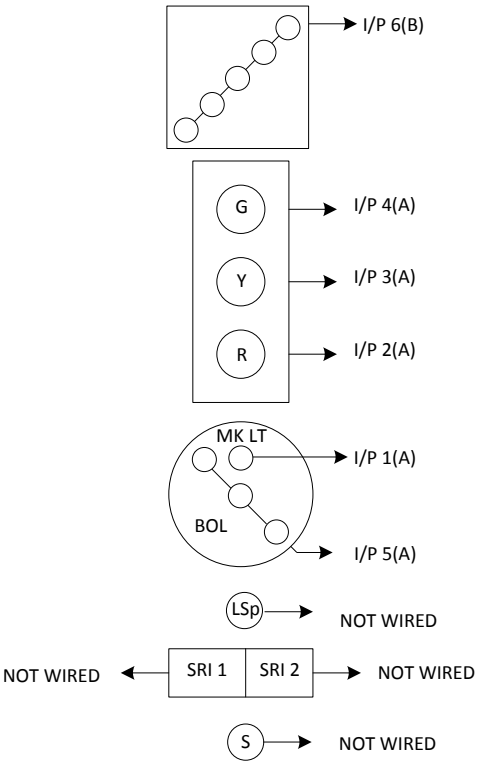
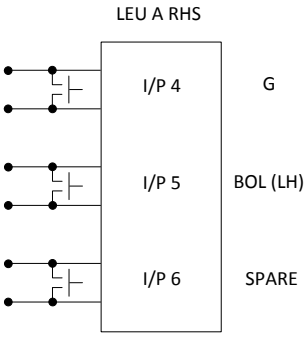
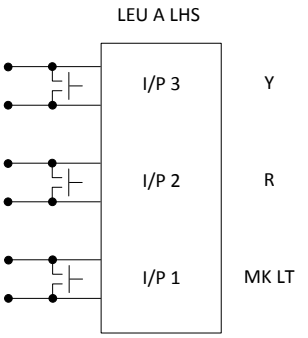
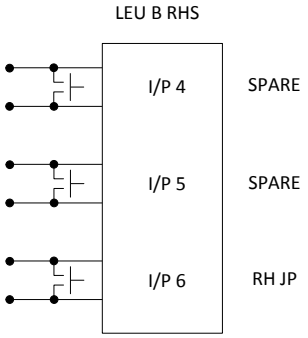
Reference material only

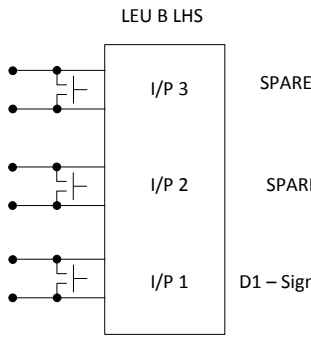


SIGNAL 1









Note: Signal 3 route indicator 'D1' obtained by:
- a new TFM output at Loc 1 (i.e. data change), or
- the function repeated from Loc 3 (i.e new multicore cable, assuming MLRI is relay driven), or
- inputting to an LEU A at Loc 3, with LEUs connected using ethernet communications. RH JP would then move to Loc 1 LEU A I/P 6.

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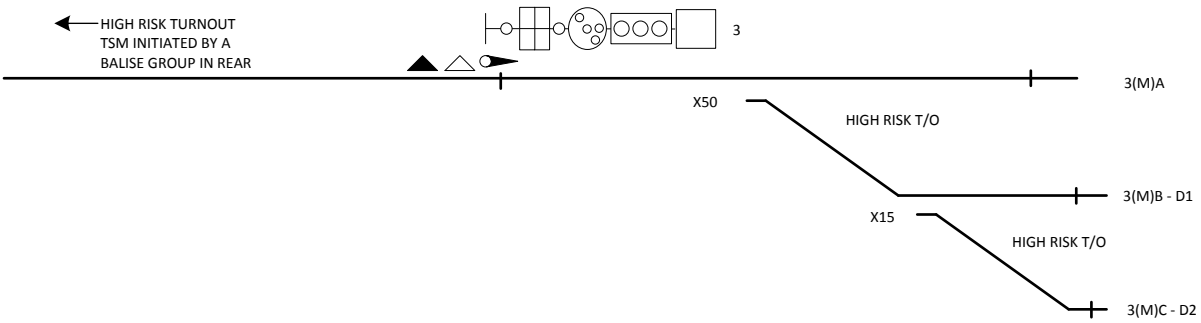
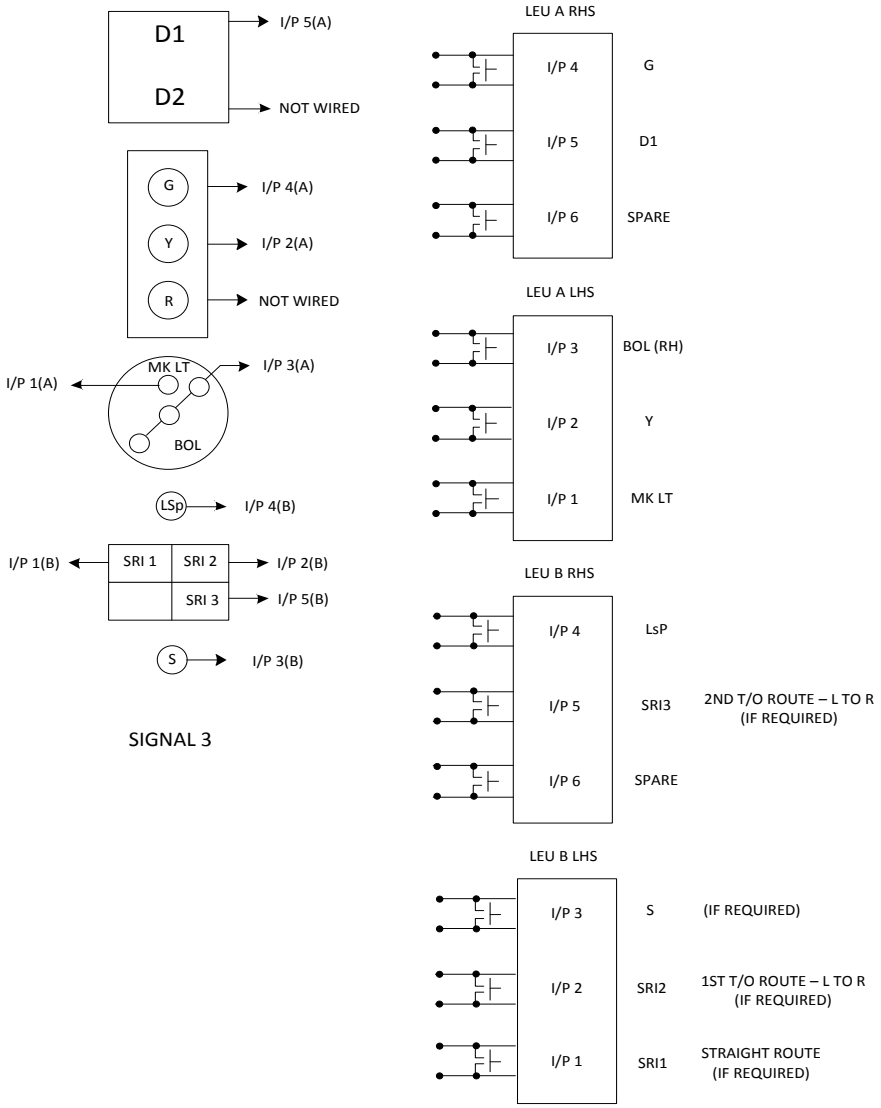
6.2.3 JUNCTION SIGNAL – SINGLE LIGHT (STANDARD CIRCUIT 14)





SIGNAL 3

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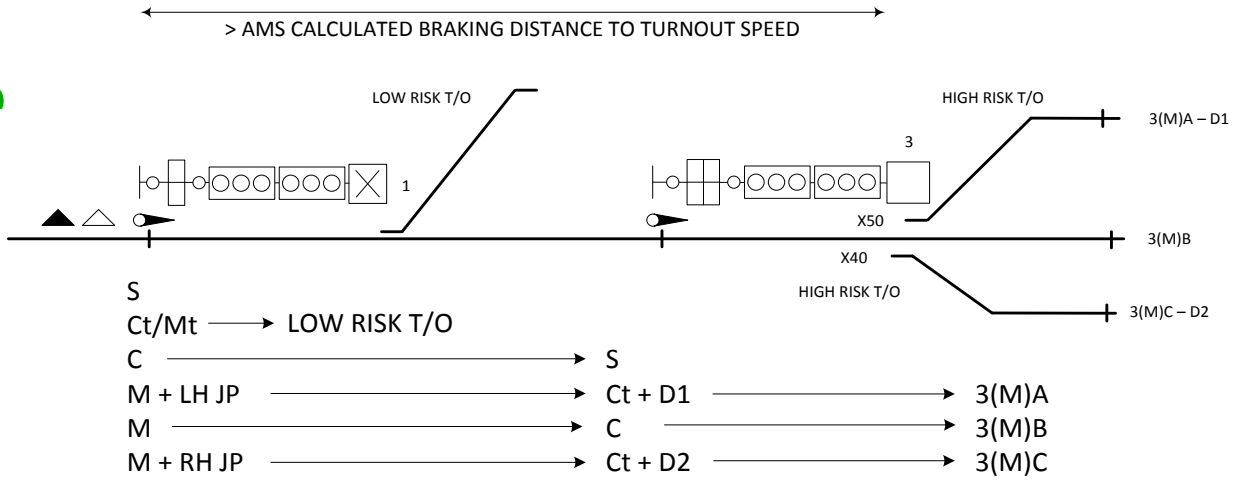
6.2.4 MULTIPLE DIVERGENCES – DOUBLE LIGHT SIGNALS (STANDARD CIRCUIT 15)



Reference material only

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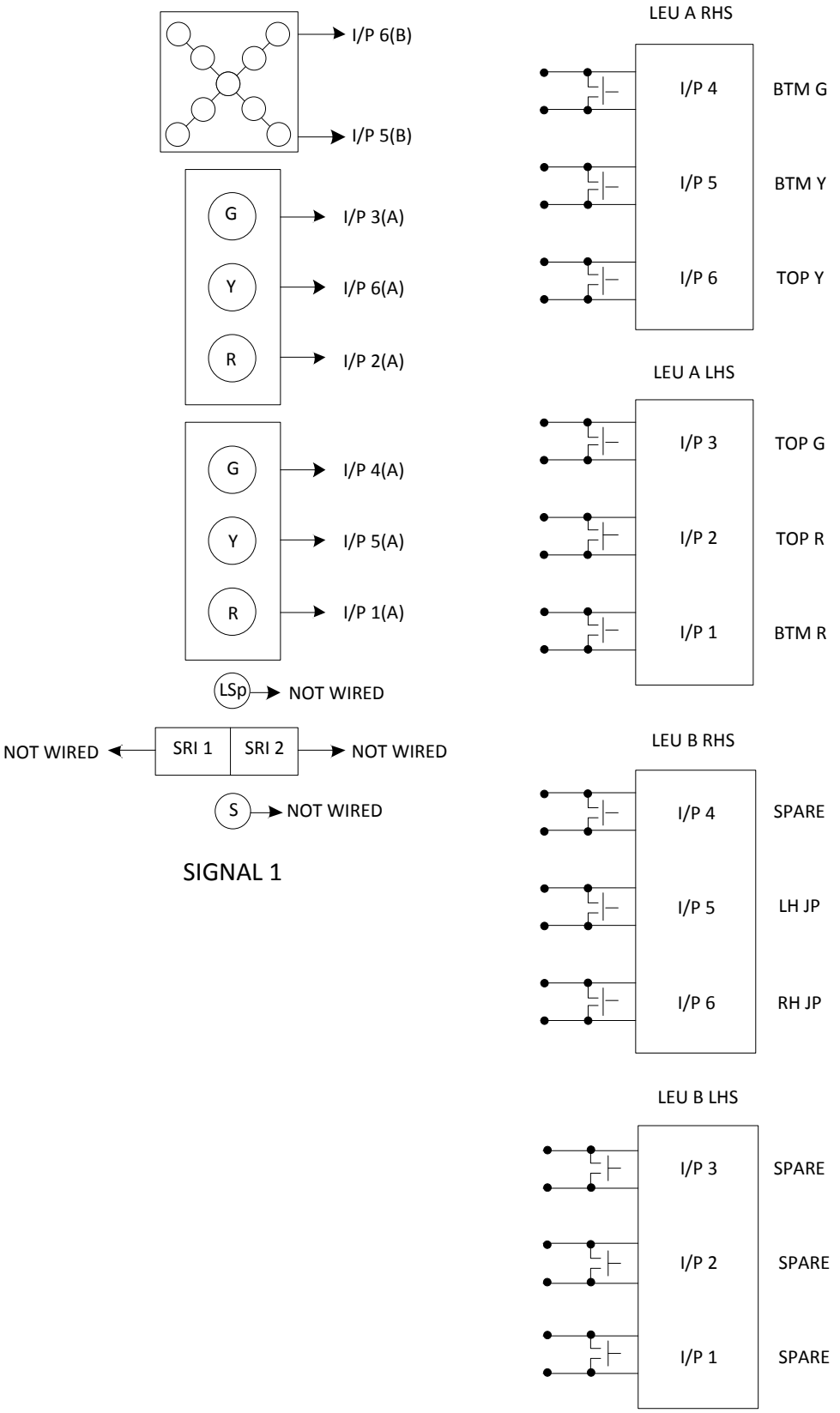

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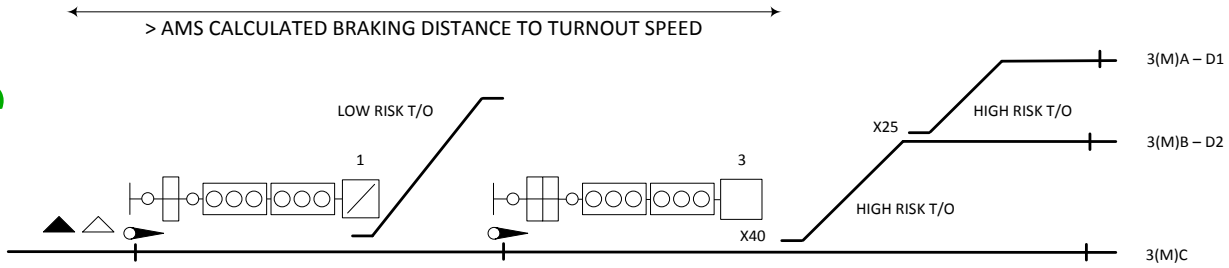
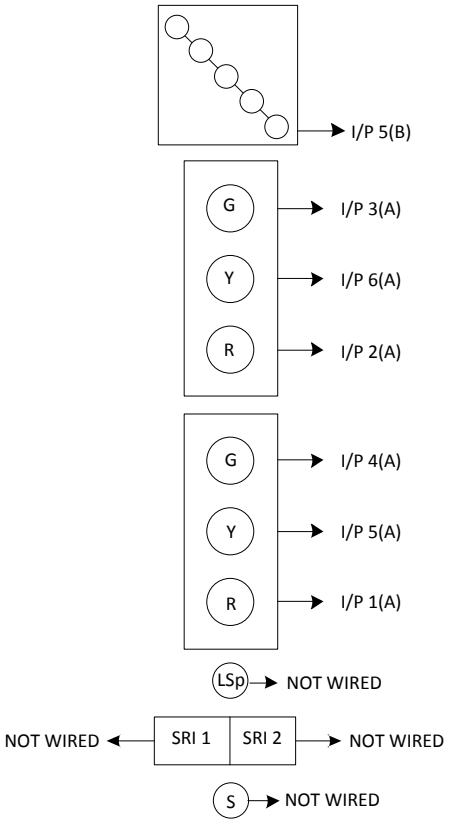
6.2.5 CONSECUTIVE DIVERGENCES – DOUBLE LIGHT SIGNALS (STANDARD CIRCUIT 16)



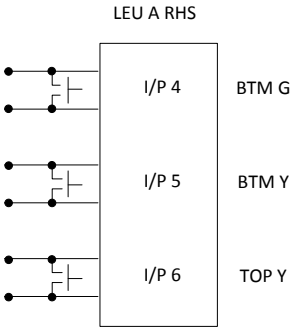
S
Ct/Mt → LOW RISK T/O
C → S
M + JP → Ct + D1 → 3(M)A
Ct + D2 → 3(M)B
M → C → 3(M)C

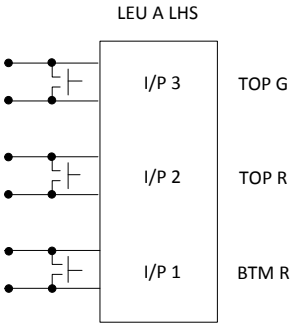
Reference material only

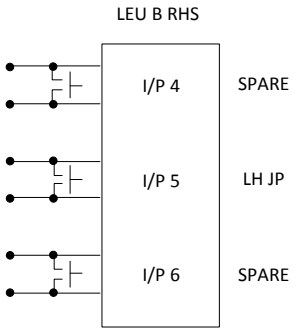
Reference material only

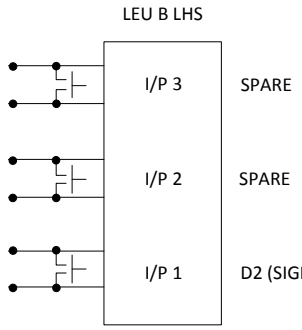


SIGNAL 1









Note: Signal 3 route indicator 'D2' obtained by:
- a new TFM output at Loc 1 (i.e. data change), or
- the function repeated from Loc 3 (i.e new multicore cable, assuming MLRI is relay driven), or
- inputting to an LEU A at Loc 3, with LEUs connected using ethernet communications.

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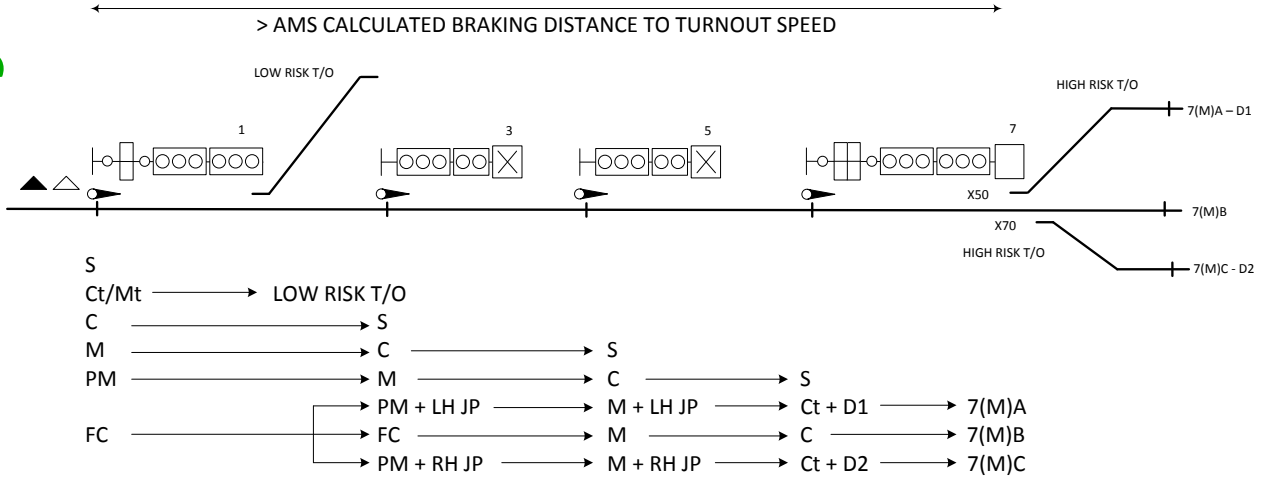
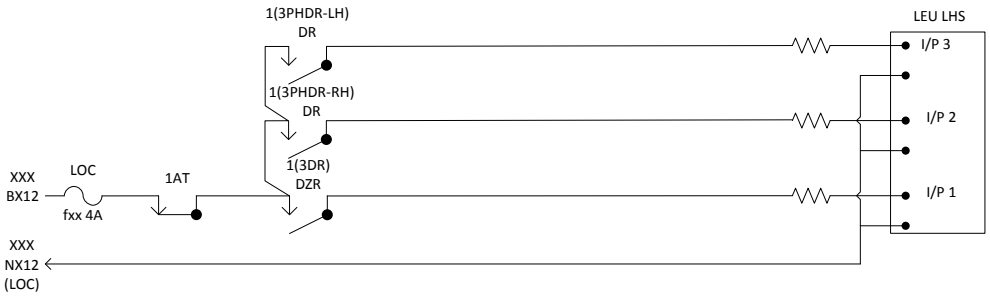
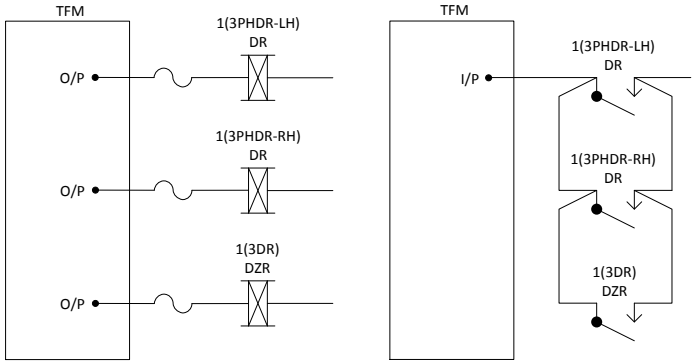
6.2.6 BRAKING POINT BEFORE FIRST WARNING SIGNAL – DOUBLE LIGHT (STANDARD CIRCUITS 17A & 17B)



STANDARD CIRCUIT 17A – LOOK-AHEAD USING CBI DATA CHANGE METHOD





- THE DZR FUNCTION WILL INCLUDE ALL CONDITIONS THAT REVOKE TSM, INCLUDING ROUTE 1(A) CLEAR.
- THE INPUT IS REQUIRED TO PROVE THE RELAYS HAVE OPERATED. IF A RELAY FAILS TO PICK, THEN THE SIGNAL ASSOCIATED WITH THE LEU SHALL DISPLAY AN ASPECT CONSISTENT WITH THE JUNCTION SIGNAL AT STOP.
- ALL THREE RELAYS BACK-PROVED IN 1AT TRACK STICK CIRCUIT.
- SCHEMATIC ONLY. FULL CIRCUIT NOT SHOWN.
- MULTIPLE ROUTES MAY BE COMBINED INTO THE ONE RELAY FUNCTION, PROVIDED EACH ROUTE HAS THE SAME AMS RESPONSE REGARDING:
  - TURNOUT SPEEDS AND TARGET POINTS;
  - POST TURNOUT SPEED.

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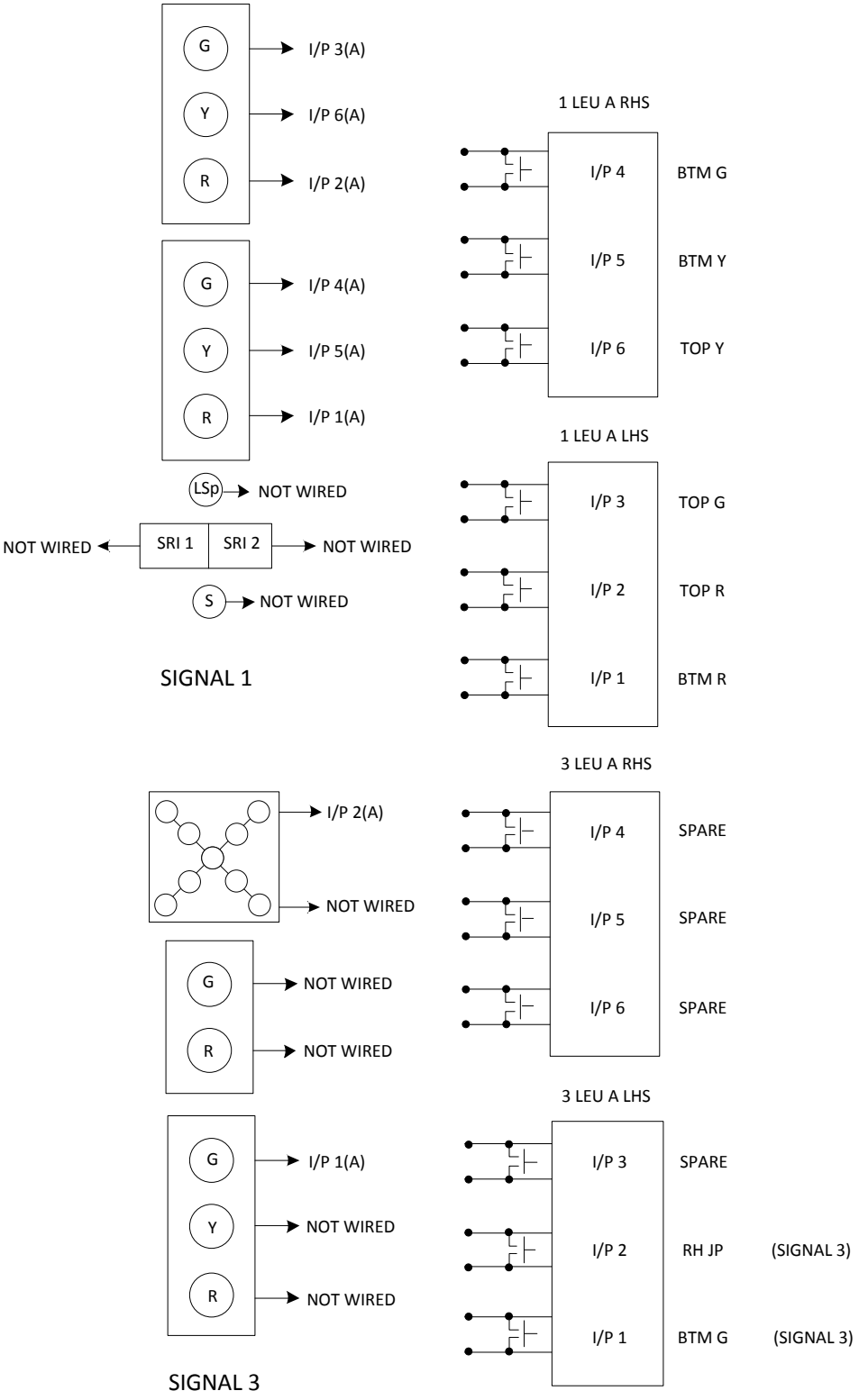
STANDARD CIRCUIT 17B – LOOK-AHEAD USING ETHERNET COMMUNICATIONS



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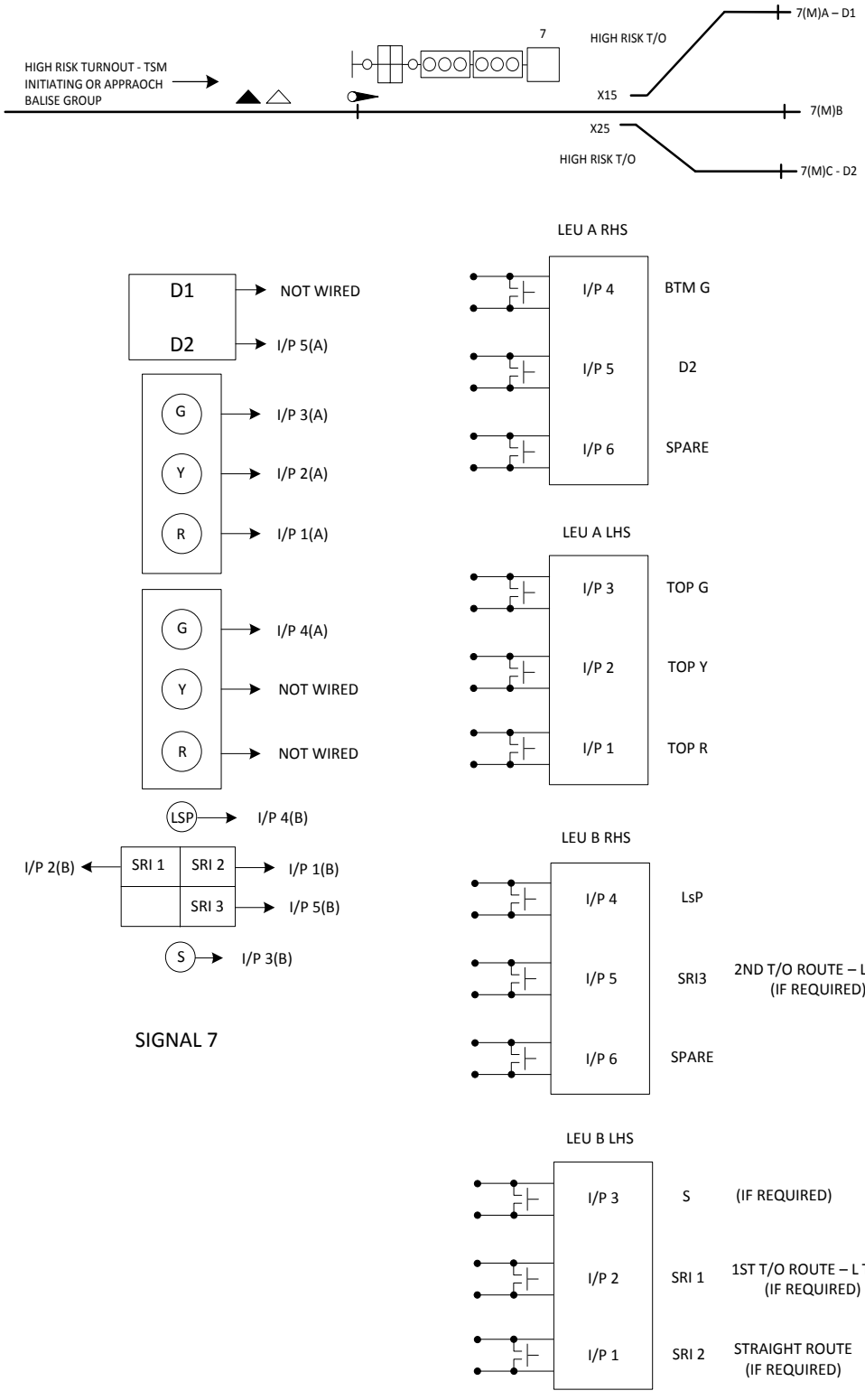
6.2.7 JUNCTION SIGNAL – DOUBLE LIGHT (STANDARD CIRCUIT 18)



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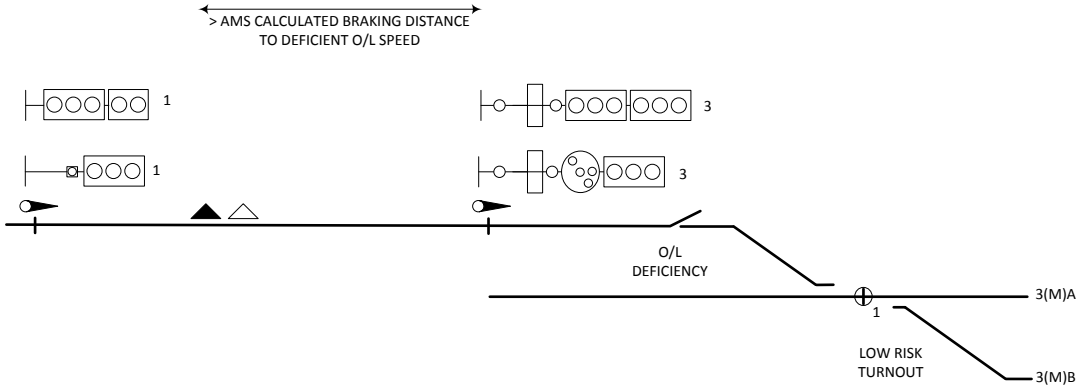
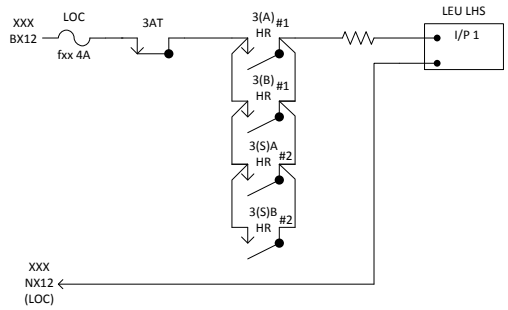
7. High Risk Overlap Deficiency

7.1 Contact sensing arrangements

7.1.1 LEU CONNECTED TO THE PROTECTING SIGNAL (STANDARD CIRCUITS 21 & 22)



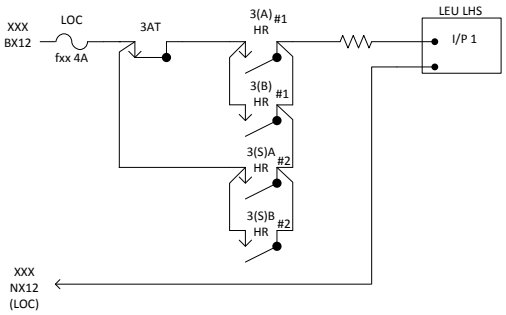
SHUNT WITH REPLACEMENT TRACK (STANDARD CIRCUIT 21)



#1 - First proceed aspect control relay – (M)HR, LSpR or (CU)HR

#2 - Shunt inputs required if:
- deficient overlap speed <25km/h, and
- shunt route drives trainstop, and
- LEU is connected to the protecting signal.

SHUNT WITH ESF/ NO REPLACEMENT TRACK (STANDARD CIRCUIT 22)



#1 - First proceed aspect control relay – (M)HR, LSpR or (CU)HR

#2 - Shunt inputs required if:
- deficient overlap speed <25km/h, and
- shunt route drives trainstop, and
- LEU is connected to the protecting signal.

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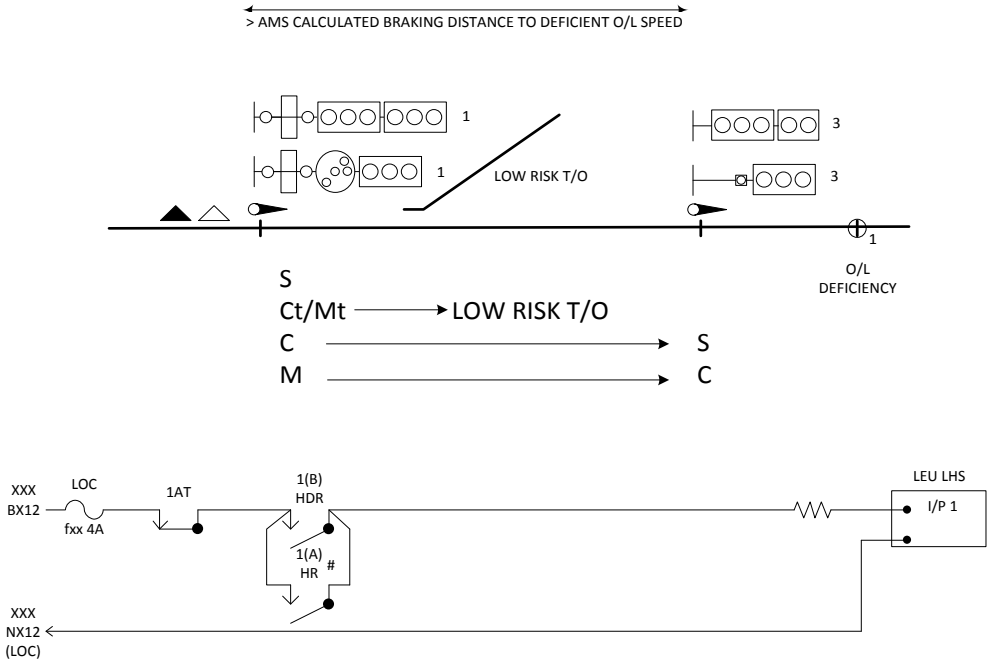
7.1.2 LEU CONNECTED TO AN OUTER SIGNAL – SINGLE AND DOUBLE LIGHT (STANDARD CIRCUIT 23)



- First proceed aspect control relay contact only - (M)HR, LSpR or (CU)HR

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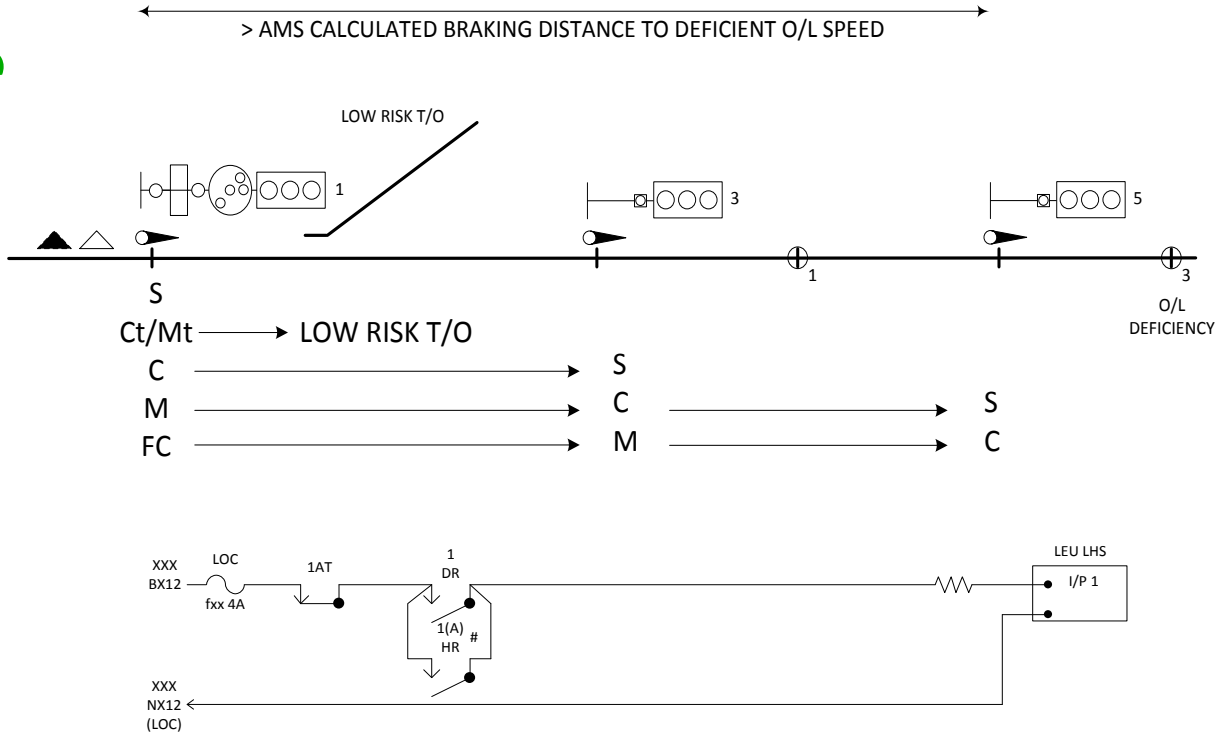
7.1.3 LEU AT TWO BLOCKS AWAY FROM OVERLAP DEFICIENCY – SINGLE LIGHT SIGNALS (STANDARD CIRCUIT 24)



- First proceed aspect control relay contact only - (M)HR, LSpR or (CU)HR

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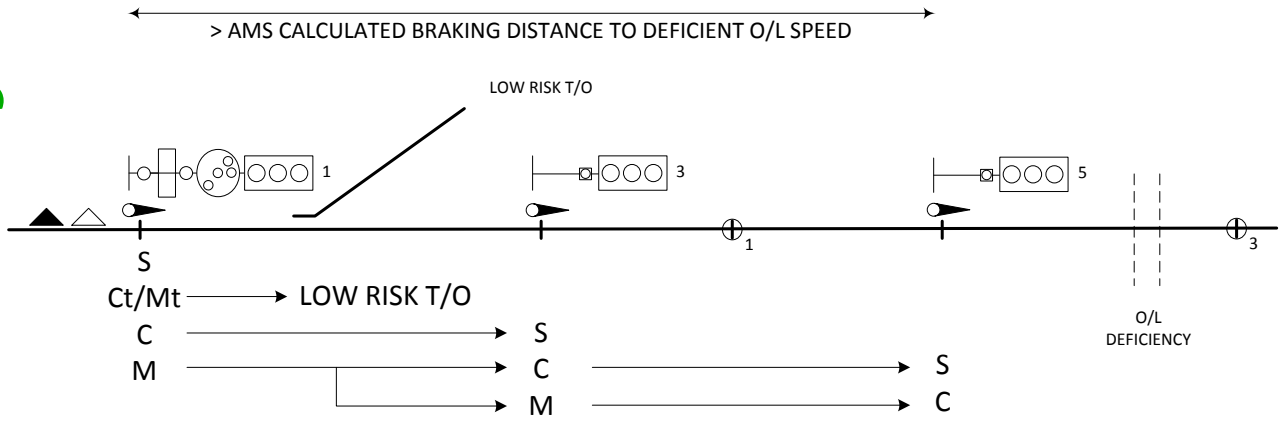
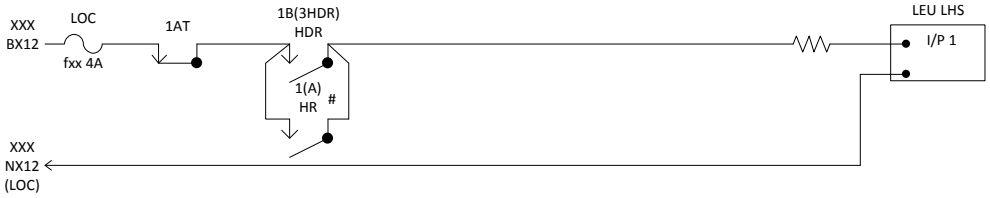
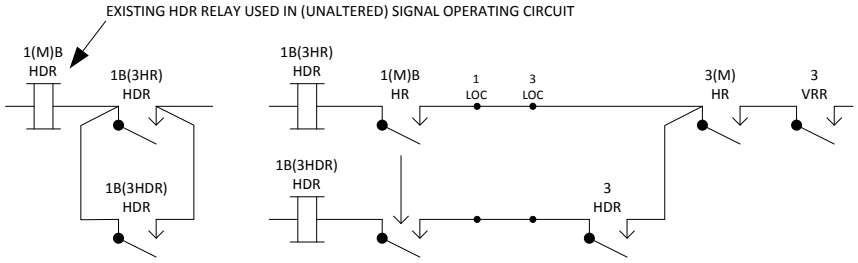
7.1.4 SUCCESSIVE MEDIUM ASPECTS – SINGLE LIGHT SIGNALS (STANDARD CIRCUIT 25)





- First proceed aspect control relay contact only - (M)HR, LSpR or (CU)HR



- 1B(3HR) HDR IS REQUIRED FOR OPERATION OF 1(M)B HDR, BUT NOT REQUIRED AS AN LEU INPUT.
- ALL THREE HDR RELAYS BACK-PROVED IN 1AT TRACK STICK CIRCUIT.
- SCHEMATIC ONLY. FULL CIRCUIT AND DOUBLE CUTTING NOT SHOWN.

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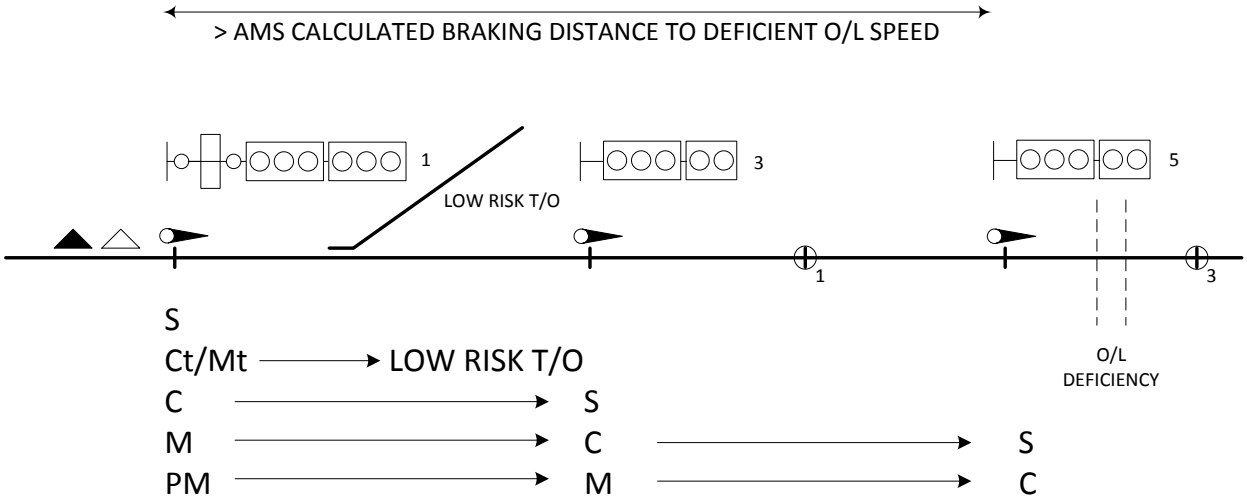
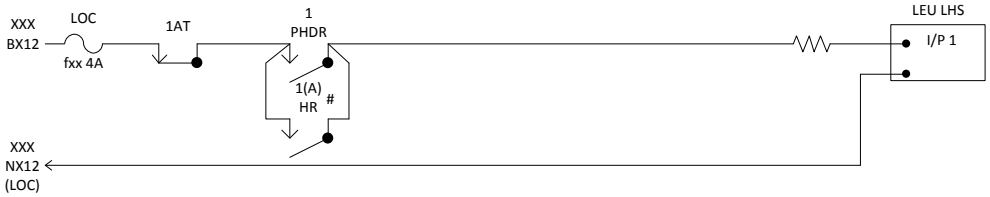
7.1.5 LEU AT TWO BLOCKS AWAY FROM OVERLAP DEFICIENCY – DOUBLE LIGHT SIGNALS (STANDARD CIRCUIT 26)





- First proceed aspect control relay contact only - (M)HR, LSpR or (CU)HR

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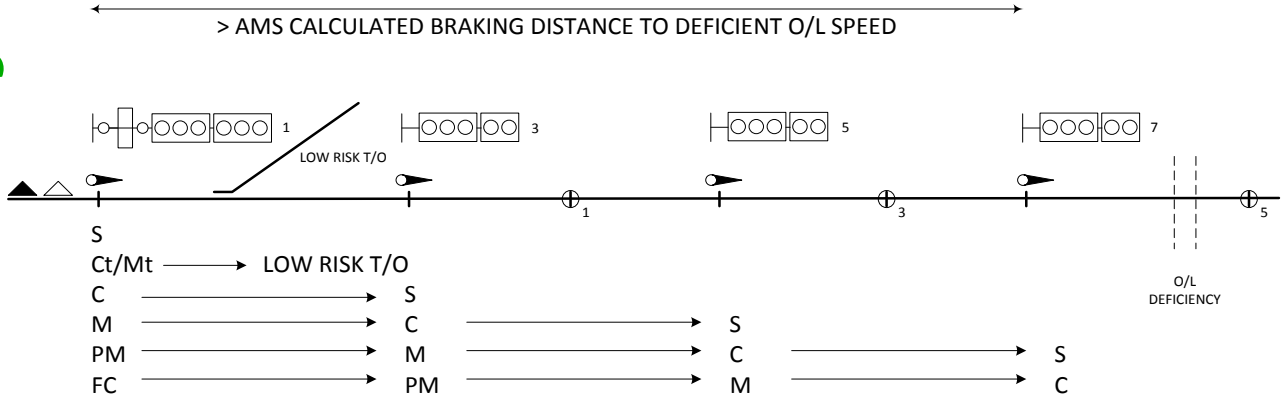
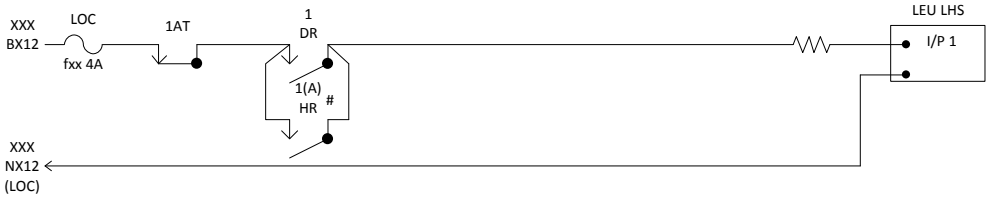
7.1.6 LEU MORE THAN TWO BLOCKS AWAY FROM OVERLAP DEFICIENCY – DOUBLE LIGHT SIGNALS (STANDARD CIRCUIT 27)





- First proceed aspect control relay contact only - (M)HR, LSpR or (CU)HR

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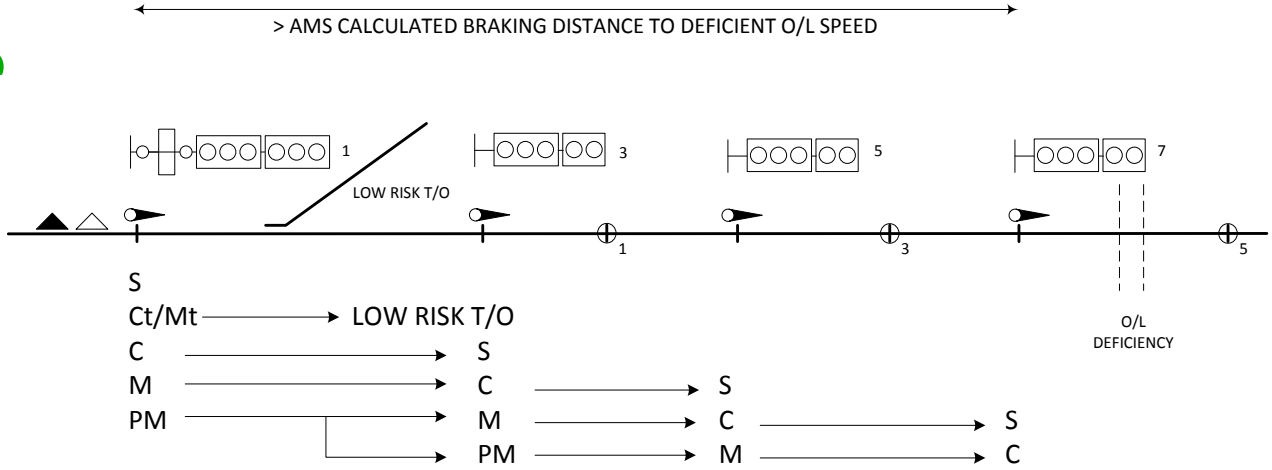
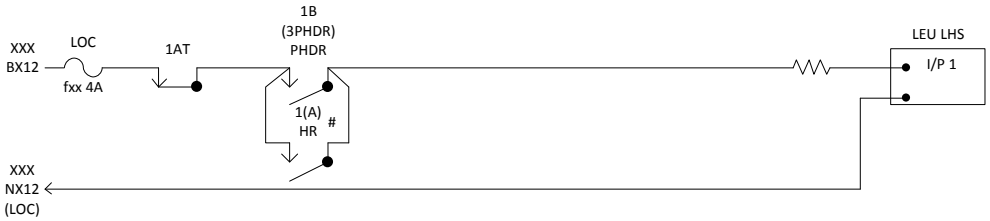
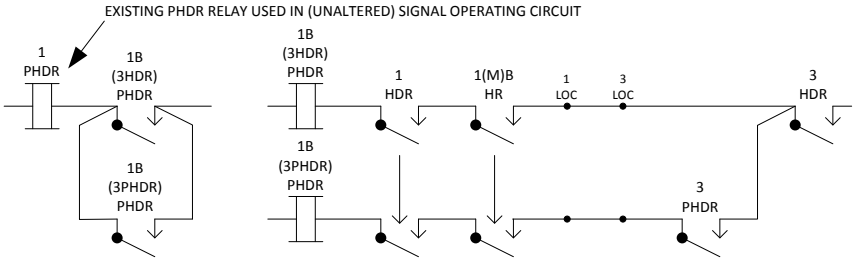
7.1.7 SUCCESSIVE PRELIMINARY MEDIUM ASPECTS – DOUBLE LIGHT SIGNALS (STANDARD CIRCUIT 28)





- First proceed aspect control relay contact only - (M)HR, LSpR or (CU)HR



- 1B(3HDR) PHDR IS REQUIRED FOR OPERATION OF 1 PHDR, BUT NOT REQUIRED AS AN LEU INPUT.
- 1(M)B HR CONTACTS REQUIRED IN PHDR FUNCTIONS IF 1 HDR IS ALSO APPLICABLE TO 1(M)A ROUTE.
- ALL THREE PHDR RELAYS BACK-PROVED IN 1AT TRACK STICK CIRCUIT.
- SCHEMATIC ONLY. FULL CIRCUIT AND DOUBLE CUTTING NOT SHOWN.

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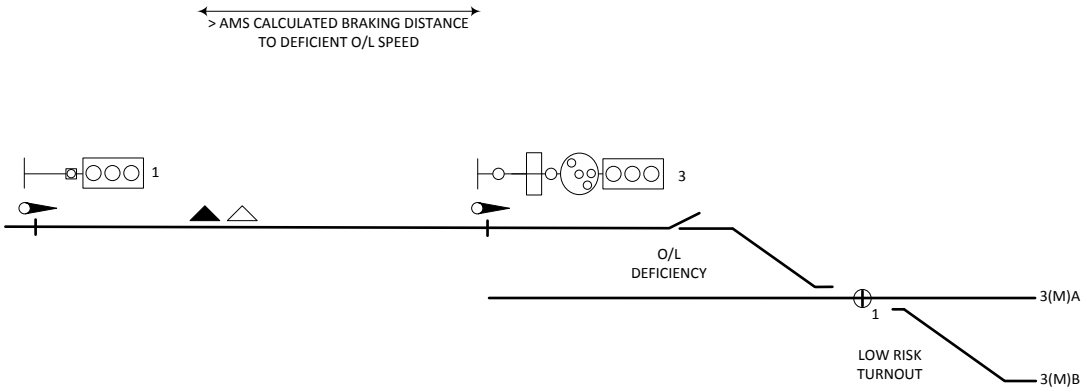
7.2 Current sensing arrangements

7.2.1 LEU CONNECTED TO PROTECTING SIGNAL – SINGLE LIGHT (STANDARD CIRCUIT 29)



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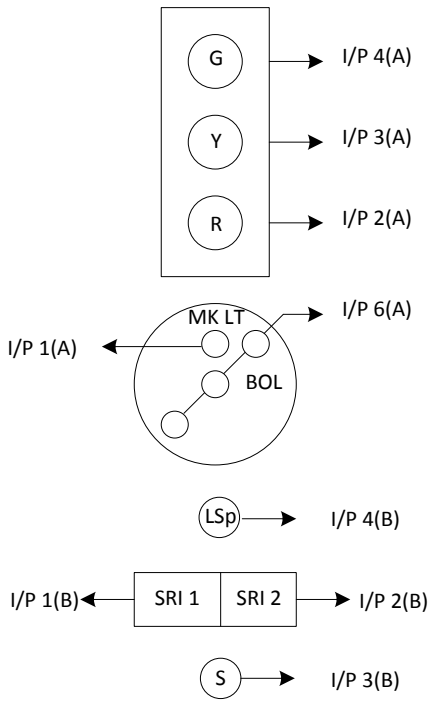
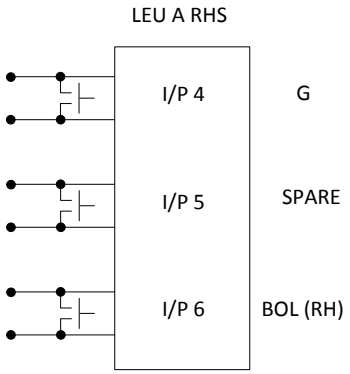
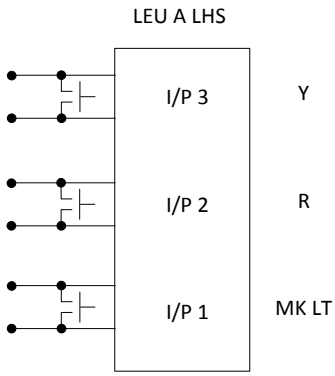
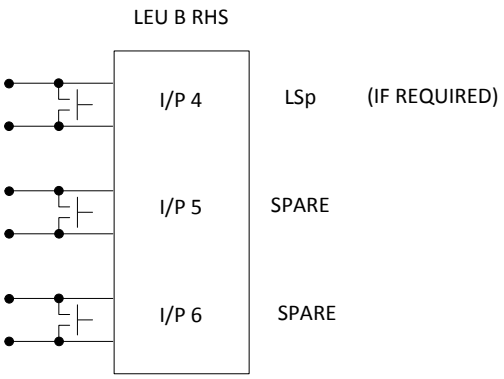
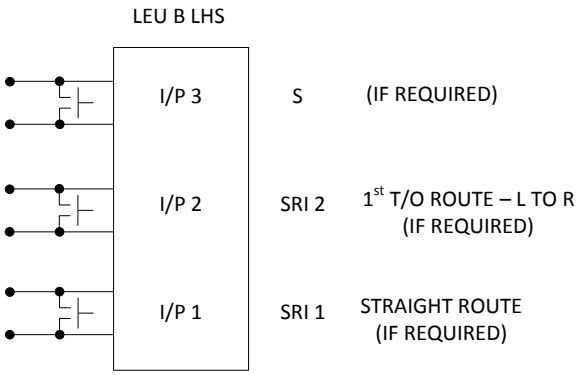


SIGNAL 3









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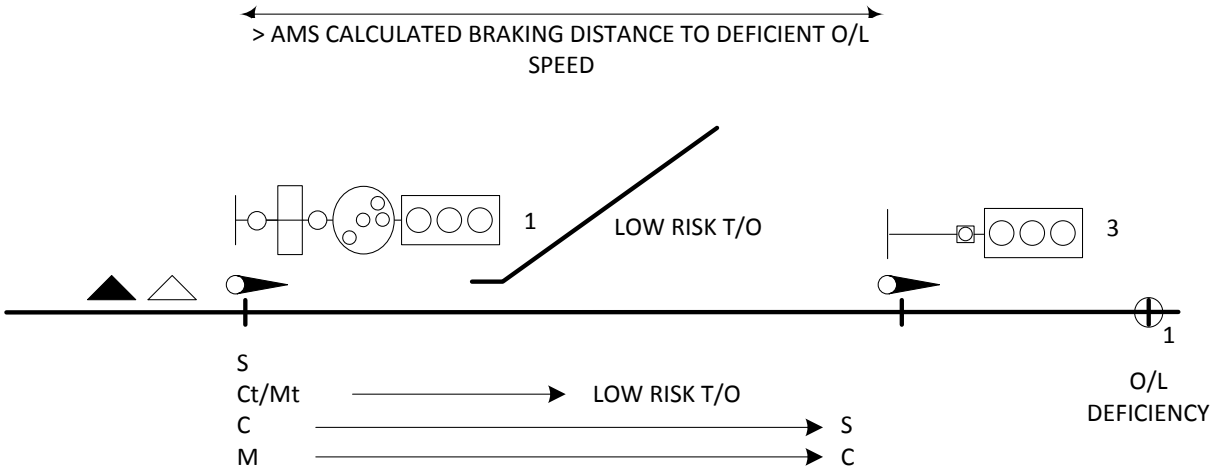
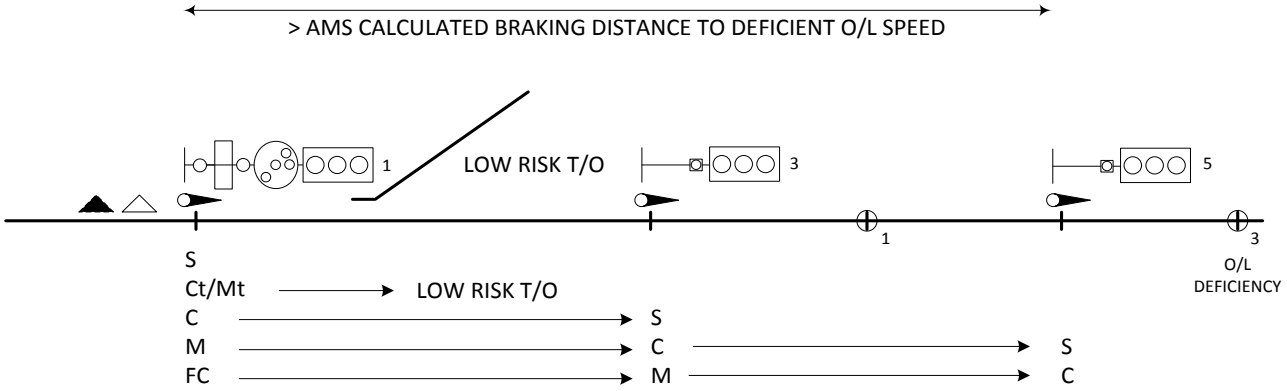
7.2.2 LEU CONNECTED TO AN OUTER SIGNAL – SINGLE LIGHT (STANDARD CIRCUIT 30)

1 BLOCK AWAY FROM OVERLAP DEFICIENCY



2 BLOCKS AWAY FROM OVERLAP DEFICIENCY



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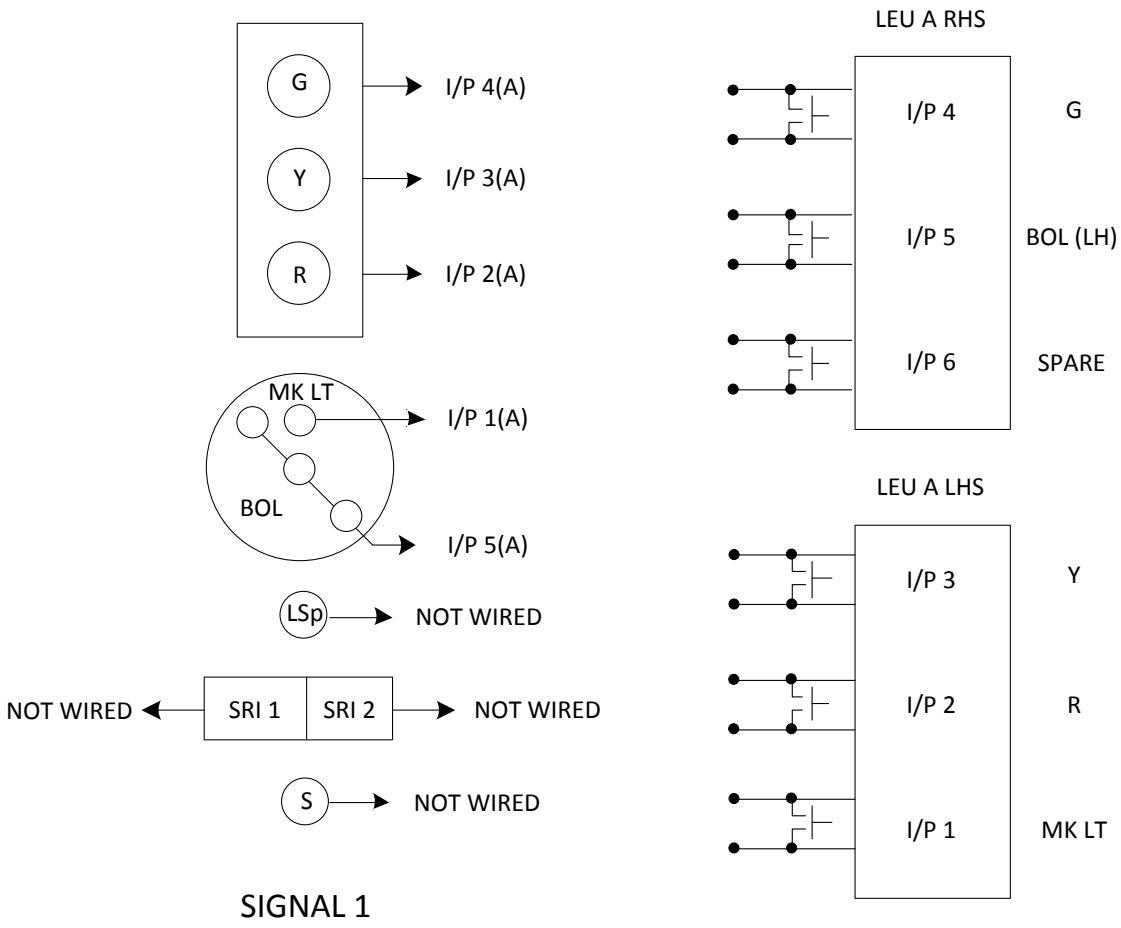
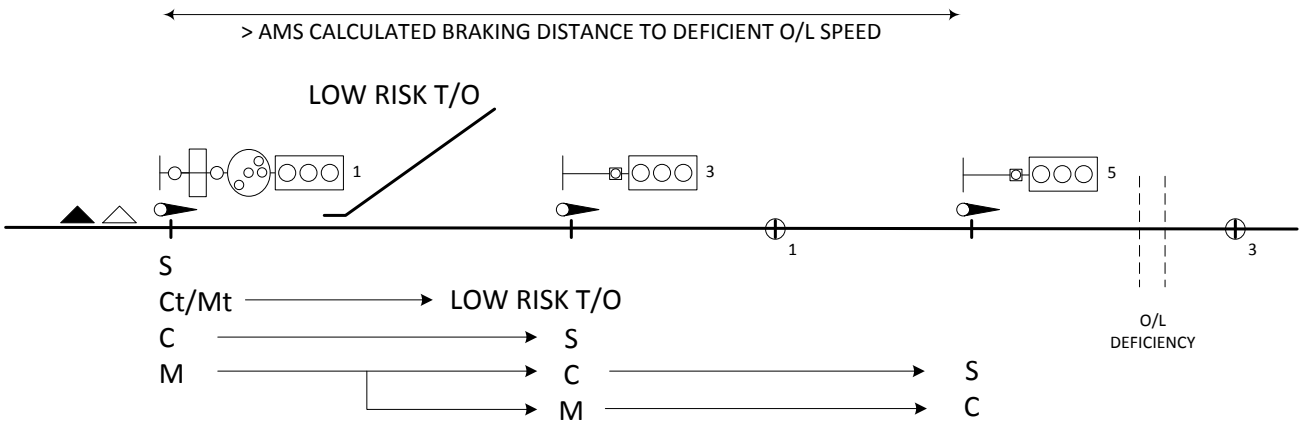


SIGNAL 1

7.2.3 SUCCESSIVE MEDIUM ASPECTS – SINGLE LIGHT (STANDARD CIRCUIT 31)



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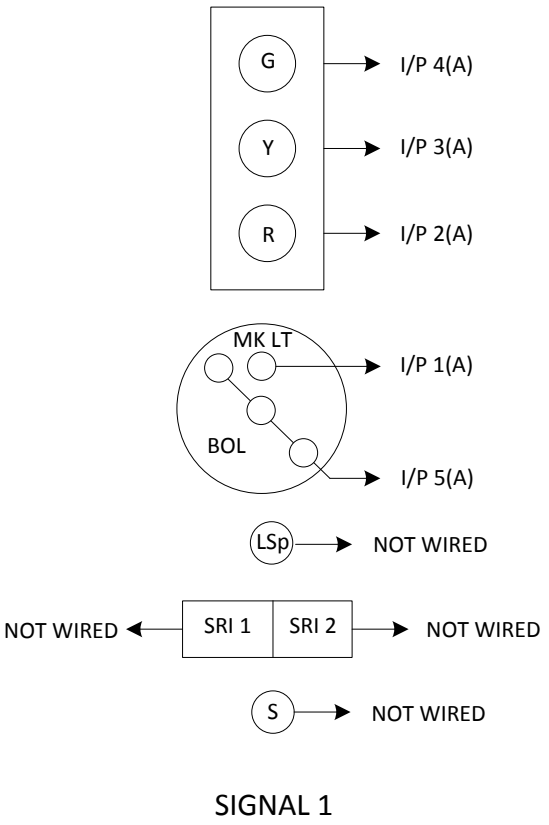
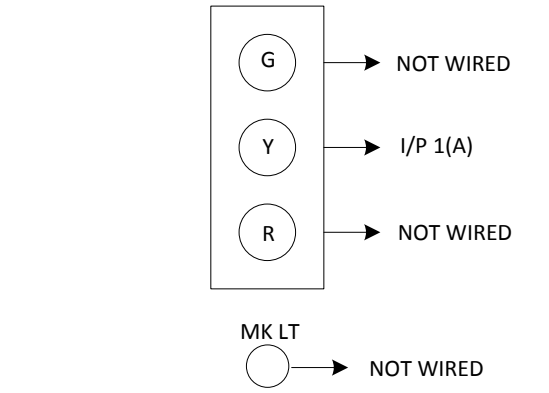
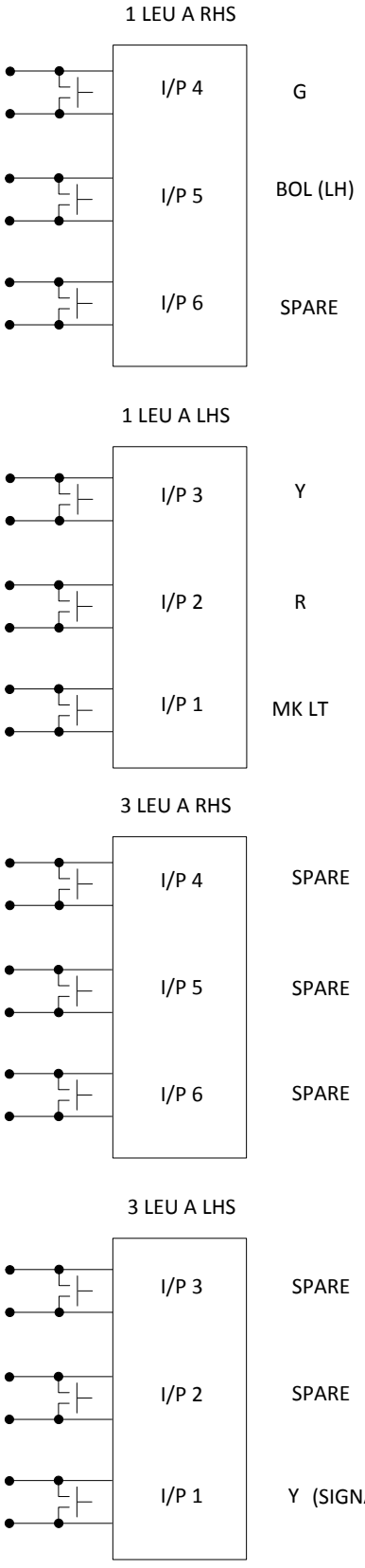


SIGNAL 1



SIGNAL 3



Note: Signal 3 yellow aspect could alternatively be obtained by a new TFM output at Loc 1 (i.e. data change). Signal 3 yellow would then move to Loc 1 LEU A I/P 6.

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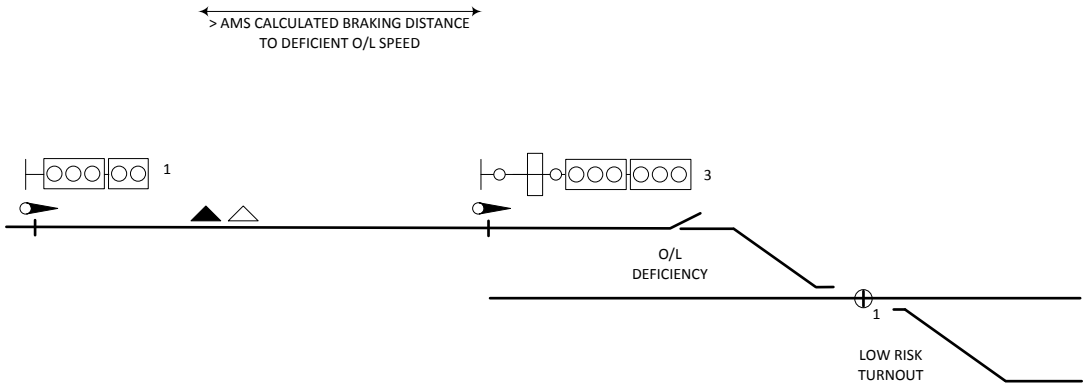
7.2.4 LEU CONNECTED TO PROTECTING SIGNAL – DOUBLE LIGHT (STANDARD CIRCUIT 32)



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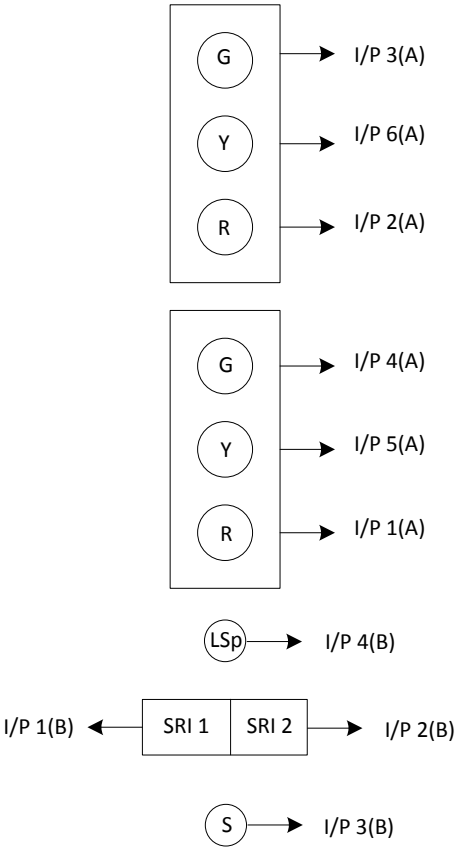
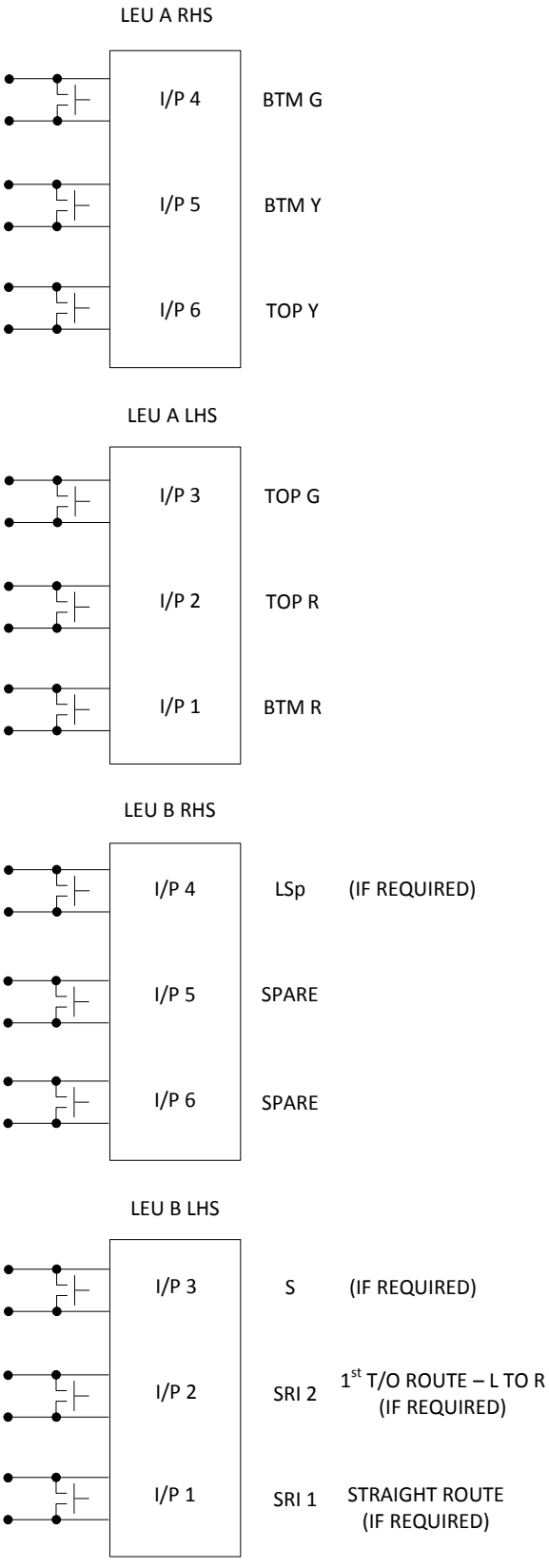


SIGNAL 3



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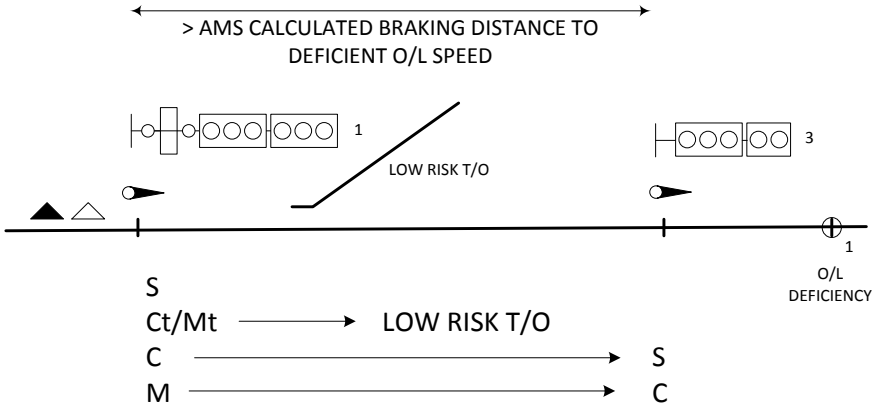
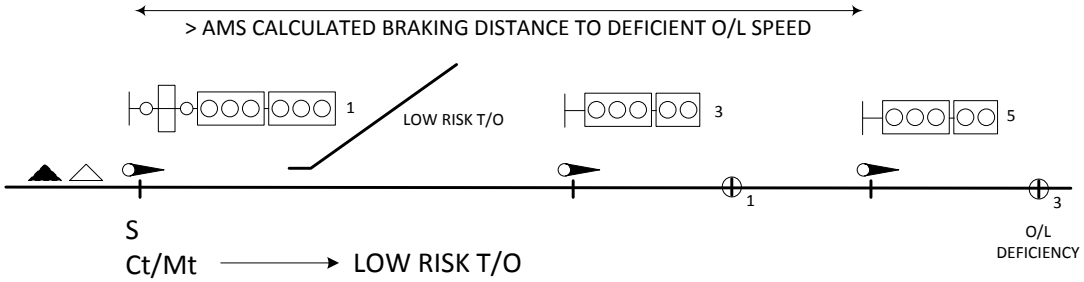
7.2.5 LEU CONNECTED TO AN OUTER SIGNAL – DOUBLE LIGHT (STANDARD CIRCUIT 33)

1 BLOCK AWAY FROM OVERLAP DEFICIENCY



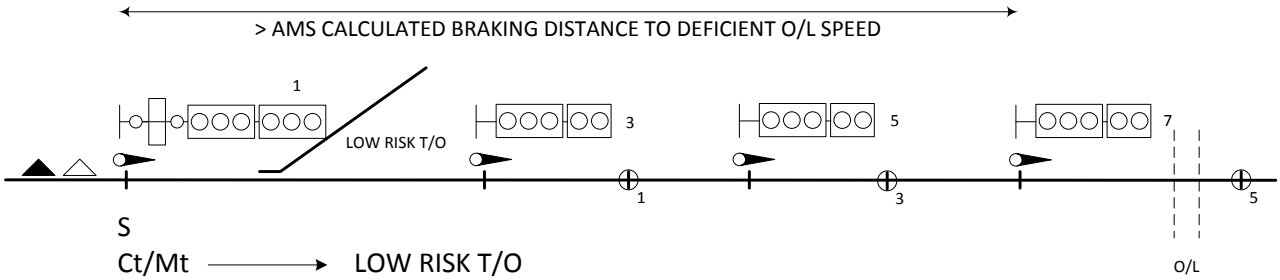
S
Ct/Mt → LOW RISK T/O
C → S
M → C

2 BLOCKS AWAY FROM OVERLAP DEFICIENCY



S
Ct/Mt → LOW RISK T/O
C → S
M → C → S
PM → M → C

MORE THAN 2 BLOCKS AWAY FROM OVERLAP DEFICIENCY



S
Ct/Mt → LOW RISK T/O
C → S
M → C → S
PM → M → C → S
FC → PM → M → C

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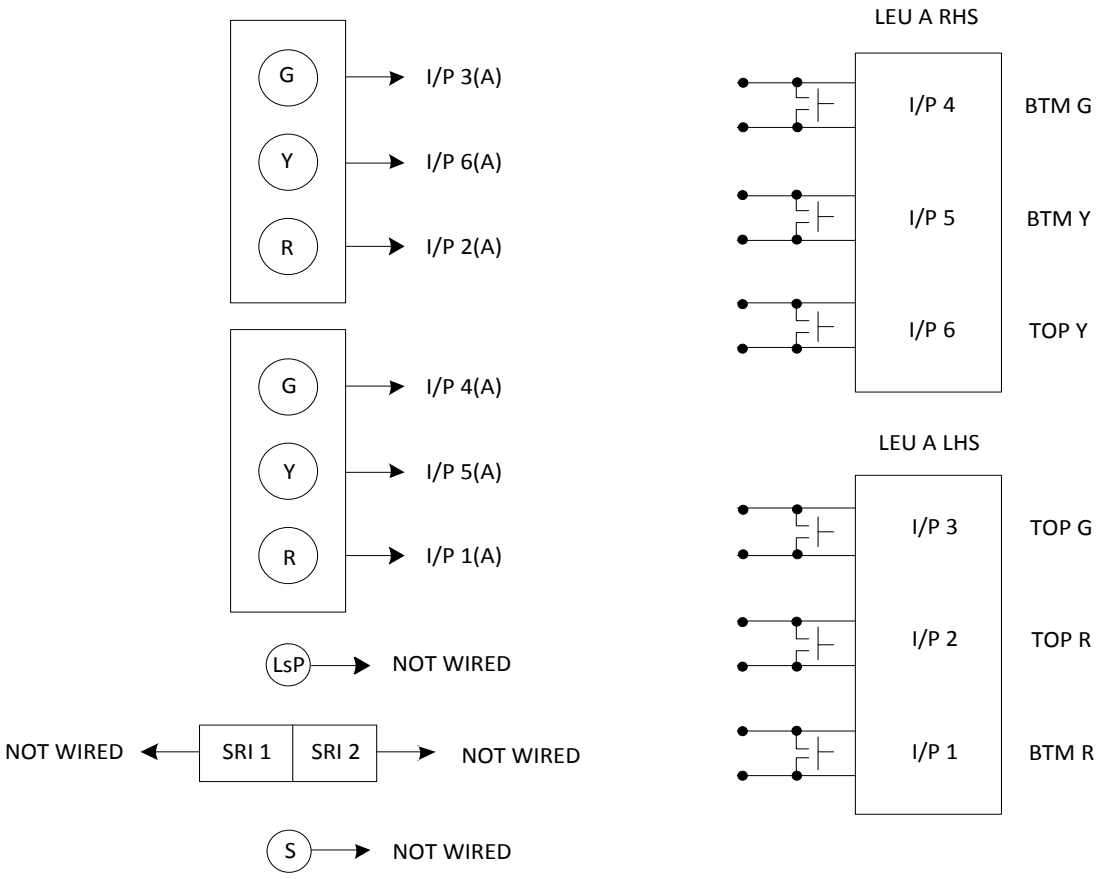

SIGNAL 1

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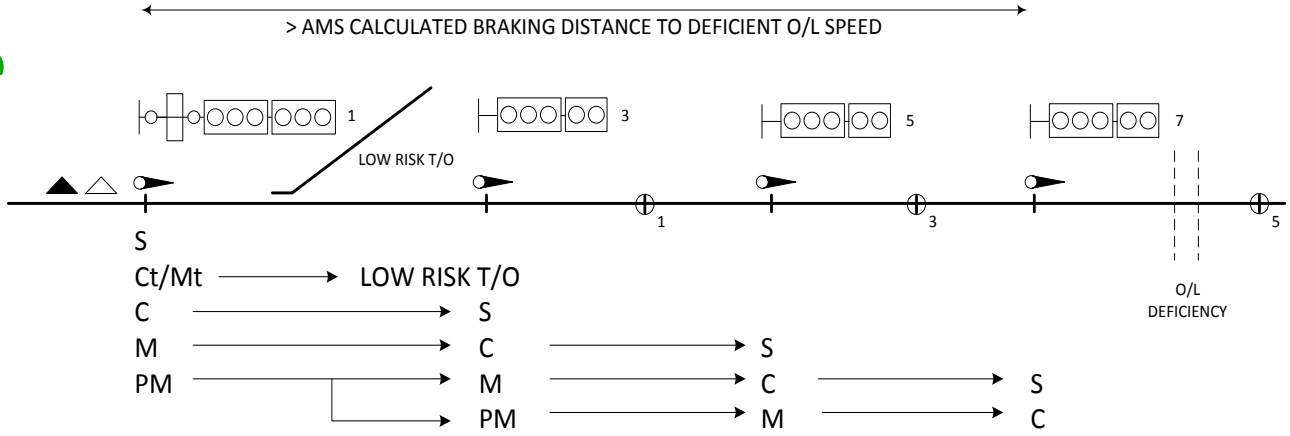
7.2.6 SUCCESSIVE PRELIMINARY MEDIUM ASPECTS – DOUBLE LIGHT SIGNALS (STANDARD CIRCUIT 34)



Reference material only

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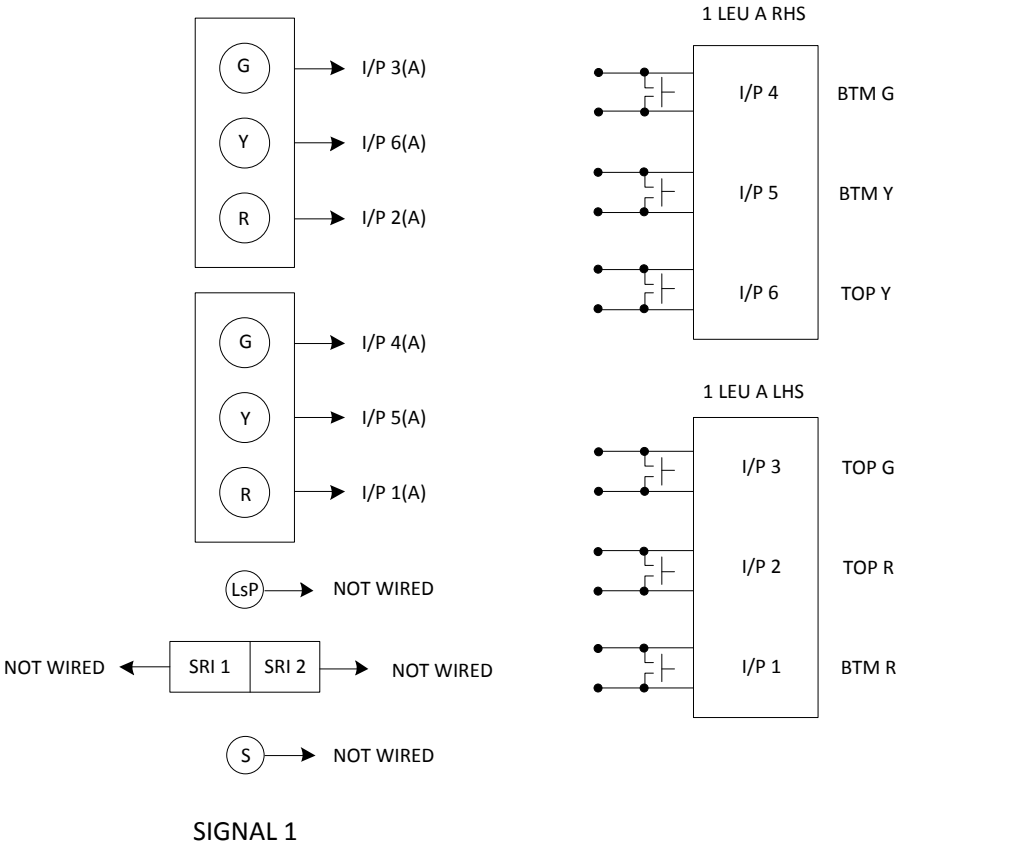
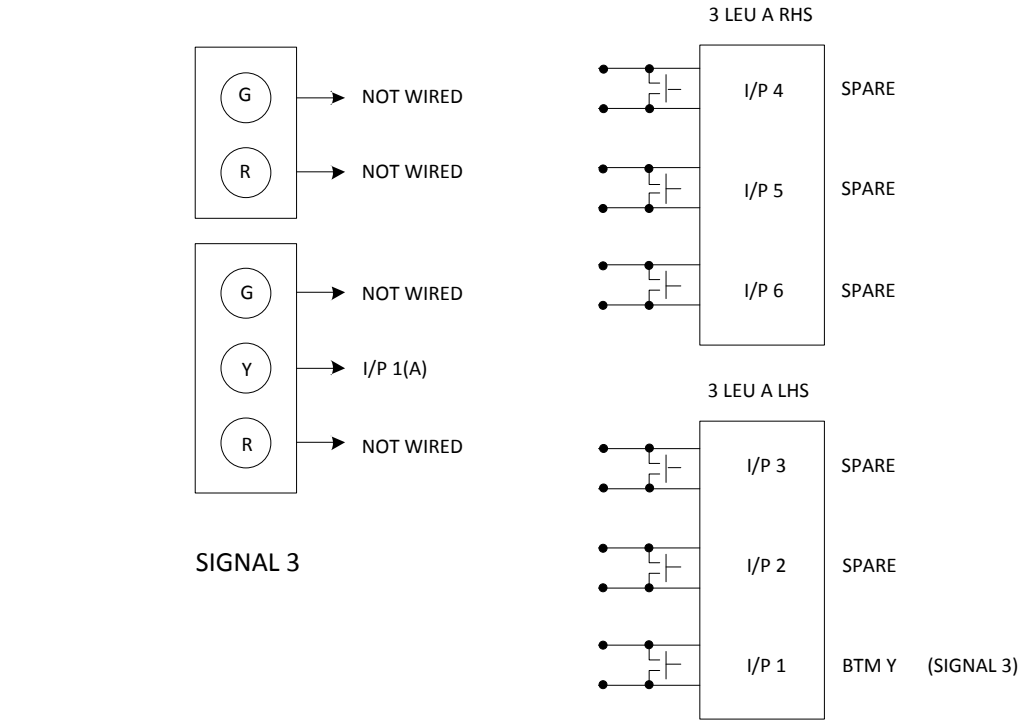


SIGNAL 1



SIGNAL 3

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8. LEU Input Allocation

8.1 Contact Sensing Arrangements

LEU input allocation will follow the below rules:

High risk turnout protection:

- I/P 1: Controls for revoking TSM
- I/P 2: Controls for least restrictive TSM, if applicable
- I/P 3: Controls for other (more restrictive) TSM, if applicable
- I/Ps 4/5: Controls for further (more restrictive) TSMs in order of increasing restriction, if required
- Note that with none of the above inputs sensed, the most restrictive TSM is applicable.
- Where subsidiary shunt inputs are required in order to avoid an unacceptable operational restriction, these are provided in parallel to the corresponding main class route input. Refer to Standard Circuits 10 & 11.

Overlap Deficiency protection:

- I/P 1: Controls for revoking TSM

ETCS Trainstop:

- I/P 6: Controls for inhibiting EBI

Cascaded Cases:

- Spare inputs shall be used if it avoids the introduction of a second LEU.
- Where the second AMS function requires a different set of inputs, it should follow the same philosophy as above, i.e. using I/P 4 for the controls for revoking TSM, and using I/P 5 and I/P 6 for other TSM controls.
- Where ETCS Trainstop function is part of an 'AMS Cascaded case', input/s for inhibiting EBI shall be allocated at I/P 6 even if the same input would be used by other AMS function/s for application of its corresponding TSM.

Note: ETCS LEU Table shall test only the legitimate state (instead of 'Don't Care') of an input corresponding to a particular 'Signal Control/Aspect' even if the input wouldn't be required for the same AMS function when considered as a stand-alone function.

Look-ahead inputs using Ethernet Communication (LEU Networking):

- Inputs to distinguish routes ahead – "Left to Right" orientation of their corresponding routes
- Inputs to distinguish aspects ahead – Higher to Lower aspects. Note that generally a single input would be sufficient where aspects ahead need to be distinguished.

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8.2 Current Sensing Arrangements

Where a Current Sensing arrangement is utilized, allocation of lamp monitoring inputs will follow the below rule for all AMS functionalities:

Single Light signals:

LEU A:

- I/P 1: MK LT
- I/P 2: R
- I/P 3: Y
- I/P 4: G
- I/P 5: BOL (LH)
- I/P 6: BOL (RH)

LEU B:

- I/P 1: SRI (Straight)
- I/P 2: SRI (1st T/O route – Left to Right)
- I/P 3: S
- I/P 4: LSp
- I/P 5: JP (LH) / SRI (2nd T/O route – Left to Right) [1]
- I/P 6: JP (RH)

Notes:

- *Shunt and SRI inputs are only required to avoid an unacceptable operational restriction.*
- *[1] LEU connected to the signal protecting the hazard – JP input is not required. LEU connected to an Outer signal – SRI input is not required.*
- *Allocation of Look-ahead inputs will be sequential and will not follow original designated allocation as shown above - refer to AMS Standard Circuits 13 and 31.*

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Single Light signals (LEU / balise group connected to Junction Signal – High Risk Turnout Protection only):

LEU A:

- I/P 1: MK LT
- I/P 2: Y
- I/P 3: BOL (Left to Right – in case of two BOL, I/P 5 or 6 to be utilized suitably)
- I/P 4: G
- I/P 5: Mainline RI (1st – L to R)
- I/P 6: Mainline RI (2nd – L to R)

LEU B:

- I/P 1: SRI (Straight)
- I/P 2: SRI (1st T/O route – Left to Right)
- I/P 3: S
- I/P 4: LSp
- I/P 5: SRI (2nd T/O route – Left to Right)
- I/P 6: Spare

Notes:

- *Shunt and SRI inputs are only required to avoid an unacceptable operational restriction.*

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Double Light signals:

LEU A:

- I/P 1: BTM R
- I/P 2: TOP R
- I/P 3: TOP G
- I/P 4: BTM G
- I/P 5: BTM Y
- I/P 6: TOP Y

LEU B:

- I/P 1: SRI (Straight)
- I/P 2: SRI (1st T/O route – Left to Right)
- I/P 3: S
- I/P 4: LSp
- I/P 5: JP (LH) / SRI (2nd T/O route – Left to Right) [1]
- I/P 6: JP (RH)

Notes:

- *Shunt and SRI inputs are only required to avoid an unacceptable operational restriction.*
- *[1] LEU connected to the signal protecting the hazard – JP input is not required. LEU connected to an Outer signal – SRI input is not required.*
- *Allocation of Look-ahead inputs will be sequential and will not follow original designated allocation as shown above - refer to AMS Standard Circuits 16, 17 and 34.*

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Double Light signals (LEU / balise group connected to Junction signal – High Risk Turnout Protection only):

LEU A:

- I/P 1: TOP R
- I/P 2: TOP Y
- I/P 3: TOP G
- I/P 4: BTM G
- I/P 5: Mainline RI (1st – L to R)
- I/P 6: Mainline RI (2st – L to R)

LEU B:

- I/P 1: SRI (Straight)
- I/P 2: SRI (1st T/O route – Left to Right)
- I/P 3: S
- I/P 4: LSp
- I/P 5: SRI (2nd T/O route – Left to Right)
- I/P 6: Spare

Notes:

- *Shunt and SRI inputs are only required to avoid an unacceptable operational restriction.*

The above rules can be deviated from in order to utilize spare inputs of LEU A before providing an additional LEU module (LEU B).

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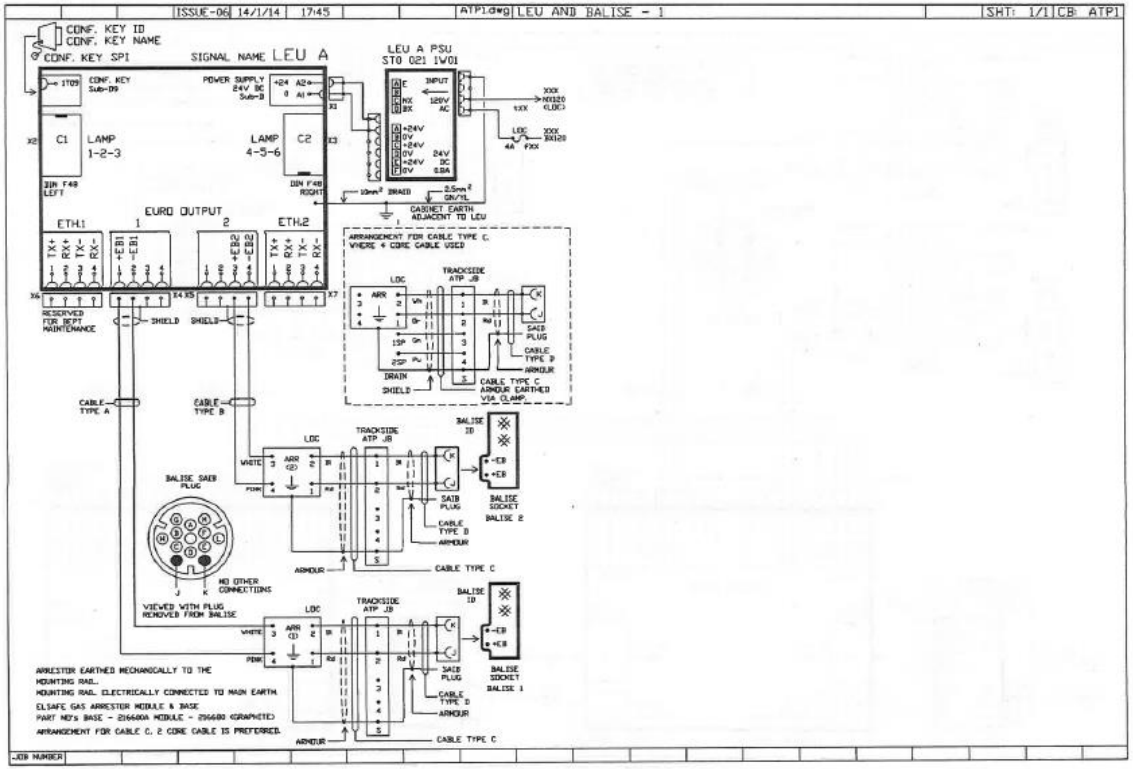
9. Applicable Circuits from ATP Full Supervision

9.1 ATP1 (Issue - 06, dated 14/1/14) – Approved but Not Published



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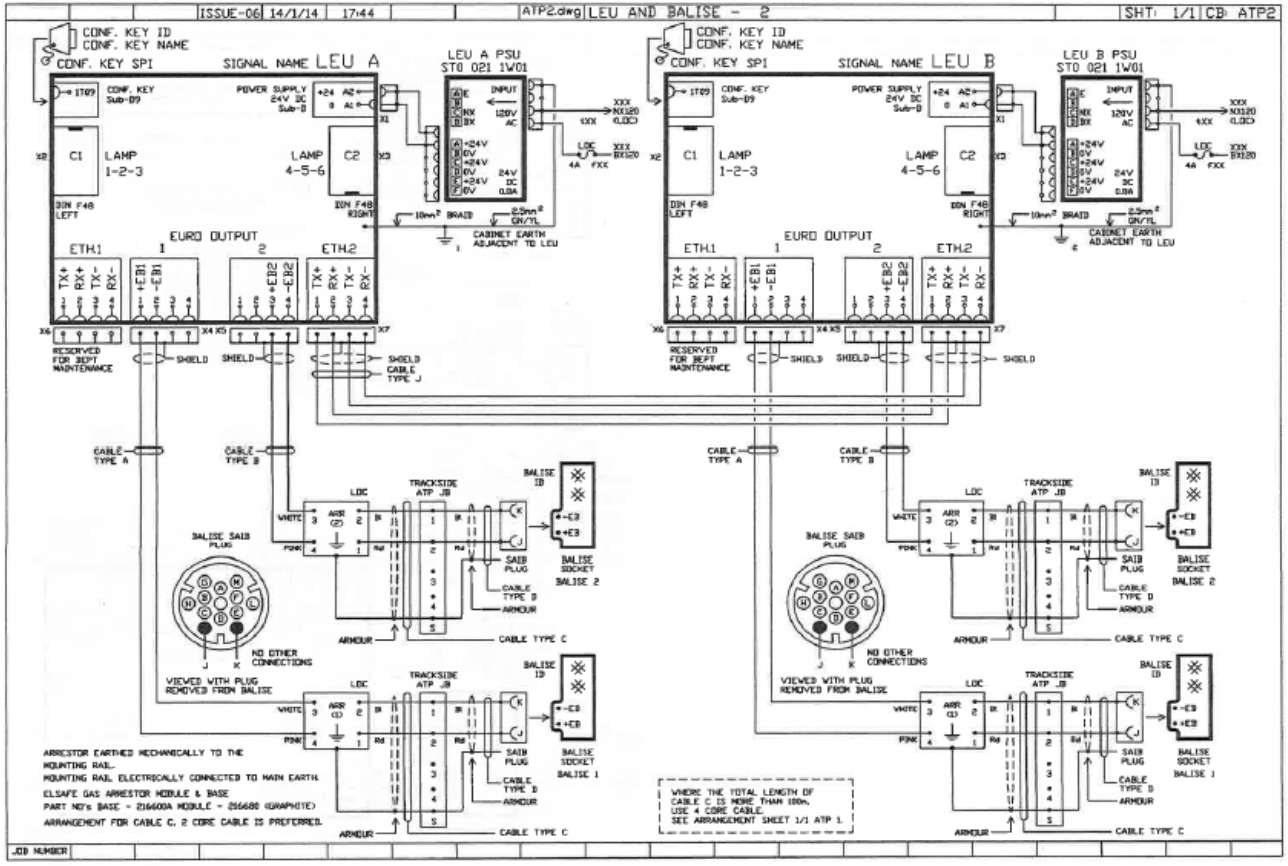
9.2 ATP2 (ISSUE – 06, dated 14/1/14) – Approved but Not Published



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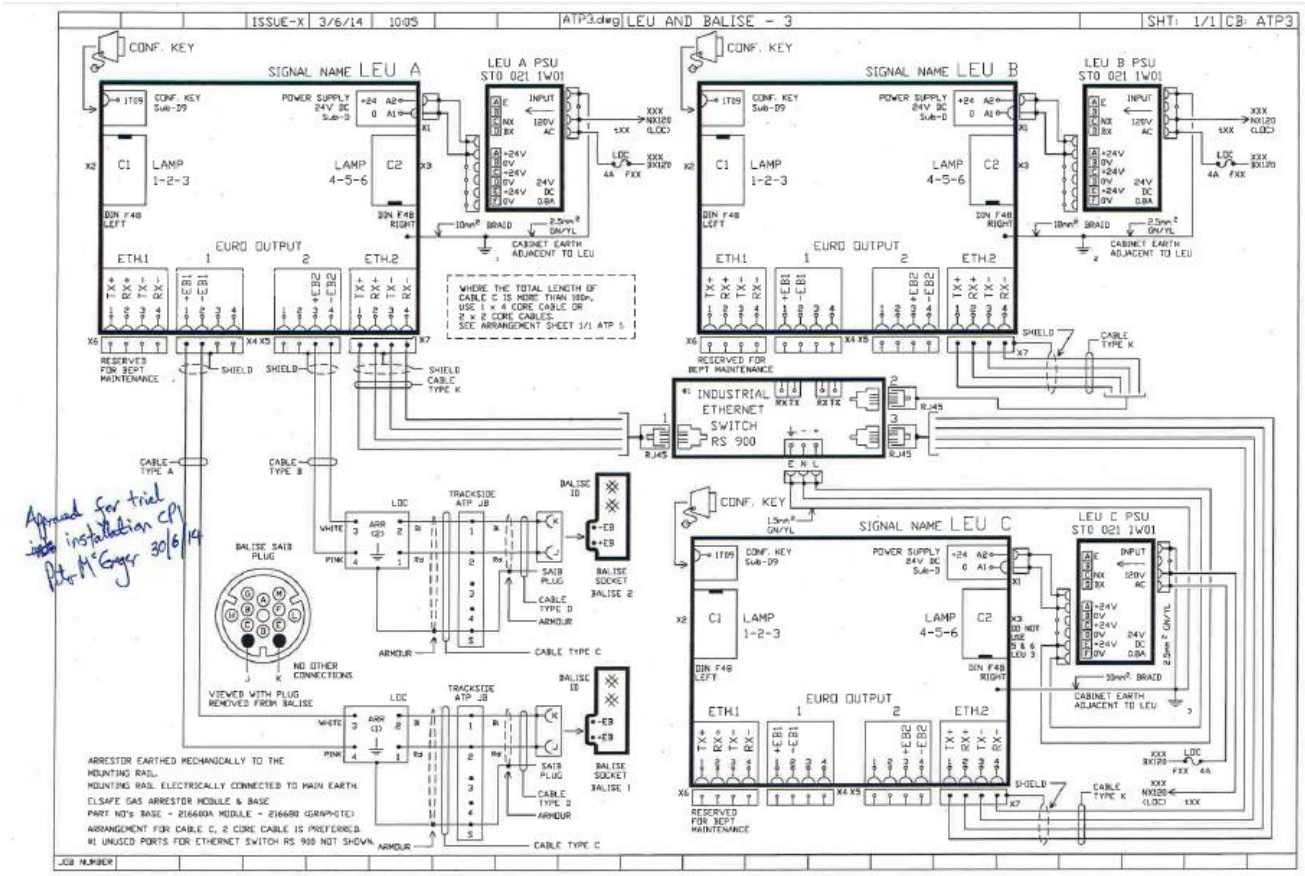
9.3 ATP3 (Hand marked copy, Approved for trial installation CP1) - Draft



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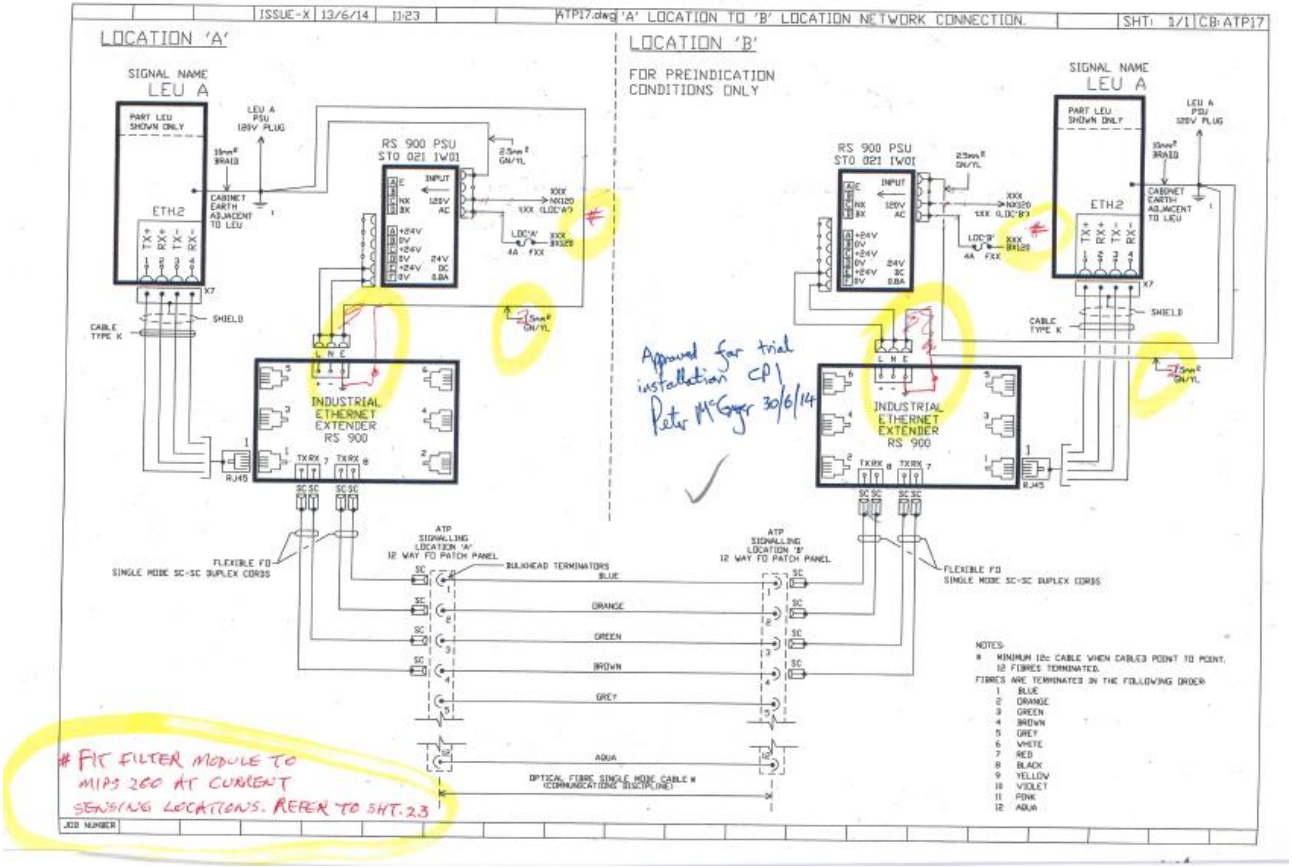
9.4 ATP17 (Hand marked copy, Approved for trial installation CP1) - Draft



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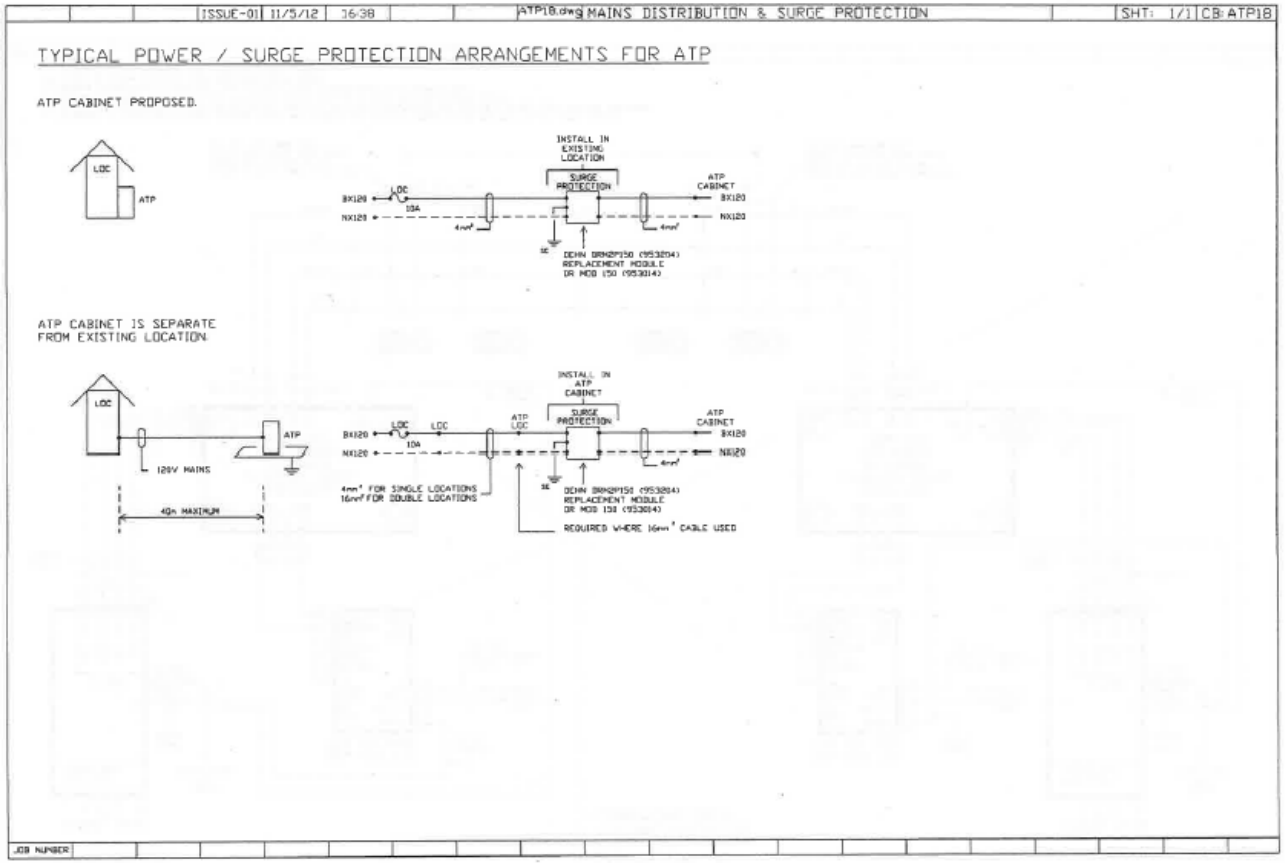
9.5 ATP18 (Issue – 01, dated 11/5/12) – Published



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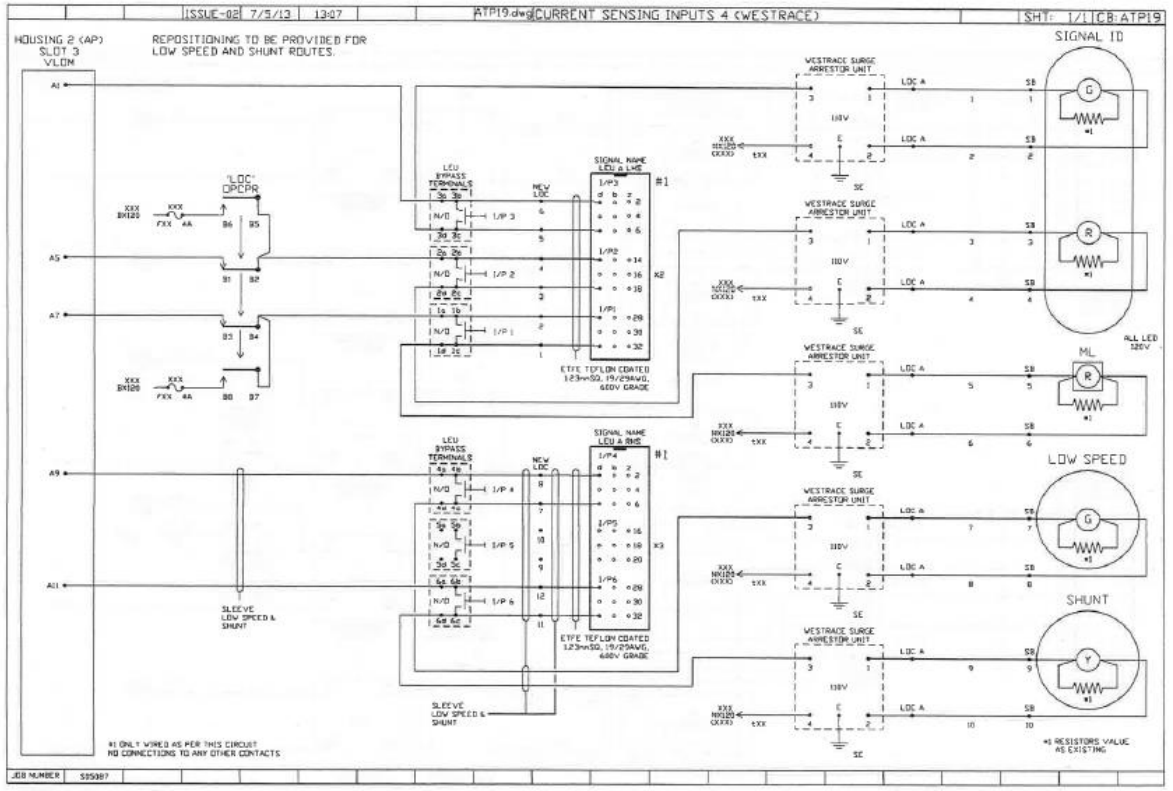
9.6 ATP19 (Issue – 02, dated 7/5/13) – Approved but Not Published



Note: The above diagram is intended to show the detailed wiring only, the LEU input allocation will follow the rules set in Section 8.

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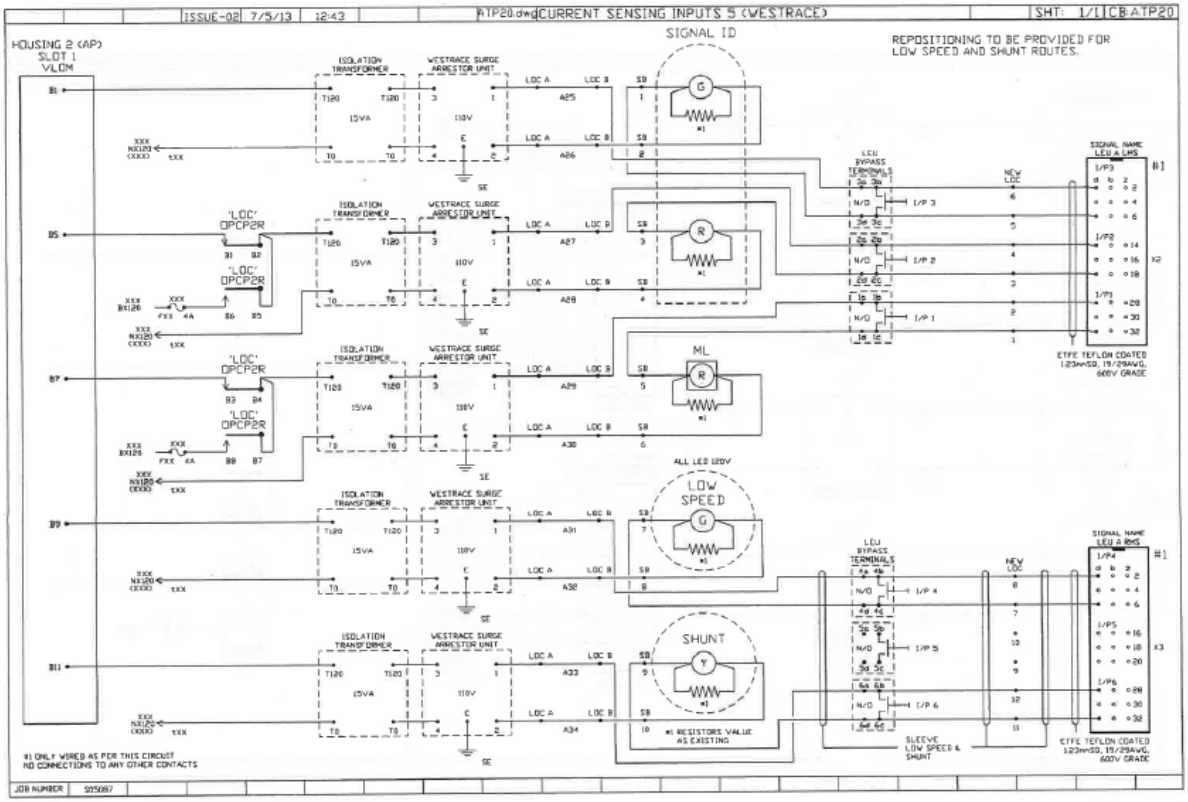
9.7 ATP20 (Issue – 02, dated 7/5/13) – Approved but Not Published



Note: The above diagram is intended to show the detailed wiring only, the LEU input allocation will follow the rules set in Section 8.

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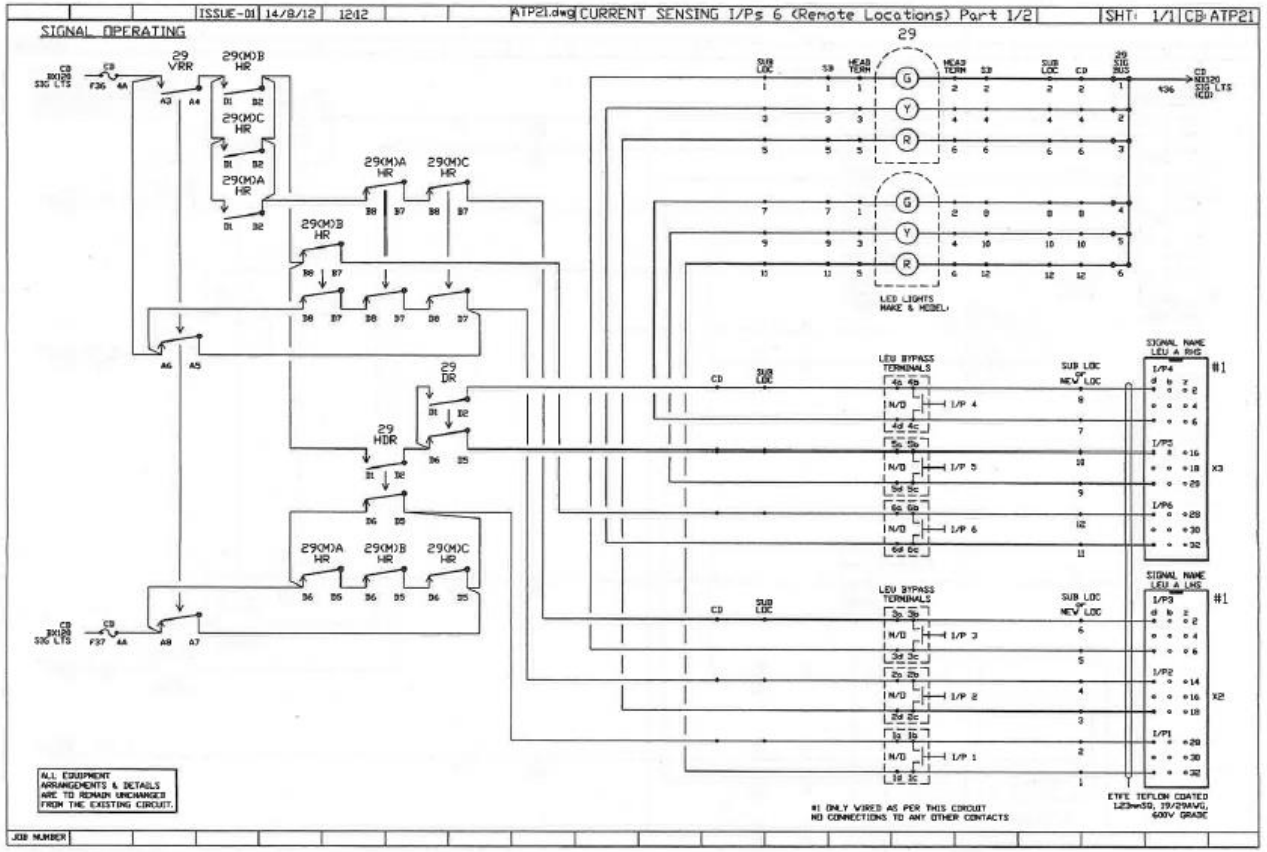
9.8 ATP21 (Issue – 01, dated 14/8/12) – Published



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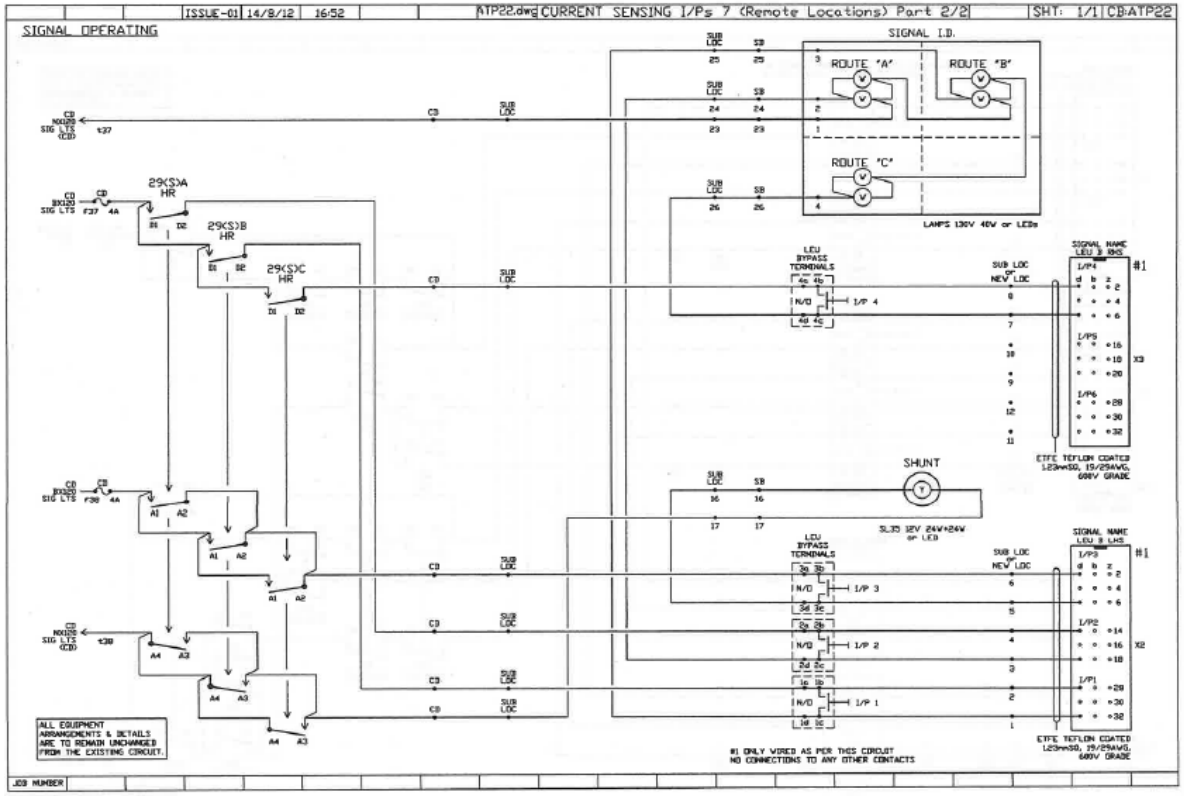
9.9 ATP22 (Issue – 01, dated 14/8/12) – Published



Note: The above diagram is intended to show the detailed wiring only, the LEU input allocation will follow the rules set in Section 8.

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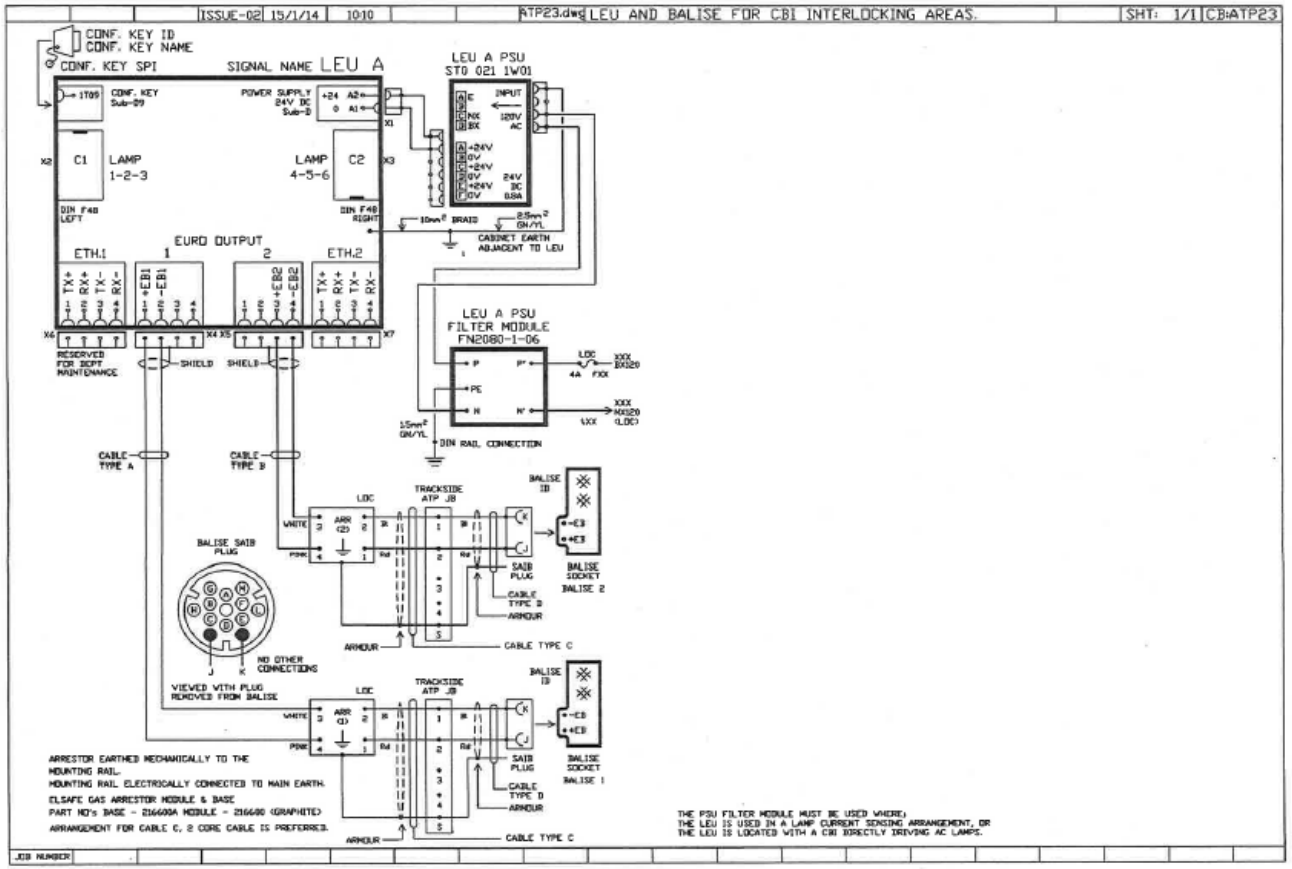
9.10 ATP23 (Issue – 02, dated 15/1/14) – Approved but Not Published



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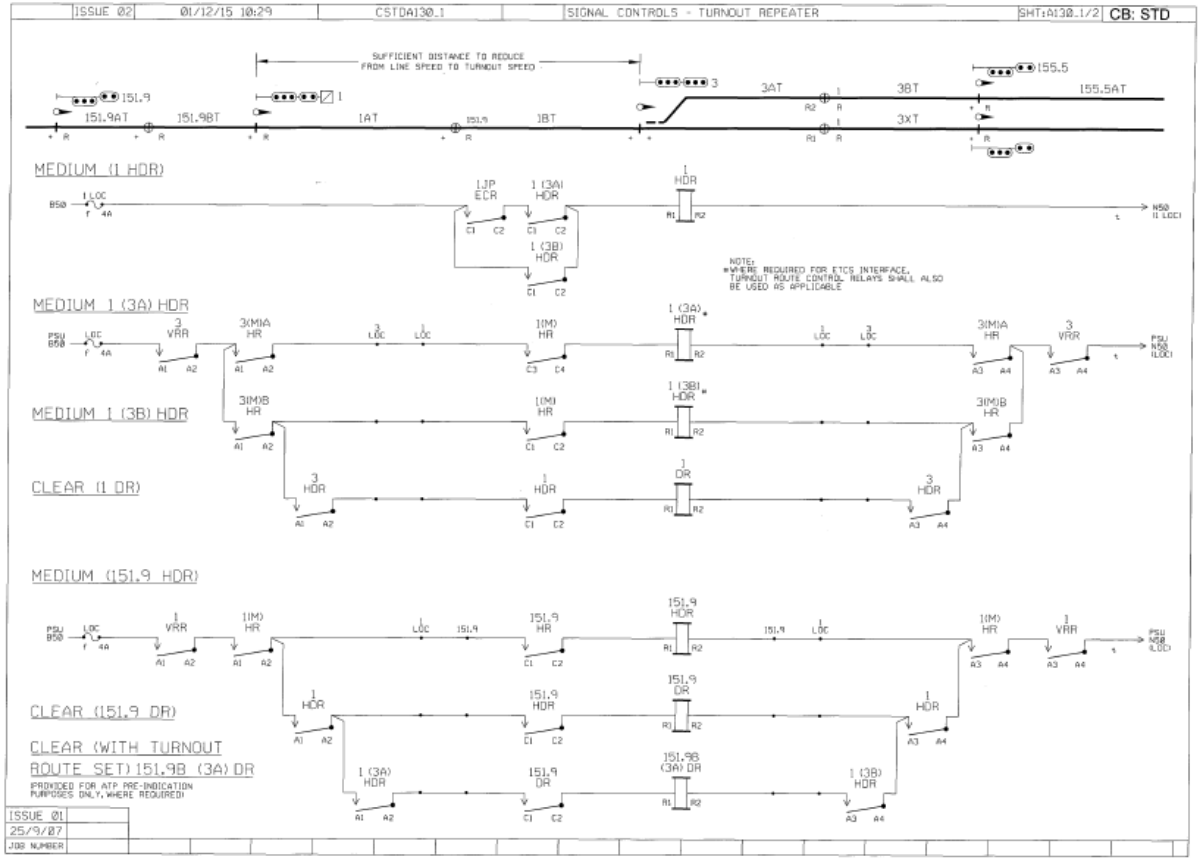
9.11 SHT130 – SDG 001 (Issue – 02, dated 1/12/15) – Draft



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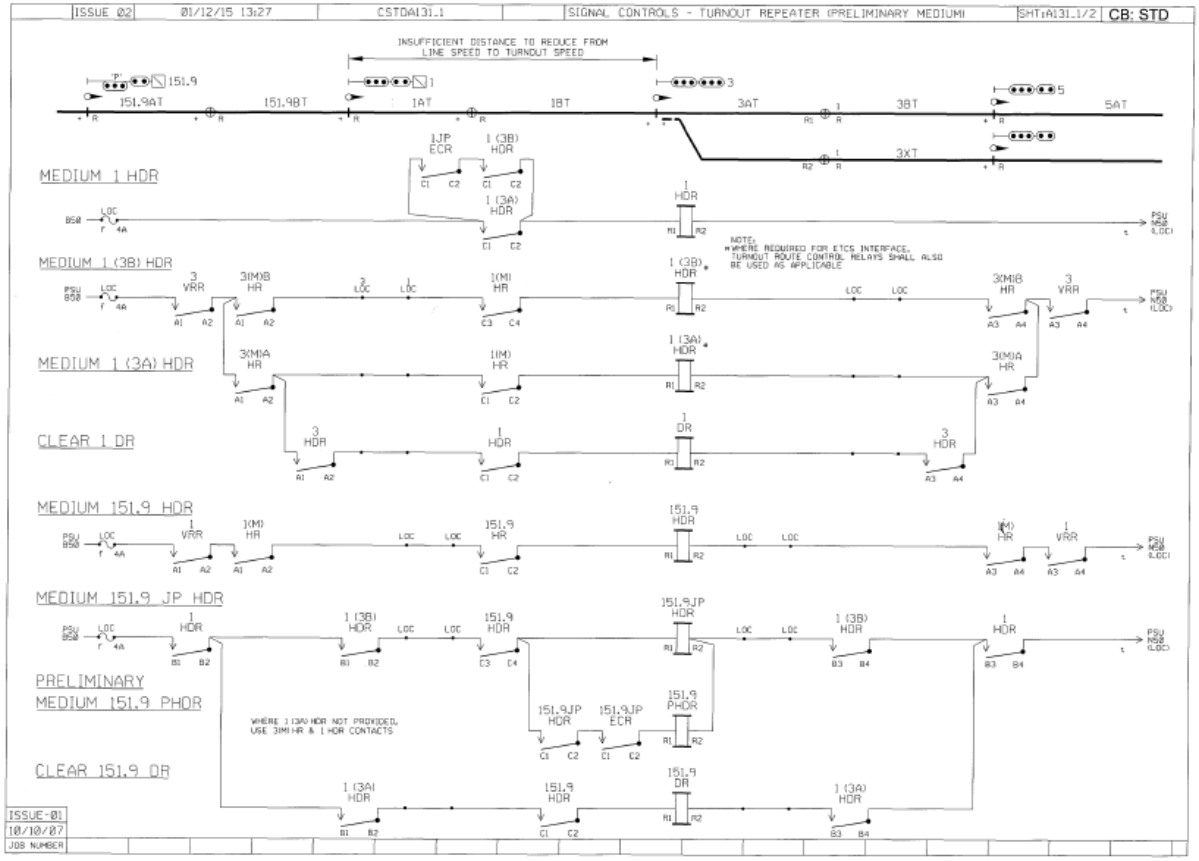
9.12 SHT131 – SDG 001 (Issue – 02, dated 1/12/15) – Draft



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10. LEU Tables

10.1 ETCS Trainstop

10.1.1 CONTACT SENSING ARRANGEMENTS

10.1.1.1 SINGLE AND DOUBLE LIGHT SIGNALS (STANDARD CIRCUITS 1 & 2)

XX – Don't Care 00 – Fault; 10 – OFF; 11 – ON		LEU												ETCS Trainstop
		1		2		3		4		5		6		
Mask	Signal Aspect	Spare		Spare		Spare		Spare		Spare		1st Proceed for all Main/ Shunt [1] HRs in parallel		AMS Response
1	Proceed											1	1	No EBI
2	Stop											1	0	EBI

Notes:

[1] Subsidiary Shunt contacts are to be included only if the applicable shunt route needs to inhibit EBI for operational reasons.

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10.1.2 CURRENT SENSING ARRANGEMENTS

10.1.2.1 SINGLE LIGHT SIGNALS (STANDARD CIRCUIT 3)

XX – Don't Care 00 - Fault; 10 - OFF 11 - ON; 01 - Pulsating		LEU A												LEU B										ETCS Trainstop
		1		2		3		4		5		6		1		2		3		4		5/6		
Mask	Signal Aspect	MK LT		R		Y		G		Spare		BOL (RH)		SRI 1 [1]		Spare		Shunt [1]		LSp		Spare		AMS Response
1	Stop	X	X	X	X	1	0	1	0			1	0	X	X			1	0	1	0			EBI
2	Caution	1	0	1	0	1	1	1	0			1	0	1	0			1	0	1	0			No EBI
3	Caution Turnout	1	0	X	X	1	0	1	0			1	1	1	0			1	0	1	0			No EBI
4	Medium	1	0	1	0	0	1	1	0			1	0	1	0			1	0	1	0			No EBI
5	Medium Turnout	1	0	X	X	1	0	1	0			0	1	1	0			1	0	1	0			No EBI
6	Clear	1	0	1	0	1	0	1	1			1	0	1	0			1	0	1	0			No EBI
7	Low Speed	X	X	X	X	1	0	1	0			1	0	X	X			1	0	1	1			No EBI
8	Shunt 1	X	X	X	X	1	0	1	0			1	0	1	1			1	1	1	0			No EBI [1]
9	Shunt SRI Fail	X	X	X	X	1	0	1	0			1	0	1	0			1	1	1	0			EBI [1]

Notes:

[1] Subsidiary Shunt and SRI are to be included only if a particular shunt route needs to inhibit EBI for operational reasons. If all shunt routes need to inhibit EBI, then SRI inputs are not required.

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10.1.2.2 DOUBLE LIGHT SIGNALS (STANDARD CIRCUIT 4)

XX – Don't Care 00 – Fault; 10 – OFF 11 – ON; 01 – Pulsating		LEU A												LEU B										ETCS Trainstop
		1		2		3		4		5		6		1		2		3		4		5/6		
Mask	Signal Aspect	BTM R		TOP R		TOP G		BTM G		BTM Y		TOP Y		Spare		SRI 1 [1]		Shunt [1]		LSp		Spare		AMS Response
1	Stop	X	X	X	X	1	0	1	0	1	0	1	0			X	X	1	0	1	0			EBI
2	Caution	X	X	1	0	1	1	1	0	1	0	1	0			1	0	1	0	1	0			No EBI
3	Caution Turnout	X	X	1	0	1	0	1	0	1	0	1	1			1	0	1	0	1	0			No EBI
4	Medium	1	0	1	0	1	1	1	0	1	1	1	0			1	0	1	0	1	0			No EBI
5	Prelim. Medium	1	0	1	0	X	X	1	0	0	1	1	0			1	0	1	0	1	0			No EBI
6	Medium Turnout	1	0	1	0	1	0	1	0	1	1	1	1			1	0	1	0	1	0			No EBI
7	Clear	1	0	1	0	X	X	1	1	1	0	1	0			1	0	1	0	1	0			No EBI
8	Dummy Proceed	1	0	1	0	1	0	1	0	1	1	1	0			1	0	1	0	1	0			No EBI
9	Low Speed	X	X	X	X	1	0	1	0	1	0	1	0			X	X	1	0	1	1			No EBI
10	Shunt 1	X	X	X	X	1	0	1	0	1	0	1	0			1	1	1	1	1	0			No EBI [1]
11	Shunt SRI Fail	X	X	X	X	1	0	1	0	1	0	1	0			1	0	1	1	1	0			EBI [1]

[1] Subsidiary Shunt and SRI are to be included only if a particular shunt route needs to inhibit EBI for operational reasons. If all shunt routes need to inhibit EBI, then SRI inputs are not required.

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10.2 High risk Turnout Protection

10.2.1 CONTACT SENSING ARRANGEMENTS

10.2.1.1 TURNOUT REPEATERS AVAILABLE (STANDARD CIRCUIT 5)

XX – Don't Care **00 – Fault; 10 – OFF; 11 - ON**		**LEU**												**High Risk Turnout Protection**
		1		**2**		**3**		**4**		**5**		**6**		
Mask	**Minimum Signal Aspect**	**Revoke TSM**		**Least Restrictive TSM**		**Other TSM**		**Spare**		**Spare**		**Spare**		**AMS Response**
1	1: Medium and 3(M)B: Caution or 1(A) clear	1	1	1	0	1	0							Line speed – 3(M)B
2	1: Medium + RH JP	1	0	1	1	1	0							X40 at 1st turnout – 3(M)C
3	1: Medium + LH JP	1	0	1	0	1	1							X25 at 2nd turnout – 3(M)A
4	Otherwise	1	0	1	0	1	0							X25 at 2nd turnout

Notes:

1. In the above layout, Signal 3 is protecting a junction consisting of two high risk turnouts and Signal 1 has turnout repeaters for these routes.
2. The layout considers that the turnout speed for 3(M)C route is higher than that of 3(M)A route. It is assumed that 3(M)A route has the earliest braking point from line speed, despite the fact that the turnout for 3(M)C occurs first. The turnout speed for 3(M)A route thus becomes the most restrictive speed for this junction.
3. With Turnout Repeaters available, if the 'Medium' aspect control relay (1 HDR) applies for both Turnout and straight routes (as in the above case), the TSM revoking input into the LEU is to test the de-energised state of 1 JP(LH) HDR and 1 JP(RH) HDR relays.

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10.2.1.2 TURNOUT REPEATERS NOT AVAILABLE

(STANDARD CIRCUIT 6A – Look-ahead using Hardwired Copper Cable Method)

XX – Don't Care 00 – Fault; 10 – OFF; 11 - ON		LEU												High Risk Turnout Protection
		1		2		3		4		5		6		
Mask	Minimum Signal Aspect	Revoke TSM		Least Restrictive TSM		Other TSM		Spare		Spare		Spare		AMS Response
1	1: Medium and 3(M)B: Caution or 1(A) clear	1	1	1	0	1	0							Line speed – 3(M)B
2	1: Medium and 3(M)A: Caution Turnout	1	0	1	1	1	0							X40 at 2nd turnout – 3(M)A
3	1: Medium and 3(M)C: Caution Turnout	1	0	1	0	1	1							X25 at 1st turnout – 3(M)C
4	Otherwise	1	0	1	0	1	0							X25 at 1st turnout

Notes:

1. In the above layout Signal 3 is protecting a junction consisting of two high risk turnouts and Signal 1 is not fitted with Turnout Repeaters for these routes. Look-ahead is thus required. See the AMS Look-ahead Design Guideline. The signalling circuits are to be altered to create 'Medium' aspect control relays for Signal 1 based on the routes from Signal 3 (3A/3B/3C) and are provided to the LEU. This is broadly based on Signalling Principle ESG 100.1.25.
2. The layout considers that the turnout speed for 3(M)A route is higher than that of 3(M)C route and hence the turnout speed for 3(M)C route becomes the most restrictive speed for this junction.

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(STANDARD CIRCUIT 6B – Look-ahead using Ethernet Communications Method)

XX – Don't Care 10 – OFF; 11 – ON; 01 – Pulsating		LEU A – 1 SIG LOC												LEU A – 3 SIG LOC						High Risk Turnout Protection
		1		2		3		4		5		6		1		2		3		
Mask	Signal Aspect	1 DR / 1(A) HR		1(B) HDR		Spare		Spare		Spare		Spare		3(M)A HR		3(M)B HR		3(M)C HR		AMS Response
1	1: Stop/Caution	1	0	1	0									X	X	X	X	X	X	RH Turnout Speed
2	1: Caution Turnout / Medium Turnout	1	1	1	0									X	X	X	X	X	X	Line Speed
3	1: Medium and 3(M)A: Caution Turnout	1	0	1	1									1	1	1	0	1	0	LH Turnout Speed
4	1: Medium and 3(M)B : Caution	1	0	1	1									1	0	1	1	1	0	Line Speed
5	1: Medium and 3(M)C: Caution Turnout	1	0	1	1									1	0	1	0	1	1	RH Turnout Speed
6	1: Full Clear	1	1	1	1									X	X	X	X	X	X	Line Speed

Notes:

1. In the above layout Signal 3 is protecting a junction consisting of two high risk turnouts and Signal 1 is not fitted with Turnout Repeaters for these routes. Look-ahead is thus required. See the AMS Look-ahead Design Guideline. This solution is based on Ethernet communications being used for Look-ahead purposes (i.e. LEU Networking).
2. 1DR input is required in this arrangement (when compared to Standard Circuit 6A) as this input is able to revoke any TSM (and apply Line speed) without the need for any Look-ahead inputs and thereby improving the operation during any failure related to the Look-ahead arrangements.

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10.2.1.3 WITH PRELIMINARY MEDIUM ASPECT (STANDARD CIRCUIT 7)

XX – Don't Care **00 – Fault; 10 – OFF; 11 - ON**		**LEU**												**High Risk Turnout Protection**
		1		**2**		**3**		**4**		**5**		**6**		
Mask	**Minimum Signal Aspect**	**Revoke TSM**		**Least Restrictive TSM**		**Other TSM**		**Spare**		**Spare**		**Spare**		**AMS Response**
1	1: Preliminary Medium with no JP or 1(A) clear	1	1	1	0	1	0							Line speed – 5(M)B
2	1: Preliminary Medium + RH JP	1	0	1	1	1	0							X40 at 2nd turnout – 5(M)C
3	1: Preliminary Medium + LH JP	1	0	1	0	1	1							X25 at 1st turnout – 5(M)A
4	Otherwise	1	0	1	0	1	0							X25 at 1st turnout

Notes:

1. In the above layout, Signal 5 is protecting a junction consisting of two high risk turnouts and Signal 1 is fitted with turnout repeaters for these routes.
2. The layout considers that the turnout speed for 5(M)C route is higher than that of 5(M)A. The turnout speed for 5(M)A route becomes the most restrictive speed for this junction.
3. Since the 'Preliminary Medium' aspect on Signal 1 applies to both straight and turnouts routes from Signal 5, the PHDR input into the LEU (for TSM revoking) is to test the de-energised state of 1 JP(LH) HDR and 1 JP(RH) HDR relays.

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10.2.1.4 BRAKING POINT BEFORE FIRST WARNING SIGNAL – SINGLE LIGHT (STANDARD CIRCUIT 8)

XX – Don't Care **00 – Fault; 10 – OFF; 11 - ON**		**LEU**												**High Risk Turnout Protection**
		1		**2**		**3**		**4**		**5**		**6**		
Mask	**Minimum Signal Aspect**	**Revoke TSM**		**Least Restrictive TSM**		**Other TSM**		**Spare**		**Spare**		**Spare**		**AMS Response**
1	1: Full Clear and 3: Full Clear or 1(A) clear	1	1	1	0	1	0							Line speed – 5(M)B
2	1: Full Clear and 3: Medium + RH JP	1	0	1	1	1	0							X40 at 2nd turnout – 5(M)C
3	1: Full Clear and 3: Medium + LH JP	1	0	1	0	1	1							X25 at 1st turnout – 5(M)A
4	Otherwise	1	0	1	0	1	0							X25 at 1st turnout

Notes:

1. The layout assumes that the braking point falls in rear of the first warning signal, i.e. Signal 3. Hence Signal 1 is provided with the LEU and Balise group. It is not possible at Signal 1 to determine which route is set from Signal 5, as the full clear aspect applies to both straight and turnout routes. Look-ahead is thus required. See the AMS Look-ahead Design Guideline. The signalling circuits are to be altered to create full-clear aspect control relays for Signal 1 based on full-clear and medium aspects (LH and RH) of Signal 3. This is broadly based on Signalling Principle ESG 100.1.25.

   The layout assumes that the turnout speed of 5(M)C route is higher than that of 5(M)A route. In this case, the turnout speed of 5(M)A route is the most restrictive speed for the junction.

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2. The medium aspect on Signal 1 applies to two conditions: Signal 3 at turnout and Signal 5 at stop. Situations like this need to be analysed on a case-by-case basis to determine whether or not enforcing the high risk turnout TSM will pose an unacceptable operational restriction for trains taking the turnout from Signal 3. This analysis will factor in braking and the position of the next balise group that a train passes when taking the turnout from Signal 3.

   In the example above, it is assumed that there is no unacceptable operational impact if TSM is applied for trains turning out at Signal 3.

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10.2.1.5 BRAKING POINT BEFORE FIRST WARNING SIGNAL – DOUBLE LIGHT (STANDARD CIRCUIT 9)

XX – Don't Care 00 – Fault; 10 – OFF; 11 - ON		LEU												High Risk Turnout Protection
		1		2		3		4		5		6		
Mask	**Minimum Signal Aspect**	**Revoke TSM**		**Least Restrictive TSM**		**Other TSM**		**Spare**		**Spare**		**Spare**		**AMS Response**
1	1: Full Clear and 3: Full Clear or 1(A) clear	1	1	1	0	1	0							Line speed – 7(M)B
2	1: Full Clear and 3: Preliminary Medium + LH JP	1	0	1	1	1	0							X40 at 1st turnout – 7(M)A
3	1: Full Clear and 3: Preliminary Medium + RH JP	1	0	1	0	1	1							X25 at 2nd turnout – 7(M)C
4	Otherwise	1	0	1	0	1	0							X25 at 2nd turnout

Notes:

1. The layout assumes that the 'braking point' falls in rear of the first warning signal i.e. Signal 3. Hence Signal 1 is provided with the LEU and Balise group. It is not possible at Signal 1 to determine which route is set from Signal 7, as the full clear aspect applies to both straight and turnout routes. Look-ahead is thus required. See the AMS Look-ahead Design Guideline. The signalling circuits are to be altered to create full-clear aspect control relays for Signal 1 based on full-clear and preliminary medium aspects (LH and RH) of Signal 3. This is broadly based on Signalling Principle ESG 100.1.25.

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2. The layout considers that the turnout speed for 7(M)A route is higher than that of 7(M)C route. It is assumed that 7(M)C route has the earliest braking point from line speed, despite the fact that the turnout for 7(M)A is closer. The turnout speed for 7(M)C route thus becomes the most restrictive speed for this junction.

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10.2.1.6 JUNCTION SIGNAL – SINGLE AND DOUBLE LIGHT (STANDARD CIRCUITS 10 & 11)

XX – Don't Care **00 – Fault; 10 – OFF; 11 - ON**		**LEU**												**High Risk Turnout Protection**
		1		**2**		**3**		**4**		**5**		**6**		
Mask	**Minimum Signal Aspect**	**Revoke TSM**		**Least Restrictive TSM**		**Other TSM**		**Most Restrictive TSM**		**Spare**		**Spare**		**AMS Response**
1	3: Straight route clear	1	1	1	0	1	0	1	0					Line speed – 3(M)B
2	3: Least restrictive turnout route clear	1	0	1	1	1	0	1	0					X40 at 3rd turnout – 3(M)C
3	3: Second least restrictive turnout route clear	1	0	1	0	1	1	1	0					X25 at 2nd turnout – 3(M)A
4	3: Third least restrictive turnout route clear	1	0	1	0	1	0	1	1					X15 at 1st turnout – 3(M)D
5	Otherwise	1	0	1	0	1	0	1	0					X15 at 1st turnout

Notes:

1) This example applies to high risk turnouts where an additional balise group is required at the junction signal or on the approach to it, to lessen the operational impact if a signal clears after TSM has been initiated. See the AMS Signal Design Principles and the AMS Approach Balise Group Selection and Position Design Guideline.

2) 3(M)B route is the highest speed route, thus it revokes TSM and uses LEU Input 1.

3) The turnout for 3(M)C, being furthest from Signal 3, is the least restrictive turnout, and so it uses LEU Input 2 for the least restrictive TSM.

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4) The turnout for 3(M)A is more restrictive than that for 3(M)C, but is less restrictive than the most restrictive turnout for 3(M)D, and so it uses LEU Input 3 for a less restrictive TSM.

5) The turnout for 3(M)D is the most restrictive, and so it uses LEU Input 4 for the most restrictive TSM.

6) It is unlikely that inputs from subsidiary shunt routes are required. Where these inputs are not provided, the LEU will consider the signal to be at stop when these routes are clear and the most restrictive speed of the junction will apply. If this imposes an unacceptable operational restriction for a particular subsidiary shunt route, the corresponding input needs to be provided in parallel to the corresponding main class route input.

7) The above table assumes that the speed monitoring due to the high risk turnout protection imposes an unacceptable operational restriction on shunt routes 3(S)A and 3(S)B, and hence a contact from each appropriate shunt HR relay has been provided in parallel to main route HR relay contact.

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10.2.2 Current Sensing Arrangements

10.2.2.1 MULTIPLE DIVERGENCES - SINGLE LIGHT SIGNALS (STANDARD CIRCUIT 12)

XX – Don't Care 10 – OFF; 11 – ON; 01 – Pulsating		LEU A												LEU B						High Risk Turnout Protection
		1		2		3		4		5		6		1/2/3/4		5		6		
Mask	Signal Aspect	MK LT		R		Y		G		BOL (LH)		Spare		Spare		LH JP		RH JP		AMS Response
1	Stop	X	X	X	X	1	0	1	0	1	0					X	X	X	X	RH Turnout Speed
2	Caution Turnout	1	0	X	X	1	0	1	0	1	1					X	X	X	X	Line Speed
3	Caution	1	0	1	0	1	1	1	0	1	0					X	X	X	X	RH Turnout Speed
4	Medium Turnout	1	0	X	X	1	0	1	0	0	1					X	X	X	X	Line Speed
5	Medium (LH Turnout Ahead)	1	0	1	0	0	1	1	0	1	0					1	1	1	0	LH Turnout Speed
6	Medium (Straight Ahead)	1	0	1	0	0	1	1	0	1	0					1	0	1	0	Line Speed
7	Medium (RH Turnout Ahead)	1	0	1	0	0	1	1	0	1	0					1	0	1	1	RH Turnout Speed
8	Clear	1	0	1	0	1	0	1	1	1	0					X	X	X	X	Line Speed

Notes:

1) With Turnout Repeaters available at Signal 1, no look-ahead information is required.

2) Lamp monitoring inputs from both the Turnout Repeaters are required in this case in order to protect from an unsafe failure. If Signal 1 could show a full clear aspect with Signal 3 at caution (instead of a medium as shown in the corresponding aspect sequence chart), LH JP Input would be sufficient and this would be connected to I/P 6 of LEU A, thereby saving one LEU.

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10.2.2.2 CONSECUTIVE DIVERGENCES - SINGLE LIGHT SIGNALS (STANDARD CIRCUIT 13)

XX – Don't Care **10 – OFF; 11 – ON** **01 – Pulsating**		**LEU A**												**LEU B**						**High Risk Turnout Protection**
		1		**2**		**3**		**4**		**5**		**6**		**1**		**2/3/4/ 5**		**6**		
Mask	**Signal Aspect**	**MK LT**		**R**		**Y**		**G**		**BOL (LH)**		**Spare**		**D1 - Signal 3 (Look-ahead)**		**Spare**		**RH JP (Signal 1)**		**AMS Response**
1	Stop	X	X	X	X	1	0	1	0	1	0			X	X			X	X	D1 & D2 Turnout Speed
2	Caution Turnout	1	0	X	X	1	0	1	0	1	1			X	X			X	X	Line Speed
3	Caution	1	0	1	0	1	1	1	0	1	0			X	X			X	X	D1 & D2 Turnout Speed
4	Medium Turnout	1	0	X	X	1	0	1	0	0	1			X	X			X	X	Line Speed
5	Medium (RH D1 Turnout Ahead)	1	0	1	0	0	1	1	0	1	0			1	1			1	1	D1 Turnout Speed
6	Medium (Straight Ahead)	1	0	1	0	0	1	1	0	1	0			X	X			1	0	Line Speed
7	Medium (RH D2 Turnout Ahead)	1	0	1	0	0	1	1	0	1	0			1	0			1	1	D1 & D2 Turnout Speed
8	Clear	1	0	1	0	1	0	1	1	1	0			X	X			X	X	Line Speed

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Notes:

1) In this particular instance, although Turnout Repeater is available at Signal 1, look-ahead information is still required since there are multiple diverging routes in the same direction at the junction ahead. If 3(M)B and 3(M)C routes have the same AMS response, look-ahead information will not be required as Turnout Repeater information will be sufficient to enforce the corresponding speed for both of these routes. Refer to the AMS Look-ahead Design Guideline.

2) Failure of the Route Indicator input (due to wire cut or failure of the lamp) is also covered by Mask 7 where the most restrictive speed of the junction (i.e. D1 & D2 turnout speeds in this case) is enforced.

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10.2.2.3 JUNCTION SIGNALS - SINGLE LIGHT (STANDARD CIRCUIT 14)

If the LEU is connected to the junction signal (Signal 3) for high risk turnout protection purposes, the LEU Table will take the below form. Lamp input from the Red aspect won't be provided in this situation.

XX – Don't Care; 10 – OFF; 01 – Pulsating; 11 - ON		LEU A												LEU B										High Risk Turnout Protection
		1		2		3		4		5		6		1		2		3		4		5/6		
Mask	Signal Aspect	MK LT		Y		BOL (RH)		G		D1		Spare		SRI 1		Spare		Shunt		LSp		Spare		AMS Response
1	Stop	X	X	1	0	1	0	1	0	X	X			X	X			1	0	1	0			D1 & D2 Turnout Speeds
2	Caution	1	0	1	1	1	0	1	0	1	0			1	0			1	0	1	0			Line Speed
3	Medium	1	0	0	1	1	0	1	0	1	0			1	0			1	0	1	0			Line Speed
4	Caution Turnout (D1)	1	0	1	0	1	1	1	0	1	1			1	0			1	0	1	0			Turnout Speed – D1
5	Medium Turnout (D1)	1	0	1	0	0	1	1	0	1	1			1	0			1	0	1	0			Turnout Speed – D1
6	Caution Turnout (D2)	1	0	1	0	1	1	1	0	1	0			1	0			1	0	1	0			D1 & D2 Turnout Speeds
7	Medium Turnout (D2)	1	0	1	0	0	1	1	0	1	0			1	0			1	0	1	0			D1 & D2 Turnout Speeds
8	Clear	1	0	1	0	1	0	1	1	1	0			1	0			1	0	1	0			Line Speed
9	Low Speed	X	X	1	0	1	0	1	0	1	0			X	X			1	0	1	1			Line Speed
10	Shunt 1	X	X	1	0	1	0	1	0	1	0			1	1			1	1	1	0			Line Speed
11	Shunt SRI Fail	X	X	1	0	1	0	1	0	1	0			1	0			1	1	1	0			D1 & D2 Turnout Speeds

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Notes:

1) If 3(M)B and 3(M)C routes have the same AMS response, route indicator information will not be required as Turnout Indicator (BOL) input will be sufficient to enforce the corresponding speed for both the routes.
2) Failure of the main line Route Indicator lamp input into the LEU will be covered by Mask 6 or Mask 7 (depending upon lamp proving feature of the route indicator).
3) In the case of failure of the BOL aspect with Route Indicator working, the aspect becomes irregular as per NSG 606. The corresponding conditions lead to Mask 1 and the most restrictive speed of the junction (i.e. D1 & D2 Turnout Speeds) will be applied. Under AMS, although the Driver needs to obey the lineside signalling indication and needs to stop under this failure condition, AMS will still monitor the Train speed against the most restrictive speed in case the Driver fails to stop the Train.
4) In the case of multiple failures, where both the turnout indicator (BOL) and its corresponding route indicator fail to lit, the corresponding conditions will satisfy Mask 1 and hence the outcome will be the same as above.
5) It is assumed in this example that there is an unacceptable restriction if trains are limited to 15km/h using 3(S)A, but there is no unacceptable operational restriction if trains are limited to 15km/h using 3(S)B. If there was also an unacceptable restriction for trains limited to 15km/h using 3(S)B, then the corresponding SRI would also need to be input, with the AMS response being the turnout speed for D1.

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10.2.2.4 MULTIPLE DIVERGENCES - DOUBLE LIGHT SIGNALS (STANDARD CIRCUIT 15)

XX – Don't Care; 10 – OFF 11 – ON; 01 – Pulsating		LEU A												LEU B						High Risk Turnout Protection
		1		2		3		4		5		6		1/2/3/4		5		6		
Mask	**Signal Aspect**	**BTM R**		**TOP R**		**TOP G**		**BTM G**		**BTM Y**		**TOP Y**		**Spare**		**LH JP**		**RH JP**		**AMS Response**
1	Stop	X	X	X	X	1	0	1	0	1	0	1	0			X	X	X	X	RH Turnout Speed
2	Caution	X	X	1	0	1	1	1	0	1	0	1	0			X	X	X	X	RH Turnout Speed
3	Caution Turnout	X	X	1	0	1	0	1	0	1	0	1	1			X	X	X	X	Line Speed
4	Medium + LH JP	1	0	1	0	1	1	1	0	1	1	1	0			1	1	1	0	LH Turnout Speed
5	Medium	1	0	1	0	1	1	1	0	1	1	1	0			1	0	1	0	Line Speed
6	Medium + RH JP	1	0	1	0	1	1	1	0	1	1	1	0			1	0	1	1	RH Turnout Speed
7	Medium Turnout	1	0	1	0	1	0	1	0	1	1	1	1			X	X	X	X	Line Speed
8	Clear	1	0	1	0	X	X	1	1	1	0	1	0			X	X	X	X	Line Speed
9	Dummy Proceed	1	0	1	0	1	0	1	0	1	1	1	0			X	X	X	X	RH Turnout Speed

Notes:

1) With Turnout Repeaters available at Signal 1, no look-ahead information is required.

2) Lamp monitoring inputs from both the Turnout Repeaters are required in this case in order to protect from an unsafe failure. If Signal 1 could show a full clear aspect with 3(M)B route set (instead of a medium aspect as shown in the corresponding aspect sequence chart), LH JP Input would be sufficient.

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10.2.2.5 CONSECUTIVE DIVERGENCES - DOUBLE LIGHT SIGNALS (STANDARD CIRCUIT 16)

XX – Don't Care; 10 – OFF 11 – ON; 01 – Pulsating		LEU A												LEU B								High Risk Turnout Protection
		1		2		3		4		5		6		1		2/3/4		5		6		
Mask	Signal Aspect	BTM R		TOP R		TOP G		BTM G		BTM Y		TOP Y		D2 - Signal 3 (Look-ahead)		Spare		LH JP		Spare		AMS Response
1	Stop	X	X	X	X	1	0	1	0	1	0	1	0	X	X			X	X			D2 & D1 Turnout Speed
2	Caution	X	X	1	0	1	1	1	0	1	0	1	0	X	X			X	X			D2 & D1 Turnout Speed
3	Caution Turnout	X	X	1	0	1	0	1	0	1	0	1	1	X	X			X	X			Line Speed
4	Medium (LH D1 Turnout Ahead)	1	0	1	0	1	1	1	0	1	1	1	0	1	0			1	1			D2 & D1 Turnout Speed
5	Medium (Straight Ahead)	1	0	1	0	1	1	1	0	1	1	1	0	1	0			1	0			Line Speed
6	Medium (LH D2 Turnout Ahead)	1	0	1	0	1	1	1	0	1	1	1	0	1	1			1	1			D2 Turnout Speed
7	Medium Turnout	1	0	1	0	1	0	1	0	1	1	1	1	X	X			X	X			Line Speed
8	Clear	1	0	1	0	X	X	1	1	1	0	1	0	X	X			X	X			Line Speed
9	Dummy Proceed	1	0	1	0	1	0	1	0	1	1	1	0	X	X			X	X			D2 & D1 Turnout Speed

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Notes:

1) In this particular instance, although Turnout Repeater is available at Signal 1, look-ahead information is required along with the Turnout Repeater input since there is multiple diverging routes in the same direction. If 3(M)A and 3(M)B routes have the same AMS response, look-ahead information will not be required as Turnout Repeater information will be sufficient to enforce the corresponding speed for both of these routes. Refer to the AMS Look-ahead Design Guideline.

2) Failure of the Route Indicator input (due to wire cut or failure of the lamp) is also covered by Mask 4 where the most restrictive speed of the junction (i.e. D2 & D1 turnout speeds in this case) is enforced.

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10.2.2.6 BRAKING POINT BEFORE FIRST WARNING SIGNAL - DOUBLE LIGHT – CBI DATA CHANGE METHOD (STANDARD CIRCUIT 17A)

XX – Don't Care **00 – Fault; 10 – OFF; 11 - ON**		**LEU**												**High Risk Turnout Protection**
		1		**2**		**3**		**4**		**5**		**6**		
Mask	**Minimum Signal Aspect**	**Revoke TSM**		**Least Restrictive TSM**		**Other TSM**		**Spare**		**Spare**		**Spare**		**AMS Response**
1	1: Full Clear and 3: Full Clear or 1(A) clear	1	1	1	0	1	0							Line speed – 7(M)B
2	1: Full Clear and 3: Preliminary Medium + RH JP	1	0	1	1	1	0							X70 at 2nd turnout – 7(M)C
3	1: Full Clear and 3: Preliminary Medium + LH JP	1	0	1	0	1	1							X50 at 1st turnout – 7(M)A
4	Otherwise	1	0	1	0	1	0							X50 at 1st turnout

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10.2.2.7 BRAKING POINT BEFORE FIRST WARNING SIGNAL - DOUBLE LIGHT – ETHERNET COMMUNICATIONS (STANDARD CIRCUIT 17B)

XX – Don't Care; 10 – OFF 11 – ON; 01 – Pulsating		LEU A (Signal 1 information)												Network Inputs: (Signal 3 LEU A – Look-ahead)				High Risk Turnout Protection
		1		2		3		4		5		6		1		2		
Mask	Signal Aspect	BTM R		TOP R		TOP G		BTM G		BTM Y		TOP Y		BTM G		RH JP		AMS Response
1	Stop	X	X	X	X	1	0	1	0	1	0	1	0	X	X	X	X	LH Turnout Speed
2	Caution	X	X	1	0	1	1	1	0	1	0	1	0	X	X	X	X	LH Turnout Speed
3	Caution Turnout	X	X	1	0	1	0	1	0	1	0	1	1	X	X	X	X	Line Speed
4	Medium	1	0	1	0	1	1	1	0	1	1	1	0	X	X	X	X	LH Turnout Speed
5	Medium Turnout	1	0	1	0	1	0	1	0	1	1	1	1	X	X	X	X	Line Speed
6	Preliminary Medium	1	0	1	0	X	X	1	0	0	1	1	0	X	X	X	X	LH Turnout Speed
7	Clear (LH Turnout at Junction)	1	0	1	0	X	X	1	1	1	0	1	0	1	0	1	0	LH Turnout Speed
8	Clear (RH Turnout at Junction)	1	0	1	0	X	X	1	1	1	0	1	0	1	0	1	1	RH Turnout Speed
9	Clear (Straight at Junction)	1	0	1	0	X	X	1	1	1	0	1	0	1	1	X	X	Line Speed
10	Dummy Proceed	1	0	1	0	1	0	1	0	1	1	1	0	X	X	X	X	LH Turnout Speed

Notes:

1) In this instance, the 'Pulsating Medium' aspect of Signal 3 only belongs to the diverging routes at the junction and hence inputs from both the Turnout Repeaters are not required.

2) Refer to the AMS Look-ahead Design Guideline.

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10.2.2.8 JUNCTION SIGNAL - DOUBLE LIGHT (STANDARD CIRCUIT 18)

If the LEU is connected to a double light junction signal (Signal 7) for protecting a high risk turnout for controlling either a TSM-initiating BG or the Approach BG, the LEU Table will take the below form. Red and Yellow Lamp inputs from the bottom head won't be required in this situation.

XX – Don't Care; 10 – OFF 01 – Pulsating; 11 - ON		LEU A												LEU B										High Risk Turnout Protection
		1		2		3		4		5		6		1		2		3		4		5/6		
Mask	Signal Aspect	TOP R		TOP Y		TOP G		BTM G		D2		Spare		SRI 2		Spare		Shunt		LSp		Spare		AMS Response
1	Stop	X	X	1	0	1	0	1	0	X	X			X	X			1	0	1	0			LH Turnout Speed
2	Proceed - Straight	1	0	1	0	1	1	X	X	1	0			1	0			1	0	1	0			Line Speed
3	Caution Turnout / Medium Turnout (D1)	1	0	1	1	1	0	1	0	1	0			1	0			1	0	1	0			LH Turnout Speed
4	Caution Turnout / Medium Turnout (D2)	1	0	1	1	1	0	1	0	1	1			1	0			1	0	1	0			RH Turnout Speed
5	Low Speed	X	X	1	0	1	0	1	0	1	0			X	X			1	0	1	1			Line Speed
6	Shunt 2	X	X	1	0	1	0	1	0	1	0			1	1			1	1	1	0			Line Speed
7	Shunt SRI Fail	X	X	1	0	1	0	1	0	1	0			1	0			1	1	1	0			LH Turnout Speed
8	Dummy Proceed	X	X	1	0	1	0	1	1	1	0			1	0			1	0	1	0			Line Speed

Notes:

1) The layout assumes that the turnout speed of 7(M)C route is higher than that of 7(M)A route. Therefore the lamp monitoring inputs corresponding to 7(M)B and 7(M)C routes are provided to the LEU. In this case, the most restrictive speed for the junction is the turnout speed of 7(M)A route – this will be applied for Masks 1 & 7 without the divergent (post-turnout) Line speed.

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2) Mask 3 also covers the failure situation where main line route indicator lamp input into the LEU has failed and as a safe outcome, LH Turnout speed (i.e. the most restrictive speed of the junction) is enforced.

3) It is assumed in this example that there is an unacceptable operational restriction if trains are limited to 15km/h using 7(S)B, but there is no unacceptable identified operational restriction if trains are limited to 15km/h using 7(S)C.

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10.3 Overlap Deficiency Protection

10.3.1 CONTACT SENSING ARRANGEMENTS

10.3.1.1 LEU CONNECTED TO THE PROTECTING SIGNAL – SINGLE & DOUBLE LIGHT (STANDARD CIRCUITS 21 & 22)

XX – Don't Care 00 – Fault; 10 – OFF; 11 – ON		LEU												High Risk Overlap Deficiency Protection
		1		2		3		4		5		6		
Mask	Signal Aspect	1st Proceed for all Main / Shunt [1] HRs in Parallel		Spare		Spare		Spare		Spare		Spare		AMS Response
1	Proceed	1	1											Line Speed
2	Stop	1	0											Overlap Speed

Notes:

The above layout assumes a Catch Point in close proximity to Signal 3 which leads to a target speed <25km/h, and 3(S)A and 3(S)B both drive the conventional trainstop.

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10.3.1.2 LEU CONNECTED TO AN OUTER SIGNAL – SINGLE AND DOUBLE LIGHT (STANDARD CIRCUIT 23)

XX – Don't Care 00 – Fault; 10 – OFF; 11 - ON		LEU												High Risk Overlap Deficiency Protection
		1		2		3		4		5		6		
Mask	**Minimum Signal Aspect**	**Revoke TSM**		**Spare**		**Spare**		**Spare**		**Spare**		**Spare**		**AMS Response**
1	1: Medium or 1(A) clear	1	1											Line speed
2	Otherwise	1	0											Overlap Speed

10.3.1.3 LEU AT TWO BLOCKS AWAY FROM OVERLAP DEFICICENCY – SINGLE LIGHT SIGNALS (STANDARD CIRCUIT 24)

XX – Don't Care 00 – Fault; 10 – OFF; 11 - ON		LEU												High Risk Overlap Deficiency Protection
		1		2		3		4		5		6		
Mask	**Minimum Signal Aspect**	**Revoke TSM**		**Spare**		**Spare**		**Spare**		**Spare**		**Spare**		**AMS Response**
1	1: Full Clear or 1(A) clear	1	1											Line speed
2	Otherwise	1	0											Overlap Speed

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10.3.1.4 SUCCESSIVE MEDIUM ASPECTS – SINGLE LIGHT SIGNALS (STANDARD CIRCUIT 25)

XX – Don't Care **00 – Fault; 10 – OFF; 11 - ON**		**LEU**												**High Risk Overlap Deficiency Protection**
		1		**2**		**3**		**4**		**5**		**6**		
Mask	**Minimum Signal Aspect**	**Revoke TSM**		**Spare**		**Spare**		**Spare**		**Spare**		**Spare**		**AMS Response**
1	1: Medium and 3: Medium or 1(A) clear	1	1											Line speed
2	Otherwise	1	0											Overlap Speed

Notes:

1) Look-ahead information from Signal 3 is required as medium aspect on Signal 1 does not unambiguously indicate a proceed aspect on Signal 5, which is protecting the high risk overlap deficiency (high risk Level Crossing within the overlap in this case).

2) 1B(3HDR) HDR relay proves Signal 3 showing a medium aspect, which indicates Signal 5 at proceed.

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10.3.1.5 LEU AT TWO BLOCKS AWAY FROM OVERLAP DEFICIENCY – DOUBLE LIGHT SIGNALS (STANDARD CIRCUIT 26)

XX – Don't Care **00 – Fault; 10 – OFF; 11 - ON**		**LEU**												**High Risk Overlap Deficiency Protection**
		1		**2**		**3**		**4**		**5**		**6**		
Mask	**Minimum Signal Aspect**	**Revoke TSM**		**Spare**		**Spare**		**Spare**		**Spare**		**Spare**		**AMS Response**
1	1: Preliminary Medium or 1(A) clear	1	1											Line speed
2	Otherwise	1	0											Overlap Speed

Notes:

The preliminary medium aspect on Signal 1 unambiguously indicates Signal 5 (protecting the overlap deficiency) at Caution, hence no need for look-ahead information.

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10.3.1.6 LEU MORE THAN TWO BLOCKS AWAY FROM OVERLAP DEFICIENCY – DOUBLE LIGHT SIGNALS (STANDARD CIRCUIT 27)

XX – Don't Care 00 – Fault; 10 – OFF; 11 - ON		LEU												High Risk Overlap Deficiency Protection
		1		2		3		4		5		6		
Mask	**Minimum Signal Aspect**	**Revoke TSM**		**Spare**		**Spare**		**Spare**		**Spare**		**Spare**		**AMS Response**
1	1: Full Clear or 1(A) clear	1	1											Line speed
2	Otherwise	1	0											Overlap Speed

Notes:

The full clear aspect on Signal 1 unambiguously indicates Signal 7 (protecting the overlap deficiency) at Caution, hence no need for look-ahead information.

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10.3.1.7 SUCCESSIVE PRELIMINARY MEDIUM ASPECTS – DOUBLE LIGHT SIGNALS (STANDARD CIRCUIT 28)

XX – Don't Care 00 – Fault; 10 – OFF; 11 - ON		LEU												High Risk Overlap Deficiency Protection
		1		2		3		4		5		6		
Mask	**Minimum Signal Aspect**	**Revoke TSM**		**Spare**		**Spare**		**Spare**		**Spare**		**Spare**		**AMS Response**
1	1: Preliminary Medium and 3: Preliminary Medium or 1(A) clear	1	1											Line speed
2	Otherwise	1	0											Overlap Speed

Notes:

1) Look-ahead information (from Signal 3) is required as preliminary medium aspect on Signal 1 does not unambiguously indicate a proceed aspect on Signal 7, which is protecting the high risk overlap deficiency.

2) 1B(3PHDR) PHDR relay proves Signal 3 showing a preliminary medium aspect, which indicates Signal 7 at proceed.

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10.3.2 CURRENT SENSING ARRANGEMENTS

10.3.2.1 LEU CONNECTED TO THE PROTECTING SIGNAL – SINGLE LIGHT (STANDARD CIRCUIT 29)

XX – Don't Care 00 – Fault; 10 – OFF 11 – ON; 01 – Pulsating		LEU A												LEU B								High Risk Overlap Deficiency Protection
		1		2		3		4		5		6		1		2		3		4/5/6		
Mask	Signal Aspect	MK LT		R		Y		G		Spare		BOL (RH)		SRI 1		Spare		Shunt		Spare		AMS Response
1	Stop	X	X	X	X	1	0	1	0			1	0	X	X			1	0			Overlap Speed
2	Caution	1	0	1	0	1	1	1	0			1	0	1	0			1	0			Line Speed
3	Caution Turnout	1	0	X	X	1	0	1	0			1	1	1	0			1	0			Line Speed
4	Medium	1	0	1	0	0	1	1	0			1	0	1	0			1	0			Line Speed
5	Medium Turnout	1	0	X	X	1	0	1	0			0	1	1	0			1	0			Line Speed
6	Clear	1	0	1	0	1	0	1	1			1	0	1	0			1	0			Line Speed
7	Shunt 1	X	X	X	X	1	0	1	0			1	0	1	1			1	1			Line Speed
8	Shunt SRI Fail	X	X	X	X	1	0	1	0			1	0	1	0			1	1			Overlap Speed

Notes:

The above layout assumes a Catch Point in close proximity to Signal 3 which leads to a target speed <25km/h, and 3(S)A drives the conventional trainstop.

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10.3.2.2 LEU CONNECTED TO AN OUTER SIGNAL – SINGLE LIGHT (STANDARD CIRCUIT 30)

XX – Don't Care 00 – Fault; 10 – OFF 11 – ON; 01 – Pulsating		LEU A												High Risk Overlap Deficiency Protection	
		1		2		3		4		5		6		AMS Response based on LEU (connected to outer signal)	
Mask	Signal Aspect	MK LT		R		Y		G		BOL (LH)		Spare		1 block away from Overlap Deficiency	2 blocks away from Overlap Deficiency
1	Stop	X	X	X	X	1	0	1	0	1	0			Overlap Speed	Overlap Speed
2	Caution	1	0	1	0	1	1	1	0	1	0			Overlap Speed	Overlap Speed
3	Caution Turnout	1	0	X	X	1	0	1	0	1	1			Line Speed	Line Speed
4	Medium	1	0	1	0	0	1	1	0	1	0			Line Speed	Overlap Speed
5	Medium Turnout	1	0	X	X	1	0	1	0	0	1			Line Speed	Line Speed
6	Clear	1	0	1	0	1	0	1	1	1	0			Line Speed	Line Speed

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10.3.2.3 SUCCESSIVE MEDIUM ASPECTS – SINGLE LIGHT SIGNALS (STANDARD CIRCUIT 31)

XX – Don't Care 00 – Fault; 10 – OFF 11 – ON; 01 – Pulsating		LEU A (Signal 1 information)												Network Inputs: (Signal 3 LEU A – Look-ahead)		High Risk Overlap Deficiency Protection
		1		2		3		4		5		6		1		
Mask	Signal Aspect	MK LT		R		Y		G		BOL (LH)		Spare		Y – Signal 3		AMS Response
1	Stop	X	X	X	X	1	0	1	0	1	0			X	X	Overlap Speed
2	Caution	1	0	1	0	1	1	1	0	1	0			X	X	Overlap Speed
3	Caution Turnout	1	0	X	X	1	0	1	0	1	1			X	X	Line Speed
4	Medium (Signal 3 showing Caution)	1	0	1	0	0	1	1	0	1	0			1	1	Overlap Speed
5	Medium (Signal 3 showing Medium)	1	0	1	0	0	1	1	0	1	0			0	1	Line Speed
6	Medium Turnout	1	0	X	X	1	0	1	0	0	1			X	X	Line Speed
7	Clear	1	0	1	0	1	0	1	1	1	0			X	X	Line Speed

Notes:

Refer to the AMS Look-ahead Design Guideline.

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10.3.2.4 LEU CONNECTED TO THE PROTECTING SIGNAL – DOUBLE LIGHT (STANDARD CIRCUIT 32)

XX – Don't Care 00 – Fault; 10 – OFF 11 – ON; 01 – Pulsating		LEU A												LEU B								High Risk Overlap Deficiency Protection
		1		2		3		4		5		6		1		2		3		4/5/6		
Mask	**Signal Aspect**	**BTM R**		**TOP R**		**TOP G**		**BTM G**		**BTM Y**		**TOP Y**		**SRI 1**		**Spare**		**Shunt**		**Spare**		**AMS Response**
1	Stop	X	X	X	X	1	0	1	0	1	0	1	0	X	X			1	0			Overlap Speed
2	Caution	X	X	1	0	1	1	1	0	1	0	1	0	1	0			1	0			Line Speed
3	Caution Turnout	X	X	1	0	1	0	1	0	1	0	1	1	1	0			1	0			Line Speed
4	Medium	1	0	1	0	1	1	1	0	1	1	1	0	1	0			1	0			Line Speed
5	Prelim. Medium	1	0	1	0	X	X	1	0	0	1	1	0	1	0			1	0			Line Speed
6	Medium Turnout	1	0	1	0	1	0	1	0	1	1	1	1	1	0			1	0			Line Speed
7	Clear	1	0	1	0	X	X	1	1	1	0	1	0	1	0			1	0			Line Speed
8	Dummy Proceed	1	0	1	0	1	0	1	0	1	1	1	0	1	0			1	0			Line Speed
9	Shunt 1	X	X	X	X	1	0	1	0	1	0	1	0	1	1			1	1			Line Speed
10	Shunt SRI Fail	X	X	X	X	1	0	1	0	1	0	1	0	1	0			1	1			Overlap Speed

Notes:

The above layout assumes a Catch Point in close proximity to Signal 3 which leads to a target speed <25km/h, and 3(S)A drives the conventional trainstop.

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10.3.2.5 LEU CONNECTED TO AN OUTER SIGNAL – DOUBLE LIGHT (STANDARD CIRCUIT 33)

XX – Don't Care 00 – Fault; 10 – OFF 11 – ON; 01 – Pulsating		LEU A												High Risk Overlap Deficiency Protection		
		1		2		3		4		5		6		AMS Response based on LEU (connected to outer signal)		
Mask	Signal Aspect	BTM R		TOP R		TOP G		BTM G		BTM Y		TOP Y		1 block away from Overlap Deficiency	2 blocks away from Overlap Deficiency	More than 2 blocks away from Overlap Deficiency
1	Stop	X	X	X	X	1	0	1	0	1	0	1	0	Overlap Speed	Overlap Speed	Overlap Speed
2	Caution	X	X	1	0	1	1	1	0	1	0	1	0	Overlap Speed	Overlap Speed	Overlap Speed
3	Caution Turnout	X	X	1	0	1	0	1	0	1	0	1	1	Line Speed	Line Speed	Line Speed
4	Medium	1	0	1	0	1	1	1	0	1	1	1	0	Line Speed	Overlap Speed	Overlap Speed
5	Prelim. Medium	1	0	1	0	X	X	1	0	0	1	1	0	Line Speed	Line Speed	Overlap Speed
6	Medium Turnout	1	0	1	0	1	0	1	0	1	1	1	1	Line Speed	Line Speed	Line Speed
7	Clear	1	0	1	0	X	X	1	1	1	0	1	0	Line Speed	Line Speed	Line Speed
8	Dummy Proceed	1	0	1	0	1	0	1	0	1	1	1	0	Line Speed	Overlap Speed	Overlap Speed

Notes:

When the LEU is connected to the signal that is one block away from the overlap deficiency, Line Speed can be sent safely with Mask 8 (Dummy Proceed) while for the other two cases (two or more blocks away from the overlap deficiency), this mask will need to send the Overlap Speed.

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10.3.2.6 SUCCESSIVE PRELIMINARY MEDIUM ASPECTS – DOUBLE LIGHT SIGNALS (STANDARD CIRCUIT 34)

XX – Don't Care 00 – Fault; 10 – OFF 11 – ON; 01 – Pulsating		LEU A (Signal 1 information)												Network Inputs: (Signal 3 LEU A – Look-ahead)		High Risk Overlap Deficiency Protection
		1		2		3		4		5		6		1		
Mask	**Signal Aspect**	**BTM R**		**TOP R**		**TOP G**		**BTM G**		**BTM Y**		**TOP Y**		**BTM Y - Signal 3**		**AMS Response**
1	Stop	X	X	X	X	1	0	1	0	1	0	1	0	X	X	Overlap Speed
2	Caution	X	X	1	0	1	1	1	0	1	0	1	0	X	X	Overlap Speed
3	Caution Turnout	X	X	1	0	1	0	1	0	1	0	1	1	X	X	Line Speed
4	Medium	1	0	1	0	1	1	1	0	1	1	1	0	X	X	Overlap Speed
5	Prelim. Medium (Signal 7 at Stop)	1	0	1	0	X	X	1	0	0	1	1	0	1	1	Overlap Speed
6	Prelim. Medium (Signal 7 at Proceed)	1	0	1	0	X	X	1	0	0	1	1	0	0	1	Line Speed
7	Medium Turnout	1	0	1	0	1	0	1	0	1	1	1	1	X	X	Line Speed
8	Clear	1	0	1	0	X	X	1	1	1	0	1	0	X	X	Line Speed
9	Dummy Proceed	1	0	1	0	1	0	1	0	1	1	1	0	X	X	Overlap Speed

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Notes:

1) It is not possible to determine the route positively at Signal 1 during the failure situations that Mask 9 (Dummy Proceed) covers. Therefore, Overlap Speed is enforced without relying on the information received from the balise group prior due to data redundancy.
2) Refer to the AMS Look-ahead Design Guideline.

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