

ELCON
AUTOMATED
START/STOP SYSTEM
FOR
LOCOMOTIVES

SYSTEM SPECIFICATION

System Overview

INTRODUCTION

The overall concept of the automatic start/stop system (Auto-SS) for locomotives is to provide a computerized system to monitor environmental conditions, to sense the operating state of the locomotive, and to startup or shutdown the locomotive as required. The purpose of the system is to prevent damage to the locomotive during hazardous cold weather conditions and to reduce fuel consumption on locomotives that remain in a prolonged idle state.

PHYSICAL DESIGN

The system consists of an electronic start/stop controller, an electronic engine protection device, and an operator display. The electronic start/stop controller is installed in the high voltage cabinet. The electronic engine protection device is installed in the AC fan contactor cabinet in the diesel engine compartment. Finally, the operator display is installed in the door of the high voltage cabinet so that it is visible to operators in the locomotive cab.

The electronic engine protection device is an existing product that is used on locomotives as a replacement for the mechanical low water engine protector. It consists of an electronic control module, water pressure sensors that are fitted to diesel engine, and wiring that connects to governor control valves and other parts of the locomotive. An enhanced version of the electronic control module has been created for the automated start/stop system. Additional features have been added so that the needs of the Auto-SS system can be met.

The electronic start/stop controller is based upon the same proven electronics as the engine protector. It operates with different system software to meet the unique requirements of the Auto-SS system.

The operator display is a variation of a proven display system used by Elcon for other rail-products. This display is unique to the Auto-SS system – but is based upon hardware that has been proven in other applications.

SYSTEM FUNCTIONAL BLOCKS

The Auto-SS system logically divides into two functional blocks, startup and shutdown. Startup starts a non running locomotive, shutdown stops a running locomotive. Each function evaluates the locomotive signals and operates the control devices that will startup or shutdown the locomotive as required by the specific conditions and limits of the system programming.

STARTUP PROCESS

The startup process is controlled by combination of signals. There are a set of signals that will activate locomotive startup, a set of signals that will cancel the startup process, and a set of signals that will inhibit the locomotive startup. The inhibit signals are used to prevent unsafe operation of the locomotive or to override the system.

Any one of the following signals will initiate the startup process.

- Push the start button on the operator display.
- The reverser handle is moved from the centered position.
- The throttle handle is moved from the idle position.
- Low ambient air temperature limit. [Default is 5 °C (40 °F)]
- Low engine water temperature limit. [Default is 30 °C (86 °F)]
- Low battery charge limit. [Default is 70% of full charge]
- Low main reservoir compressed air pressure limit. [Default is 105 psi]

Any one of the following signals will cancel the startup process when the signal occurs during the startup process.

- Push the stop button.
- Move the reverser handle back to the centered position.
- Move the throttle handle from power to idle or low idle position.

Any one of the following signals will inhibit the locomotive Automatic startup process.

- The Auto-SS system is locked out from the operator display.
- Locomotive was not shutdown by the Auto-SS system. The Auto-SS system will only re-start a locomotive if it had caused the shutdown. This prevents the Auto-SS from restarting a locomotive that was shutdown by the operator or other events.
- The number of startup retry attempts was exceeded.

SHUTDOWN PROCESS

The shutdown process is controlled by combination of signals. There are a set of signals that will indicate it is safe to shutdown the locomotive, a set of signals that will initiate the shutdown process, and a set of signals that will inhibit the shutdown process.

When all of the following conditions are met, it will be safe to shutdown the locomotive.

- Locomotive is running.
- The Auto-SS system is active (i.e. it has not been locked out).
- Reverser handle is in the centered position.
- Throttle handle is in the idle or low idle position.

Any one of the following signals will initiate the shutdown process.

- Push Stop button on Auto-SS system.
- Engine Shutdown timer has expired.
- After low battery limit startup, battery recharge is complete.

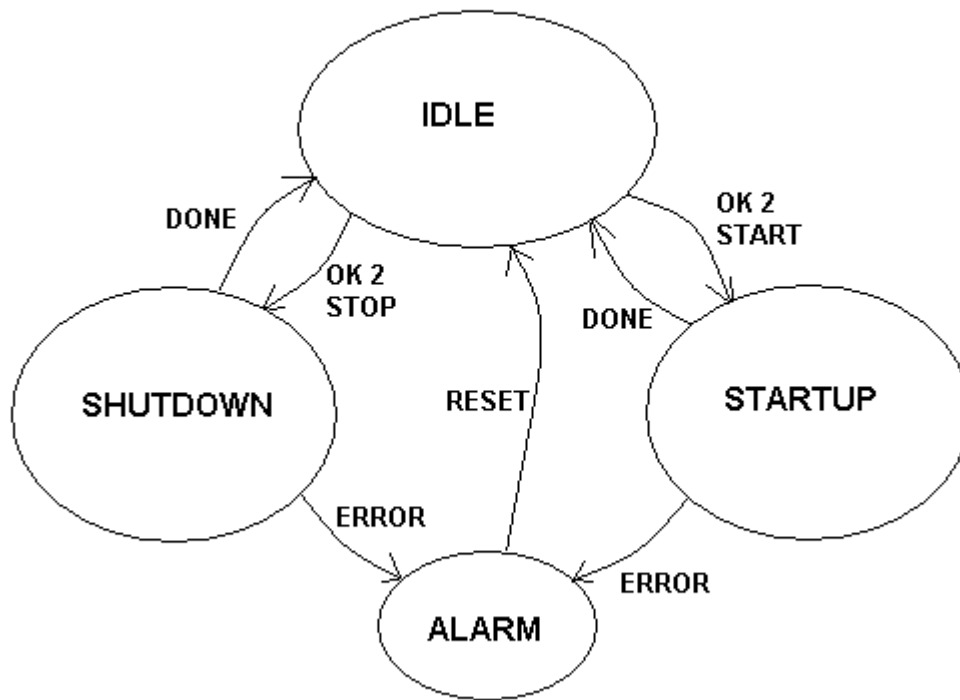
Any one of the following signals will inhibit the shutdown process.

- The Auto-SS system is locked out from the operator display.
- Ambient air temperature is below the limit. [Default is 5 °C (40 °F)]
- Engine water temperature is below the limit. [Default is 30 °C (86 °F)]
- Battery is below the charge limit. [Default is 70% of full charge]
- Main reservoir air pressure is below limit. [Default is 120 psi]
- Minimum run time has not been met. [Default is 30 minutes]

SOFTWARE DESIGN

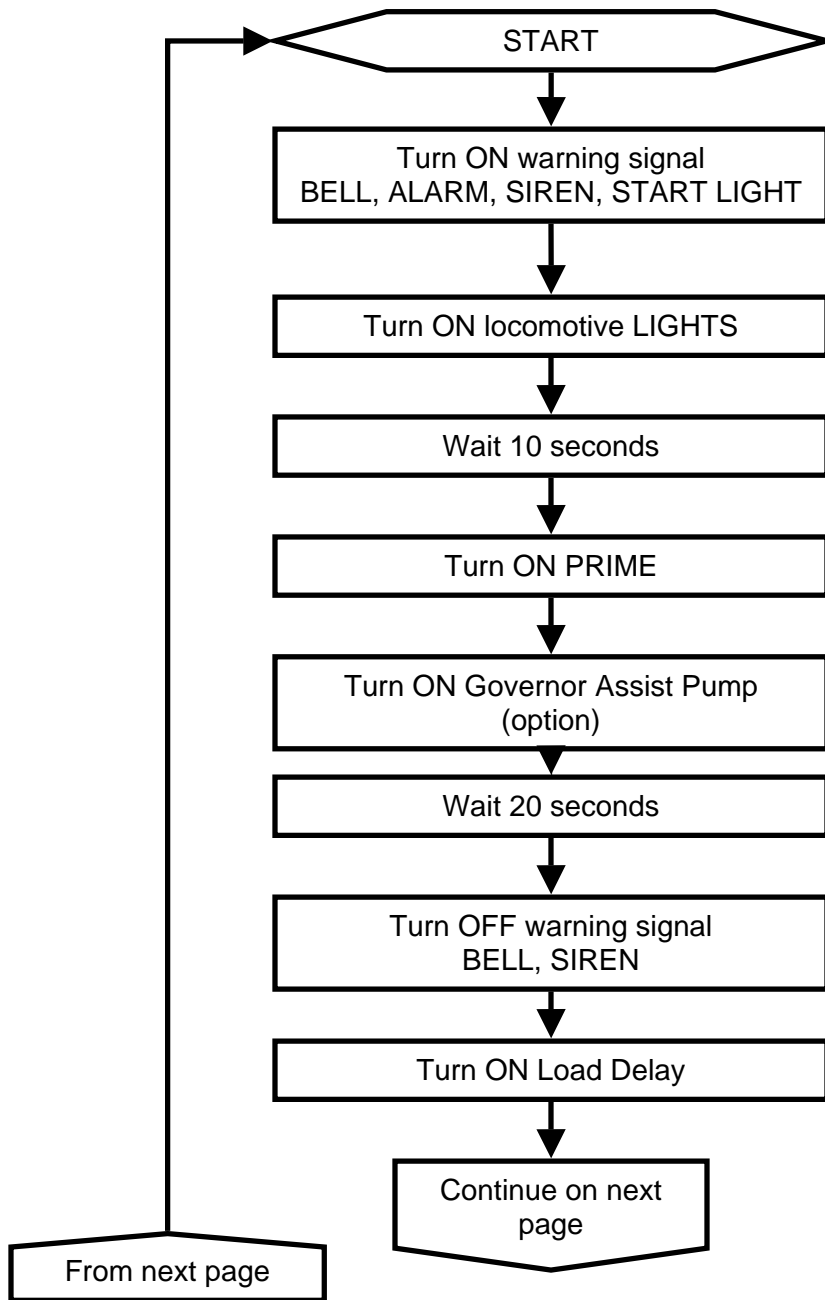
LOGIC STATE AND TRANSITION

The Auto-SS system software programming can be simplified into a number of logic states and transitions from one state to the other state. The following illustrates a very simplified state/transition diagram for the purpose of this document. The most important states are Startup and Shutdown. The sequence of events, for each of these states is described in the following sections.

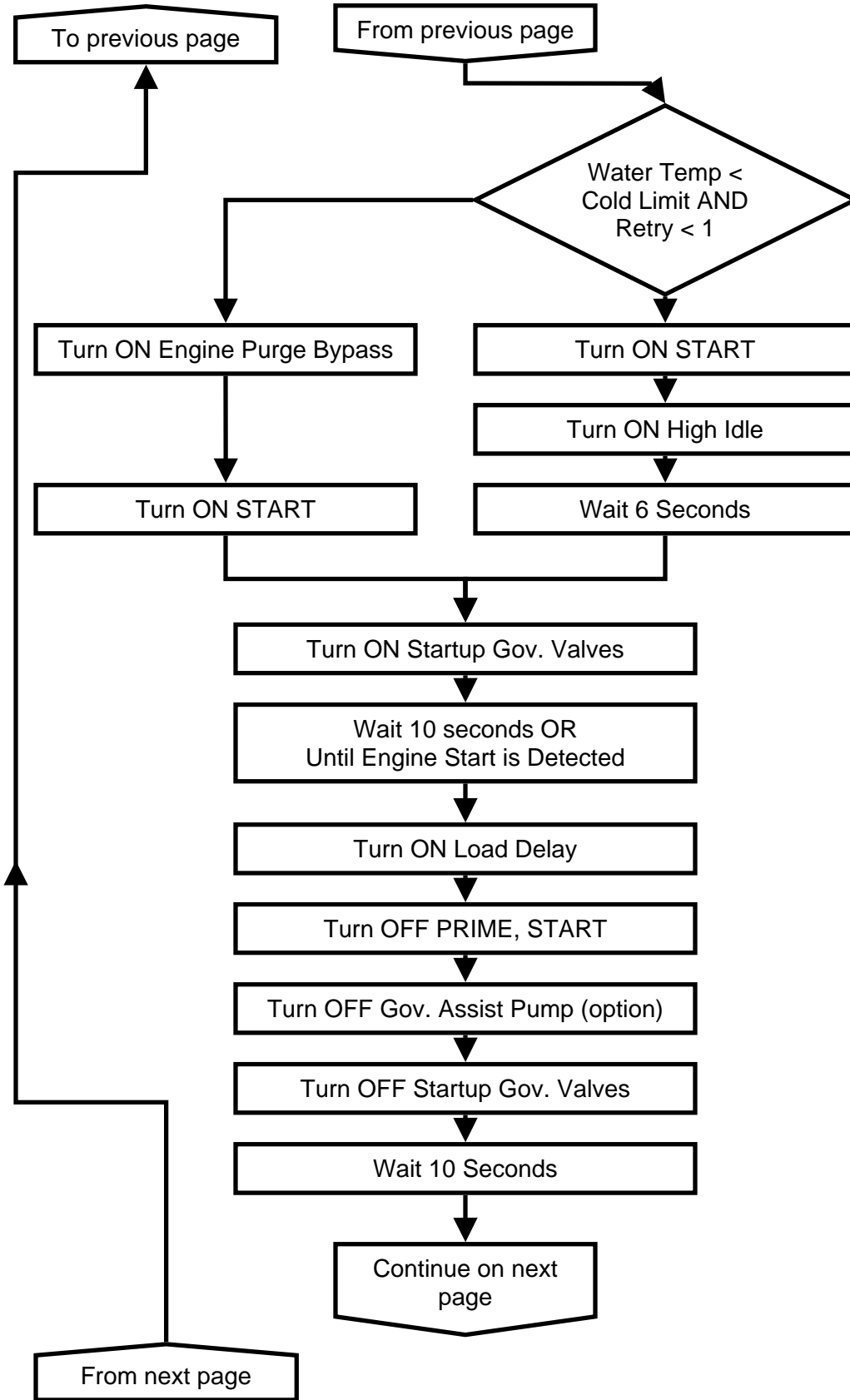


STARTUP SEQUENCE

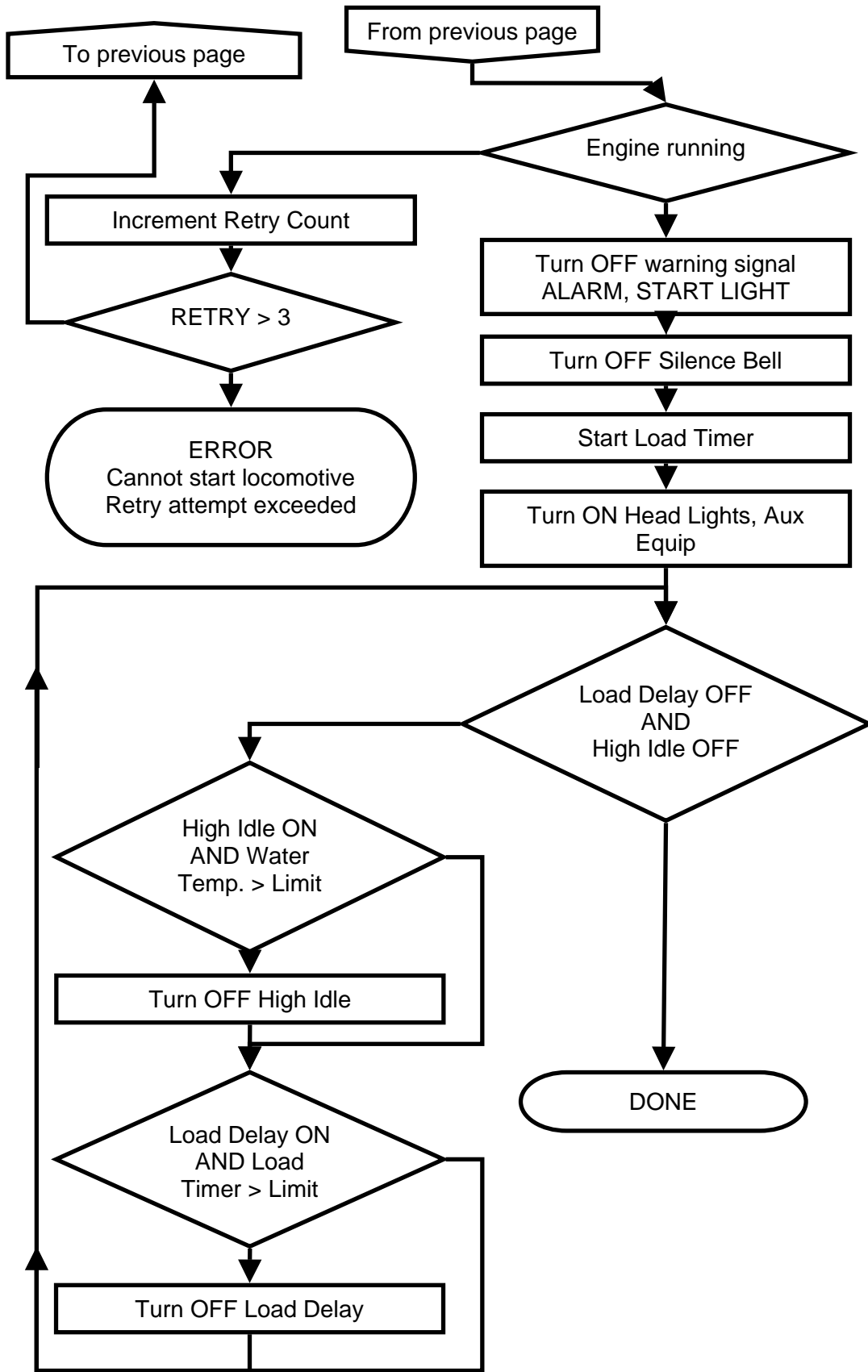
When the startup enable conditions are satisfied and the startup inhibit conditions are clear (see page 3), the Auto-SS system will perform the sequence of steps shown below to start the locomotive. At any time during the startup process and before the locomotive is running a cancel signal will cause the Auto-SS system to undo the startup steps and return to an idle condition.



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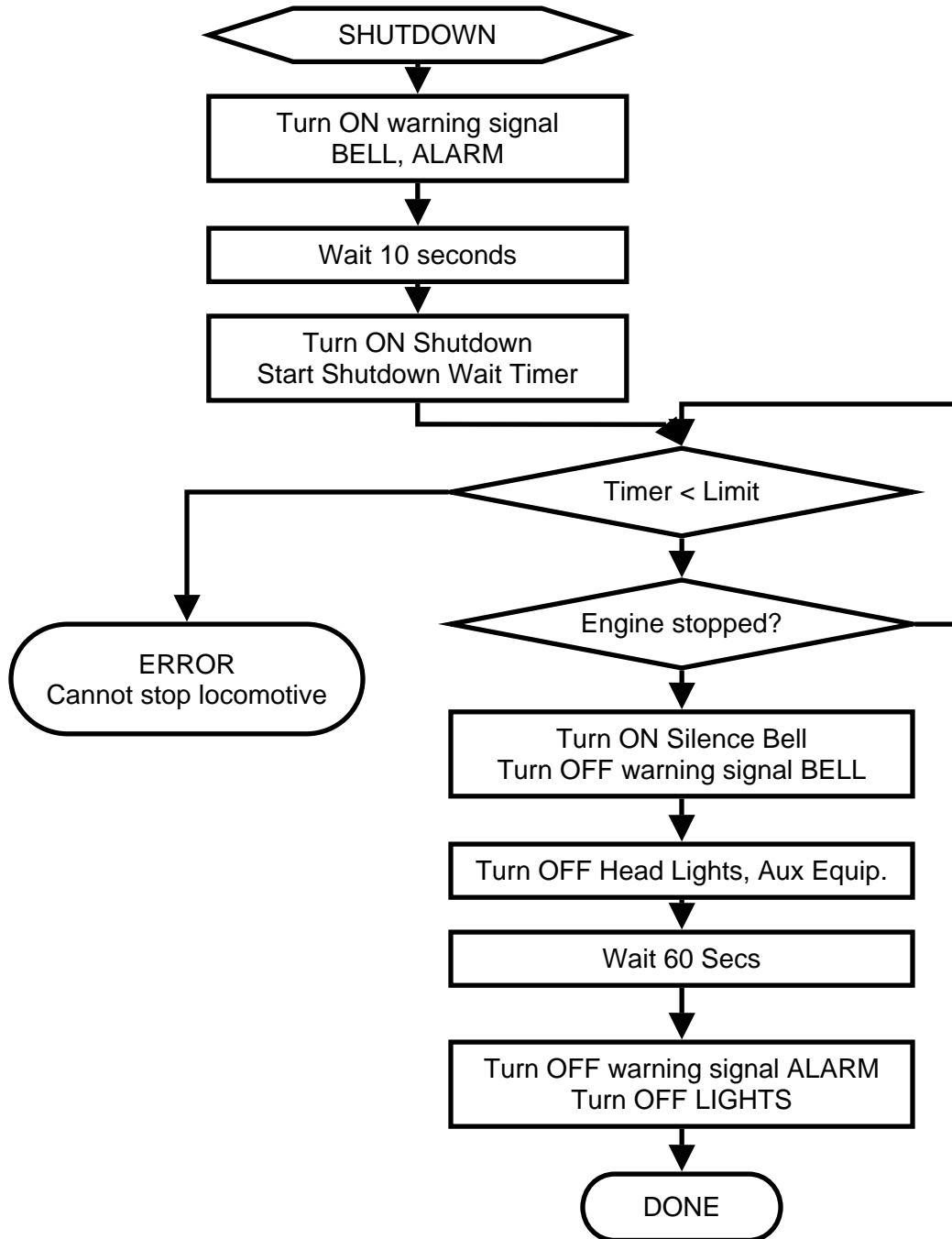
AUTO START STOP SYSTEM SPECIFICATION



****Note:** For the purpose of this document, the error detection and error recovery steps have been omitted from the startup sequence. See Error Sequence on page **Error! Bookmark not defined.**

SHUTDOWN SEQUENCE

When the shutdown enable conditions are satisfied and the shutdown inhibit conditions are clear (see page 4), the Auto-SS system will perform the sequence of steps shown below to shutdown the locomotive. At any time during the shutdown process and before the locomotive is stopped a cancel signal will cause the Auto-SS system to undo the shutdown steps and return to an idle condition.



Note: For the purpose of this document, the error detection and error recovery steps have been omitted from the shutdown sequence. See Error Sequence on page **Error! Bookmark not defined.

CONFIGURABLE PARAMETERS

The Auto-SS system provides a number of parameters that can be configured to customize the system to the needs of a particular operator. These parameters are configured via a menu system on the operator interface. The following section describes each of the configurable parameters.

- Ambient Temperature Limit – When the ambient temperature falls below this limit, the Auto-SS system will not shutdown the locomotive. [Default is 5 °C (40 °F)]
- Engine Water Temperature Limit – When the Engine water temperature falls below this limit, the Auto-SS system will re-start the locomotive. [Default is 30 °C (86 °F)]
- Low Battery Charge Limit – When the battery charge falls below this limit, the Auto-SS system will re-start the locomotive. [Default is 70% of full charge]
- Low Main Reservoir Pressure Limit – When the main reservoir pressure falls below this limit, the Auto-SS system will re-start the locomotive. [Default is 105 psi]
- Main Reservoir Shutdown Pressure Limit – The Auto-SS system will not allow the locomotive to be shutdown until the main reservoir air pressure exceeds this limit. [Default is 120 psi]
- Startup Retry Limit – The number of re-start attempts made by the Auto-SS system before a fault is indicated, and further automatic starts are prohibited. [Default is 3 attempts]
- Minimum Run Time – This parameter configures the minimum time the locomotive must run before the Auto-SS system is allowed to initiate an automatic shutdown. [Default is 30 minutes]
- Parking Brake Signal – This parameter configures whether the locomotive parking brake provides a signal indicating it is applied.

HARDWARE DESIGN

ELECTRICAL SIGNALS

The main electrical components of the system are the electronic start/stop controller and the electronic engine protection device. Each component has a serial communication port which is used to establish a communication link between the devices. The system microcontroller programming will perform all the logic tasks, and the system electrical signals will control the operating state of the locomotive. The following is a detailed description of the input and output signals.

INPUT SIGNALS

Wiring will be installed in the locomotive to connect each of the controller inputs to the required signal source. Input signals that are connected to the electronic engine protection device are available to the automated start/stop controller from the serial communication port.

The following paragraphs describe the function of each signal.

- VR-1 – Voltage Regulator Pin 1 – An input will be provided for measuring the regulated output voltage from the VR module. At startup a voltage greater than 50VDC indicates locomotive engine is running. At shutdown a voltage less than 20 VDC indicates the locomotive engine is stopped.
- Throttle Position – The Auto-SS controller will obtain throttle position information from the electronic engine protection device. The Stop signal prevents the Auto-SS system from starting the locomotive. The Idle and Low Idle signals are used in combination with the Direction signal to determine if it is appropriate to shutdown the locomotive.
- Air Temperature – An air temperature sensor will be provided for measuring the ambient air temperature. This signal is used to detect freezing weather conditions that will damage the locomotive. When the low air temperature limit is detected a non running locomotive will be started, a running locomotive will not be allowed to shutdown.
- Water Temperature – An input will be provided to read a temperature sensor that will be fitted to the locomotive water cooling system. The signal is used to determine the internal operating state of the engine.
- Forward – An input will be provided to detect the forward direction signal. The electrical signal will be +74VDC or an open circuit. +74VDC indicates the reverser handle is in Forward position.
- Reverse – An input will be provided to detect the reverse direction signal. The electrical signal will be +74VDC or an open circuit. +74VDC indicates the reverser handle is in Reverse position.

- Battery Charge Current – An input will be provided for measuring the Battery charging current via RE-BC. See Battery Cell Voltage.
- Battery Cell Voltage – An input will be provided for measuring the battery voltage. The input measurement range will be 30 to 80 Volts. With both the Battery Charge Current input and the Battery Cell Voltage input, the software program will use an algorithm to calculate the state of battery charge.
- Turbo Lube Pump – An input will be provided to detect when the turbo lube pump is running. The electrical signal will be +74VDC or an open circuit. +74VDC indicates turbo lube pump is running. The software program will use this information to calculate the amount of drain on the battery due to turbo lube pump load.
- Air Pressure Sensor – A sensor will be installed in the Main compressed Air Reservoir. Air pressure low limit detection causes the locomotive to startup and recharges the compressed air system. There is no guarantee that the Auto-SS system can maintain the air brakes. This is a safety issue, the parking brake is supposed to be used to hold the locomotive at standstill.
- Parking Brake – An input will be provided to detect when the locomotive parking brake is applied. The electrical signal will be +74VDC or an open circuit. +74VDC indicates the parking brake is applied.
- Lead Unit – An input will be provided to detect when the locomotive is the lead unit of a consist. The electrical signal will be +74VDC or an open circuit. +74VDC indicates the locomotive is the lead unit.

OUTPUT SIGNALS

Wiring will be installed in the locomotive to connect the output signals to each load. Any load located in the engine room area will be connected to the electronic engine protection device and will be controlled by the automated start/stop controller from the serial communication port.

The following paragraphs describe the function of each signal.

- Prime – An output will be provided that will provide the same function as putting the isolation switch in start position and turning the fuel prime / engine start switch to the prime position.
- Start – An output will be provided that will provide the same function as turning the fuel prime / engine start switch to the start position.
- Alarm – An output will be provided to drive an alarm in the cabin area. This load is expected to be an indicator light on the locomotive control stand and the will provide a visual warning signal in the cabin area.

- Bell – An output will be provided to drive the cabin bell. This will provide an audible warning signal in the cabin area
- Siren – An output will be provided to drive a siren in the engine room. An audible warning device will be added to the engine room. This output will be provided by the electronic engine protection device.
- Start Light – An output will be provided to drive a warning light in the engine room area. A warning light will be added to the engine room.
- Load Delay – An output will be provided to prevent the main generator field (GFC) contactor pickup. This will prevent the locomotive from operating in power mode and trying to move immediately after startup. This control is required when the locomotive startup is initiated by moving the throttle handle from the idle position to a power position because the normal reaction of the locomotive is to move.
- Governor Valves – An output will be provided by the electronic engine protection device to control each governor valve.
- Silence Bell – An output will be provided to interrupt the electrical feed to the bell circuit. When the Auto-SS system shuts down the locomotive, normally the bell will ring continuously. This output is used to prevent the bell from ringing after an Auto-SS system shutdown. When Silence Bell is active, the Bell output from the Auto-SS controller can still operate the bell.
- Head Lights – An output will be provided to drive an external contactor to interrupt the electrical feed to the Head Lights circuit. This output is used to turn off the head lights and reduce the unnecessary load on the battery when the locomotive is shutdown
- Lights – An output will be provided to drive an external contactor to interrupt the electrical feed to the Lights circuit. This output will turn off the all the other lights on the locomotive except for the head lights. This output will activate one minute after locomotive is shutdown to allow the operator to safely exit the locomotive.

OPTIONAL OUTPUT SIGNALS

- Engine Purge Bypass – An optional output will be provided to interrupt the normal operation of the Engine Purge Module. The engine purge module forces the engine cranking circuit to operate for six seconds before the engine is allowed to start. The output is used to reduce the extra load on the battery by eliminating the extra six seconds of engine cranking during an Auto-SS system startup.
- Aux. Equipment – An optional output will be provided to drive an external contactor and interrupt the electrical feed to an auxiliary circuit. This output is similar to the Lights and Head Lights except that it is not

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committed to any specific load circuit. This output will be an installation specific configuration and is used to reduce an extra unnecessary load on the battery when the locomotive is shutdown.

- Gov. Assist Pump – An output will be provided to drive the governor assist pump. This device is supplied as a kit from EMD and will be installed in the engine room. This output will be provided by the electronic engine protection controller.