Freescale Semiconductor
User's Guide

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WCT Runtime Debug User's Guide

1 Read Me First

Freescale provides the FreeMASTER GUI tool for the WCT1000 wireless charging solution. The GUI based on the FreeMASTER tool can be used to fine tune the parameters in running state. To set up the FreeMASTER connection, see the *WCT1000 A11 Reference Design System User's Guide* (WCT1000SYSUG).

Contents

2 Runtime Tuning and Debugging

2.1 NVM parameters

This chapter describes the configuration and tuning of the WCT library. The main configuration structure of the library is initially stored in the Flash memory and is copied to the NvmParams structure in RAM. The initialization data for the Flash-memory structure are stored in the EEdata_FlashDefaults.asm file.

The WCT GUI based on the FreeMASTER tool can be used to fine tune the parameters in runtime. The same GUI may also be used to generate the assembler initialization data for the Flash-based configuration. Alternatively, the WCT GUI may also be used to trigger the application to backup the actual RAM content of the data structure to Flash.

The WCT GUI is prepared for this application:

- *A11 - /example/WCT_A11.pmp*

Section 3 “Configuration Structure Reference” provides detailed information about each configuration parameter. The same reference information is also available in the GUI tool where the parameters can be changed at runtime.

2.1.1 Runtime access to NVM parameters

As outlined in the previous sections, the WCT GUI based on FreeMASTER tool can be used to read and modify the parameters at runtime. The modification of the parameters is performed immediately, so that any change in the behavior of the Wireless Charging system can be evaluated instantly.

The GUI also enables to restore all configuration parameters to their default values or synchronize the configuration in GUI with board values by pressing a single button.

The parameters are split into several tabs in the GUI view:

- System Parameters
- Coil Parameters
- Calibration Parameters

To make the fine-tuned configuration values permanent and default for the next application build, the whole structure can be exported into the assembler syntax of initialization data block. The generated data can be put to *EEdata_FlashDefaults.asm* file directly and used as a new default configuration set.

In addition to the actual configuration values, the GUI also calculates proper checksum values to make the data block valid for use by the Wireless Charging library.

The exported initialization data block is available on the “NVM Raw” tab in the GUI.

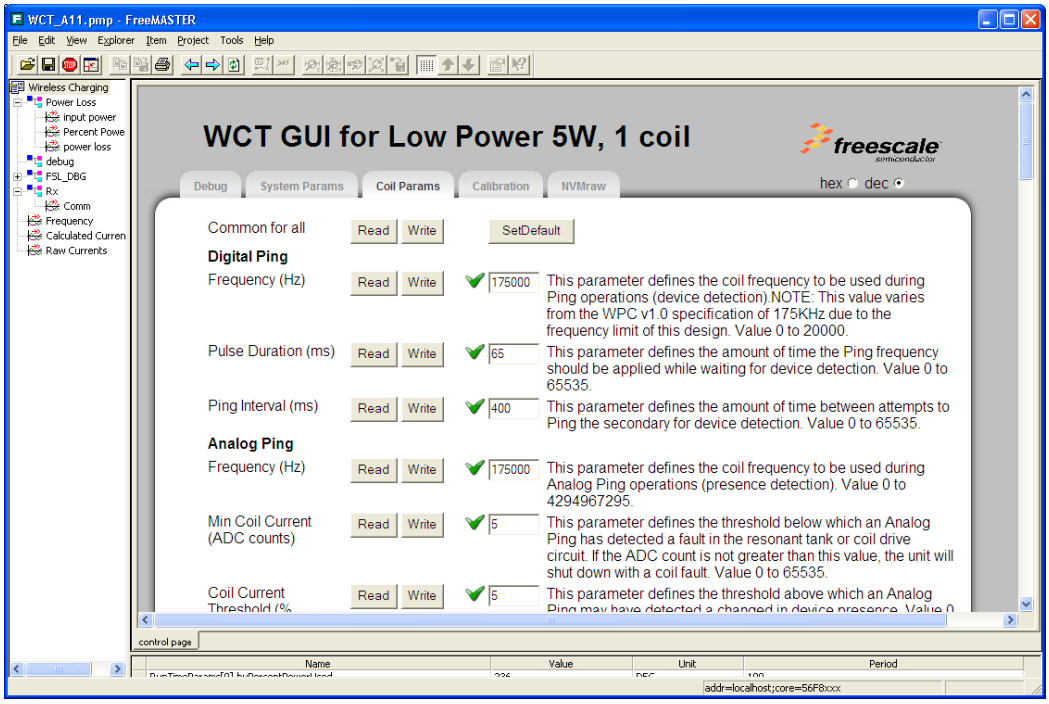

Figure 1 WCT GUI (1)

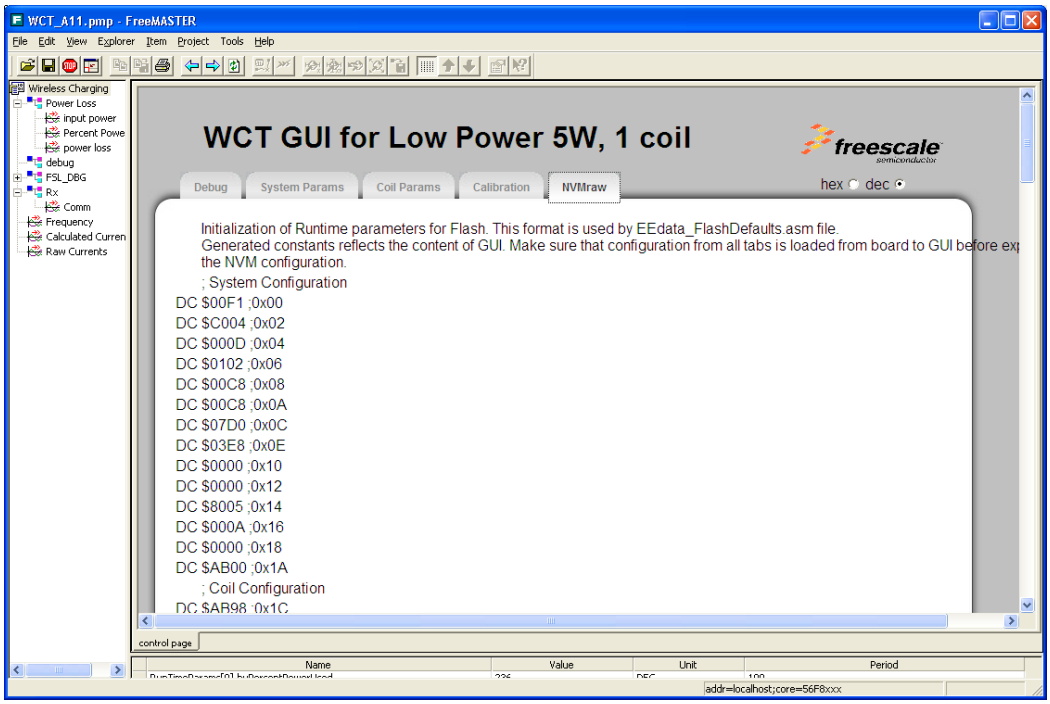

Figure 2 WCT GUI (2)

2.2 Tuning and debugging

The library is used together with the FreeMASTER visualization tool to calibrate input values and to observe the behavior of the Wireless Charging transmitter. The FreeMASTER tool connects to the target board by using the UART, JTAG, or CAN communication interface.

2.2.1 Data visualization

The FreeMASTER tool enables visualization of any variables or registers in the application running on the target system. This feature is particularly useful with Wireless Charging application to observe voltage and currents at real time by using a graphical representation.

The FreeMASTER project file which comes in the Library package contains the pre-configured scope views with the most frequently used runtime parameters. The graphs and views can be easily extended by more parameters or user-defined data.

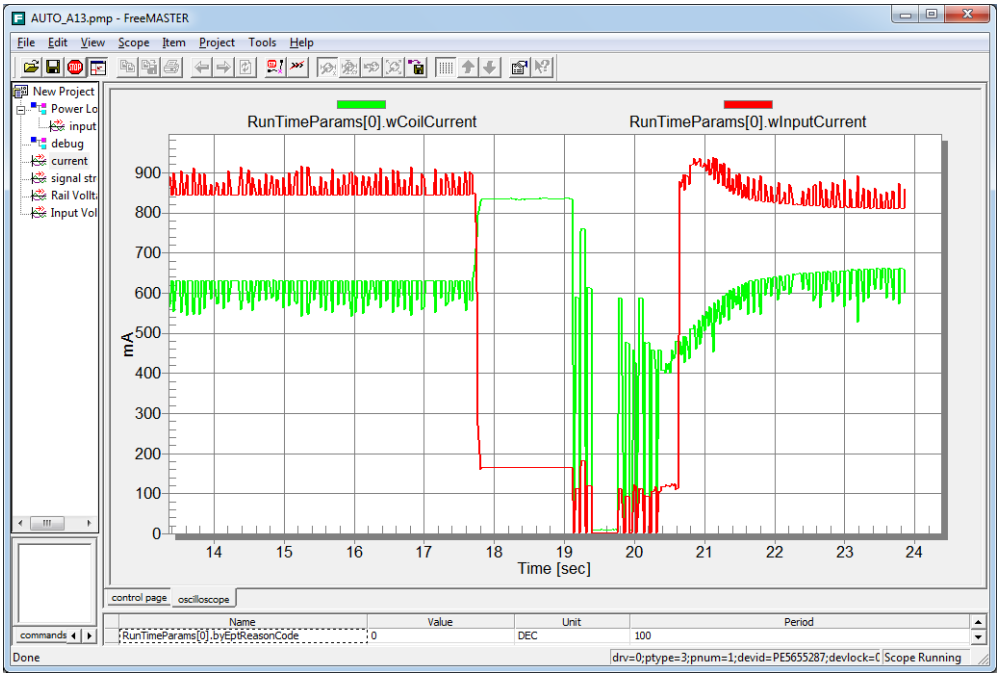

Figure 3 Data visualization

2.2.2 Debug console

In addition to the FreeMASTER visualization, the WCT library provides an option to continuously dump the selected debug information to the user console over the UART interface. The debug messages are sent to UART every time an important event occurs if the appropriate message type is enabled.

Note that the console UART port must be different than the UART port used by the FreeMASTER communication. If only one UART port is available, consider the use of an alternative communication interface for the FreeMASTER connection. Next to UART, the FreeMASTER also supports CAN or JTAG cable interface.

Chapter 3.4 “Debug Console” gives more details about possible events in the WCT system and about debug messages associated with each event. These are the message types:

- General operation events
- Operational state changes
- Communication status changes
- Multichannel communication status changes
- Auto-baud rate calibration events
- Analog ping events
- PID events
- Coil switcher events

2.3 Calibration

The library behavior and its parameters should be calibrated before the library can be successfully used. The calibration procedure is described in detail in the following file:

- *WCT1000 A11 Reference Design Calibration User’s Guide* (WCT1000CALUG) for A11 solution

2.3.1 Input voltage calibration

Follow the instructions specified in Section “Input Voltage Calibration” in the *WCT1000 A11 Reference Design Calibration User’s Guide* (WCT1000CALUG).

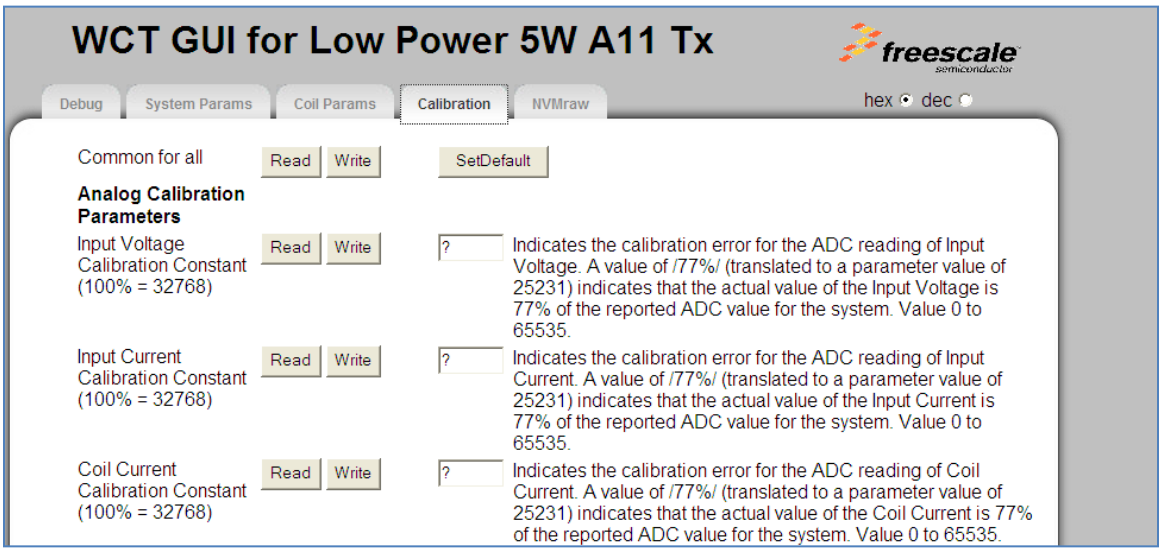

Figure 4 Input voltage calibration

2.3.2 Input current calibration

Follow the instructions specified in Section “Input Current Calibration” in the *WCT1000 A11 Reference Design Calibration User’s Guide* (WCT1000CALUG).

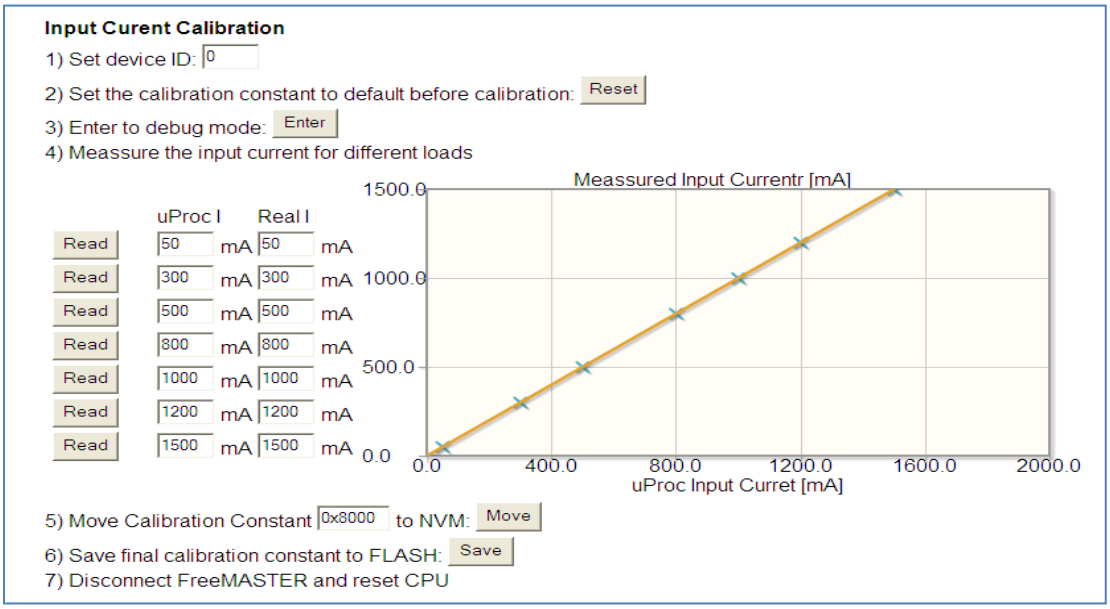

Figure 5 Input current calibration

2.3.3 FOD calibration

Follow the instructions specified in Section “FOD Calibration” in the *WCT1000 A11 Reference Design Calibration User’s Guide* (WCT1000CALUG).

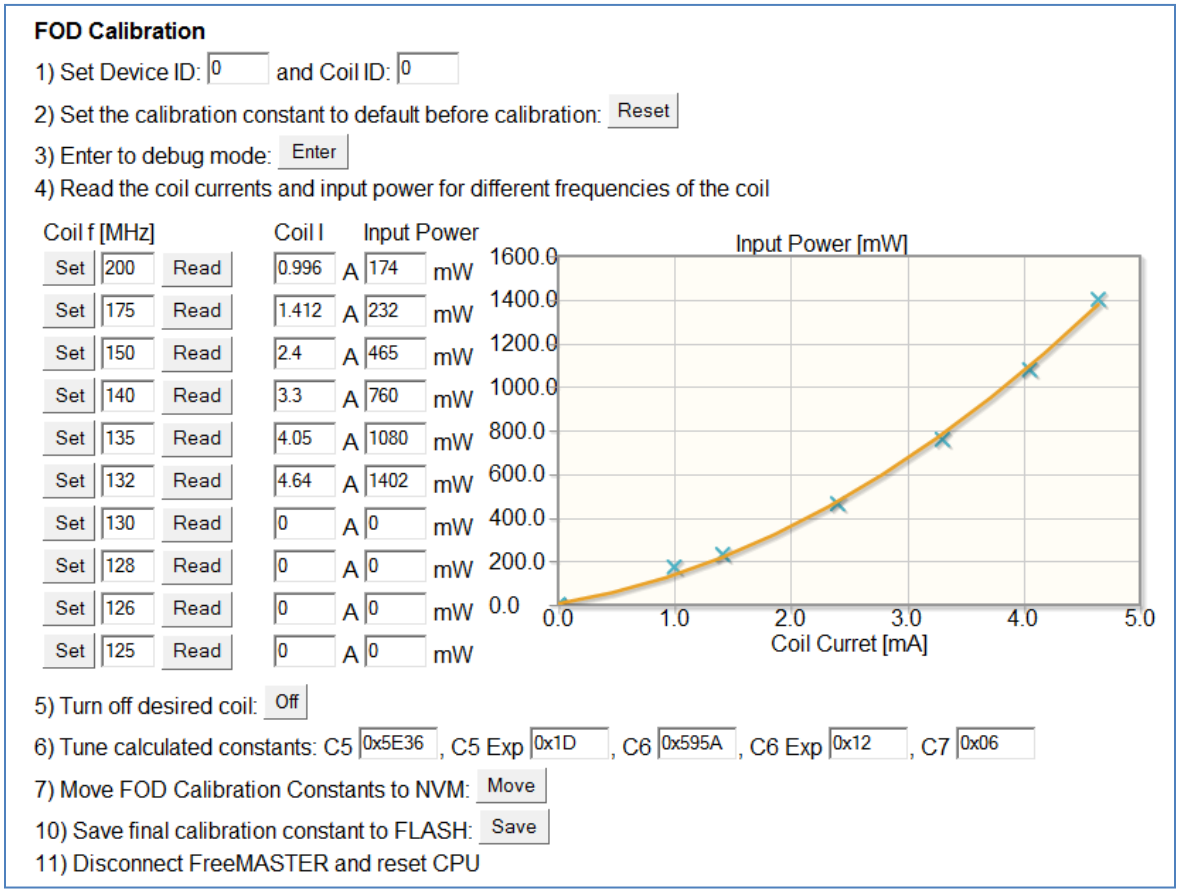

Figure 6 FOD calibration

2.3.4 FOD normalization

Follow the instructions specified in Section “FOD Normalization” in the *WCT1000 A11 Reference Design Calibration User’s Guide* (WCT1000CALUG).

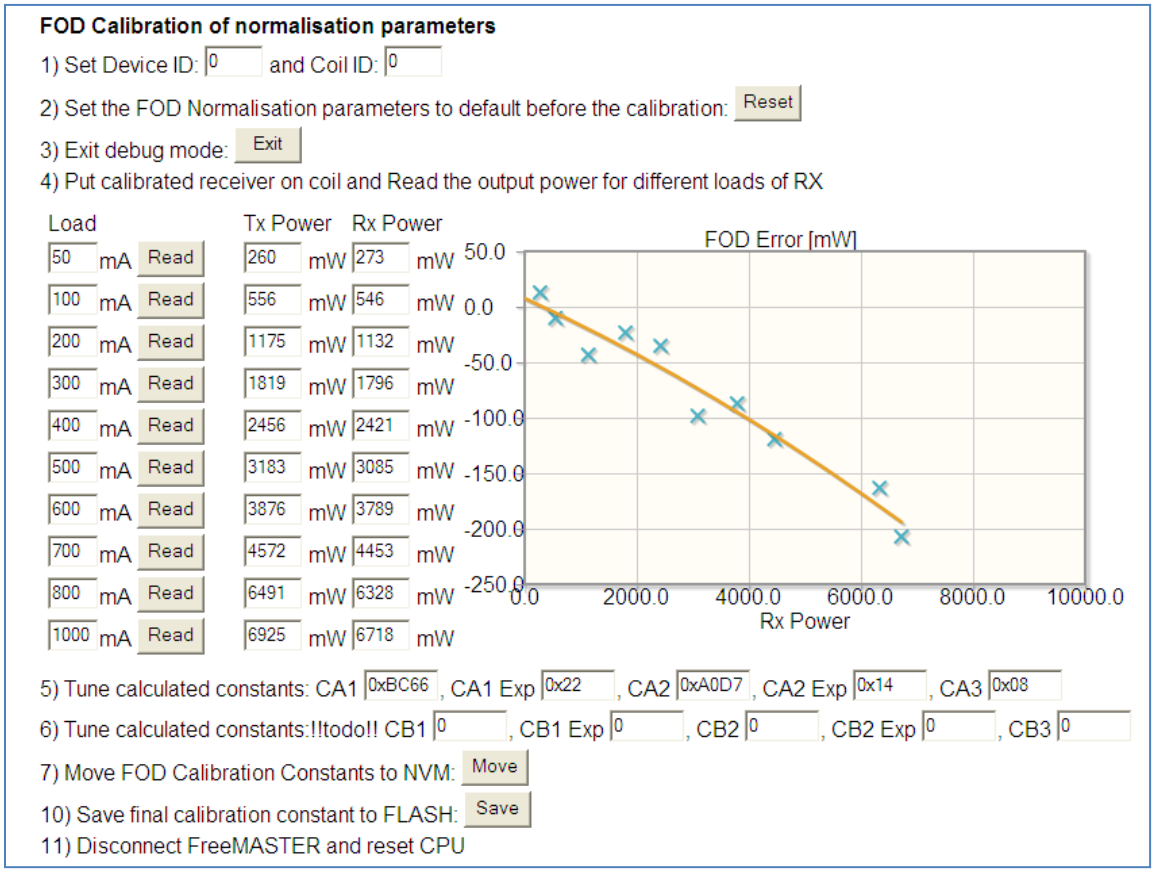

Figure 7 FOD normalization

2.3.5 Resonance shift FOD calibration

Follow the instructions specified in Section “RS FOD Calibration” in the *WCT1000 A11 Reference Design Calibration User’s Guide* (WCT1000CALUG).

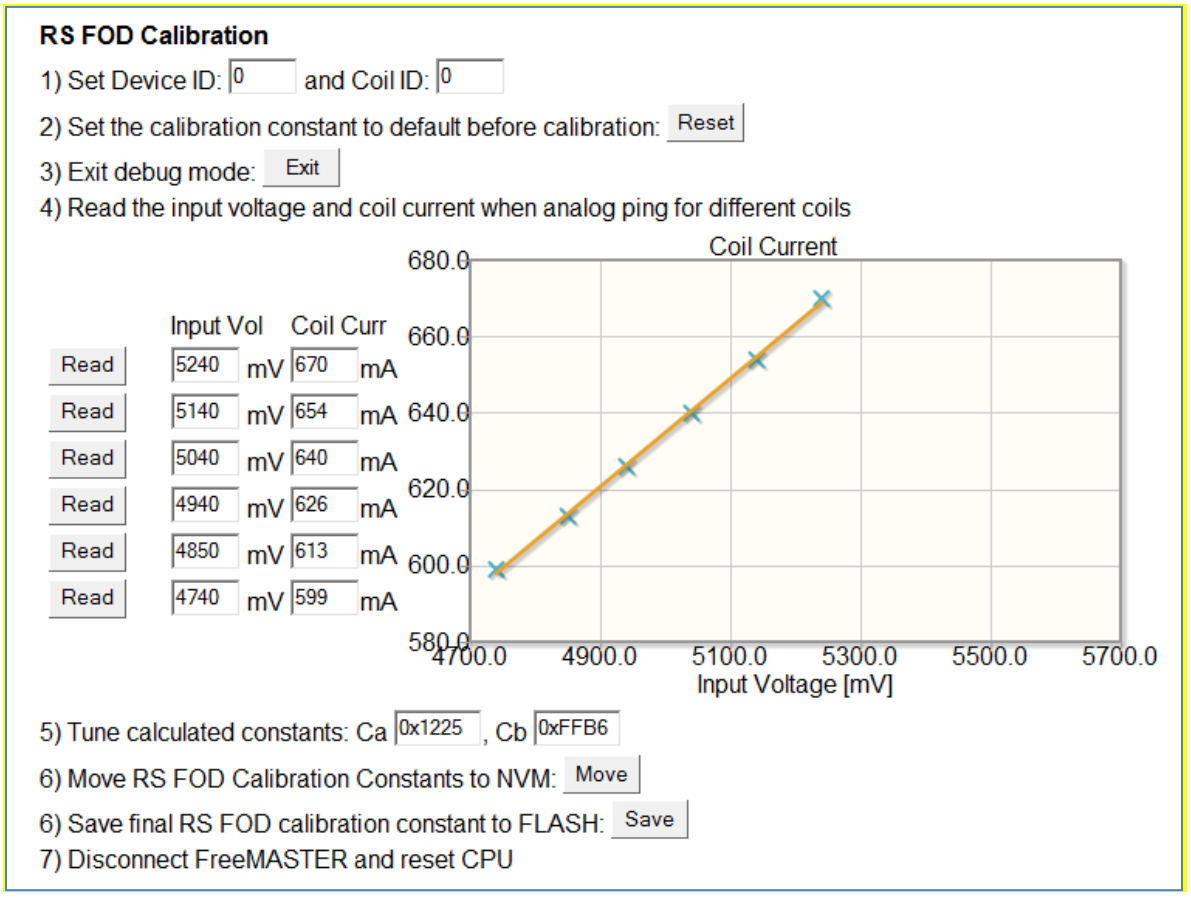

Figure 8 RS FOD calibration

3 Configuration Structure Reference

3.1 System parameters

LED1 Operation ON/OFF Bitfield

Details:

This parameter configures On/Off behavior of LED1 diode.

Bit0 – This parameter, when set, indicates LED1 should be ON in the Initialization state.

Bit1 – This parameter, when set, indicates LED1 should be ON in the STANDBY state.

Bit2 – This parameter, when set, indicates LED1 should be ON in the Power Xfer state.

Bit3 – This parameter, when set, indicates LED1 should be ON in the Device Charged state.

Bit4 – This parameter, when set, indicates LED1 should be ON in the FOD Fault state.

Bit5 – This parameter, when set, indicates LED1 should be ON in the Device Fault state.

Bit6 – This parameter, when set, indicates LED1 should be ON in the System Fault state.

Bit7 – This parameter, when set, indicates LED1 should be ON in the NVM Fault state.

Bit8 – This parameter, when set, indicates LED1 should be ON in the Power Limit state.

Bit9 – This parameter, when set, indicates LED1 should be ON for the LED ON diagnostic cmd.

Bit10 – This parameter, when set, indicates LED1 should be ON for the LED OFF diagnostic cmd.

Default Value: `0x00F1`
Member: `NvmParams.SystemParams.LedOperation.LedParams[0].wLedOnOffStateBitfield.all`

LED1 Operation Blink Bitfield

Details:

This parameter configures Blinking behavior of LED1 diode.

Bit0 – This parameter, when set, indicates LED1 should Blink in the Initialization state.

Bit1 – This parameter, when set, indicates LED1 should Blink in the STANDBY state.

Bit2 – This parameter, when set, indicates LED1 should Blink in the Power Xfer state.

Bit3 – This parameter, when set, indicates LED1 should Blink in the Device Charged state.

Bit4 – This parameter, when set, indicates LED1 should Blink in the FOD Fault state.

Bit5 – This parameter, when set, indicates LED1 should Blink in the Device Fault state.

Bit6 – This parameter, when set, indicates LED1 should Blink in the System Fault state.

Bit7 – This parameter, when set, indicates LED1 should Blink in the NVM Fault state.

Bit8 – This parameter, when set, indicates LED1 should Blink in the Power Limit state.

Bit9 – This parameter, when set, indicates LED1 should Blink for the LED ON diagnostic cmd.

Bit10 – This parameter, when set, indicates LED1 should Blink for the LED OFF diagnostic cmd.

Default Value: `0xC104`
Member: `NvmParams.SystemParams.LedOperation.LedParams[0].wLedBlinkStateBitfield.all`

LED2 Operation ON/OFF Bitfield

Details:

This parameter configures On/Off behavior of LED2 diode.

Bit0 – This parameter, when set, indicates LED2 should be ON in the Initialization state.

Bit1 – This parameter, when set, indicates LED2 should be ON in the STANDBY state.

Bit2 – This parameter, when set, indicates LED2 should be ON in the Power Xfer state.

Bit3 – This parameter, when set, indicates LED2 should be ON in the Device Charged state.

Bit4 – This parameter, when set, indicates LED2 should be ON in the FOD Fault state.

Bit5 – This parameter, when set, indicates LED2 should be ON in the Device Fault state.

Bit6 – This parameter, when set, indicates LED2 should be ON in the System Fault state.

Bit7 – This parameter, when set, indicates LED2 should be ON in the NVM Fault state.

Bit8 – This parameter, when set, indicates LED2 should be ON in the Power Limit state.

Bit9 – This parameter, when set, indicates LED2 should be ON for the LED ON diagnostic cmd.

Bit10 – This parameter, when set, indicates LED2 should be ON for the LED OFF diagnostic cmd.

Default Value: `0x000D`
Member: `NvmParams.SystemParams.LedOperation.LedParams[1].wLedOnOffStateBitfield.all`

LED2 Operation Blink Bitfield

Details:

This parameter configures Blinking behavior of LED2 diode.

Bit0 – This parameter, when set, indicates that LED2 should Blink in the Initialization state.

Bit1 – This parameter, when set, indicates that LED2 should Blink in the STANDBY state.

Bit2 – This parameter, when set, indicates that LED2 should Blink in the Power Xfer state.

Bit3 – This parameter, when set, indicates that LED2 should Blink in the Device Charged state.

Bit4 – This parameter, when set, indicates that LED2 should Blink in the FOD Fault state.

Bit5 – This parameter, when set, indicates that LED2 should Blink in the Device Fault state.

Bit6 – This parameter, when set, indicates that LED2 should Blink in the System Fault state.

Bit7 – This parameter, when set, indicates that LED2 should Blink in the NVM Fault state.

Bit8 – This parameter, when set, indicates that LED2 should Blink in the Power Limit state.

Bit9 – This parameter, when set, indicates that LED2 should Blink for the LED ON diagnostic cmd.

Bit10 – This parameter, when set, indicates that LED2 should Blink for the LED OFF diagnostic cmd.

Default Value: `0x0102`
Member: `NvmParams.SystemParams.LedOperation.LedParams[1].wLedBlinkStateBitfield.all`

Fault Blink Rate (ms)

Details:

This parameter represents the period of time used to establish a blink rate for any LED in a SYSTEM FAULT or DEVICE FAULT condition.

Default Value: `200`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.SystemParams.LedOperation.wFaultBlinkRateMs`

FOD Fault Blink Rate (ms)

Details:

This parameter represents the period of time used to establish a blink rate for any LED in an FOD FAULT condition.

Default Value: `200`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.SystemParams.LedOperation.wModFaultBlinkRateMs`

Operational State Blink Rate (ms)

Details:

This parameter represents the period of time used to establish a blink rate for any LED when the system is in a non-fault state.

Default Value: `2000`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.SystemParams.LedOperation.wOpStateBlinkRateMs`

Delay At Power-Up (ms)

Details:

This parameter can be used to “hold” the state of the LED(s) following initial power-up of the system.

Default Value: `1000`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.SystemParams.LedOperation.wDelayAtPowerUpMs`

Default PWM Dead Time (ns)

Details:

This parameter defines the default dead time that is used for PWM outputs when configured with a standard FET driver.

Default Value: `0`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.SystemParams.OpStateParams.wPwmDeadTimeNs`

WPC Diagnostics Bitfield A

Details:

Bit0 – Sends PID status to Console when enabled

Bit1 – Sends verbose PID info to Console when enabled

Bit2 – Sends operational status to Console when enabled

Bit3 – Sends verbose operational status to Console when enabled

Bit4 – Sends operational state to Console when enabled

Bit5 – Sends Comm status to Console when enabled

Bit6 – Sends received packet channel to Console when enabled

Bit7 – Sends Auto-baud reference count to Console when enabled

Bit8 – Sends PLD status to Console when enabled

Bit9 – Sends Analog Ping status to Console when enabled

Bit14 – This parameter determines whether or not an audible tone is generated when power transfer is stopped.

Bit15 – This parameter determines whether or not an audible tone is generated when power transfer is initiated.

Default Value: `0x8005`
Member: `NvmParams.SystemParams.OpStateParams.WpcDiagnostics`

WPC Protections Bitfield A

Details:

Bit0 – This parameter, when set, forces the primary to cease power transfer if the reported secondary version is not greater.

Bit1 – This parameter, when set, forces a cessation of Power Xfer state when the Rectified Power packet is not received.

Bit2 – This parameter, when set, disables the use of Analog Ping.

Bit3 – This parameter, when set, means hardware support FOD.

Bit4-Bit7 – These parameters, when less than 13, indicates that the FOD function is active.

Bit8 – This parameter, when set, LED does not indicate when an unknown error happens.
Default Value: `0x000A`
Member: `NvmParams.SystemParams.OpStateParams.WpcProtections`

3.2 Operation parameters

Ping Frequency (Hz)

Details:

This parameter defines the coil frequency to be used during Ping operations (device detection). NOTE: This value varies from the WPC v1.0 specification of 175KHz due to the frequency limit of this design.

Default Value: `175000`
Min Value: `0`
Max Value: `20000`
Member: `NvmParams.OpParams[0].OpStateParams.dwPingFrequency`

Ping Pulse Duration (ms)

Details:

This parameter defines the amount of time the Ping frequency should be applied while waiting for device detection.

Default Value: `65`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].OpStateParams.wPingPulseDurationTimeMs`

Ping Interval (ms)

Details:

This parameter defines the amount of time between attempts to Ping the secondary for device detection.

Default Value: `400`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].OpStateParams.wPingIntervalMs`

Frequency (Hz)

Details:

This parameter defines the coil frequency to be used during Analog Ping operations (presence detection).

Default Value: `175000`
Min Value: `0`
Max Value: `4294967295`
Member: `NvmParams.OpParams[0].OpStateParams.dwAnalogPingFrequency`

Min Coil Current (ADC counts)

Details:

This parameter defines the threshold below which an Analog Ping detects a fault in the resonant tank or coil drive circuit. If the ADC count is not greater than this value, the unit shuts down with a coil fault.

Default Value: `5`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].OpStateParams.wAnalogPingMinCoilCurrentThreshold`

Coil Current Threshold (% change)

Details:

This parameter defines the threshold above which an Analog Ping may have detected a changed in the device presence.

Default Value: `20`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].OpStateParams.wAnalogPingCoilCurrentThreshold`

Duty Cycle (%)

Details:

This parameter defines the duty cycle to be used during Analog Ping operations.

Default Value: `50`
Min Value: `0`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byAnalogPingDutyCycle`

Pulse Duration (# cycles)

Details:

This parameter defines the number of cycles that the coil is driven during Analog Ping operations.

Default Value: `3`
Min Value: `0`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byAnalogPingPulseDuration`

ADC Sampling Time Delay (# cycles)

Details:

This parameter defines the time at which the ADC samples the coil current (referenced to the start of the pulse).

Default Value: `4`
Min Value: `0`

Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byAnalogPingAdcSampleTime`

Digital Ping Retry Interval (seconds)

Details:

This parameter defines the interval at which a digital ping is forced.

Default Value: `5`
Min Value: `0`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byDigitalPingRetryIntervalSeconds`

Over Current Threshold (mA)

Details:

This parameter represents the maximum allowable average current on the coil (in mA). If this value is exceeded, the power transfer is aborted and the coil is shut down.

Default Value: `4000`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].OpStateParams.wOverCurrentThreshold`

Safety Input Threshold (mV)

Details:

This parameter represents the maximum allowable safety input voltage. If the input voltage exceeds this threshold, the operational state machine shuts down the associated coil.

Default Value: `6000`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].OpStateParams.wSafetyInputThreshold`

Input Power Threshold (mW)

Details:

This parameter represents the maximum allowable input power to the channel (in mW). If the input power exceeds this threshold, the operational state machine shuts down the associated coil.

Default Value: `12000`
Min Value: `0`
Max Value: `20000`
Member: `NvmParams.OpParams[0].OpStateParams.dwInputPowerThreshold`

Minimum Frequency (Hz)

Details:

This parameter defines the absolute minimum allowable frequency used during charging. If the power transfer algorithm attempts to set the “Active Frequency” below this value, the coil is turned OFF.

NOTE: This value varies from the WPC v1.0 specification of 110 KHz due to the frequency limit of this design.

Default Value: `111000`
Min Value: `0`
Max Value: `200000`
Member: `NvmParams.OpParams[0].OpStateParams.dwMinFreq`

Maximum Frequency (Hz)

Details:

This parameter defines the maximum allowable frequency used during power transfer. If the power transfer algorithm attempts to set the “Active Frequency” above this value, the coil is turned OFF.NOTE: This value varies from the WPC v1.0 specification of 205 KHz due to the frequency limit of this design.

Default Value: `205000`
Min Value: `0`
Max Value: `200000`
Member: `NvmParams.OpParams[0].OpStateParams.dwMaxFreq`

Integral Update Interval

Details:

This parameter defines the time constant for the integrator update rate in ms.

Default Value: `5`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].OpStateParams.wIntegralUpdateInterval`

Derivative Update Interval

Details:

This parameter defines the time constant for the derivative update rate in ms.

Default Value: `5`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].OpStateParams.wDerivativeUpdateInterval`

Integral Upper Limit

Details:

This parameter defines the maximum allowable value for the Integral Term of the PID control signal, as described below.

Default Value: `3000`
Min Value: `-32768`
Max Value: `32767`
Member: `NvmParams.OpParams[0].OpStateParams.iIntegralUpperLimit`

Integral Lower Limit

Details:

This parameter defines the minimum allowable value for the Integral Term of the PID control signal, as described below.

Default Value: `-3000`
Min Value: `-32768`
Max Value: `32767`
Member: `NvmParams.OpParams[0].OpStateParams.iIntegralLowerLimit`

PID Output Upper Limit

Details:

This parameter defines the maximum allowable value for the PID output, as described below.

Default Value: `20000`
Min Value: `-32768`
Max Value: `32767`
Member: `NvmParams.OpParams[0].OpStateParams.iPidUpperLimit`

PID Output Lower Limit

Details:

This parameter defines the minimum allowable value for the PID output, as described below.

Default Value: `-20000`
Min Value: `-32768`
Max Value: `32767`
Member: `NvmParams.OpParams[0].OpStateParams.iPidLowerLimit`

PID Scale Factor

Details:

This parameter defines how the PID output is scaled when calculating the new Frequency setpoint, as described below.

Default Value: `200`
Min Value: `0`

Max Value: `65535`
Member: `NvmParams.OpParams[0].OpStateParams.wPidScaleFactor`

Proportional Gain (Kp)

Details:

NOTE: Maximum value = 127

Default Value: `10`
Min Value: `0`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byKp`

Integral Gain (Ki)

Details:

NOTE: Maximum value = 127

Default Value: `1`
Min Value: `0`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byKi`

Derivative Gain (Kd)

Details:

NOTE: Maximum value = 127

Default Value: `1`
Min Value: `0`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byKd`

PID Delay Time (ms)

Details:

This parameter defines the delay between receipt of a voltage error message and activation of the PID. This period of time is necessary to allow the primary current to return to steady state before attempting an adjustment. According to the WPC specification, this value should be set to '5'.

Default Value: `5`
Min Value: `0`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byDelayTimeMs`

PID Active Time (ms)

Details:

This parameter defines how long the PID is active to attempt an adjustment to a new setpoint. According to the WPC specification, this value should be set to ‘20’.

Default Value: `20`
Min Value: `0`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byActiveTimeMs`

PID Settle Time (ms)

Details:

This parameter defines how long the PID loop continues to sample the primary current after PID adjustment is complete. This allows the primary current and the digital filter to settle. The final settled value becomes the basis for the next adjustment. According to the WPC specification, this should be ‘3’.

Default Value: `3`
Min Value: `0`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.bySettleTimeMs`

Num PID Adjustments Per Active Window

Details:

This parameter defines the number of PID iterations that the firmware runs within the Active Time window. Adjustments are only attempted upon receipt of a non-zero error message.

Default Value: `5`
Min Value: `0`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byNumPidAdjustmentsPerActiveWindow`

Maximum Duty Cycle (%)

Details:

Maximum Duty Cycle (%)

Default Value: `50`
Min Value: `0`
Max Value: `50`
Member: `NvmParams.OpParams[0].OpStateParams.byMaxDutyCycle`

Minimum Duty Cycle (%)

Details:

Minimum Duty Cycle (%): This value varies from the typical value of 10%.

Default Value: `10`
Min Value: `0`
Max Value: `50`
Member: `NvmParams.OpParams[0].OpStateParams.byMinDutyCycle`

Duty Cycle Step (hundredths of %)

Details:

Duty Cycle Step (in hundredths of a %, equivalent to breakpoint value for frequency control)

Default Value: `10`
Min Value: `1`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byDCStep`

Duty Cycle PID Scaling Factor

Details:

Defines how the PID output is scaled when calculating a new Duty Cycle setpoint.

Default Value: `10`
Min Value: `1`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byDCPidScaleFactor`

Duty Cycle Proportional Gain (Kp)

Details:

NOTE: Maximum value = 127

Default Value: `10`
Min Value: `0`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byDCKp`

Duty Cycle Integral Gain (Ki)

Details:

NOTE: Maximum value = 127

Default Value: `1`
Min Value: `0`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byDCKi`

Duty Cycle Derivative Gain (Kd)

Details:

NOTE: Maximum value = 127

Default Value: `0`
Min Value: `0`
Max Value: `255`
Member: `NvmParams.OpParams[0].OpStateParams.byDCKd`

Delta Frequency 1 (Hz)

Details:

This is the frequency step to take when the current frequency is less than or equal to the specified Frequency Breakpoint 1.

Default Value: `100`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].OpStateParams.FreqBreakPointTable[0].dwDeltaFreq`

Frequency Breakpoint 1 (Hz)

Details:

This is the upper frequency limit for this entry in the look-up table.

Default Value: `130000`
Min Value: `0`
Max Value: `4294967295`
Member: `NvmParams.OpParams[0].OpStateParams.FreqBreakPointTable[0].dwFreqBreakPoint`

Delta Frequency 2 (Hz)

Details:

This is the frequency step to take when the current frequency is less than the specified Frequency Breakpoint 2, but greater than Frequency Breakpoint 1.

Default Value: `150`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].OpStateParams.FreqBreakPointTable[1].dwDeltaFreq`

Frequency Breakpoint 2 (Hz)

Details:

This is the upper frequency limit for this entry in the look-up table.

Default Value: `140000`
Min Value: `0`

Max Value: `4294967295`
Member: `NvmParams.OpParams[0].OpStateParams.FreqBreakPointTable[1].dwFreqBreakPoint`

Delta Frequency 3 (Hz)

Details:

This is the frequency step to take when the current frequency is less than the specified Frequency Breakpoint 3, but greater than Frequency Breakpoint 2.

Default Value: `200`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].OpStateParams.FreqBreakPointTable[2].dwDeltaFreq`

Frequency Breakpoint 3 (Hz)

Details:

This is the upper frequency limit for this entry in the look-up table.

Default Value: `160000`
Min Value: `0`
Max Value: `4294967295`
Member: `NvmParams.OpParams[0].OpStateParams.FreqBreakPointTable[2].dwFreqBreakPoint`

Delta Frequency 4 (Hz)

Details:

This is the frequency step to take when the current frequency is less than the specified Frequency Breakpoint 4, but greater than Frequency Breakpoint 3.

Default Value: `300`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].OpStateParams.FreqBreakPointTable[3].dwDeltaFreq`

Frequency Breakpoint 4 (Hz)

Details:

This is the upper frequency limit for this entry in the look-up table.

Default Value: `180000`
Min Value: `0`
Max Value: `4294967295`
Member: `NvmParams.OpParams[0].OpStateParams.FreqBreakPointTable[3].dwFreqBreakPoint`

Delta Frequency 5 (Hz)

Details:

This parameter defines the default frequency step during power transfer (when the “Active Frequency” is greater than the “Frequency Breakpoint” defined by Charging Frequency Breakpoint 4).

Default Value: `500`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].OpStateParams.dwDeltaFreq5`

Power Loss Indication To Power Cessation (ms)

Details:

This parameter defines how long the MOD indication is permitted to be active before removal of power.

Default Value: `10000`
Min Value: `0`
Max Value: `4294967295`
Member: `NvmParams.OpParams[0].PowerLossParams.dwPowerLossIndicationToPwrCessationMs`

Power Loss Fault Retry Time (ms)

Details:

This parameter defines how long the Transmitter waits before attempting power transfer following a MOD Fault.

Default Value: `300000`
Min Value: `0`
Max Value: `4294967295`
Member: `NvmParams.OpParams[0].PowerLossParams.dwPowerLossFaultRetryTimeMs`

Power Loss Base Threshold (mW)

Details:

This parameter defines the base threshold for MOD in mW, representing the threshold used by the firmware if the MOD selection is set to bin ‘0’.

Default Value: `400`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].PowerLossParams.wPowerLossBaseThreshold`

Power Loss Incremental Threshold (mW)

Details:

“This parameter defines the incremental threshold used to calculate the overall MOD threshold based on the MOD bin selection. The formula is as follows:MOD Threshold = MOD Base Threshold + (MOD Incremental Threshold * Bin#)”

Default Value: `100`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.OpParams[0].PowerLossParams.wPowerLossIncrementalThreshold`

Number of Trips to Indication

Details:

This parameter defines how many consecutive threshold breaches are required to trigger a MOD indication.

Default Value: `3`
Min Value: `0`
Max Value: `255`
Member: `NvmParams.OpParams[0].PowerLossParams.byNumFodTripsToIndication`

Default Window Offset (ms)

Details:

This parameter defines the amount of time (in milliseconds) between when the Secondary measures its operating parameters and when the START bit of the Power Usage packet occurs. This parameter is used by the primary firmware to synchronize its ADC samples with those of the secondary for MOD calculations when a Receiver is not compliant with v1.1 or greater (does not support FOD).

Default Value: `18`
Min Value: `0`
Max Value: `15`
Member: `NvmParams.OpParams[0].PowerLossParams.byDefaultWindowOffset`

Dump PLD Results for Legacy Devices

Details:

This parameter, when set, forces the reporting of all PLD calculation results when a legacy (v1.0 compliant) device is detected. (Normally, this information is 25oiled25sed since these devices do not support Received Power packets.)

Default Value: `0`
Min Value: `0`
Max Value: `1`
Member: `NvmParams.OpParams[0].PowerLossParams.byDumpPldResultsForLegacyDevices`

Coil curr raw offset for RSFOD

Details:

This parameter defines the offset based on normal coil current raw value, the less the value, the easier RSFOD is triggered.

Default Value: `40`
Min Value: `0`
Max Value: `1`
Member: `NvmParams.OpParams[0]. RSFodParams. wRSFODdetectionOffset`

3.3 Calibration parameters

Input Voltage Calibration Constant (100% = 32768)

Details:

Indicates the calibration error for the ADC reading of Input Voltage. A value of /77%/ (translated to a parameter value of 25231) indicates that the actual value of the Input Voltage is 77% of the reported ADC value for the system.

Default Value: `32349`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.CalParams.AnalogParams[0].wInputVoltageCalibration`

Input Current Calibration Constant (100% = 32768)

Details:

Indicates the calibration error for the ADC reading of Input Current. A value of /77%/ (translated to a parameter value of 25231) indicates that the actual value of the Input Current is 77% of the reported ADC value for the system.

Default Value: `31690`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.CalParams.AnalogParams[0].wInputCurrentCalibration`

Coil Current Calibration Constant (100% = 32768)

Details:

Indicates the calibration error for the ADC reading of Coil Current. A value of /77%/ (translated to a parameter value of 25231) indicates that the actual value of the Coil Current is 77% of the reported ADC value for the system.

Default Value: `32768`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.CalParams.AnalogParams[0].wCoilCurrentCalibration`

Coil Current Diode Drop (mV)

Details:

This parameter defines the nominal voltage drop of the diode used in the Coil Current peak detect circuitry. NOTE: A value of 0.700 is represented as 700.

Default Value: `0`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.CalParams.AnalogParams[0].wCoilCurrentDiodeDrop`

C5 – Quadratic Coefficient (mW/mA^2 x 2^N5)

Details:

This parameter defines the quadratic coefficient of the equation used to calculate Tx losses represented in units of mW/mA^2 multiplied by the value of 2^N5, where N5 is the exponent defined by the next parameter.

Default Value: `16491`
Min Value: `-32768`
Max Value: `32767`
Member: `NvmParams.CalParams.PowerLossParams[0].FodCharacterizationParams[0].swQuadCoefficient`

C5 Exponent (N5)

Details:

This parameter is the value of the exponent used to scale the C5 coefficient to obtain an integer value in units of mW/mA^2.

Default Value: `27`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.CalParams.PowerLossParams[0].FodCharacterizationParams[0].wQuadExponent`

C6 – Linear Coefficient (mW/mA x 2^N6)

Details:

This parameter defines the linear coefficient of the equation used to calculate Tx losses represented in units of mW/mA multiplied by the value of 2^N6, where N6 is the exponent defined by the next parameter.

Default Value: `47125`
Min Value: `-32768`
Max Value: `32767`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodCharacterizationParams[0].swLinearCoefficient`

C6 Exponent (N6)

Details:

This parameter is the value of the exponent used to scale the C6 coefficient to obtain an integer value in units of mW/mA.

Default Value: `20`
Min Value: `0`
Max Value: `65535`
Member: `NvmParams.CalParams.PowerLossParams[0].FodCharacterizationParams[0].wLinearExponent`

C7 – Constant Term (mW)

Details:

This parameter represents the constant term of the equation used to calculate Tx losses (represented in mW). This value equates to the static losses of the FET drive circuitry.

Default Value: `72`
Min Value: `-32768`
Max Value: `32767`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodCharacterizationParams[0].swConstantCoefficient`

Power Loss Calibration Offset (mW)

Details:

This parameter represents the offset to be used with the calculation of system Power Loss to prevent negative results due to resolution on reported Rx power received, curve-fit and other calibration errors.

Default Value: `0`
Min Value: `-30000`
Max Value: `30000`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodCharacterizationParams[0].swPowerLossCalibrationOffset`

CA1 – Quadratic Coefficient for region A (mW/mW^2 x 2^NA1)

Details:

This parameter defines the quadratic coefficient of the equation used to calculate the normailization for system power losses represented in units of mW/mW^2 multiplied by the value of 2^NA1, where NA1 is the exponent defined by the next parameter.

Default Value: `-20743`
Min Value: `-32768`
Max Value: `32767`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[0].swQuadCoefficient`

CA1 Exponent (NA1)

Details:

This parameter is the value of the exponent used to scale the CA1 coefficient to obtain an integer value in units of mW/mW^2.

Default Value: `32`
Min Value: `0`
Max Value: `65535`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[0].wQuadExponent`

CA2 – Linear Coefficient for region A(mW/mW x 2^NA2)

Details:

This parameter defines the linear coefficient of the equation used to calculate the normalization for system power losses represented in units of mW/mW multiplied by the value of 2^NA2, where NA2 is the exponent defined by the next parameter.

Default Value: `19906`
Min Value: `-32768`
Max Value: `32767`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[0].swLinearCoefficient`

CA2 Exponent (NA2)

Details:

This parameter is the value of the exponent used to scale the CA2 coefficient to obtain an integer value in units of mW/mW.

Default Value: `20`
Min Value: `0`
Max Value: `65535`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[0].wLinearExponent`

CA3 – Constant Term for region A (mW)

Details:

“This parameter represents the constant term of the equation used to calculate the normalization for system power losses (represented in mW).

Default Value: `159`
Min Value: `-32768`
Max Value: `32767`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[0].swConstantCoefficient`

CB1 – Quadratic Coefficient for region B(mW/mW^2 x 2^NB1)

Details:

This parameter defines the quadratic coefficient of the equation used to calculate the normailization for system power losses represented in units of mW/mW^2 multiplied by the value of 2^NB1, where NB1 is the exponent defined by the next parameter.

Default Value: `0`
Min Value: `-32768`
Max Value: `32767`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[1].swQuadCoefficient`

CB1 Exponent (NB1)

Details:

This parameter is the value of the exponent used to scale the CB1 coefficient to obtain an integer value in units of mW/mW^2.

Default Value: `16`
Min Value: `0`
Max Value: `65535`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[1].wQuadExponent`

CB2 – Linear Coefficient for region B(mW/mW x 2^NB2)

Details:

This parameter defines the linear coefficient of the equation used to calculate the normalization for system power losses represented in units of mW/mW multiplied by the value of 2^NB2, where NB2 is the exponent defined by the next parameter.

Default Value: `0`
Min Value: `-32768`
Max Value: `32767`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[1].swLinearCoefficient`

CB2 Exponent (NB2)

Details:

This parameter is the value of the exponent used to scale the CB2 coefficient to obtain an integer value in units of mW/mW.

Default Value: `16`
Min Value: `0`
Max Value: `65535`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[1].wLinearExponent`

CB3 – Constant Term for region B (mW)

Details:

This parameter represents the constant term of the equation used to calculate the normalization for system power losses (represented in mW).

Default Value: `0`
Min Value: `-32768`
Max Value: `32767`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[1].swConstantCoefficient`

CC1 – Quadratic Coefficient for region C (mW/mW^2 x 2^NC1)

Details:

This parameter defines the quadratic coefficient of the equation used to calculate the normailization for system power losses represented in units of mW/mW^2 multiplied by the value of 2^NC1, where NC1 is the exponent defined by the next parameter.

Default Value: `0`
Min Value: `-32768`
Max Value: `32767`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[2].swQuadCoefficient`

CC1 Exponent (NC1)

Details:

This parameter is the value of the exponent used to scale the CC1 coefficient to obtain an integer value in units of mW/mW^2.

Default Value: `16`
Min Value: `0`
Max Value: `65535`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[2].wQuadExponent`

CC2 – Linear Coefficient for region C(mW/mW x 2^NC2)

Details:

This parameter defines the linear coefficient of the equation used to calculate the normalization for system power losses represented in units of mW/mW multiplied by the value of 2^NC2, where NC2 is the exponent defined by the next parameter.

Default Value: `0`
Min Value: `-32768`
Max Value: `32767`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[2].swLinearCoefficient`

CC2 Exponent (NC2)

Details:

This parameter is the value of the exponent used to scale the CC2 coefficient to obtain an integer value in units of mW/mW.

Default Value: `16`
Min Value: `0`
Max Value: `65535`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[2].wLinearExponent`

CC3 – Constant Term for region C (mW)

Details:

This parameter represents the constant term of the equation used to calculate the normalization for system power losses (represented in mW).

Default Value: `0`
Min Value: `-32768`
Max Value: `32767`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].QuadraticParams[2].swConstantCoefficient`

Normalization Region A Breakpoint (mW)

Details:

This parameter defines the maximum Received Power in mW for Normalization Region A.

Default Value: `10000`
Min Value: `0`
Max Value: `200000`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].dwNormalizationBreakpoint[0]`

Normalization Region B Breakpoint (mW)

Details:

This parameter defines the maximum Received Power in mW for Normalization Region B.

Default Value: `11000`
Min Value: `0`
Max Value: `200000`
Member:
`NvmParams.CalParams.PowerLossParams[0].FodNormalizationParams[0].dwNormalizationBreakpoint[1]`

Ca – LinearCoeff

Details:

This parameter defines the Linear coefficient of the equation used to calculate coil current raw value based on current input voltage.

Default Value: `4788`
Min Value: `-32768`
Max Value: `32767`
Member: `NvmParams.CalParams.PowerLossParams[0]. RSFodCharacterizationParams[0].swLinearCoeff`

Cb – ConstantCoeff

Details:

This parameter defines the Constant coefficient of the equation used to calculate coil current raw value based on current input voltage.

Default Value: `-72`
Min Value: `-32768`
Max Value: `32767`
Member: `NvmParams.CalParams.PowerLossParams[0].RSFodCharacterizationParams[0]. wConstantCoeff`

3.4 Debug console

The console prints debug information to the SCI port. The amount of the debug information depends on the configuration of the debug console in the *NvmParams.SystemParams.OpStateParams.WpcDiagnostics* variable.

This variable is also available in the WCT debug tool.

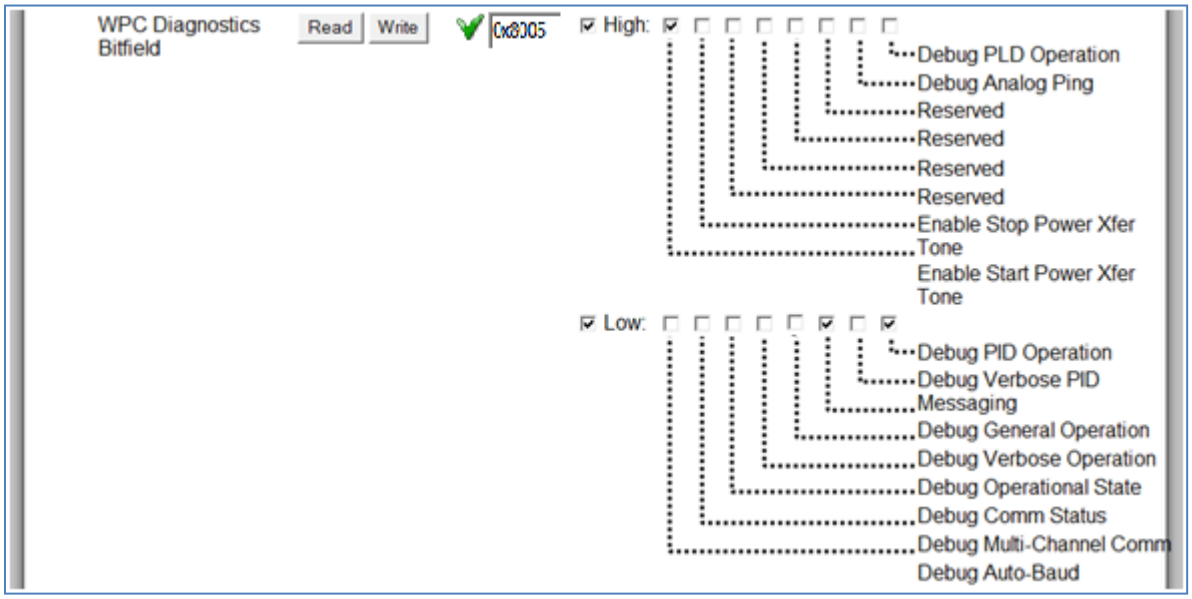

Figure 9 Debugging information

List of the configuration:

- WpcDiagnostics.btDebugPidOperation, enables debug of PID
- WpcDiagnostics.btDebugVerbosePidOperation, enables more detail of PID
- WpcDiagnostics.btDebugGeneralOperation, enables debug of the general operation
- WpcDiagnostics.btDebugVerboseOperation, enables printing more details
- WpcDiagnostics.btDebugOperationalState, enables debug of operational state
- WpcDiagnostics.btDebugCommStatus, enables debug of the communication
- WpcDiagnostics.btDebugMultiChannelComm, multichannel communication
- WpcDiagnostics.btDebugAutobaud, shows auto baud rate calibration
- WpcDiagnostics.btDebugPmdOperation, enable debug of power loss
- WpcDiagnostics.btDebugAnalogPing, enables debug of analog ping

The following sections describe the messages printed on different events when debugging is enabled.

3.4.1 WpcDiagnostics.btDebugCommStatus

This option enables debugging of the communication decoder.

On parity or checksum error

```
~ID Channel: Chksm Packet
~ID Channel: Parity Packet
```

Legend:

ID – Index of device

Channel – Index of channel

Packet – Received packet

On Error

```
~coilId: Error errorCode
```

Legend:

53oiled – Active Coil

errorCode – Value of iReportedError

On Detected Rx

```
PLDWSIZE: windowSize ms, offset: offset ms
```

Legend:

windowsSize – Configuration of Rx

offset – Configuration of Rx

On invalid packet

```
~coilId: Unknown Packet
```

Legend:

53oiled – Active Coil

3.4.2 WpcDiagnostics.btDebugMultiChannelComm

This option enables debugging of the multi-channel communication decoder.

On received packet

```
commChannelIndex
```

Legend:

commChannelIndex – Index of communication channel

3.4.3 WpcDiagnostics.btDebugAutobaud

This option enables debugging of the auto baudrate functionality.

On received valid packet

```
~calibVal
```

Legend:

calibVal – Timer Calibration Value

3.4.4 btDebugVerboseOperation

This option enables the printing details of the library state and Over Limit warning events.

On Application init

`LED Select: ledConfig`

Legend:

ledConfig – Actual configuration of LED

On Application init

`Power Loss Select: powerLossConfig`

Legend:

powerLossConfig – Actual configuration power loss detection

On Set New Freq, when Frequency is too high

`~coilId: High Freq`

Legend:

54oiled – Active Coil

On Set New Freq, when Frequency is too low

`~coilId: Low Freq`

Legend:

55oiled – Active Coil

On Set New Duty Cycle, when duty cycle is too low

`~coilId: Low DC`

Legend:

55oiled – Active Coil

On shut down fault

`~coilId: E systemFault / deviceFaultStatus`

Legend:

55oiled – Active Coil

systemfault – Code of system fault

deviceFaultStatus – Value of device fault status

On coil HW overcurrent fault

`~coilId: HW Overcurrent`

Legend:

55oiled – Active Coil

On coil SW overcurrent fault

`~coilId: Overcurrent(coilCurrent)`

Legend:

55oiled – Active Coil

coilCurrent – Actual Coil Current

3.4.5 WpcDiagnostics.btDebugGeneralOperation

This option enables printing the general information related to the operational state machine or state of the receiver.

On state machine update

```
#  oiled  newState
```

Legend:

56oiled – Active Coil

newState – New state of internal state machine

On Ept diagnostic (reported by Rx)

```
ETP 56oiled:  CHGD    (Charge complete)
ETP 56oiled:  FAULT   (Internal fault)
ETP 56oiled:  OVS     (Over Voltage)
ETP 56oiled:  OTS     (Over Temperature)
ETP 56oiled:  OVC     (Over Current)
ETP 56oiled:  BAT     (Batery fault)
ETP 56oiled:  RECONF  (Reconfigure)
ETP 56oiled:  NO RESP (No response)
ETP 56oiled:  UNKWN   (Unknown)
```

Legend:

*56*oiled – Active Coil

On analog ping and too low current

```
~Coil Fault
```

On digital ping timeout

```
ERR 57oiled: Timeout on Start
```

Legend:

57oiled – Active Coil

On digital ping timeout

```
ERR 57oiled: Recvd Packet 0xpacketType
```

Legend:

57oiled – Active Coil

packetType – Type of received packet

On device identification

```
ID ERR 57oiled: Not Compatible
~ 57oiled: N/C(majorVersion.minorVersion)    (allows to continue)
```

Legend:

57oiled – Active Coil

majorVersion – Major version of Rx

minorVersion – Minor version of Rx

On Extended ID packet

```
EXT ID ERR 57oiled: Recvd Paxket 0xpacketType
ERR 57oiled: Timeout On ExtID
```

Legend:

57oiled – Active Coil

packetType – Type of received packet

On configuration state

```
HOLDOFF 58oiled: invalid
HOLDOFF 58oiled: DelayTime=pidDelayTime
CONFIG 58oiled: Max Pwr: maxHalfWats
ERR 58oiled: Invalid CONFIG Packet 0xpacketType
ERR 38oiled: Timeout On CONFIG
```

Legend:

58oiled – Active Coil

pidDelayTime – PID Delay Time

maxHalfWats – Max Half Watts reported by Rx

packetType – Type of received packet

On Xfer state

```
~coilId: Not compact
~coilId: Safety(safetyInputVoltage)
~coilId: CEP Timeout
Received Power Timeout
Power Loss Timeout
PWR 58oiled percetPowerUsed
Max InputPower(inputPower mW) Exceeds: calculatedPower mW
CHG 58oiled percetCharged
PROP 58oiled proprietaryPacket
~RESET 58oiled ReceivedPacket
RSVD 58oiled ReceivedPacketRes
```

Legend:

58oiled – Active Coil

safetyInputVoltage – Safety Input Voltage

percetPowerUsed – Percet Power Used of Rx

inputPower – Input Power
calculatedPower – Calculated power
percetCharged – Percent Charged
proprietaryPacket – ID of proprietary packet
ReceivedPacket – ID of received packet, which generates interruption
ReceivedPacketRes – ID of received packet, which is reserved

On HW Fault

```
~coilId: hardware Faults
```

Legend:
59oiled – Active Coil

3.4.6 WpcDiagnostics.btDebugAnalogPing

This option enables debugging of the Analog Ping.

On Analog Ping

```
~A devId: 60oiled(coilCurrentFeedback, AnalogPingAdcCounts)
```

Legend:
devId – Device ID
60oiled – Active Coil
coilCurrentFeedback – Coil Current Feedback
AnalogPingAdcCounts – Analog Ping Adc Counts

3.4.7 WpcDiagnostics.btDebugPidOperation & WpcDiagnostics.btDebugVerbosePidOperation

This option enables debugging of the PID Regulator.

On PID adjustment

```
~coilId: R railVoltage D dutyCycle  A railVoltage T setPoint P pTerm I iTerm D dTerm E
Error

~coilId: F freq D dutyCycle A inputCurrent T setPoint
P pTerm I iTerm D dTerm E error
```

Legend:
60oiled – Active Coil
railVoltage – Controlled by Rail Voltage
freq – Controlled by Frequency
dutyCycle – Actual Duty Cycle

pTerm – Proportional Term
iTerm – Integral Term
dTerm – Derivative Term
error – Reported Error

3.4.8 WpcDiagnostics.btDebugOperationalState

This option enables debugging of the Operation State Machine.

On Next Op State

```
~coilId: State newOpState
```

Legend:
61oiled – Active Coil
newOpState – New Operation State

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