GM	**WORLDWIDE ENGINEERING STANDARDS**	**General Specification**	**INACTIVE GMW8778**

Platform to Powertrain Electrical Interface Specification Generator Control Subsystem

This document is inactive with no replacement.

1 Scope

This standard is inactive with no replacement.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

None

3 Release and Revisions

This standard was originated in June 2003. It was first approved by the Global PPEI Core Team in December 2003. It was first published in February 2004.

Issue	Publication Date	Description (Organization)
1	FEB 2004	Initial publication.
2	AUG 2004	Global PPEI Version 3.5 Release.
3	JUL 2005	Global PPEI Version 3.6 Release.
4	MAR 2006	Global PPEI Version 3.7 Release.
5	AUG 2010	Global PPEI Version 3.8 Release. (Global PPEI Core Team)
6	SEP 2011	This standard is inactive with no replacement. (Powertrain Interface)

GM	WORLDWIDE ENGINEERING STANDARDS	General Specification Electrical/Electronic	GMW8778

Platform to Powertrain Electrical Interface Specification Generator Control Subsystem

1 Introduction

Note: Nothing in this standard supersedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Scope. This standard identifies the generator control electrical interface between Platform and Powertrain. Functional charging system interfaces are also covered.

1.2 Mission/Theme. Not applicable.

1.3 Classification. This specification applies to all vehicles.

1.4 Applicability. The **GMW8762** Platform to Powertrain Electrical Interface (PPEI) Standard Specification includes: General Information, On-Board Diagnostics and Electrical Requirements and GM Local Area Network (GMLAN) Serial Data Signal Definitions and Framing for the following 19 PPEI subsystems standard specifications:

- **GMW8763** Power and Ground
- **GMW8764** Four Wheel Drive/All Wheel Drive Controls
- **GMW8765** Displays and Gauges
- **GMW8766** Engine Power Management
- **GMW8767** Starter Control
- **GMW8768** Vehicle Theft Deterrent
- **GMW8769** Cruise Control
- **GMW8770** Cooling Fan Control
- **GMW8771** Air Conditioning Compressor Control
- **GMW8772** Serial Data Architecture
- **GMW8773** Brakes and Traction Control
- **GMW8774** Enhanced Evaporative Emissions and Fuel
- **GMW8775** Exhaust After-Treatment
- **GMW8776** Suspension Control
- **GMW8777** Transmission
- **GMW8778** Generator Control
- **GMW8779** Post Collision Operation
- **GMW8780** Power Take-Off and Fast Idle Control
- **GMW8781** Vehicle Speed and Rough Road Sensing

Each of the 19 PPEI subsystem standard specifications contains the hardware, serial data, algorithms and calibrations for the named subsystem.

The master PPEI document and all 19 PPEI subsystem standard specifications are required to define the complete set of PPEI requirements.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW3001	GMW8771
GMW3059	GMW8772
GMW8762	GMW8773
GMW8763	GMW8774
GMW8764	GMW8775
GMW8765	GMW8776
GMW8766	GMW8777
GMW8767	GMW8779
GMW8768	GMW8780
GMW8769	GMW8781
GMW8770	

2.3 Additional References.

Global Electric Power Management – Gen IV/V SSTS

3 Subsystem Requirements

3.1 Functional Overview. The functional charging system interfaces are defined in 3.1.1 thru 3.1.9. These include regulated voltage control (RVC), idle boost, generator on/off control, engine load management, field monitor, generator load estimation, dual generators, Powertrain voltage

override and regulated torque control (RTC) and regulated voltage control for coast down, braking and idle. Refer to 4.1 and 4.2 for algorithm descriptions for generator status and control and to GMW8766 for idle boost calibrations.

3.1.1 Regulated Voltage Control (RVC). Regulated voltage control (RVC) is a platform optional system where the generator-regulated setpoint voltage is controlled remotely. In a conventional (non-RVC) system, the regulated setpoint voltage is determined by the generator's internal regulator. In the RVC system, a body controller on the Platform side of the interface determines the optimal setpoint voltage based on battery state-of-charge, battery temperature, and battery charge current. The optimal setpoint is transmitted to Powertrain as a duty cycle through the GMLAN signal Generator Regulator Setpoint Duty Cycle Request. Powertrain passes the setpoint command to the generator through a PWM interface to the generator L-terminal. Refer to 4.2 for detailed Powertrain requirements for RVC.

The RVC system allows for improved fuel economy by lowering the system voltage, and therefore the generator load on the engine, when the battery is sufficiently charged. It also improves battery life through improved charging control.

When in the Run power mode, the RVC algorithm uses the GMLAN signal Engine Run Active to determine if the engine is running. The algorithm only executes if the signal is "active".

RVC is part of a larger system called Electric Power Management (EPM). EPM is a platform optional system consisting of RVC, idle boost, and load shedding. Idle boost is defined in 3.1.2. Load shedding is a Platform implemented function, which turns off Platform electrical loads to reduce the electrical load on the generator. Load shedding is not addressed in this document. The EPM algorithm uses GMLAN signal Engine Intake Air Temperature and Outside Air Temperature Powertrain Estimated as an input to estimate the battery temperature.

Note: RVC, as defined in this section, has been approved as a standard feature for GM North America applications only. Although RVC has not been approved by Opel for European applications, it shall be implemented in Opel engine control modules (ECM) when required on GM North America applications.

3.1.2 Platform Idle Boost (via serial data). The Generator Control Subsystem may request an increased engine idle speed from Powertrain via the GMLAN signal Platform Minimum Idle Boost Level Request to enhance/improve charging system performance. Refer to GMW8766, Platform Idle Boost Functional Requirements, and section 4.2 Platform Idle Boost Calibrations.

3.1.3 Generator On/Off Control (via L-terminal). Powertrain has the ability to turn the generator on or off. The exact method depends on whether or not the RVC function is implemented. To prevent excessive parasitic current draw when the engine is not running, the generator shall be turned off as described 3.1.3.1 and 3.1.3.2 (when diagnostics do not require it to be turned on). Refer to 4.2 for algorithm requirements.

3.1.3.1 RVC Systems. Generator turn-on is normally initiated by pulse-width modulating the L-terminal to match the duty cycle commanded by Platform. When the engine is running, generator turn-off is accomplished by pulse-width modulating the L-terminal to a low duty cycle that corresponds to a voltage setpoint below battery voltage. The turn-off duty cycle should be 15% (corresponding to approximately 11.0 V). If, when the generator is rotating, the L-terminal is opened, pulled low (0% duty cycle), or pulled high (100% duty cycle), the generator will regulate to a default setpoint of 13.8 V. Note that if the L-terminal remains low after engine start, the generator will self-start once a nominal operating speed is detected. To turn the generator off when the engine is not rotating, the L-terminal must be commanded to zero percent duty cycle.

3.1.3.2 Conventional (non-RVC) Systems. Generator turn-on is initiated by pulling the L-terminal high. With a high applied on the L-terminal, the generator regulator shall apply field excitation and regulate generator output when proper operating speed is detected. Generator turn-off is accomplished by pulling the L-terminal low, regardless of engine speed. Note that the generator will not operate with an open L-terminal.

3.1.4 Engine Load Management (via generator control). Engine load management is a Powertrain function that allows the generator load to be minimized under certain conditions. Refer to 4.2 for algorithm details.

To reduce accessory load and improve engine starting performance, the generator may be commanded off as described in 3.1.3 during engine cranking and starting. The generator remains commanded off up to **K_EngStrtDsblDly** time after engine has started to allow engine idle to stabilize. To clarify for RVC applications, upon key-on the generator is commanded off with a 0% duty cycle on L-terminal.

During crank the duty cycle remains at 0%. Immediately after the engine starts, the duty cycle on L-terminal is set to 15% to keep the generator "off" until the engine idle has stabilized.

If a potential engine stall condition has been detected, the generator is commanded off to reduce accessory loading.

3.1.5 Field Monitor (via F-Terminal). Powertrain shall monitor the generator F-terminal duty cycle. This duty cycle is an indication of the generator load on the engine and a diagnostic aid. Powertrain shall filter and transmit the F-terminal duty cycle and validity to Platform through the GMLAN signal Generator Field Duty Cycle. Powertrain F-terminal filtering requirements are defined in 4.1.

Platform uses for field duty cycle include generator full-field determination for RVC and electric heater control. If the generator is operating at full-field (high field duty cycle), the Platform RVC algorithm freezes at the current setpoint value because voltage cannot be controlled when the generator is at full output. A high field duty cycle can be used to reduce performance of an electric heater in order to reduce deep-cycling of the battery.

3.1.6 Generator Load Estimation (via F-terminal). Powertrain shall monitor the generator F-Terminal duty cycle. This duty cycle is an indication of the generator load on the engine. Powertrain may utilize the duty cycle for idle stability purposes and engine torque calculations.

3.1.7 Dual Generators. The mechanization supports dual (base and secondary) generator applications for vehicles with additional accessory load requirements (e.g., ambulance vehicles). In these applications, the secondary generator L-terminal shall share the primary L-terminal signal from the ECM. The F-terminal on the secondary generator is not required.

3.1.8 Powertrain Voltage Override. Some Powertrain components and subsystems on certain applications under specific (temporary) operating conditions may require the system voltage to be higher than the Platform commanded voltage, especially if the RVC algorithm is in the "fuel economy" mode. These at-risk subsystems and components are:

- **Fuel Pump:** Sufficient voltage must be provided to the fuel pump to supply adequate engine fuel flow. If an issue, it is typically under high fuel demand scenarios.
- **Airmeter:** Sufficient voltage must be provided to the airmeter to ensure accurate airflow measurement at or near peak engine air consumption.
- **Cylinder Deactivation (DoD):** On some applications the DoD solenoids may require voltage levels higher than the RVC fuel economy mode voltage.
- **Diagnostics:** Some engine diagnostic routines may require voltage levels higher than **the RVC fuel economy mode voltage.**

A minimum voltage request is calculated within the ECM for each at-risk component. Voltage requests will be arbitrated by the generator subsystem and compared to the Platform voltage request (which is transmitted by the GMLAN signal Generator Setpoint Duty Cycle Request). If the arbitrated voltage is higher than the platform request, then the Powertrain generator subsystem ring will assume control of the generator setpoint voltage by controlling the L-terminal duty cycle. Powertrain will notify Platform by asserting the GMLAN signal Generator Setpoint Duty Cycle Powertrain Override Active. Platform will then stop normal RVC operation and track the system voltage in preparation for release of the override. When the condition requiring the override ends, Powertrain notifies Platform by releasing the override signal and Platform slowly ramps the RVC command voltage back to the desired value.

3.1.9 RVC with Generator Torque Estimation.

Note: Applies to GM Powertrain (GMPT) controllers.

RVC with generator torque estimation is an optional system to RVC where the generator torque is calculated by Powertrain in order to adjust the generator setpoint duty cycle to improve fuel economy, engine idle quality and engine idle combustion variability. The Powertrain generator control algorithm calculates Generator torque at the crankshaft based on generator voltage, generator current, engine speed and pulley ratio.

Currently, Base Spark Timing is retarded at idle from Mean Best Timing (MBT) to allow a "torque reserve" for quick response to unanticipated engine loads (example, Power Steering Cramp).

RVC with generator torque estimation functionality will be used to rapidly remove generator load to offset the unanticipated engine load so that the Base Spark Timing can be advanced closer (or move closer) to the MBT value.

During coast down and idle, Powertrain will ramp up the generator voltage to a setpoint determined by outside air temperature and advance the spark to a value closer to MBT. This action is intended to increase the generator load on the engine crankshaft and secondly to potentially store free energy into the battery to be recuperated later in the drive cycle.

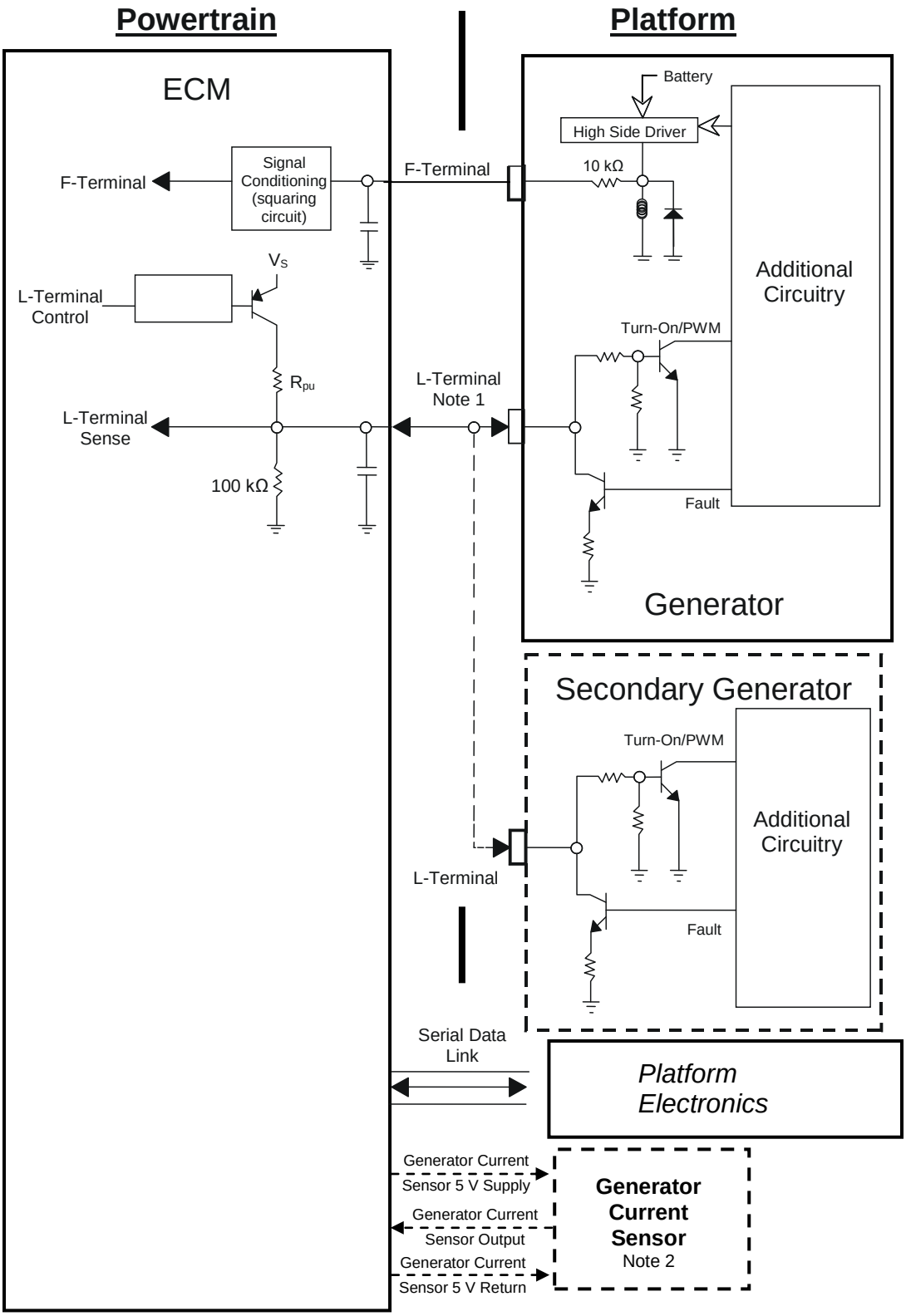
When Powertrain is controlling the generator setpoint, the GMLAN signal Powertrain Regulated Generator Control Active shall be communicated to Platform.

Powertrain shall read generator output current from a sensor and transmit this value to Platform via the GMLAN signal Generator Current. Powertrain shall perform generator current sensor diagnostics.

The generator distinguishes between RVC and RTC modes by the frequency of the L-terminal pulse width modulated (PWM) signal.

3.2 Hardware Overview. The description of this subsystem covers the F- and L-terminals, and the serial data link between the Powertrain and Platform Controllers. The generator voltage regulator shall provide a low-side driver (L-terminal) and a PWM high-side driver (F-terminal) as signals to the Powertrain Controller. The Powertrain Controller shall provide a high-side driver on the L-terminal as input to the voltage regulator.

3.2.1 Block Diagram. The block diagram depicts the mechanization for generator control. The L-terminal circuits are examples only and may not reflect an actual implementation of the voltage regulator circuits shown. This electrical interface between Powertrain and Platform is the only standard defined.



Note 1: The L-Terminal interface for the Secondary generator is required on some truck applications.
Note 2: For GM Powertrain controllers, Generator Current Sensor is required to support RVC with generator torque estimation.

Figure 1: Generator Control Block Diagram

3.3 Interface Description.

3.3.1 Serial Data Link. Refer to GMW8762, PPEI Serial Data Signal and Definitions and Framing for definition of the signals listed in Table 1.

3.3.2 Calibrations. Table 2 contains calibrations that cross the Platform to Powertrain Electrical Interface (i.e., calibrations are located in devices on one side of the interface but controlled by the other side of the interface or driven by variation in the other side of the interface). Refer to Section 4 for calibration definitions.

Table 1: Generator Control Serial Data Signals

Signal Name	Transmitter	Notes
Engine Cooling Fan Speed	Powertrain	Required
Engine Intake Air Temperature	Powertrain	Required
Engine Intake Air Temperature Validity	Powertrain	Required
Engine Run Active	Powertrain	Required
Engine Shutdown Active	Powertrain	Required
Engine Speed	Powertrain	Required
Engine Speed Status	Powertrain	Required
Generator Current	Powertrain	Required
Generator Current Validity	Powertrain	Required
Generator Failed	Powertrain	Required
Generator Field Duty Cycle	Powertrain	Required
Generator Field Duty Cycle Validity	Powertrain	Required
Generator Regulator Setpoint Duty Cycle Request	Platform	Required
Generator Setpoint Duty Cycle Powertrain Override Active	Powertrain	Required
Powertrain Regulated Generator Control Active	Powertrain	Required
Outside Air Temperature Powertrain Estimated	Powertrain	Required
Outside Air Temperature Powertrain Estimated Mask	Powertrain	Required
Outside Air Temperature Powertrain Estimated Validity	Powertrain	Required
Platform Minimum Idle Boost Level Request	Platform	Required

Table 2: Generator Control Calibrations

Calibration Name	Location	Owner	Refer to
K_CumulativeL_TermOff	Powertrain	Platform	4.2
K_CumulativeL_TermOffDC	Powertrain	Platform	4.2
K_EngSpdCutout	Powertrain	Platform/Powertrain	4.2
K_EngStrtDsblDly	Powertrain	Platform/Powertrain	4.2
K_F_DC_KeyOnTest	Powertrain	Platform	4.1
K_F_DC_RunTest	Powertrain	Platform	4.1
K_F_KeyOnTestTime	Powertrain	Platform	4.1

Calibration Name	Location	Owner	Refer to
K_CumulativeL_TermOff	Powertrain	Platform	4.2
K_CumulativeL_TermOffDC	Powertrain	Platform	4.2
K_EngSpdCutout	Powertrain	Platform/Powertrain	4.2
K_EngStrtDsblDly	Powertrain	Platform/Powertrain	4.2
K_F_RPM_RunTest	Powertrain	Platform	4.1
K_F_RunTestTime	Powertrain	Platform	4.1
K_F_TerminalPresent	Powertrain	Platform	4.1
K_F_TermInFilt	Powertrain	Platform	4.1
K_L_KeyOnTestDC	Powertrain	Platform	4.1
K_L_KeyOnTestTime	Powertrain	Platform	4.1
K_L_RunTestTime	Powertrain	Platform	4.1
K_PlatformIdleBoost[gear, level]	Powertrain	Platform/Powertrain	GMW8766 Paragraph 4.2
K_RVC_DefaultDutyCycle	Powertrain	Platform	4.2
K_RVC_DefaultTime	Powertrain	Platform/Powertrain	4.2
K_TorqueEstimationFunctionPresent	Powertrain	Platform	4.1
K_RVC_FunctionPresent	Powertrain	Platform	4.1, 4.2
K_RVC_MinDutyCycle	Powertrain	Platform	4.2
K_Stable_Time	Powertrain	Platform	4.1
K_ZeroSpdThresh	Powertrain	Platform/Powertrain	4.2
K_GenTorqueModelCoeff_A	Powertrain	Platform	4.2
K_GenTorqueModelCoeff_B	Powertrain	Platform	4.2
K_GenTorqueModelCoeff_C	Powertrain	Platform	4.2
K_GenTorqueModelCoeff_D	Powertrain	Platform	4.2
K_GenTorqueModelCoeff_E	Powertrain	Platform	4.2
K_GenTorqueModelCoeff_F	Powertrain	Platform	4.2
K_GenTorqueModelCoeff_G	Powertrain	Platform	4.2
K_GenPulleyRatio	Powertrain	Platform	4.2
K_GenSetpoint_RampRateUp	Powertrain	Platform	4.2
K_GenSetpoint_RampRateDown	Powertrain	Platform	4.2
K_GenSetpointVoltage	Powertrain	Platform	4.2
K_TorqueEstimationFunctionPresent	Powertrain	Platform	4.2

3.3.3 L-Terminal. The L-terminal is used for generator on/off control and to indicate generator status. For RVC, the L-terminal is also used for setpoint voltage control. In addition the L-terminal is used for generator torque control. The generator voltage regulator shall provide a low-side drive to pull the L-terminal low when the generator is near or at zero speed, or not operating properly.

The Powertrain controller shall provide a discrete high-side driver with current-limiting circuitry (a simple resistor is strongly preferred) and a pull-down resistor for generator on/off control.

3.3.3.1 Conventional (non-RVC) Systems. When the high-side driver is turned on, the voltage regulator is commanded on and the L-terminal monitor is enabled. When the high-side driver is turned off, the voltage regulator is commanded off and the L-terminal monitor is disabled.

3.3.3.2 RVC Systems. For RVC applications, the L-terminal high-side driver shall be pulse-width modulated at 128 Hz. The PWM duty cycle is communicated to Powertrain from Platform via serial data. The PWM hardware shall follow duty cycle changes with no intermediate drop-outs or anomalies between previous and new duty cycles.

When the high-side driver is turned on or pulse width modulated, the voltage regulator is commanded on and the L-terminal monitor is enabled. When the high-side driver is turned off and the generator is not rotating, the voltage regulator is commanded off and the L-terminal monitor is disabled.

The following conditions will occur if the L-terminal is open, held low (0% duty cycle), or held high (100% duty cycle) with the engine rotating. When the generator is rotating above 800 ± 50% generator rpm (GRPM), the voltage regulator may turn on and the L-terminal monitor may be enabled. When the generator is rotating above 3100 ± 15% GRPM, the voltage regulator will turn on, the L-terminal monitor is enabled, and the generator output will be regulated to 13.8 V.

Powertrain shall be able to minimize the generator load by commanding a PWM duty cycle signal of 10% to 15% which drops the generator output to its minimum value. The generator/regulator setpoint will be approximately 11.0 V at 15% duty cycle, thereby unloading the generator torque from the engine.

Powertrain shall not turn off the generator for more than 10 s (**K_CumulativeL_TermOff**).

3.3.3.3 RTC Mode.

Note: Applies to GMPT controllers only.

RTC is momentary mode that becomes active when a large engine speed error is detected by Powertrain and attempts to restore engine speed to the desired setpoint.

In RTC mode the frequency of the L-terminal is 192 Hz ± 5% and the duty cycle range is 5% to 95%. If the L-terminal is outside the range of 192 Hz ± 5% for 100 ms the regulator shall enter the default RVC mode setpoint (13.8 ± 0.25 V).

In RTC mode, the maximum voltage is controlled by the algorithm to an over-voltage limit of 15.5 ± 0.25 V. Also, the voltage regulator shall limit the maximum voltage to 15.5 ± 0.25 V.

3.3.4 F-Terminal. This input to Powertrain shall be a PWM voltage signal that replicates the duty cycle being applied to the generator field. This signal shall switch between ground and battery voltage, and its average duty cycle generally shall be proportional to generator output current and torque load. However, on a transient basis, the torque lags the PWM signal by the field's load/response (L/R) time constant (typically 100 ms).

The Powertrain Controller shall digitize the voltage signal from the generator PWM high-side driver and determine the corresponding PWM percent high time (i.e., duty cycle). Powertrain can use this raw duty cycle information in its idle speed control algorithm to anticipate changes in generator load. Powertrain shall process this raw duty cycle information with a digital low pass filter and send the filtered duty cycle output to Platform via the serial data link. The digital filter time constant shall be a calibratable value between 0.5 and 5.0 s. At full output (with full field), the duty cycle can go to 100% and result in a constant high state for an indefinite time. Conversely, when the load is reduced, the duty cycle may go to zero for a maximum of 2 s in order to decrease the generator field current and help prevent overvoltage. Moreover, the instantaneous duty cycle can change significantly from one cycle to the next due to ripple within the voltage regulation loop.

Upon generator turn-on, the voltage regulator shall limit the field current by limiting the initial duty cycle to a value between 5% and 35%. With the engine idling and the generator above cut-in speed, the voltage regulator shall limit the rate of increase of the field duty cycle to avoid sudden increases in engine load. This limited rate, known as Load Response Control (LRC), shall be 40% of rated field per second (2.5 s/100% field change) for all applications. The LRC tolerance shall be ± 20%, i.e., 2.0 to 3.0 s/100% field change. LRC is in effect until the LRC cut-out speed of 3100 ± 15% GRPM is exceeded.

Above the LRC cut-out speed, only the field L/R time constant (typically 100 ms) will limit the rate of torque loading and unloading.

3.3.5 Generator Current Sensor.

Note: Applies to GMPT controllers with generator torque estimation.

RVC with generator torque estimation shall use a current sensor to measure the generator output current. This current sensor is required for the ECM to calculate the electrical torque load on the engine.

The ECM shall provide a +5 V/20 mA power supply, a +5 V return line, and a PWM sense input. Refer to 3.5.3.

3.4 Failure Modes and Diagnostics. Refer to GMW8772, PPEI Serial Data Architecture Requirements for serial data failure modes and diagnostic information.

Generator faults and wiring faults are detected by the defined diagnostics for both L- and F-terminal. The wiring faults detected are: open, shorted high, and shorted low. Diagnostic status is communicated from Powertrain to Platform through the GMLAN signal Generator Failed. The generator diagnostics are defined in detail in 4.1.

3.4.1 L-Terminal Diagnostics. Powertrain shall monitor generator L-terminal signal voltage and transmit its diagnostic status to Platform via serial data. The generator internal voltage regulator will pull the L-terminal low when the generator is near zero speed or not operating properly.

3.4.2 F-Terminal Diagnostics. Powertrain shall monitor generator F-terminal signal duty cycle and transmit its diagnostic status to Platform via serial data.

3.4.3 Generator Current Sensor Diagnostics Suggested Guidelines.

Note: Applies to GMPT controllers with generator torque estimation.

Generator Current Sensor Diagnostics are only required for RVC with generator torque estimation. Powertrain shall monitor continuously the frequency of operation to be within 128 Hz ± 15%. If the frequency is not within that range for a period of 100 ms, a diagnostic trouble code (DTC) will be set; the algorithm will not calculate the Estimated Generator Torque and will default to production spark timing control.

Powertrain shall also monitor the PWM duty cycle of the 128 Hz signal. If the duty cycle is less than 5% or greater than 95% for a period of 100 ms, a DTC will be set, the algorithm will not calculate the Estimated Generator Torque and will default to production spark timing control.

The ECM and Generator shall be protected from shorts to ground or battery voltage on either the L-terminal or the F-terminal.

3.5 Electrical Characteristics.

3.5.1 L-Terminal. The electrical characteristics described in this section pertain to the requirements for using the L-terminal to turn on or turn off the generator and monitor for generator faults or insufficient rotation. For RVC systems, after initial turn-on the generator torque loading on the engine can be reduced to a minimum by commanding a low PWM ratio (i.e., low output voltage).

The Powertrain electronics shall provide the following to turn on the generator:

$V_{L\text{-}term}$ = 1.2 V minimum at $I_{L\text{-}term}$ = 6.0 mA minimum available

The voltage, $V_{L\text{-}term}$, is referenced to ECM ground.

The Powertrain electronics shall provide the following to hold on the generator:

$V_{L\text{-}term}$ = 3.5 V minimum at $I_{L\text{-}term}$ = 1.5 mA minimum available

The voltage, $V_{L\text{-}term}$, is referenced to ECM ground.

In order to turn-off the generator, the Powertrain electronics shall limit the L-terminal leakage current to less than 25 µA with L-terminal shorted to ECM ground. This requirement does not apply to RVC generators when rotating. Refer to 3.1.3 for additional generator turn-off requirements.

The generator shall signal a fault or low rotational speed by clamping the L-terminal within the following limits:

$V_{L\text{-}term}$ = 1.5 V maximum at $I_{L\text{-}term}$ = 10.0 mA maximum

Note: It is not necessary to design for generator turn on during cranking. Generator turn-on after cranking from a battery voltage of 11.0 V is sufficient.

The Powertrain Controller shall provide the L-Terminal turn-on current, have the capability of switching the L-Terminal pull-up source voltage using a high-side driver, and limit the L-terminal current when the generator signals a fault. Typically, a high-side driver operating from 5 V requires a 470 Ω series resistor or 1500 Ω with a 12 V driver.

For RVC, this output shall be PWM capable as defined in Table 3. Zero percent (0%) Duty Cycle is defined as the output driver continuously in the not active (high impedance) state.

3.5.1.1 ECM L-Terminal Fault Monitor Characteristics. The Powertrain Electronics shall interpret the L-terminal as a fault when $V_{L\text{-}term} \leq 1.5V$ at the ECM while the output driver is on. The pull-down resistance shall be 100 kΩ ± 10%.

A 0.5 V maximum ground voltage difference between the ECM and the regulator should be used for worst case analysis. Refer to GMW8763, PPEI Power and Ground Subsystem.

Table 3: Generator L-Terminal Electrical Characteristics

Parameter	Value	Comments
Frequency	128 Hz	Accuracy of ± 5.0%
Duty Cycle Range	0 to 100%	Accuracy of ± 1.0% duty cycle and a resolution of 0.5% duty cycle

3.5.2 F-Terminal. The generator shall provide a PWM voltage on the F-Terminal through a series resistor according to the following specifications defined in Tables 4 and 5.

Table 4: Generator F-Terminal PWM Electrical Characteristics

Parameter	Value/Conditions
$V_{F\text{-Terminal High}}$	Open Circuit Voltage: 8.0 to 16.0 V
$V_{F\text{-Terminal Low}}$	Open Circuit Voltage: 1.0 to -1.0 V
Series Resistance	10 kΩ ± 30%
PWM range	5% to 100% (continuous) 0% to 100% (overvoltage for 2 s or less)
Control Frequency	60 to 500 Hz

Table 5: Generator F-Terminal ECM Input Characteristics

Parameter	Value
Duty cycle input range	5 to 100%
Accuracy	± 1.0% duty cycle
Minimum resolution	0.5% duty cycle

3.5.3 Generator Current Sensor Output.

Note: Applies to GMPT controllers with generator torque estimation.

The current sensor is sampled every 12.5 ms by the ECM. These samples shall be averaged over 500 ms period. This average value is transmitted to Platform via the GMLAN signal “Generator Current”.

The current sensor shall be capable of measuring the generator current in the range of 0 to 160 A with an accuracy of ± 1.5 A (in the range of 15 to 70 A) and a resolution of ± 0.3 A.

3.5.3.1 Generator Current Sensor Output Driver. The current sensor output driver is a push-pull driver, which has to interface with a 2.2 kΩ resistor to +5 V and a 1 nF capacitor to ground on the ECM side. The maximum ground voltage variation allowed shall be less than 0.5 V. The PWM output signal frequency of the Generator Current Sensor shall be 128 Hz ± 15%.

3.5.3.2 PWM Input. The ECM shall determine the percentage duty cycle of the PWM generator current signal by ratioing the positive part of the 128 Hz cycles to the sum of the positive and negative (or ground) part of the cycle. The resultant will be converted to a current value as shown in Table 6.

Table 6: Generator Current Sensor Input Characteristics

Duty Cycle	Conversion
0 to 4%	Sensor Failed
5 to 10%	Undercurrent
10 to 90%	0 to 160 A
90 to 95%	Overcurrent
96 to 100%	Sensor Failed

Note: To avoid the ambiguity of high and low threshold voltage trigger variations at the input capture timer of the microprocessor side of the ECM, a Schmitt trigger gate, or a comparator with hysteresis is recommended before or part of the input capture timer.

3.5.3.3 Generator Current Sensor Polarity Algorithm. During start-up, Powertrain shall monitor the PWM duty cycle output of the current sensor to determine if the polarity of the sensor is correct. The following suggested algorithm is recommended to accomplish this function:

Whenever the Engine Run Flag value is greater than or equal to 1, initiate a timer Timer_Gen_Sen_Polarity. When the timer expires (10 s), read the generator current sensor PWM duty cycle. If the generator current sensor PWM duty cycle is greater than or equal to 15%, the polarity of the sensor is correct. No more tests need to be done for the remainder of the ignition cycle.

If the generator current sensor PWM duty cycle is less than or equal to 15%, the polarity of the sensor is incorrect, i.e., the sensor is connected backwards. If Powertrain detects the above condition, the system will default to production spark timing control, a DTC will be set, and the MIL shall be illuminated. Because this component is considered to be a Comprehensive Component, i.e., On-Board Diagnostics (OBD II) compliant, Rationality Diagnostics need to be performed by the ECM.

This interface is emissions-related. Refer to GMW8762, for platform design guidelines.

3.5.4 Generator Current Sensor 5 V Supply.

Note: Applies to GMPT controllers with generator torque estimation.

Refer to GMW8762 for electrical characteristics. This interface is emissions-related. Refer to GMW8762 for platform design guidelines.

3.5.5 Generator Current Sensor 5 V Return.

Note: Applies to GMPT controllers with generator torque estimation.

This signal is a ground reference that is tied to the ECM ground, internal to the ECM. Refer to GMW8763, PPEI Power and Ground Electrical Characteristics. This interface is emissions-related. Refer to GMW8762, for platform design guidelines.

4 Algorithm

4.1 L-Terminal/F-Terminal Monitor Algorithm Requirements.

4.1.1 General Overview. This software algorithm determines when to command the generator telltale or Driver Information Center (DIC) message using serial data. The generator telltale command decision is based on L-terminal diagnostic trouble code, F-terminal diagnostic trouble code, and the ignition switch and engine running state.

4.1.2 Context Diagram. Figure 2.

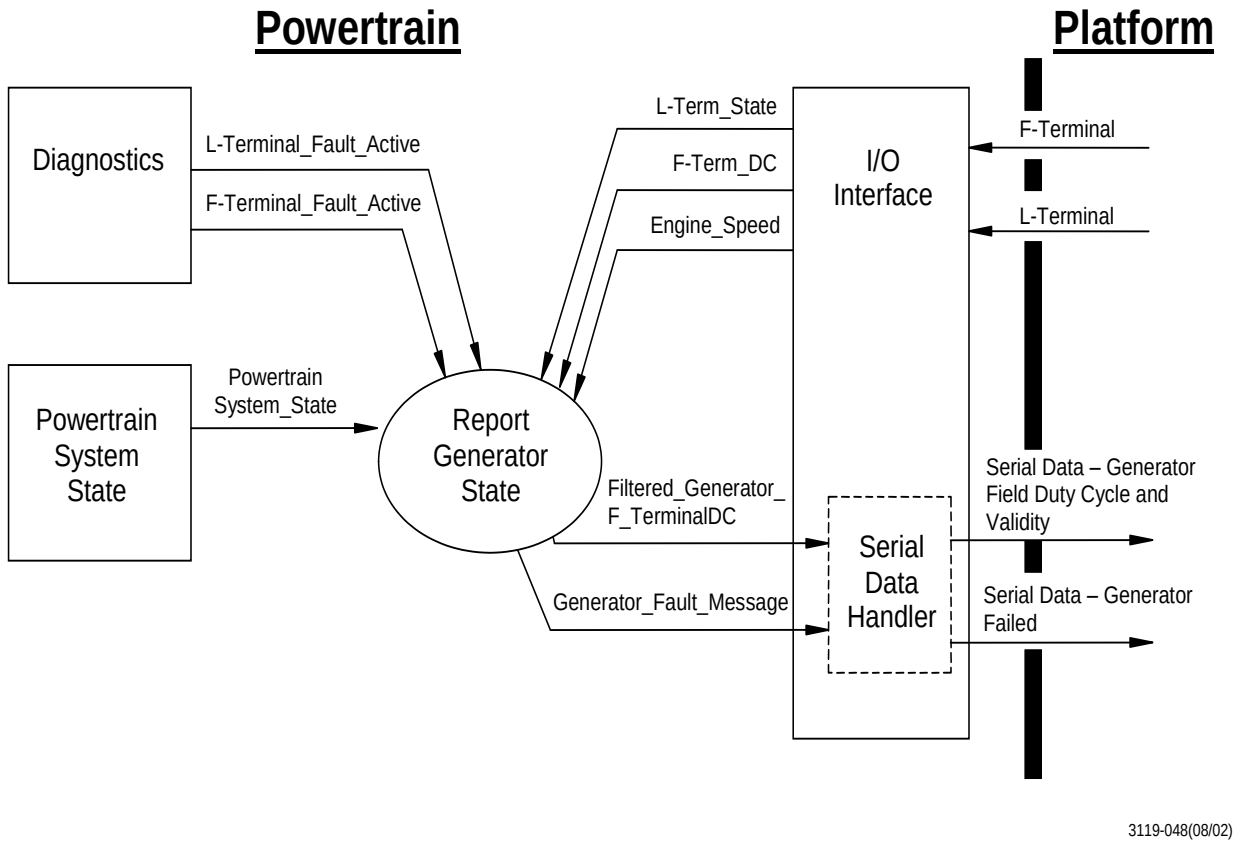


Figure 2: Generator L-Terminal/F-Terminal Monitor Context Diagram

4.1.3 Generator L-Terminal/F-Terminal Monitor Algorithm Description. The Powertrain electronics shall monitor the L-Terminal and F-Terminal for proper operation as defined in the following sections.

4.1.3.1 L-Terminal Signal Processing. The Powertrain electronics shall sample the L-terminal at least once every 500 ms.

4.1.3.2 Generator L-Terminal Diagnostic. The generator L-terminal circuit shall be monitored by the Powertrain controller.

The generator (voltage regulator) indicates a fault condition exists (i.e., internal fault, broken belt) to the Powertrain controller by pulling the L-terminal input to a “low” state.

4.1.3.2.1 Set L-Terminal Fault DTC. The generator L-terminal fault diagnostic trouble code (DTC) shall be logged if the following conditions for the “Key-on Test” or “Run Test” are satisfied:

4.1.3.2.1.1 Key-on Test.

Note: Applies to all applications.

4.1.3.2.1.1.1 Enable Conditions.

a. The Run/Crank input is active following a “Key-on” event, and

b. No engine crank or cam sensor DTCs are currently logged, and
c. Engine_Speed is equal to 0 rpm, and
d. Vehicle_Spd_Is_0 is equal to “True” (Vehicle_Speed is zero, refer to 4.2.7.2), and
e. Stable_condition is equal to “True”.

When the enable conditions are met, the L-terminal output shall be turned on. For an RVC system, the PWM Duty Cycle shall be set to **K_L_KeyOnTestDC**.

4.1.3.2.1.1.2 Stable_condition.

IF ((new power-on [Note 1]) OR (more than **K_Stable_Time** seconds has elapsed since last key-off [Note 2]))
THEN Stable_condition = “True”.
Note 1: The ECM went to sleep at last key-off.
Note 2: The ECM never went to sleep at last key-off.

4.1.3.2.1.1.3 Disable condition. The Key-on Test shall be terminated and the L-term ECM output stage deactivated immediately when the starter relay is engaged, regardless of whether the Key-on Test has finished. This is necessary to protect the generator voltage regulator.

4.1.3.2.1.1.4 Failure Conditions. The generator L-terminal does not indicate a short to ground condition continuously for a time period, L_Term_Open_Timer, that is greater than or equal to **K_L_KeyOnTestTime** following a Run/Crank transition from “Off” to “On”. The generator will ground the L-terminal input when the engine is at or near zero engine speed. If the circuit is intact, the ECM should detect a short to ground condition when the L-terminal output is enabled. In an open circuit condition, the short to ground condition will not be detected by the ECM and the failure condition is met.

4.1.3.2.1.2 Run-Test.

Note: Applies to all applications.

4.1.3.2.1.2.1 Enable Conditions.

a. Generator L-terminal fault is not active due to “Key-on Test”, and
b. Engine Run Active is “True”, and
c. The generator is not disabled via the L-Terminal Control function (refer to 4.2), and
d. No engine crank or cam sensor DTCs are currently logged.

4.1.3.2.1.2.2 Failure Conditions.

4.1.3.2.1.2.2.1 L-Terminal with Discrete Input (non-RVC). The generator L-terminal is in a “low” state continuously for a time period, **L_Term_Shorted_Timer**, that is greater than or equal to **K_L_RunTestTime**.

4.1.3.2.1.2.2.2 L-Terminal with PWM Output (RVC). The generator L-terminal output diagnostics indicate a short to power failure or a short to ground failure continuously for a time period, **L_Term_Shorted_Timer**, that is greater than or equal to **K_L_RunTestTime**.

4.1.3.2.1.3 Fault Timers.

4.1.3.2.1.3.1 L_Term_Open_Timer.

Shall be reset when:

a. The enable conditions for the Generator L-terminal Key-On test are not met, or
b. The Powertrain electronics is executing power-on initialization.

4.1.3.2.1.3.2 L_Term_Shorted_Timer.

Shall be reset when:

a. The enable conditions for the Generator L-terminal Run test are not met, or
b. The Powertrain electronics is executing power-on initialization.

4.1.3.2.1.4 Clear L-Terminal Fault DTC. The generator L-terminal fault diagnostic trouble code (DTC) shall be cleared if the following conditions are satisfied:

a. The conditions for “Set L-Terminal Fault DTC” are not present, and the corresponding, ECM-internal DTC delete counter has reached zero, or

b. A Service Test Tool has commanded clearing of the DTC.

4.1.3.3 F-Terminal Signal Processing. The Powertrain electronics shall sample the averaged Generator F-Terminal duty cycle at least once every 50 ms. The F-Terminal duty cycle shall be averaged over the number of periods completed since the last sample of averaged duty cycle. The F-Terminal duty cycle shall be filtered using a first order lag filter, with a filter coefficient **K_F_TermInFilt**, that corresponds to a time constant between 0.5 and 5.0 s.

4.1.3.4 Generator F-Terminal Diagnostic. The generator F-terminal circuit shall be monitored by the Powertrain controller.

4.1.3.4.1 Set F-Terminal Fault DTC. The generator F-terminal fault diagnostic trouble code (DTC) shall be logged if the following conditions for the "Key-on Test" or "Run Test" are satisfied:

4.1.3.4.1.1 Key-On Test.

Note: Applies to all applications.

4.1.3.4.1.1.1 Enable Conditions.

a. **K_F_TerminalPresent** is equal to "True", and
b. Generator F-terminal fault is not active due to "Run Test", and
c. The Run/Crank input is active following a "Key-on" event, and
d. Engine_Speed is equal to 0 rpm, and
e. No engine crank or cam sensor DTCs are currently logged, and
f. Vehicle_Spd_Is_0 is equal to True (Vehicle_Speed is zero, refer to 4.2.7.2), and
g. Stable_condition is equal to "True".

4.1.3.4.1.1.2 Stable_condition.

IF ((new power-on [Note 1]) OR (more than **K_Stable_Time** seconds has elapsed since last key-off [Note 2]))
THEN Stable_condition = "True".
Note 1: The ECM went to sleep at last key-off.
Note 2: The ECM never went to sleep at last key-off.

4.1.3.4.1.1.3 Failure Conditions. The filtered generator F-terminal duty cycle, Filtered_Generator_F_TerminalDC, is greater than or equal to **K_F_DC_KeyOnTest** continuously for a time period, F_Term_DC_High_Timer, that is greater than or equal to **K_F_KeyOnTestTime** following a Run/Crank transition from "Off" to "On".

4.1.3.4.1.2 Run-Test.

Note: Applies to all conditions.

4.1.3.4.1.2.1 Enable Conditions.

a. **K_F_TerminalPresent** is equal to "True", and
b. Generator F-terminal fault is not active due to "Key-on Test", and
c. The generator is not disabled via the L-Terminal Control function (refer to 4.2), and
d. The Run/Crank input is active, and
e. Engine_Speed is less than **K_F_RPM_RunTest**, and
f. The Generator L-Terminal Fault DTC is not currently active, and
g. No engine crank or cam sensor DTCs are currently logged.

4.1.3.4.1.2.2 Failure Conditions. The filtered generator F-terminal duty cycle, Filtered_Generator_F_TerminalDC, is less than or equal to **K_F_DC_RunTest** continuously for a time period, F_Term_DC_Lo_Timer, that is greater than or equal to **K_F_RunTestTime**.

4.1.3.4.1.3 Fault Timers.

4.1.3.4.1.3.1 F_Term_DC_High_Timer.

Shall be reset when:

a. The enable conditions for the Generator F-terminal Key-On test are not met, or
b. The Powertrain electronics is executing power-on initialization.

4.1.3.4.1.3.2 F_Term_DC_Lo_Timer.

Shall be reset when:

a. The enable conditions for the Generator F-terminal Run test are not met, or
b. The Powertrain electronics is executing power-on initialization.

4.1.3.4.1.4 Clear F-Terminal Fault DTC. The generator F-terminal fault diagnostic trouble code (DTC) shall be cleared if the following conditions are satisfied:

a. The conditions for "Set F-Terminal Fault DTC" are not present and the corresponding, ECM-internal DTC delete counter has reached zero, or
b. A Service Test Tool has commanded clearing of the DTC.

4.1.4 On Vehicle Communications/Serial Data Interaction Requirements. Refer to Table 7.

Table 7: Generator L-Terminal and F-Terminal Serial Data Signals

GMLAN Signal	Transmitter
Generator Failed	Powertrain
Generator Field Duty Cycle	Powertrain
Generator Field Duty Cycle Validity	Powertrain

4.1.4.1 Determine Generator Failed Message Data. The Generator Failed serial data signal status shall be set to "True", if any of the following conditions are satisfied:

a. A generator L-terminal fault has been detected, or
b. A generator F-terminal fault has been detected.

Otherwise the Generator Failed serial data signal status shall be set equal to "False".

4.1.4.2 Determine Generator Field Duty Cycle Message Data. The Generator Field Duty Cycle serial data signal shall be set to 0%, if a generator F-terminal fault has been detected and an associated DTC has been set.

Otherwise, the Generator Field Duty Cycle serial data signal shall be set equal to Filtered_Generator_F_TerminalDC.

If **K_F_TerminalPresent** is equal to "False", this signal data value shall be set to 0%.

4.1.4.3 Determine Generator Field Duty Cycle Validity. The Generator Field Duty Cycle Validity serial data signal status shall be set to "Invalid", if a generator F-terminal fault has been detected and an associated DTC has been set.

Otherwise, the Generator Field Duty Cycle Validity serial data signal status shall be set equal to "Valid".

If **K_F_TerminalPresent** is equal to "False", this signal shall be set to "Valid".

4.1.5 Execution/Activation Requirements. Refer to Table 8.

Table 8: Generator L-Terminal and F-Terminal Execution Requirements

Algorithm Section	Execution Interval
Generator Status	1 s maximum
L-Terminal Signal Processing	500 ms maximum
F-Terminal Signal Processing	50 ms maximum

4.1.6 Data Dictionary.

4.1.6.1 Calibrations. All calibrations are Platform-owned.

4.1.6.1.1 K_F_DC_KeyOnTest. If F-Terminal Duty Cycle is equal to or greater than this threshold, the F-Terminal Key-On Test fails after a continuous amount of time.

Units: Percent Duty Cycle
Minimum Range: 0 to 100%
Minimum Resolution: 1%
Typical Value: 65%

4.1.6.1.2 K_F_DC_RunTest. If F-Terminal Duty Cycle is equal to or less than this threshold, the F-Terminal Run-Test fails after a continuous amount of time.

Units: Percent Duty Cycle
Minimum Range: 0 to 100%
Minimum Resolution: 1%
Typical Value: 5%

4.1.6.1.3 K_F_KeyOnTestTime. The conditions for F-Terminal Key-On Test shall exist for a continuous period greater than or equal to this calibration.

Units: s
Minimum Range: 1 to 125 s
Minimum Resolution: 1 s
Typical Value: 5 s

4.1.6.1.4 K_F_RPM_RunTest. Engine Speed must be below this threshold to enable the F-Terminal Run-Test.

Units: rpm
Minimum Range: 0 to 8000 rpm
Minimum Resolution: 25 rpm
Typical Value: 1000 rpm

4.1.6.1.5 K_F_RunTestTime. The conditions for F-Terminal Run-Test Test shall exist for a continuous period greater than or equal to this calibration.

Units: s
Minimum Range: 1 to 125 s
Minimum Resolution: 1 s
Typical Value: 30 s

4.1.6.1.6 K_F_TerminalPresent. Identifies the F-Terminal function is being utilized.

Units: Logical
Minimum Range: “True”, “False”
Minimum Resolution: Not applicable.
Typical Value: “True”

4.1.6.1.7 K_F_TermInFilt. First order lag filter coefficient used to filter the generator F-Terminal duty cycle input for use with diagnostic and serial data. When sampling every 50 ms, a coefficient that corresponds to a 1 s time constant is approximately equal to 12/256.

$$K\_F\_TermInFilt = 1 - e^{-SampleInterval/TimeConstant}$$

Units: Factor
Minimum Range: 0 to 1
Minimum Resolution: 1/256
Typical Value: 101/256

4.1.6.1.8 K_L_KeyOnTestDC. The duty cycle commanded for L-Terminal Key-On Test. For non-RVC applications with a PWM output driver, this must be set to 100%.

Units: Percent Duty Cycle

Minimum Range: 0 to 100%

Minimum Resolution: 1%

Typical Value: 100%

4.1.6.1.9 K_L_KeyOnTestTime. The conditions for L-Terminal Key-On Test shall exist for a continuous period greater than or equal to this calibration.

Units: s

Minimum Range: 1 to 125 s

Minimum Resolution: 1 s

Typical Value: 1 s

4.1.6.1.10 K_L_RunTestTime. The conditions for L-Terminal Run-Test Test shall exist for a continuous period greater than or equal to this calibration.

Units: s

Minimum Range: 1 to 125 s

Minimum Resolution: 1 s

Typical Value: 15 s

4.1.6.1.11 K_TorqueEstimationFunctionPresent. This calibration must be set to “True” if the Generator Torque Estimation function is present. Otherwise, the calibration must be set to “False”. This is a Platform-owned calibration and applies to GMPT controllers.

Minimum Range: “False” or “True”

Typical Value: “True”

4.1.6.1.12 K_RVC_FunctionPresent. This calibration must be set to “True” if the Regulated Voltage Control (RVC) function is present. Otherwise, the calibration must be set to “False”. This is a Platform-owned calibration.

Minimum Range: “False” or “True”

Typical Value: “True”

4.1.6.1.13 K_Stable_Time. If the time the ignition key has been in the Off position is greater than this threshold, the generator is in a stable condition, suitable to run the Key-on Test.

Units: s

Minimum Range: 0 to 60 s

Minimum Resolution: 1 s

Typical Value: 15 s

4.1.6.2 Variables.

4.1.6.2.1 Engine_Speed. Calculated speed of the engine based on available engine position sensor(s).

Units: rpm

Minimum Range: 0 to 8192 rpm

Minimum Resolution: 32 rpm

Initial Value: 0 rpm

4.1.6.2.2 F_Term_DC_High_Timer. Keeps track of the continuous amount of time the F-terminal Duty Cycle is equal to or greater than its fail threshold during the F-terminal Key-On Test.

Units: s

Minimum Range: 0.0 to 125.0 s

Minimum Resolution: 0.5 s

Initial Value: 0.0 s

4.1.6.2.3 F_Term_DC_Lo_Timer. Keeps track of the continuous amount of time the F-terminal Duty Cycle is equal to or less than its fail threshold during the F-terminal Run Test.

Units: s

Minimum Range: 0.0 to 125.0 s

Minimum Resolution: 0.5 s

Initial Value: 0.0 s

4.1.6.2.4 Filtered_Generator_F_TerminalDC. Indicates the filtered current duty cycle of the generator F-Terminal.

Units: Percent Duty Cycle

Minimum Range: 0 to 100%

Minimum Resolution: 1%

Initial Value: 0%

4.1.6.2.5 L_Term_Open_Timer. Keeps track of the continuous amount of time the L-terminal state is not indicating a ground short during the L-terminal Key-On Test.

Units: s

Minimum Range: 0 to 125 s

Minimum Resolution: 1 s

Initial Value: 0 s

4.1.6.2.6 L_Term_Shorted_Timer. Keeps track of the continuous amount of time the L-terminal state is shorted (either high or low) during the L-terminal Run Test.

Units: s

Minimum Range: 0 to 125 s

Minimum Resolution: 1 s

Initial Value: 0 s

4.1.6.2.7 Ignition_State. The ignition switch input to the Powertrain electronics input interface.

Units: Logical

Minimum Range: “Off”, “Accessory”, “Run”, “Crank”

Initial Value: “Off”

4.2 Generator L-Terminal Control Algorithm Requirements.

4.2.1 General Overview. The generator L-terminal control algorithm controls the L-terminal based on inputs from Platform, Powertrain, and Service.

a. Pulse width modulates the generator L-terminal according to the command received from serial data in Regulated Voltage Control (RVC) applications.
b. Determines when to disable the generator for engine starting and stall-saver purposes.
c. Processes service tool requests for controlling the generator L-terminal to disable or enable the generator output.
d. Pulse width modulates the generator L-terminal to control generator torque for RTC applications.

   Note: Applies to GMPT controllers with generator torque estimation. Refer to Global Electric Power Management - Gen IV/V SSTS.

4.2.2 Context Diagram. Refer to Figure 3.

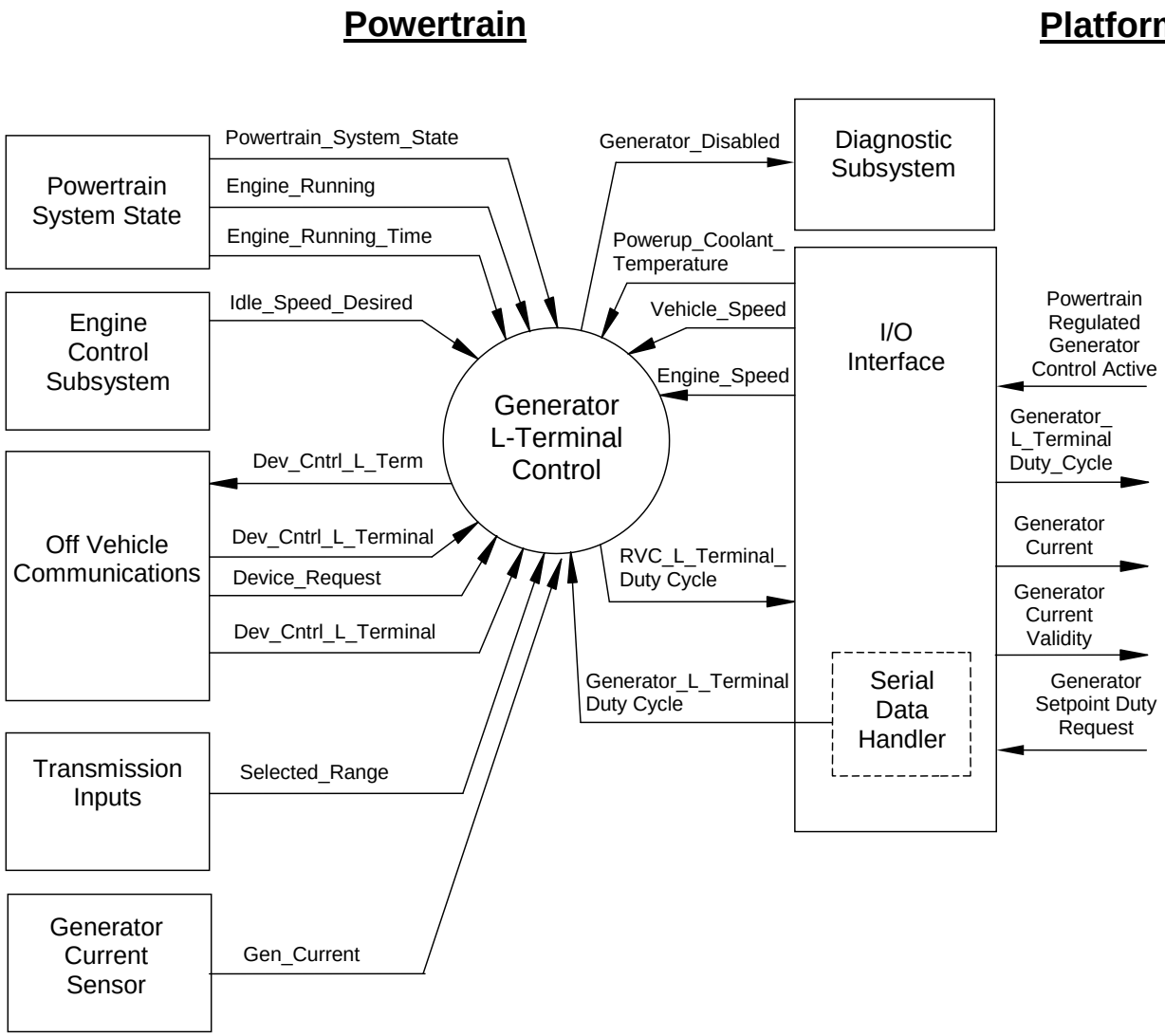


Figure 3: Generator L-Terminal Control Context Diagram

4.2.3 Generator L-Terminal Control Algorithm Description.

4.2.3.1 Generator Control. The Generator shall be enabled or disabled by the powertrain controller based on conditions for normal control and device control in Table 9. If the Regulated Voltage Control function is being used, the calibration **K_RVC_FunctionPresent** must be set to "True". Conversely, the calibration **K_RVC_FunctionPresent** must be set to "False", if Regulated Voltage Control function is not being used. If Regulated Torque Control is used in conjunction with generator torque estimation, the calibration **K_TorqueEstimationFunctionPresent** must be set to "True", otherwise it shall be set to "False".

Note: Applies to GMPT controllers only, refer to Global Electric Power Management - Gen IV/V SSTS.

If either of the following conditions is present, **RVC_L_Terminal_Duty_Cycle** must be defaulted to the previous undefaulted RVC value. If **RVC_L_Terminal_Duty_Cycle** has defaulted longer than a calibrated amount of time, **K_RVC_DefaultTime**, set **RVC_L_Terminal_Duty_Cycle** to 100%.

a. The received serial data message Generator Regulator Setpoint Duty Cycle Request is less than a minimum calibration, **K_RVC_MinDutyCycle**.

b. A serial data failure (State of Health) is detected with the serial data message Generator Regulator Setpoint Duty Cycle Request.

Table 9: Generator L-Terminal Control Enable/Disable Requirements

Generator L-Terminal Control					
Outputs					
K_RVC_-Function-Present	L_Terminal_Device_Request	L_Terminal_-Normal_-Control	Engine_Running	Generator_L_-Terminal_-Cntrl_DC	Comments
"False"	"No Request"	"On"	do not care	Set to "100%" (For Discrete Output, set to "On")	Generator turned "On" for Normal Control w/o RVC
"False"	"No Request"	"Off"	do not care	Set to "0%" (For Discrete Output, set to "Off")	Generator turned "Off" for Normal Control w/o RVC
"False"	"On"	do not care	do not care	Set to "100%" (For Discrete Output, set to "On")	Generator turned "On" for Device Control w/o RVC
"False"	"Off"	do not care	do not care	Set to "0%" (For Discrete Output, set to "Off")	Generator turned "Off" for Device Control w/o RVC
"True"	"No Request"	"On"	do not care	Set to Generator Regulator Setpoint Duty Cycle Request	Generator turned "On" for Normal Control with RVC
"True"	"No Request"	"Off"	"True"	Set to "15%"	Generator turned "Off" for Normal Control with RVC
"True"	"No Request"	"Off"	"False"	Set to "0%"	Generator turned "Off" During Engine Start
"True"	"On"	do not care	do not care	Set to "85%"	Generator turned "On" for Device Control with RVC
"True"	"Off"	do not care	do not care	Set to "15%"	Generator turned "Off" for Device Control with RVC

4.2.3.2 Normal Control. The Generator shall be enabled for normal control, and the L_Terminal_Normal_Control set equal to “On”, if all of the following conditions are satisfied:

a. The Engine is running, and

b. No engine stall conditions are present, where Stall_Genr_Dsbl_Required is equal to “False”, and

c. EngStartGenrDsblDelayRequired is equal to “False”.

Otherwise, the Generator shall be disabled for normal control, and L_Terminal_Normal_Control set equal to “Off”.

4.2.3.3 Device Control. The Generator shall be enabled via device control if L_Terminal_Device_Request is set equal to “On”. Conversely, the Generator shall be disabled via device control if L_Terminal_Device_Request is set equal to “Off”. Refer to 4.2.6 Off Vehicle Communications (OFVC) Device Control of L-Terminal.

4.2.3.4 Generator Disable. The Generator shall be disabled by the powertrain controller when the Generator_L_Terminal_Control is set equal to “Off”. The Generator_Disabled state shall be set equal to “True” anytime the Generator_L_Terminal_Control is set equal to “Off”, so that the Generator L-Terminal and Generator F-Terminal diagnostics can be disabled.

4.2.3.5 Evaluate Engine Speed for Possible Stall. The generator shall be disabled by the Powertrain controller for a possible engine stall condition by setting Stall_Genr_Dsbl_Required equal to “True”, when the Engine_Speed is less than or equal to **K_EngSpdCutout[Idle_Speed_Desired, In_Park_Or_Neutral].**

The Powertrain controller shall indicate that possible engine stall conditions no longer exist by setting Stall_Genr_Dsbl_Required equal to “False” (the generator is allowed to be enabled), when Engine_Speed is greater than **K_EngSpdCutout[Idle_Speed_Desired, In_Park_Or_Neutral].**

The generator shall not be disabled due to a possible engine stall condition for longer than **K_CumulativeL_TermOff** seconds within the same ignition cycle.

4.2.3.6 Determine Generator Turn-On Delay. The generator shall be disabled after each engine start for a calibrated period of time by setting EngStartGenrDsblDelayRequired equal to “True”, when the engine running time, Engine_Running_Time, is equal to or less than **K_EngStrtDsblDly[Powerup_Coolant_Temperature],** otherwise EngStartGenrDsblDelayRequired shall be set equal to “False”. The calibration, **K_EngStrtDsblDly[Powerup_Coolant_Temperature],** can also be calibrated to handle generator cold start disable. By varying the calibration based on power-up coolant temperature, the calibration can be optimized for generator turn-on delay and generator cold start disable.

4.2.4 Execution/Activation Requirements. Refer to Table 10.

Table 10: Generator L-Terminal Control Execution Requirements

Algorithm Section	Execution Interval
Evaluate Engine Speed for Possible Stall	12.5 ms maximum
All other Algorithm Sections	50 ms maximum

4.2.5 On Vehicle Communications/Serial Data Interaction Requirements. Refer to Table 11.

Table 11: Generator L-Terminal Control Serial Data Requirements

GMLAN Signal	Transmitter
Generator Regulator Setpoint Duty Cycle Request	Platform

Applications which do not support Regulated Voltage Control (RVC) shall always transmit this signal with a data value of 100%.

4.2.6 Off Vehicle Communications/Serial Data Interaction Requirements.

4.2.6.1 Off Vehicle Communications (OFVC) Device Control of L-Terminal. A scan tool may request to override the generator L-terminal via serial data device control. An override request will be identified by Dev_Cntrl_L_Terminal set to Enabled and Dev_Cntrl_L_Terminal_State set to either “On” or “Off”. The Powertrain controller will grant the device control request and override the generator L-terminal for as long as requested while there are no protection limits exceeded. If any of the protection limits are exceeded during generator L-terminal device control override, Dev_Cntrl_L_Term_Exceeded will be set to the appropriate value (i.e., “EngnNotRunning”, “NotParkOrNeutral”, “SpdNot0”, or “L_TermMaxOffTime”) depending on the specific limit which has been exceeded. If the protection limits are NOT exceeded, the Dev_Cntrl_L_Term_Exceeded will be set to “Null”. The limit checks are bypassed during vehicle end of line test, which is indicated by Service_Limit_Status being set to Disabled. The protection limits are exceeded if any of the following occur:

a. Engine Run Active is not “True”, or
b. Vehicle_Spd_Is_0 is set to “False” (refer to 4.2.6.2), or
c. In_Park_Or_Neutral is set to “False”, or
d. L_Term_Off_Tmr_Expired to set to “True” (refer to 4.2.6.3).

Table 12 shows the output for Generator L-Terminal Device Control. This output will be used to determine when to turn “On” and “Off” the Generator L-Terminal for Device Control.

Table 12: Generator L-Terminal Device Control Output

Generator L-Terminal Device Control Output				
Dev_Cntrl_L_-Terminal	**Dev_Cntrl_L_-Terminal_State**	**Service_Limit_Status**	**Dev_Cntrl_L_-Term_Exceeded**	**L_Terminal_-Device_Request**
“Disabled”	do not care	do not care	do not care	“No Request”
“Enabled”	“On”	“Disabled”	do not care	“On”
“Enabled”	“Off”	“Disabled”	do not care	“Off”
“Enabled”	“On”	“Enabled”	“Null”	“On”
“Enabled”	“On”	“Enabled”	“EngnNotRunning” OR “NotParkOrNeutral” OR “SpdNot0” OR “L_TermMaxOffTime”	“No Request”
“Enabled”	“Off”	“Enabled”	“Null”	“Off”
“Enabled”	“Off”	“Enabled”	“EngnNotRunning” OR “NotParkOrNeutral” OR “SpdNot0” OR “L_TermMaxOffTime”	“No Request”

4.2.6.2 Determine if Vehicle Speed is Zero. The vehicle speed shall be determined as zero, Vehicle_Spd_Is_0 is set equal to "True", if Vehicle_Speed is less than or equal to **K_ZeroSpdThresh** km/h, otherwise Vehicle_Spd_Is_0 is set equal to "False".

4.2.6.3 Determine if L-Terminal Off Time is Expired for Device Control. L_Term_Off_Tmr_Expired shall be determined from the following conditions:

If the **L_Terminal_Device_Request** is set to "Off" for a cumulative time, **CumulativeL_TermOff,** greater than or equal to **K_CumulL_TermOffDC** seconds, then **L_Term_Off_Tmr_Expired** shall be set equal to "True".

CumulativeL_TermOff timer shall accumulate any time **L_Terminal_Device_Request** is set to "Off".

4.2.6.4 Determine Estimated Generator Torque.

Note: Applies to GMPT controllers with generator torque estimation. Refer to Global Electric Power Management – Gen IV/V SSTS for calculating Estimated Generator Torque.

4.2.7 Data Dictionary.

4.2.7.1 Calibrations. All calibrations are Powertrain-owned unless otherwise specified.

4.2.7.1.1 K_CumulativeL_TermOff. Cumulative amount of time that generator L-terminal can be disabled in normal operation during one ignition cycle (not including disable time due to cold start). This is a Platform-owned calibration.

Minimum Range: 0 to 20 s

Minimum Resolution: 1 s

Typical Value: 10 s

4.2.7.1.2 K_CumulativeL_TermOffDC. Cumulative amount of time that generator L-terminal can be off for device control during one ignition cycle. This is a Platform-owned calibration.

Minimum Range: 0 to 100 s

Minimum Resolution: 1 s

Typical Value: 30 s

4.2.7.1.3 K_EngSpdCutout. A calibration table of values dependent on the desired idle speed and Park/Neutral position.

Minimum Range: 0 to 2000 rpm

Minimum Resolution: 1 rpm

Typical Values: Refer to Table 13.

Table 13: K_EngSpd Cutout Calibration

Desired Idle Speed	In_Park_Or_Neutral	Not_Park_Or_Neutral
800 rpm	750 rpm	750 rpm
1000 rpm	800 rpm	800 rpm
1500 rpm	1100 rpm	1000 rpm

4.2.7.1.4 K_EngStrtDsblDly. The generator will be disabled initially after an engine start for this calibrated amount of time for either idle stability or cold start disable. The calibration table of values (in seconds) is dependent on power-up coolant temperature. This calibration shall be jointly determined by Platform and Powertrain.

Maximum Output Range: 0 to 10 s

Minimum Output Resolution: 0.5 s

Minimum Table Axis Range: -40 to +140°C

Minimum Table Size: 9 breakpoints

Typical Values: Refer to Table 14.

Table 14: K_EngStrtDsblDly Calibration

Power-Up Coolant Temperature	K_Eng_StrtDsblDly
-40°C	5.0 s
…	…
40°C	2.0 s
…	…
120°C	1.0 s

4.2.7.1.5 K_RVC_DefaultTime. The ECM generator control algorithm shall enter default mode operation whenever the RVC default time has elapsed.

Minimum Range: 0.0 to 10.0 s

Minimum Resolution: 0.1 s

Typical Value: 2.0 s

4.2.7.1.6 K_RVC_FunctionPresent. This calibration must be set to "True" if the Regulated Voltage Control (RVC) function is present. Otherwise, the calibration must be set to "False" when the RVC function is not being used. This is a Platform-owned calibration.

Minimum Range: "False" or "True"

Typical Value: "True"

4.2.7.1.7 K_RVC_MinDutyCycle. The ECM generator control algorithm shall enter default mode operation whenever the RVC duty cycle from serial data is less than this calibration. This is a Platform-owned calibration.

Minimum Range: 0 to 100%

Minimum Resolution: 1%

Typical Value: 36%

4.2.7.1.8 K_ZeroSpdThresh. Calibratable value, determines vehicle speed zero threshold.

Minimum Range: 0.0 to 10.0 km/h

Minimum Resolution: 0.1 km/h

Typical Value: 1.0 km/h

4.2.7.1.9 K_GenTorqueModelCoeff_A. Constant used to calculate the estimated generator Torque. Applicable to GMPT controllers with generator torque estimation. Refer to Global Electric Power Management – Gen IV/V SSTS for calibration usage.

Units: Factor

Data Type: Single Precision Floating Point

Minimum Range: -1000 to 1000

Minimum Resolution: 1.00 E-16

Typical Value: -3.433 × 1.00 E-01

Owner: Platform

4.2.7.1.10 K_GenTorqueModelCoeff_B. Constant used to calculate the estimated generator Torque. Applicable to GMPT controllers with generator torque estimation. Refer to Global Electric Power Management – Gen IV/V SSTS for calibration usage.

Units: Factor

Data Type: Single Precision Floating Point

Minimum Range: -1000 to 1000

Minimum Resolution: 1.00 E-16

Typical Value: 9.715 × 1.00 E-05

Owner: Platform

4.2.7.1.11 K_GenTorqueModelCoeff_C. Constant used to calculate the estimated generator torque. Applies to GMPT controllers with generator torque estimation. Refer to Global Electric Power Management - Gen IV/V SSTS for calibration usage.

Units:	Factor
Data Type:	Single Precision Floating Point
Minimum Range:	-10 000 to 10 000
Minimum Resolution:	1.00 E-16
Typical Value:	5.991 × 1.00 E-11
Owner:	Platform

4.2.7.1.12 K_GenTorqueModelCoeff_D. Constant used to calculate the estimated generator torque. Applies to GMPT controllers with generator torque estimation. Refer to Global Electric Power Management - Gen IV/V SSTS for calibration usage.

Units:	Factor
Data Type:	Single Precision Floating Point
Minimum Range:	-10 000 to 10 000
Minimum Resolution:	1.00 E-16
Typical Value:	1.192 × 1.00 E+02
Owner:	Platform

4.2.7.1.13 K_GenTorqueModelCoeff_E. Constant used to calculate the estimated generator Torque. Applies to GMPT controllers with generator torque estimation. Refer to Global Electric Power Management - Gen IV/V SSTS for calibration usage.

Units:	Factor
Data Type:	Single Precision Floating Point
Minimum Range:	-10 000 to 10 000
Minimum Resolution:	1.00 E-16
Typical Value:	2.504 × 1.00 E+01
Owner:	Platform

4.2.7.1.14 K_GenTorqueModelCoeff_F. Constant used to calculate the estimated generator torque. Applies to GMPT controllers with generator torque estimation. Refer to Global Electric Power Management - Gen IV/V SSTS for calibration usage.

Units:	Factor
Data Type:	Single Precision Floating Point
Minimum Range:	-10 000 to 10 000
Minimum Resolution:	1.00 E-16
Typical Value:	7.076 × 1.00 E-02
Owner:	Platform

4.2.7.1.15 K_GenTorqueModelCoeff_G. Constant used to calculate the estimated generator torque. Applies to GMPT controllers with generator torque estimation. Refer to Global Electric Power Management – Gen IV/V SSTS for calibration usage.

Units:	Factor
Data Type:	Single Precision Floating Point
Minimum Range:	-10 000 to 10 000
Minimum Resolution:	1.00 E-16
Typical Value:	3.674 × 1.00 E-01
Owner:	Platform

4.2.7.1.16 K_GenPulleyRatio. This calibration determines the ratio between the Generator Pulley and the Crankshaft Pulley and is used to calculate Generator rotational speed from Engine Speed. Applies to GMPT

controllers with generator torque estimation. Refer to Global Electric Power Management - Gen IV/V SSTS for calibration usage.

Units: Factor
Minimum Range: 0 to 5
Minimum Resolution: 0.01
Typical Value: 3.34
Owner: Platform

4.2.7.1.17 K_GenSetpoint_RampRateUp. This calibration determines the rate at which the ECM will raise the voltage whenever the current engine state is either at Idle, Coastdown or Decel Fuel Cutoff (DFCO). Applies to GMPT controllers with generator torque estimation. Refer to Global Electric Power Management - Gen IV/V SSTS for calibration usage.

Units: V/s
Minimum Range: 0.00 to 1.00 V/s
Minimum Resolution: 0.01 V/s
Typical Value: 0.20 V/s
Owner: Platform

4.2.7.1.18 K_GenSetpoint_RampRateDown. This calibration determines the rate at which the ECM will lower the voltage whenever the current engine state is NOT Idle, Coastdown or Decel Fuel Cutoff (DFCO). Applies to GMPT controllers with generator torque estimation. Refer to Global Electric Power Management - Gen IV/V SSTS for calibration usage.

Units: V/s
Minimum Range: 0.00 to 1.00 V/s
Minimum Resolution: 0.01 V/s
Typical Value: 0.20 V/s
Owner: Platform

4.2.7.1.19 K_GenSetpointVoltage. This calibration is a 5 value table which defines the voltage value that the ECM will ramp up to whenever the current engine state is Idle, Coastdown or Decel Fuel Cutoff (DFCO). This table will be a function of Powertrain calculated ambient air temperature. Applies to GMPT controllers with generator torque estimation. Refer to Global Electric Power Management - Gen IV/V SSTS for calibration usage.

Units: V
Minimum Range: 11.0 to 16.0 V
Minimum Resolution: 0.1 V
Typical Values: Refer to Table 15.
Owner: Platform

Table 15: K_Gen_SetpointVoltage Typical Values

Outside Air Temperature Powertrain Estimated (°C) Typical Values	Setpoint Voltage Typical Values
-29°C	15.5 V
-18°C	15.5 V
0°C	15.0 V
25°C	14.7 V
52°C	14.7 V

4.2.7.2 Variables.

4.2.7.2.1 CumulativeL_TermOff. The device control timer, shall be activated/deactivated based on the state of L_Terminal_Device_Request.

Minimum Range: 0 to 100 s

Minimum Resolution: 1 s

Initial Value: 30 s

4.2.7.2.2 Dev_Cntrl_L_Term_Exceeded. If a technician device control request to disable L-terminal is made and the control limits are not met, then Dev_Cntrl_L_Term_Exceeded will be assigned an appropriate exceeded limit. If the limits are met, then Dev_Cntrl_L_Term_Exceeded will be set equal to "null".

Minimum Range: "EngnNotRunning", "NotParkOrNeutral", SpdNot0", "L_TermMaxOffTime", or "Null"

Initial Value: "Null"

4.2.7.2.3 Dev_Cntrl_L_Terminal. Allows an Off-Board Vehicle Communication (OFVC) tool to control L-terminal. The OFVC tool requires a response from the Powertrain electronics (Generator Control Algorithm) whether control is allowed or not.

Minimum Range: "Enabled" or "Disabled"

Initial Value: "Disabled"

4.2.7.2.4 Dev_Cntrl_L_Terminal_State. When the state of this variable is "On", the generator subsystem is commanded to enable L-Terminal. If the Variable state is "Off", the generator subsystem is commanded to disable the L-Terminal.

Minimum Range: "On" or "Off"

Initial Value: "Off"

4.2.7.2.5 Engine_Running. Indicates that the engine is considered to be running.

Minimum Range: "True" or "False"

4.2.7.2.6 Engine_Running_Time. The period of time that the engine has been considered running (or the time that PTSS_Engine_Running has been equal to "True").

Minimum Range: 0.0 to 204.8 s (3.41 minutes)

Minimum Resolution: 0.003125 s

4.2.7.2.7 Engine_Speed. Calculated speed of the engine based on available engine position sensor(s).

Minimum Range: 0 to 8192 rpm

Minimum Resolution: 32 rpm

4.2.7.2.8 EngStartGenrDsblDelayRequired. This flag will be set to True to turn off the generator after the engine initially starts for idle stability and generator cold start disable.

Minimum Range: "True" or "False"

Initial Value: "True"

4.2.7.2.9 Generator_Disabled. Goes to Diagnostic. Set to "True" if L-terminal is Off, otherwise set to "False" if L-terminal is On (i.e., enabled).

Minimum Range: "True" or "False"

Typical Value: "False"

Initial Value: "True"

4.2.7.2.10 Generator_L_Terminal_Control. Indicates whether the Generator L-Terminal output is commanded "On" or "Off".

Minimum Range: "On" or "Off"

Typical Value: "On"

Initial Value: "Off"

4.2.7.2.11 Generator_L_Terminal_Cntrl_DC. Outputs pulse width modulated signal to ECM output pin to enable or disable L-terminal.

Minimum Range: 0 to 100%

Minimum Resolution: 1%

Typical Value: 60%

Initial Value: 10%

4.2.7.2.12 Idle_Speed_Desired. The final desired idle speed of the engine.

Minimum Range: 200 to 2000 rpm

Minimum Resolution: 32 rpm

Typical Value: 800 rpm

4.2.7.2.13 In_Park_Or_Neutral. For automatic transmissions, "True" is defined as the vehicle being in Park or Neutral position. For manual transmissions, this variable is always equal to "True".

Minimum Range: "True" or "False"

Initial Value: "True"

4.2.7.2.14 L_Term_Off_Tmr_Expired. Set to "True" when the maximum amount of time L-terminal can be disabled has expired during device control.

Minimum Range: "True" or "False"

Initial Value: "False"

4.2.7.2.15 L_Terminal_Device_Request. When a device control request is made, it is validated and this variable, L_Terminal_Device_Request, is set to either "On" or "Off". If no request is made, the L_Terminal_Device_Request is set to "No_Request".

Minimum Range: "On", "Off", or "No_Request"

Initial Value: "No_Request"

Typical Value: "No_Request"

4.2.7.2.16 Powerup_Coolant_Temperature. Temperature of the engine coolant as determined by the I/O interface of the Powertrain Controller.

Minimum Range: -40 to +140°C

Minimum Resolution: 1°C

4.2.7.2.17 RVC_L_Terminal_Duty_Cycle. Commanded L-Terminal Duty Cycle from the Platform via serial data for Regulated Voltage Control.

Minimum Range: 0 to 100%

Minimum Resolution: 0.5%

4.2.7.2.18 Selected_Range. The operator selected automatic transmission range as indicated by the transmission range selector.

Minimum Range: "First Gear", "Second Gear", "Third Gear", "Fourth Gear", "Fifth Gear", "Sixth Gear", "Neutral", "Reverse", "Park"

Initial Value: "Park"

4.2.7.2.19 Service_Limit_Status. When Service_Limit_Status is set to "Disabled" (by the technician), the generator subsystem will not check any limits and will enable/disable the generator as requested by the technician via the OFVC tool.

Minimum Range: "Enabled" or "Disabled"

Initial Value: "Enabled"

Typical Value: "Enabled"

4.2.7.2.20 Vehicle_Speed. Vehicle_Speed is defined as the final ground speed of the vehicle.

Minimum Range: 0.0 to 350.0 km/h

Minimum Resolution: 0.1 km/h

Initial Value: 0.0 km/h

4.2.7.2.21 Vehicle_Spd_Is_0. When "True", this state variable indicates that Vehicle_Speed is less than a calibration threshold defined as 0 vehicle speed.

Minimum Range: "True" or "False"

Initial Value: "True"

4.2.7.2.22 Vehicle_State_For_Dev_Cntrl. Identifies if the vehicle is in the right state to be controlled by an OFVC tool or not.

Minimum Range: "OK", "Not OK"

Initial Value: "Not OK"

5 Provisions for Shipping

Not applicable.

6 Notes

6.1 Glossary. Not applicable.

6.2 Acronyms, Abbreviations, and Symbols.

Refer to GMW8762, Appendix A3.

7 Additional Paragraphs

7.1 All materials supplied to this specification must comply with the requirements of GMW3001, **Rules and Regulations for Materials Specifications.**

7.2 All parts or systems supplied to this standard must comply with the requirements of GMW3059, **Restricted and Reportable Substances for Parts.**

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

GMW8778

9 Release and Revisions

This standard was originated in June 2003. It was first approved by The Global PPEI Core Team in December 2003. It was first published in February 2004.

Issue	Publication Date	Description (Organization)
1	FEB 2004	Initial publication.
2	AUG 2004	Global PPEI Version 3.5 Release.
3	APR 2005	Global PPEI Version 3.6 Release.
4	AUG 2010	Global PPEI Version 3.6 Release. (Global PPEI Core Team)

Appendix A

The following Change Requests were written against GMW8778 PPEI Version 3.8 Release, impacting the Generator Control Subsystem.

Sections Changed	Description of Changes	Rationale/Authorization
2.3	Added Global Electrical Power Management – Gen IV/V SSTS to Additional References.	CR317
3.1	Added Regulated Torque Control (RC) overview section.	
3.1.9	Added generator torque estimation description.	
Figure 1	Revised block diagram to include the Generator Current Sensor (3-pin) wiring required for RTC. Removed the F-Terminal hardwire from Generator to ECM.	
3.3.1	Added the following new PPEI GMLAN signals: 1. Generator Current Validity and Generator Current 2. Powertrain Regulated Generator Control Active	
Table 2	Added new calibrations to table.	
3.3.3	Revise section to add RTC mode.	
3.3.5	Add Generator Current Sensor description.	
3.5	Add Generator Current Sensor electrical requirements.	
4.1.6.1	Add calibrations to data dictionary.	
4.2	Add RTC description.	
4.2.2	Add generator current to context diagram and new GMLAN signals.	
4.2.3.1	Revise Generator Control with description of RTC.	
4.2.6.4	Add paragraph referring to Global Electrical Power Management - Gen IV/V SSTS for calculating Estimated Generator Torque.	
4.2.7	Added calibrations to dictionary.	
4.1.3.2.4 4.1.3.4.4	Revise condition 1 to add “and the corresponding, ECM-internal DTC delete counter has reached zero.”	CR683
Table 1	Add new signal: Engine Shutdown Active	CR3754
4.1.3.2.1 4.1.3.2.2 4.1.3.4.1 4.1.3.4.2	Modified L-Terminal Open Circuit Diagnostic. Enable L-terminal output at key-on and test for no ground short as the fail criteria. Also replaced obsolete references to Powertrain System State with Run/Crank active.	CR6112

Deviations

Not applicable.