5.2.10 Sagging tracks

Failure Mode	Complete	Partial
Track Circuit Status	Stable	Unstable
Poses Release Risk	No	Yes
Comments	Under adverse environmental conditions, the track circuits may become unstable, dropping and picking repeatedly.	
Additional Controls		

5.2.11 Human Action - Vandalism

Failure Mode	Complete	Partial
Track Circuit Status	Stable	Unstable
Poses Release Risk	No	Yes
Comments	Faults caused by vandalism may in some cases clear themselves, or may be removed by the vandals or other people.	
Additional Controls		

5.2.12 Human Action - Engineering works

Failure Mode	Complete	Partial
Track Circuit Status	Stable	Unstable
Poses Release Risk	No	Yes
Comments	Infrastructure teams have caused track circuit failures by a variety of means. However, most affect only one track at a time, or are sustained for extended periods. Signaller(s) should be consulted before engineering works are undertaken in an interlocked area.	
Additional Controls		

6 SAFETY ANALYSIS

For a single failure to permit unsafe normalisation of a route, several factors must coincide:

- The situation must occur in an interlocked area;
- The two track circuits used to release the locking must both be affected;
- The signaller must not be aware that the tracks are unstable;
- Due to the delays applied to track circuit functions, the track circuits must simultaneously be up for several seconds to permit the signal to clear;
- The signal must remain clear for several seconds in order that the driver of an approaching train will see a higher indication and begin to adjust the speed of the train accordingly;
- The track circuits must then drop and pick in correct sequence; and
- The train must be approaching with speed and distance such that it cannot be stopped safely.

The existing failure reporting system is not geared toward identifying faults of a nature that could cause unsafe release of the approach locking with the proposed arrangement. A simple analysis of a limited set of records is included in Appendix B.

Anecdotal evidence from technical specialists supports the risk analysis assertion that a proved item is unlikely to fail. Track circuits will either be stable and reliable, completely failed, or so unstable that the signals affected will not remain clear for more than a few seconds, and the signallers will be aware that there is a problem.

The following table shows an assessment of the safety of all three options during the failures previously identified as posing a risk. The safety ranking is a comparative value only, as the lack of comprehensive track circuit failure data precludes calculation of probabilities. The safety rank is given a value on a scale of 1 to 5, 5 being the most safe. In this situation, 5 is applied to occurrences in which unsafe release should not be possible. Other values are based on a relative assessment of the rigour of the sequence testing in each option.

Assuming that for any failure that can affect both tracks, the probability of each track dropping is equal, the probability of producing each of the states identified in section 4.1 is 1/4. If a single failure should affect both tracks, the <u>relative probability</u> of a providing an unsafe release is:

Option 1: 1/4 x 1 x (1/4 + 1/4) x 1 x 1/4 = 1/32

Option 2: 1/4 x 1 x 1/4 x 1 x 1/4 = 1/64

Option 3: 1/4 x 1 x 1/4 x 1/4 x 1/4 = 1/256

6.1 Safety Ranking

Element	Failure Mode	Effect on Track Circuit Status	Additional Control	Safety Rank Option 1	2	3
Track Circuit 24V supply	Partial	Unstable. If both critical tracks affected, could pick ALSR depending on timing issues.	Design to ensure critical tracks do not share common small power supply.	5	5	5
Track circuit TX - AF centre fed or DPU	Partial	Unstable. If both critical tracks affected, could pick ALSR depending on timing issues.	Design to ensure these configurations not used where risk exists.	5	5	5
Traction Current Imbalance - AF Tuned Loop	Partial	Unstable. If both critical tracks affected, could pick ALSR depending on timing issues.		1	2	4
Block joint short circuit - any configuration	Complete or Partial	Unstable. If both critical tracks affected, could pick ALSR depending on timing issues.		1	2	4
Track Cable - AF tuned loop equipment	Partial	Unstable. If both critical tracks affected, could pick ALSR depending on timing issues.		1	2	4
Sagging tracks	Complete or partial	Unstable. If both critical tracks affected, could pick ALSR depending on timing issues.		1	2	4
Human Activity - Vandalism, Infrastructure (civil) work		Unstable. If both critical tracks affected, could pick ALSR depending on timing issues.		1	2	4

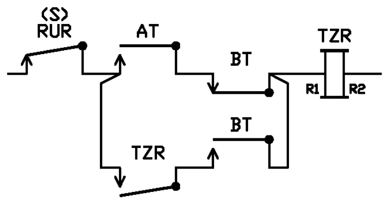
Recognising the other factors involved, such as signaller awareness of faults, and the timing of a train approaching, it is reasonable to conclude that Option 3 presents minimal risk to safety. Option 2 may also provide a sufficient level of safety, but Option 2 offers no technical or economic advantage over Option 3.

7 ENHANCEMENTS

The following is an assessment of enhancements that may be desirable or required in particular situations. They will not be considered part of the basic logic for release of approach locking, but would only be used where required and according to restrictions as noted.

7.1 Shunting Onto Occupied B Track

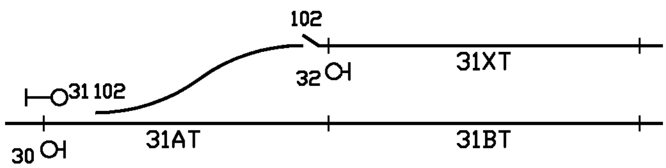
If a train has been signalled into a route, and remains on the B track, the TZR will remain up. If a shunt route is then cleared onto that occupied B track, the approach locking would not be effective because the A track and TZR are both up - if the signal were returned to stop, the route would normalise immediately. To avoid this, shunt RURs down are added in series in the front of the TZR logic.



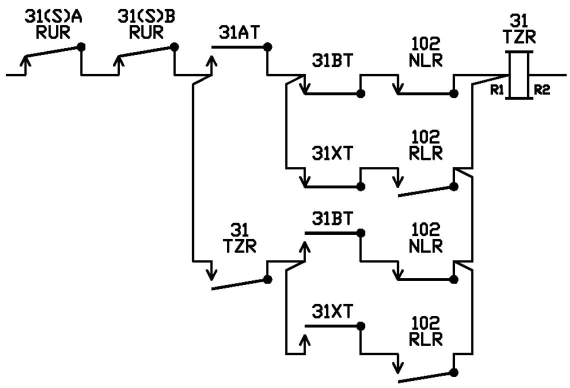
When the shunt route is set, the RUR picks and the TZR drops out. While the B track remains occupied, the TZR will not pick again, and in this case the ALSR must either time out or the approach path must be clear for the route to normalise.

This arrangement is only required for Option 3.

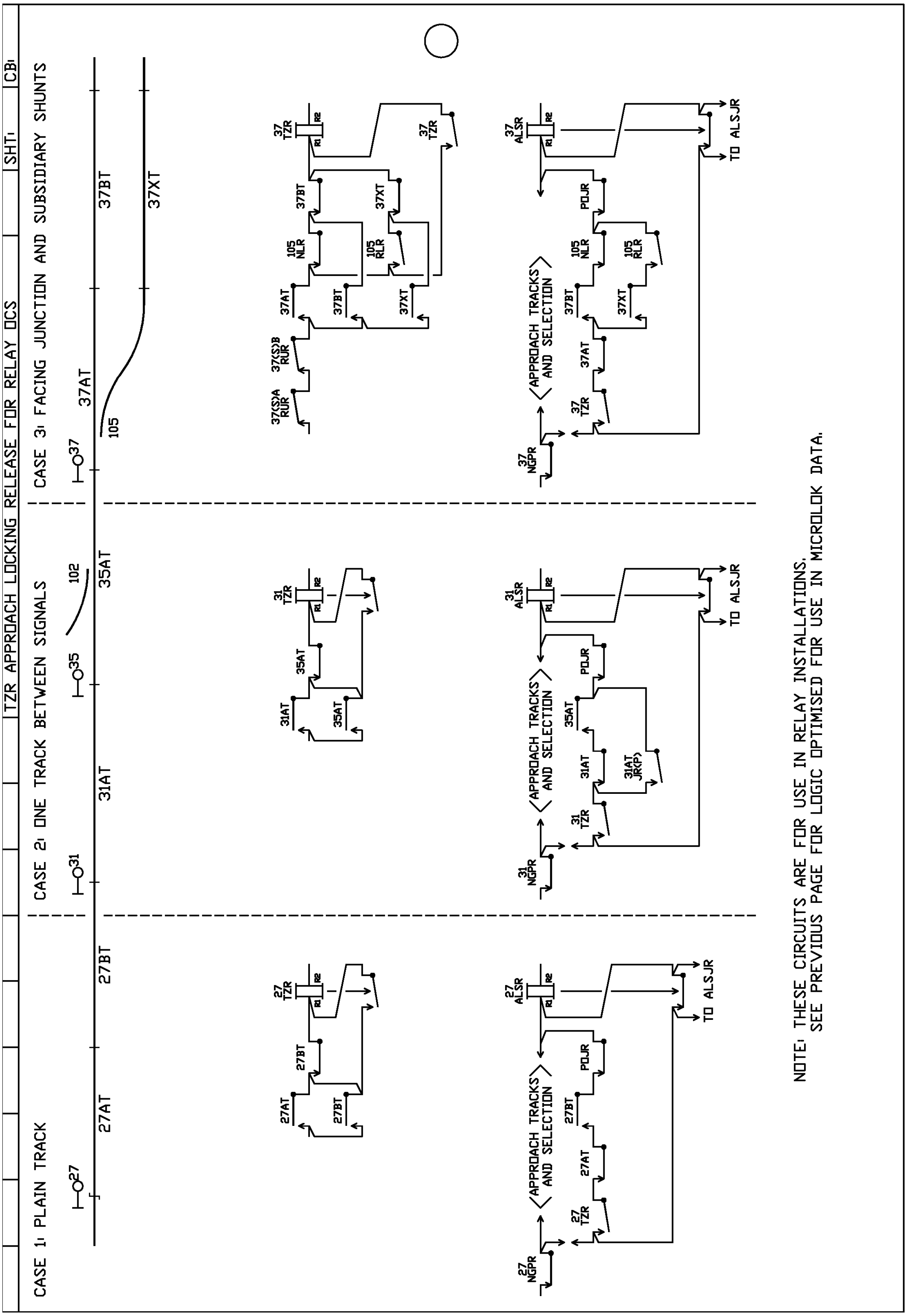
7.2 Selecting Alternate "B" Track Through Points



Where the A track has facing points, the B track will be different depending on the lie of the points. The correct B track must be selected to ensure that approach locking cannot be compromised by a train on the "wrong" B track, but can still be released by the passage of the train. Similar selection is required in Options 1 and 2.



Circuits for Relay Use



In the Microlok processor, a "front" bit "opens" in the same processing cycle as the "back" closes, and vice versa. As there is a finite delay in relay contacts changing over, the circuits for relay use differ from the Microlok logic but provide the same functionality.

APPENDIX B: TESTING OF LOGIC, LD61 SIGNAL, SEFTON PARK SIMULATION

Normal Operating Scenarios	Routes				Comments
	(M)A	(M)B	(S)A	(S)B	
Single through train. Set route. Operate track circuits as for normal passage of train approaching and passing signal. ALSR should pick when all approach tracks clear, with A track still occupied.	✓	✓	✓	✓	
Single train, detach locomotive and draw forward. Set route. Operate track circuits as for normal passage of train approaching signal. With berth track occupied, drop A track then B (or X) track. ALSR should pick with A track, with berth still occupied. TZR will remain up while B (or X) track occupied. With B (or X) track still occupied, proceed to next test.	✓	✓	✓	✓	
Cancelled shunt route onto occupied second track. With the second track still down and TZR up, set shunt route. Ensure TZR is dropped. Cancel route, ensure approach locking is effective. With B (or X) track still occupied, proceed to next test.	N/A	N/A	✓ ✓	✓ ✓	
Use shunt route onto occupied second track. With the second track still down, set shunt route. With approach occupied, drop A track, pick A track. Ensure approach locking still effective.	N/A	N/A	✓	✓	
Pick B track, ensure approach locking still effective.	N/A	N/A	✓	✓	
Second track occupied, set route to call points to opposite position. Manipulate tracks to pick TZR, pick A track, leave B or X track down. Set route over points in opposite position, ensure TZR drops.	✓	✓	✓	✓	
With approach occupied, cancel route, ensure approach locking effective.	✓	✓	✓	✓	
Route set over points, shunting moves on adjacent track. Set route. With approach occupied, drop A track, then track which would be second with points in opposite position (ie points normal, drop X track). Pick A track, ensure approach locking remains effective.	✓	✓	✓	✓	
Tracks bobbing, normal passage of long train Set route. With approach occupied, drop A track, pick A track, drop A track.	✓	✓	✓	✓	
Drop B track, pick B track, drop B track. Ensure route still approach locked.	✓	✓	✓	✓	
Long train and Route Release timer Set route. With approach occupied, drop all tracks to next signal. Ensure route remains approach locked until expiry of route release timer.	✓	N/A	N/A	N/A	SP61 does not meet criteria for use of route release timer, but proves concept.
Set route. Drop route release timer track on adjacent track (ie Y track with points normal). Drop A track, ensure that at expiry of route release timer approach locking is not released.	N/A	N/A	N/A	N/A	

Note that in the context of this testing, X track (first track after A with points reverse) refers to 61WT.

Failure Scenarios	Routes				Comments
	(M)A	(M)B	(S)A	(S)B	
Second track drops before A track Set route. With approach occupied, ensure approach locking remains effective at each step: Drop B (or X) track.	*	*	*	*	B (or X) Does not cancel route
Drop A track.	✓	✓	✓	✓	
Pick A track.	✓	✓	✓	✓	
Drop A track, pick B (or X) track.	✓	✓	✓	✓	
Pick A track	✓	✓	✓	✓	
A track picks before second track drops Set route. With approach occupied, ensure approach locking remains effective at each step: Drop A track.	✓	✓	✓	✓	
Pick A track.	✓	✓	✓	✓	
Drop B track.	✓	✓	✓	✓	
Pick B track.	✓	✓	✓	✓	
A track drops, then wrong second track for points position drops. Set route. With approach occupied, ensure approach locking remains effective at each step: Drop A track.	✓	✓	✓	✓	
If points normal, drop X track (drop B track if points reverse).	✓	✓	✓	✓	
Pick A track.	✓	✓	✓	✓	
Tracks drop simultaneously Set route. With approach occupied, ensure approach locking remains effective at each step: Drop AT, BT or AT, XT simultaneously. Ensure TZR does not pick up.	✓	✓	✓	✓	
Pick A track.	✓	✓	✓	✓	
Pick second track.	✓	✓	✓	✓	
Tracks pick simultaneously Set route. With approach occupied, ensure approach locking remains effective at each step: Drop A track, then second track (TZR should pick).	✓	✓	✓	✓	
Pick AT and second track simultaneously.	✓	✓	✓	✓	

Note that in the context of this testing, X track (first track after A with points reverse) refers to 61WT.

APPENDIX C: PRELIMINARY ANALYSIS OF ACTUAL TRACK CIRCUIT FAILURES

A report covering the year Jul 22 2004 - Jul 22 2005 was extracted from IFMS, and reviewed for track circuit failure data.

At the time of preparing this document the review is incomplete, but the following details have been observed from the IFMS report:

Period Reviewed:	22 Jul 04 - 21 Oct 04	92 days
Total track circuit failures	249	~ 2.7/day
Unstable track failures [1]	58	~ 23.3%
Failure affects two tracks [2]	36	~ 14.5%
Failure affects controlled signal [3]	145	~ 58%
SPAD of affected signal [4]	2	~ 0.8%

This is obviously a limited sampling, but it yields the following:

For Option 3, the probability of unsafe normalisation based simply on the product of the identified occurrence rates and the assumed relative probability of the sequenced failures shown in section 6 is:

$0.233 \times 0.145 \times 0.58 \times 0.008 \times 0.004 = 6.3 \times 10^{-7}$

or 1 unsafe normalisation in 1.6 million track circuit failures. At 2.7 failures per day, this translates to a roughly 1-in-1600 year event.

It is important to understand that this calculation is based on a statistically small sample, and the method of calculation has not been validated. Also, IFMS reports may not record all relevant details. Specifically:

1. Failures identified as "Unstable" include those reported as momentary, intermittent, came good after first train, or OK on arrival of staff. They have not been divided up to exclude those which are continuously down for longer than the normal 120" approach timer, unless the record states that a data logger revealed a long failure time.
2. Failures identified as affecting two tracks include those which have identified potential, on the basis of the equipment affected, to affect two tracks, even if only one track is listed on the report. This primarily relates to trackside components of jointless tracks, and short circuit block joints. In most cases only one track has been recorded failed in the report. The number of incidents where two tracks are actually affected is thus lower than shown in the table. Also, failures affecting two tracks may not have affected the two critical tracks for releasing the approach locking - the failure could affect the berth track and A track, or B and C tracks, etc. The number shown in the table does exclude those incidents where the failure is originally reported as affecting multiple tracks, but this is due to grouped indications to the signal box.
3. The records do not always record which signal is affected, so an attempt has been made to determine this based on track circuit names, local knowledge, and other information (such as track failed due to defective points rod insulation). Except where otherwise known tracks with distance-based

numbers are assumed to affect automatic signals, and tracks with lever-based numbers are assumed to affect controlled signals. This is not universal practice, as some controlled signals work over distance-numbered tracks, and some automatic signals between controlled signals in larger interlockings have been given lever-number identifications.

4. 1 of the 2 SPADs identified was not reported as a SPAD, but "signal returned to stop in face of train". There is no mention of whether the train actually passed the signal, if it pulled up short of the signal, or if it was even moving - it may have been waiting to depart a platform. The second SPAD occurred when a track in the overlap, not in the signal route, failed. There is also no reference to the severity of the SPADs - whether the overrun was only a few metres or hundreds of metres. For all other track circuit events, there is no reference to trains approaching affected signals.

It is also worth noting that there have been no recorded instances of unsafe release of approach locking, even in older interlockings where approach locking did not extend back to the first warning signal, and single drop track release was provided.