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About This Standard

This specification details the requirements for a Railway - Road level crossing event logger, remote battery tester, and monitor for the ARTC.

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1. Introduction

1.1. Scope

This specification details the requirements for a Railway - Road level crossing event logger, remote battery tester, and monitor for the ARTC.

1.2. Definitions

The following definitions apply for this specification:

ARTC

The Infrastructure Owner, Australian Rail Track Corporation

2. Referenced Documents

The following ARTC documents are referenced:

SPS 01	<i>Standard Requirements for Signalling Electronic Systems.</i>
SPS 06	<i>Connections for Signalling Interface.</i>
SPS 04	<i>General Requirements for Labelling of Signalling Equipment.</i>
SPS 07	<i>Vital Indication Optoisolator.</i>
SDS 25	<i>Signal Circuit Design Standards.</i>

3. General Description

- The level crossing monitor, monitors the status of a level crossing, logs events, reports warning or failure conditions to a central location, and provides facilities to remotely test the level crossing battery supply.
- The level crossing monitor shall be designed in such a way as to minimise the risk of providing incorrect information in a manner that is not obviously incorrect, or of reducing the integrity of the level crossing.
- The event logging retains at least the last 8000 selected relay status, analogue voltage or "number of lamps operating" changes.
- Level crossing protection equipment is essentially non fail-safe in its operation. It relies on the illumination of normally dark signal lamps to provide a safe indication, and on the road users' response to the signal, to halt safely clear of the rail crossing.
- ARTC level crossings are constructed and maintained to provide the highest levels of reliability and safety. Nevertheless, reports of failure to operate correctly are received from time to time. Any such report is investigated exhaustively, to determine what the cause of the reported failure might be, and to provide urgent repair of any fault revealed by the inspection. If, as often occurs, no fault is found, the question remains unresolved whether the failure report was prompted by an intermittent fault, or an error of observation by the person making the report.

Likewise, any accident or incident on a level crossing calls into question the safety of the system. The subsequent enquiry would benefit from the ability to provide a detailed record of the operation of the equipment at the time of the incident.

There is an evident need for a method of data recording that will enable the recent operational history of a level crossing to be 'read', after the report of that level crossing equipment having failed to operate properly.

It is considered inevitable that once a unit is installed, it will eventually be required to provide data acceptable as legal evidence, for instance in the event of an enquiry following a level crossing fatality. In that case the normal software design and testing will need to have been augmented by a stringent process of specification, documentation and independent validation, to produce a record that can be presented and accepted by the court as reliable evidence.

4. Specific Requirements

4.1. Functional Requirements

4.1.1 Operation and self checking

The level crossing monitor shall:

- Automatically start-up and commence monitoring on initiation of electrical power.
- Automatically re-start if the software ceases to operate correctly.
- Shut-down if more than 3 re-starts occur without 300 seconds of continuous operation.
- Check all configuration data on start-up and indicate a system fault if it is invalid.
- Shutdown if the power supply is out of limits for correct operation.
- Continuously check that the software, and real time clock are operating correctly.
- Log the date and time that the level crossing monitor starts operating or stops operating.

4.1.2 Digital inputs

The Level Crossing monitor shall have a minimum of 32 digital inputs (48 digital inputs preferred) that are logged and 8 inputs that are not logged.

The following digital inputs shall to be connected to the Level Crossing monitor when available at the particular Level Crossing:

- All track circuits that control the operation of the level crossing.
- Direction stick relays.
- The level crossing control and repeat relays.

- Test switch.
- Gate (Boom Arm) 85-90 degree state.
- Lights, Bell and Gate (Boom Arm) emergency switches.
- AC supply state.
- Low battery voltage indication from charger.
- Any other function that qualifies the operation of the Level Crossing (for example approach signals).
- Bell state.
- Crossing normal relay.
- Reset fault or warning.
- Output state of each flasher.
- Other relays/contacts of interest.

The state of each digital input shall be checked at least once every 0.25 seconds.

4.1.3 Digital outputs

The Level Crossing monitor shall have a minimum of 8 digital outputs. All digital outputs shall be logged.

Outputs shall comply with SPS 06 *Connections for Signalling Interface* and be suitable to drive 12 volt BRB 930 series relays directly.

The current state of the outputs shall be indicated on the level crossing monitor.

The Level Crossing monitor shall provide outputs as follows:

- Battery test

Used to control battery test.

- No Fault

This output is ON when no fault condition has been detected with the level crossing equipment. The fault indication remains until acknowledged.

- No Warning

This output is ON when no warning condition has been detected with either the level crossing monitor or the level crossing equipment. The warning indication remains until acknowledged.

- System fault

This output operates in conjunction with the No Warning output. This output is ON when a fault has been detected with the level crossing equipment. The output

remains on until the fault condition has been acknowledged.

- Battery low

This output operates in conjunction with the No Fault and No Warning outputs. This output is ON when a fault or warning condition has been detected with the level crossing battery. The output remains on until the fault or warning condition has been acknowledged.

- Lamp problem

This output operates in conjunction with the No Fault and No Warning outputs. This output is ON when a fault or warning condition has been detected with the level crossing lamps. The output remains on until the fault or warning condition has been acknowledged.

- Logic problem

This output operates in conjunction with the No Fault and No Warning outputs. This output is ON when a fault or warning condition has been detected with the operation of the level crossing equipment. The output remains on until the fault or warning condition has been acknowledged. This output FLASHES to indicate that the Level Crossing monitor is maintenance disabled.

- Timer test
- Used to control both the timer and battery tests.

4.1.4 Analogue Inputs

The Level Crossing monitor shall have a minimum of 8 analogue inputs.

Analogue inputs shall be protected against reverse polarity connections and surges.

The first analogue input shall be electrically conditioned for a 0 to 20 volts DC input voltage. This input shall be used to monitor the Level Crossing battery voltage.

The Battery voltage shall be considered to have changed when the voltage is more than 0.5 volts different to the last recorded value.

At least 4 Analogue inputs shall be provided to monitor the Level Crossing lamp currents in the range of 0 to 20 amps DC.

Normally two sets of lamps are connected to each circuit which is monitored by one analogue channel. An electronic flasher changes between the sets of lamps at about 45 times per minute when the lamps are operating. The two sets of lamps may be identified as Flasher Up and Flasher Down for the purposes of the Level Crossing monitor. A digital input may be used to monitor the state of the flasher.

It is expected that both the flasher state digital input and the lamp current input will be used to determine the number of lamps operating in each set of lamps for each circuit.

A change shall be considered to have occurred on a lamp analogue channel when a different number of lamps are determined to be operating for either set of lamps to the previously determined number.

At least 2 Analogue inputs shall be provided as general purpose analogue inputs. These shall be configurable to monitor temperature, currents, lamps, or voltages.

One Analogue input shall be used to monitor the battery test load current in the range of 0 to 20 amps DC. A change shall be considered to have occurred when the current is more than 0.5 amperes different to the last recorded value.

4.1.5 Logging

The Level Crossing monitor shall detect changes in its analogue inputs, digital inputs and its digital outputs. Details of these changes shall be stored with their date and time (to the tenth of second) of occurrence. At least the last 8000 changes shall be stored.

The log shall be maintained in a non-volatile storage medium. The log shall still be retrievable after the Level Crossing monitor has been removed from service, transported to another location, and left without power for at least 31 days.

The oldest event shall be automatically replaced by the next new event when the event log is full.

Changes to the state of the flasher inputs shall not be logged. This is solely to prevent wasting log space.

4.1.6 Monitoring

The Level Crossing monitor shall check the digital inputs and analogue inputs for correct relationship, sequence and timing.

The Level crossing monitor shall process Boolean logic with, internal intermediate states and timer facilities.

The logic shall be configurable for each particular level crossing.

The Level crossing monitor shall determine the number of lamps operating on each lamp circuit; check the number of lamps operating against the number that should be operating; provide a fault indication when the number of lamps detected is more than expected on any particular lamp circuit, or two or more less than the expected; and provide a warning indication when the number of lamps detected is one less than the expected.

The Level Crossing monitor shall provide for the use of additional fault or warning inputs.

The Level crossing monitor shall provide an indication that remote battery testing is in progress.

The Level crossing monitor shall provide spare inputs for logging additional track circuits and control relays.

In general the logic shall be as follows:

In normal operation the level crossing monitor will display two green LEDs which indicate NO FAULT and NO WARNING. If the monitor reports its status to a computer these two indications are combined to give a status of NORMAL. If a designated FAULT occurs then the LED for NO FAULT shall extinguish indicating

that a **FAULT** has occurred. If a designated **WARNING** occurs then the LED for **NO WARNING** shall extinguish indicating that a **WARNING** has occurred. As well as **WARNINGS** or **FAULTS** being indicated on the front panel appropriate messages are reported via the serial port to allow remote reporting of **FAULTS** and **WARNINGS**.

The **NO FAULT** status indicates that the battery voltage is not low, no more than one lamp is out, more lamps than expected have not been found, and that there is no other designated fault condition detected by the level crossing monitor logic. The Fault indication is latched until the fault reset push button is pressed or the fault reset command with the appropriate pin number is received from a serial channel.

The **NO WARNING** status indicates that none of the designated warning conditions are present. The Warning indication is latched until the fault reset push button is pressed or the fault reset command with the appropriate pin number is received from a serial channel.

A status indication of **WARNING** is indicated if one or more of the following has occurred:

- No remote test or local test of the level crossing has occurred within the last 36 hours.
- No train has traversed the level crossing within the last 72 hours.
- The Emergency switches have been turned off for more than 10 minutes.
- There has been a failure of some nominated item of signalling equipment near the level crossing eg. points detection failure, signal lamps out or track failure.

A status indication of **WARNING & LAMP** is indicated if:

- One of the lamps is not working.

A status indication of **WARNING & BATTERY** is indicated if:

- The AC Supply has been OFF for more than 6 hours 30 minutes.

A status indication of **WARNING & SYS_FAULT** is indicated if:

- The Level Crossing Monitor itself has an internal fault. A possible internal fault could be due to failure of the clock, CPU, memory, log data, analogue input, EPROM, a test output being ON without a test being requested.

A status indication of **FAULT & LOGIC** is indicated if the level crossing has:

- not started operating 6 seconds after the time that it should start operating.
- not stopped operating 6 seconds after it should have stopped operating.
- not had a change of state on the flasher inputs within the last 5 seconds when the level crossing should be operating.
- operated continuously for more than 20 minutes.

- the Boom normal when it should not be, or not normal when it should be normal.
- either direction stick relay is energised when no train is present.
- Battery Test relay is faulty or not present (possibly causing the battery charger to be without power).

A status indication of **FAULT & LAMP** is indicated if:

- Two or more of the lamps are not working.
- More lamps are operating than expected on any lamp circuit (a possible short circuit).

A status indication of **FAULT & BATTERY** is indicated if:

- the battery voltage is below its configured alarm point as measured by the level crossing monitor for more than 3 seconds.
- the low battery alarm card input is off for more than 3 seconds.
- the remote testing of the level crossing battery has not drawn sufficient test current for more than 7 seconds.

Due to track maintenance vehicle considerations, the following entry is to be recorded in the log but not alarmed:

- level crossing lights have been operating for less than 20 seconds before the train arrives at the level crossing.

It is possible to have multiple status indications which would indicate that more than one fault has occurred. For example a failure of a flasher unit will give **FAULT & LAMP & LOGIC**.

A status indication with **LOGIC flashing** once per second indicates that the monitor has had its reporting of status changes disabled temporarily. When in this state the monitor will not report changes of status to the control centre. This state, if available is entered by holding the Fault Reset button pressed for 5 seconds. It is cancelled by a momentary push of the Fault Reset button or at a pre-programmed interval after activation. Normally this time-out is set for 45 minutes. All Faults and Warnings must be cleared before cancelling this mode otherwise they are to be reported to the remote site (Control Centre).

4.1.7 Status reporting

The Level Crossing monitor shall indicate its status locally using No Warning and or No Fault outputs. If a warning or fault occurs, it shall turn off the No Fault or No Warning outputs as appropriate and indicate the cause by turning on either system, lamp, battery, or logic output as appropriate. Status changes shall be reported to either of two pre-programmed phone numbers via a dial-up modem if this facility is enabled. One phone number will be the normal the other the alternate. The message requires an acknowledgment. If not acknowledged the modem shall be hung-up and the call terminated. The level crossing monitor shall continue for 3 attempts, at 3minute intervals on each phone number, to report the status change. A delay of up to 4 hours is waited before re-commencing to attempt to report the

status change. The process must comply with Austel requirements for modems.

A facility is required for local level crossing maintenance staff to temporarily disable the status reporting whilst maintenance is carried out. The maintenance staff shall not be required to have any equipment to use the temporary disable facility.

4.1.8 Battery Testing

The level crossing monitor shall have the facility for testing the current state of the level crossing battery and reporting the results to a remote location via a dial-up modem.

The level crossing monitor shall use outputs 1 and 8 (that is Battery Test, and Timer Test) to control the battery test. These outputs control the 120 V AC supply to the level crossing battery charger, and a test load for the level crossing battery.

The process of testing the level crossing battery and the level crossing monitor when requested shall be as follows:

- Perform a through check of the operation of the Level Crossing monitor which includes processor test, event log integrity check, program checksum, configuration check, and memory test. If all checks do not pass then abort the battery test, indicate a system fault and report it.
- Check battery voltage to determine if it is within limits. If it is too low, then abort the battery test, indicate a battery Fault and report it.
- Check that the battery test current is less than 1.0 amps and the Battery test cut-off indication is ON.
- Report that the test will commence and break the communications link. That is hang-up the modem.
- Turn on output 8 (that is Timer test). Check that the Battery test cut-off indication turns OFF between 270 and 330 seconds later. If it does not, then abort the battery test, indicate a Fault and report it.
- Turn OFF timer test output 8.
- Check that the battery test current is less than 1.0 amps and the Battery test cut-off indication is ON.
- If the crossing is operating, delay until at least 30 seconds after the crossing has stopped operating.
- Turn ON both timer test output 8 and Battery test output 1 at the same time, for 4 minutes.
- Monitor that the Battery test current is greater than 6 amps and battery voltage remains greater than alarm voltage.

If the battery voltage drops below the alarm voltage during the test, stop the test, and indicate a battery fault;

if the battery test current drops below 6 amps for more than 7 seconds during the test, stop the test, and indicate a battery fault; otherwise terminate the test at the

end of 4 minutes and indicate and report that the test passed, and the current state of the level crossing.

- The previous step is terminated if the crossing starts operating and the process is restarted at “Turn ON both timer test output 8 and Battery test output 1 at the same time, for 4 minutes”, at least 30 seconds after the crossing has stopped operating.

4.1.9 Control and Interrogation

The control and interrogation facilities shall be via an RS232 serial port. The user should see no difference in operation between a local connection and a remote connection via a dial-up modem.

The following facilities shall be provided:

- Display all logged events starting from the oldest and finishing with the most recent event. The user shall be able to pause, continue, and abort this display.
- Display all logged events starting from a given date and time and finishing with the most recent event. The user shall be able to pause, continue, and abort this display.
- Display all logged events starting from a given date and time and finishing with a given date and time. The user shall be able to pause, continue, and abort this display.
- Display time and date.
- Set time and date. This facility shall be protected by requiring the user to provide a predetermined operations security code.
- Display inputs, outputs, intermediate (internal logic states), and timer names and current state.
- Display current lamp status and configuration.
- Display current battery voltage and configuration.
- Set serial port configuration.
- Display serial port configuration.
- Reset warnings and faults. This facility shall be protected by requiring the user to provide a predetermined maintenance security code.
- Initialise the event log. This facility shall be protected by requiring the user to provide a predetermined maintenance security code.
- Perform a self test and battery test. This facility shall be protected by requiring the user to provide a predetermined operations security code.
- Enable or disable the immediate reporting of changes to the user in addition to logging changes.

- Enable or disable dial-up on status changes. This facility shall be protected by requiring the user to provide a predetermined maintenance security code.
- Set the phone number to dial when a warning or fault occurs. This facility shall be protected by requiring the user to provide a predetermined operations security code.
- Display name, data version, code version, status, report phone number, and report state.
- Set security codes. This facility shall be protected by requiring the user to provide a predetermined master security code.
- Conduct a self test and report results.
- Set and display modem configuration. This facility shall be protected by requiring the user to provide a predetermined maintenance security code.
- Download and Upload permanent configuration data. This facility shall be protected by requiring the user to provide a predetermined maintenance security code.
- Calculate the location specific lamp offsets and apply them if they are valid. This facility shall be protected by requiring the user to provide a predetermined maintenance security code.
- Display lamp calculation details.

4.1.10 Configuration

There are two types of configurable items. One set may be changed during normal operation. The other set cannot. Both are stored in non-volatile memory.

Configurable items that cannot be changed during normal operation are:

- Name and date of the permanent configuration data.
- For each digital input, its name.
- For each digital output, and intermediate state their names and controlling boolean expressions.
- For each Timer its name, controlling boolean expression, and duration in hours, minutes, and seconds.
- For the battery analogue input, its name, fail voltage, and bus voltage correction.
- For each lamp analogue input, its name, analogue channel number, number of lamps expected on flasher up, number of lamps expected on flasher down, flasher input, and an intermediate state that identifies when the lamps should be on.
- For the battery test current analogue input, its name, analogue channel number, “on” current in amperes, “off” current in amperes.

The configuration details above shall have a checksum or equivalent mechanism that is checked to confirm that they are valid.

Configurable items that can be changed during normal operation are:

- Name of crossing
- Phone number to report too
- Serial port setup
- Reporting state. That is report changes, dial-up on status change, or do not report changes or dial-up on status change.
- Current date and time
- Battery bus offset from measured value
- Lamp offsets for each particular lamp set. This may be required to allow for variations in level crossing installations. This should be able to be manually entered as well as learnt from level crossing operation.

4.2. Interface Requirements

4.2.1 Lamps

A non-invasive method of detecting the number of lamps operating shall be used. This method shall be designed so that any fault in the lamp detection is detectable.

The method used for detecting the number of lamps operating shall cater for the initial peak current each time a lamp is turned on, the tolerances in lamps, and fluctuations in battery voltage.

The lamp detection method shall be able to discriminate between 0, 1, 2, 3, 4, or 5 lamps operating.

4.2.2 Voltage free contacts

The level crossing monitor shall have a minimum of 32 optically isolated digital inputs in accordance with SPS 06 *Connections for Signalling Interface*.

These inputs shall operate from a 12 volts DC nominal signalling power supply. Each input shall draw at least 5 mA. This is required to ensure reliable operation of the safety relay contracts.

4.2.3 Intermediate points in circuits

Digital inputs that monitor intermediate points in Signalling circuits shall use Vital Indication Optoisolators in accordance with SPS 07 *Vital Indication Optoisolator*.

4.2.4 Power supply

The Level Crossing monitor shall operate from the 12 volt nominal battery supply for the level crossing. This supply varies from 11 to 18 volts depending on the equipment installed and the state of the batteries and charger.

The Level Crossing monitor shall not earth the power supply or connect either polarity of the supply to the case.

The Level Crossing monitor shall operate from a 10.5 to 20 volt DC supply.

The Level Crossing monitor shall have a breakdown voltage to earth of greater than 500 Volts DC.

4.2.5 Communications

The level crossing monitor shall be supplied with a V22 bis or better dial-up modem that operates from a 10.5 to 20 volt DC supply. This modem shall support the 'Hayes AT' compatible command protocol.

The modem shall not earth the power supply or have either polarity of the supply connected to its case.

The modem shall have Austel approved surge protection fitted to the telephone line.

The level crossing monitor shall manage:

- initiating a call via the modem,
- terminating a call via the modem,
- configuring the modem,
- and answering a call via the modem.

The modems and the their operation shall comply with Austel requirements. Primarily these include answering calls after 2 or more rings, and not dialling the same number repeatedly.

4.2.5.1. Serial Protocol

- The level crossing monitor must support 1200, 9600 and preferably support 19200 bits per second asynchronous. It shall support character formats of eight data bits with odd, even, or no parity and one stop bit.
- Messages shall sent and received in packets. Each packet shall have error checking and its correct reception shall be acknowledged.
- Messages that are not acknowledged shall be resent a minimum of three times with a delay between sending. If they remain un-acknowledged. Then the communications link is deemed to have failed and the connection is terminated.

4.2.5.2. Message content

Each message shall contain the identity of the particular level crossing monitor that it concerns.

4.2.6 Standard Signalling circuits

The level crossing monitor shall interface to the level crossing signalling equipment in accordance with the approved circuits for connecting the Level Crossing monitor to

ARTC Level Crossings. Circuit sheets X14 to X26 are the relevant sheets of SDS 25 *Signal Circuit Design Standards*.

4.3. Environmental Requirements

The Level Crossing Monitor shall perform as specified herein in ambient temperatures of 0 to 55 degrees Celsius and relative humidities up to 85% non-condensing.

The Level Crossing monitor shall operate correctly with a 10 watt FM radio transmitter in the frequency range of 100 to 600 MHz operating at a distance of 3 metres.

The Level crossing monitor shall operate correctly after each of the following tests have been conducted:

- AS 1099.2.31 Test Ec Drop and Topple. The Level Crossing Monitor is not connected or operational. The test surface shall be concrete. All 4 bottom edges are to be used. Height of drop onto a face is to be 100mm and height of drop onto a corner is to be 100mm.
- AS1099.2 Test Ed Free fall. The Level Crossing Monitor is not connected or operational. The test surface shall be concrete. Height of fall shall be 1000mm. The Level Crossing Monitor will be released from a horizontal position (ie. bottom of case is parallel with test surface). The test shall be conducted twice.
- AS1099.2.6 Test Fc: Vibration tests while Level Crossing Monitor is operating with test software. The Frequency range shall be 1 to 100 Hz. The vibration amplitude shall be 0.35mm. The type and duration of endurance shall be 20 sweep cycles. At the completion of the test the Level Crossing Monitor shall still be functioning correctly with no faults encountered.
- The housing for the level crossing monitor shall meet the requirements of IP 32. The Level Crossing monitor shall be protected against power supply and lightning surges. The Level Crossing monitor shall not use or require forced cooling to meet the environmental requirements.

4.4. Mechanical Requirements

The Level Crossing monitor and its ancillary equipment should mount on DIN Mounting rail TS32, or BRB 930 style relay racking.

4.5. Integrity

The Level Crossing monitor shall detect all faults with itself that could reasonably be expected and indicate a system fault. The faults detected shall include : Memory faults - RAM and EPROM, CPU faults, Digital input faults, Analogue input faults, Digital output faults, corruption of memory contents, Real Time Clock failure, and current sensor faults.

Faults with the operation of most digital inputs shall be detected and indicated within the passage of one train. Digital inputs that are only logged are not required to have faults automatically detected.

Faults with the lamp detection shall be detected and indicated on the Level Crossing

Monitors front panel and reported to the Control Centre within or immediately after the passage of one train.

Assurance shall be provided by an independent review of the system that it is improbable that the level crossing monitor will indicate that the level crossing is operating correctly after the passage of a train without both the monitor and the Level Crossing equipment being essentially operating correctly given that a self test and battery test is carried out every day.

The level crossing monitor shall be designed and tested to provide proof that the level crossing monitor will not reduce the safety, integrity of, reliability of, or public confidence in the level crossing.

The level crossing monitor shall turn off all its outputs if the monitor is not operating reliably.

The level crossing monitor shall have an independent method of disconnecting the battery test load and restoring power to the level crossing battery charger that is automatically tested as part of the battery test process.

4.6. Reliability

The designed Mean Time Between Failures (MTBF) for the Level Crossing monitor shall be greater than 50,000 hours.