P9261-3C-CRBv2

Power-Loss and FOD Tuning Guide

This application note describes the functionality of the P9261 Automotive CRB 2.0 Wireless Power Transmitter (Tx) and its Foreign Objects Detection (FOD) by measuring the power that is being absorbed by the object.

Contents

1. **Introduction** 1
2. **P9261 Power-Loss FOD Tuning Overview** 2
3. **Step-by-Step Power-Loss FOD Thresholds Tuning** 3
4. **P9261 Power-Loss FOD Applicable Registers** 6
5. **Revision History** 6

1. Introduction

The P9261 Automotive CRB 2.0 Wireless Power Transmitter (Tx) is used to transmit wireless power to wireless power receivers (Rx) devices following WPC specifications and protocols. An important operating attribute of all WPC systems is the ability to detect Foreign Objects (FO) by measuring the power that is being absorbed by the object. In standard operating mode, the Rx device will send a Received Power Packet (RPP) approximately every 500ms. The RPP informs the Tx how much power the Rx is currently receiving and includes the estimate of the power loss in the Rx device due to friendly metal energy absorption. Once the RPP is received, the Tx compares this power to the Tx_{POWER} (see Equation 1) and if three consecutive results of PDiff (see Equation 2) are above the PThreshold, then the Tx will shut down due to FOD alarm.

$$Tx_{POWER} = VBRG(mV) x\, IBRG(mA)/1000$$ **Equation 1**

where,

VBRG = input voltage to the Tx controller IC (measured at VBRG_IN (pin 40) of the P9261)
IBRG = DC average current in the Tx Full Bridge (measured across RSNS (R18) on P9261 EVK)

The VBRG and IBRG values are directly measured by the P9261 during operation and the values that need to be tuned are the various power loss levels due to friendly metal associated with the Tx device under design at the various power levels. The P9261 FOD tuning includes tuning the Tx losses out of the equation used to determine if a FO is present or not. The Renesas solution uses regions with gain and offset to change the threshold based on the latest value of the RPP packets received. If RPP is larger than Tx_{POWER}, PDiff will be treated as 0.

$$PDiff = Tx_{POWER} - RPP$$ **Equation 2**

After PDiff is calculated, the P9261 calculates the thresholds used to determine if FOs are present or if normal power transfer can continue safely. The thresholds can be calculated using the following formulas and the value of the threshold is dependent upon the most recently received RPP value:

$$FOD\ Pthreshold = (PRX*Gain_{REGION} + FOD\_Offset_{REGION}) + Offset\_FOD$$ **Equation 3**

Once the FOD power thresholds are calculated, they are compared to the calculated P_{DIFF} result and the result is used based on the following FW code snippet:

```
If PDIFF > PThreshold
{
     Count_FOD++
     IF Count_FOD > 3
     {
          FOD Shutdown
     }
}
Else
{
     Count_FOD = 0
}
```

2. P9261 Power-Loss FOD Tuning Overview

This section describes how to tune the P9261 Power Loss FOD using the registers available for this purpose.

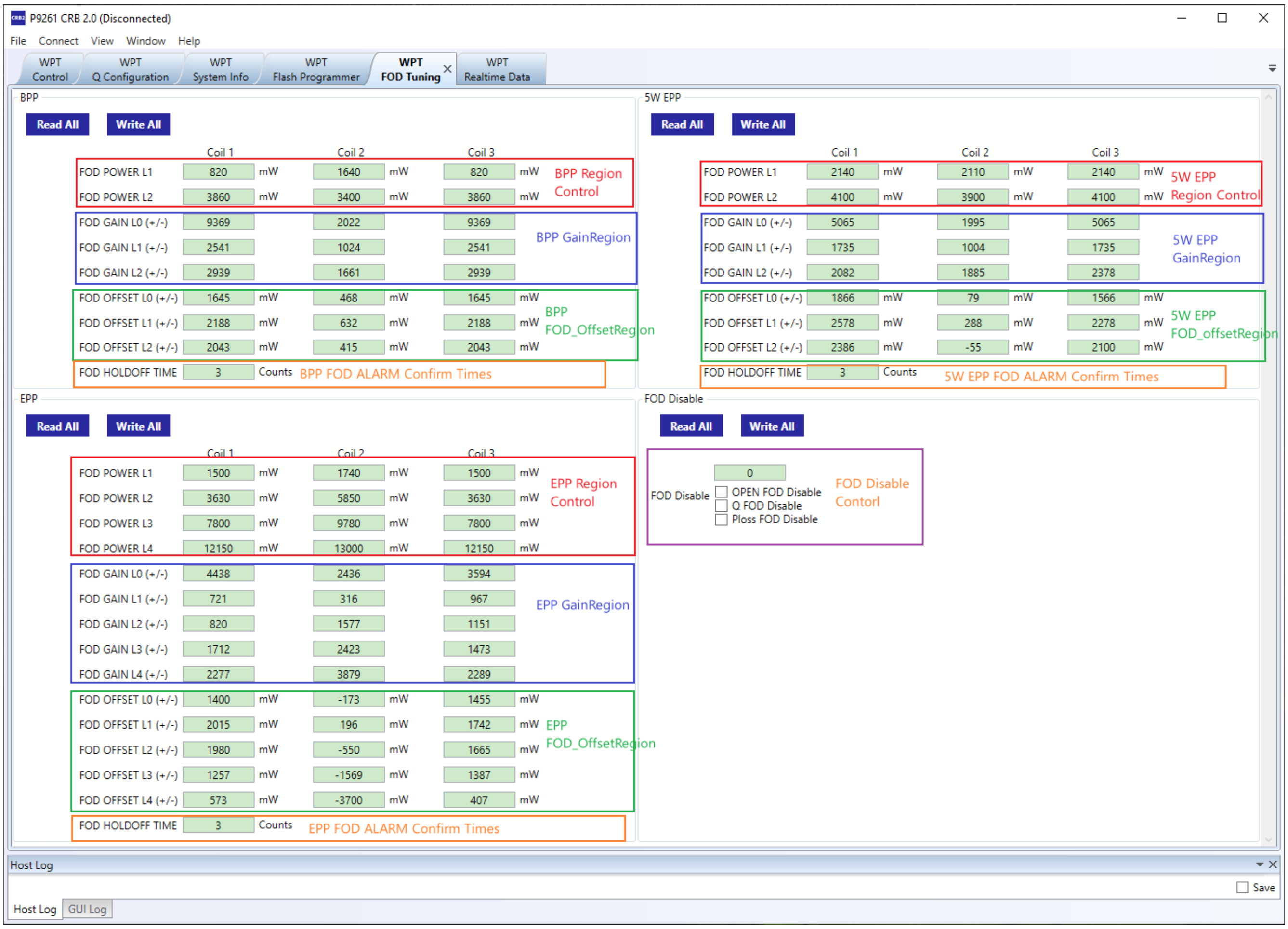

Figure 1. P9261 Automotive CRB 2.0 GUI Screen Capture FOD Tuning Tab

The Power Difference (P_{DIFF}) thresholds are segmented by power regions and are programmed by the Region Control registers and are entered based on the most recent RPP value. For example, In BPP mode there are two regions that must be programmed. Region 1 (L0) applies for RPP values from 0W up FOD_POWER_LP_L1_CoiIn (0x0890), Region 2 (L1) applies to FOD_POWER_LP_L1_CoiIn < RPP < FOD_POWER_LP_L2_CoiIn (0x0892) values and Region 3 (L2) applies for RPP values greater than FOD_POWER_LP_L2_CoiIn (0x0892). Equation 3 can be used to calculate the threshold that is compared to P_{DIFF} based on the current region being used for the FOD_{Pdiff} calculation.

In order to tune the PowerLoss FOD, use the RPP value to select the Region that the OFFSET and GAIN will be applied to, and to select which OFFSET and GAIN will be used for the calculation. The FOD_Offset should be programmed, and this parameter shifts the threshold up or down for specific. The GAIN is used to set the slope for the specific region being tuned. The primary purpose of these tunable parameters is to try to match (or account for) the efficiency changes of the system as the load changes from no load to full load.

3. Step-by-Step Power-Loss FOD Thresholds Tuning

1. Connect the P9261's coil#2 to an BPP Rx (calibrated WPC-Certified Rx recommended) and sweep the load from 0A up to 10% beyond the full-scale output load (for example, 5W BPP Rx, sweep the load up to 5.5W or 1.1A), and record Tx_{POWER} (PTx), Rx_{POWER} (PRx) and PowerDiff at each load.
2. Disable power loss FOD and put the FO between Rx and Tx, then record the PRx, PRx and PowerDiff the same as step 1.

Table 1. Power Data with Rx, Rx and FO, and Threshold

Coil#2	BPP Rx			BPP Rx and FO				Threshold (mW)
Load	PTx(mW)	PRx(mW)	PowerDiff	PTx (mW)	PRx (mW)	PowerDiff		
0mA	430	468	0	920	507	413		206.5
100mA	1100	1105	0	1520	1100	420		210
200mA	1500	1520	0	1960	1520	440		220
300mA	2100	2030	70	2600	2030	570		300
400mA	2610	2500	110	3100	2500	600		355
500mA	3170	3000	170	3700	3000	700	→	435
600mA	3800	3590	210	4360	3550	810		530
700mA	4430	4140	290	5040	4100	940		615
800mA	5080	4690	390	5760	4690	1070		730
900mA	5780	5310	470	6480	5270	1210		840
1000mA	6490	5890	600	7250	5870	1380		1000
1100mA	7200	6440	760	8030	6450	1580		1170

3. Calculate the threshold from the power data in "BPP Rx" and "BPP Rx and FO" as (Equation 4). Usually, we make the threshold similar to $PowerDiff_{BPP\_RX\_and\_FO}$ by Adjust_Offset and make the Trendline Curve linearly.

$$Threshold = (PowerDiff_{BPP\_RX} + PowerDiff_{BPP\_RX}\_and\_FO)/2 \pm Adjust\_Offset \quad \textbf{Equation 4}$$

4. Draw "$PowerDiff_{BPP\_RX}$ vs PRx_{BPP_RX}", "$PowerDiff_{BPP\_RX\_and\_FO}$ vs $PRx_{BPP\_RX\_and\_FO}$" and "Threshold vs PRx_{BPP_RX}" in the same chart. From the chart below (see Figure 2), we can see slope changes, then we can get the Region Control setting: the 3rd and 10th point's PRx will be used as the "FOD Power L1" and "FOD Power L2".
5. Now the threshold line has been separated into 3 regions, with each region getting a linear trendline. From the trendline's equation, we can get each region's $Gain_{REGION}$ and FOD_Offset_{REGION}. $Gain_{REGION}$ = Slope * 10000 and FOD_Offset_{REGION} = y-Intercept in mW.

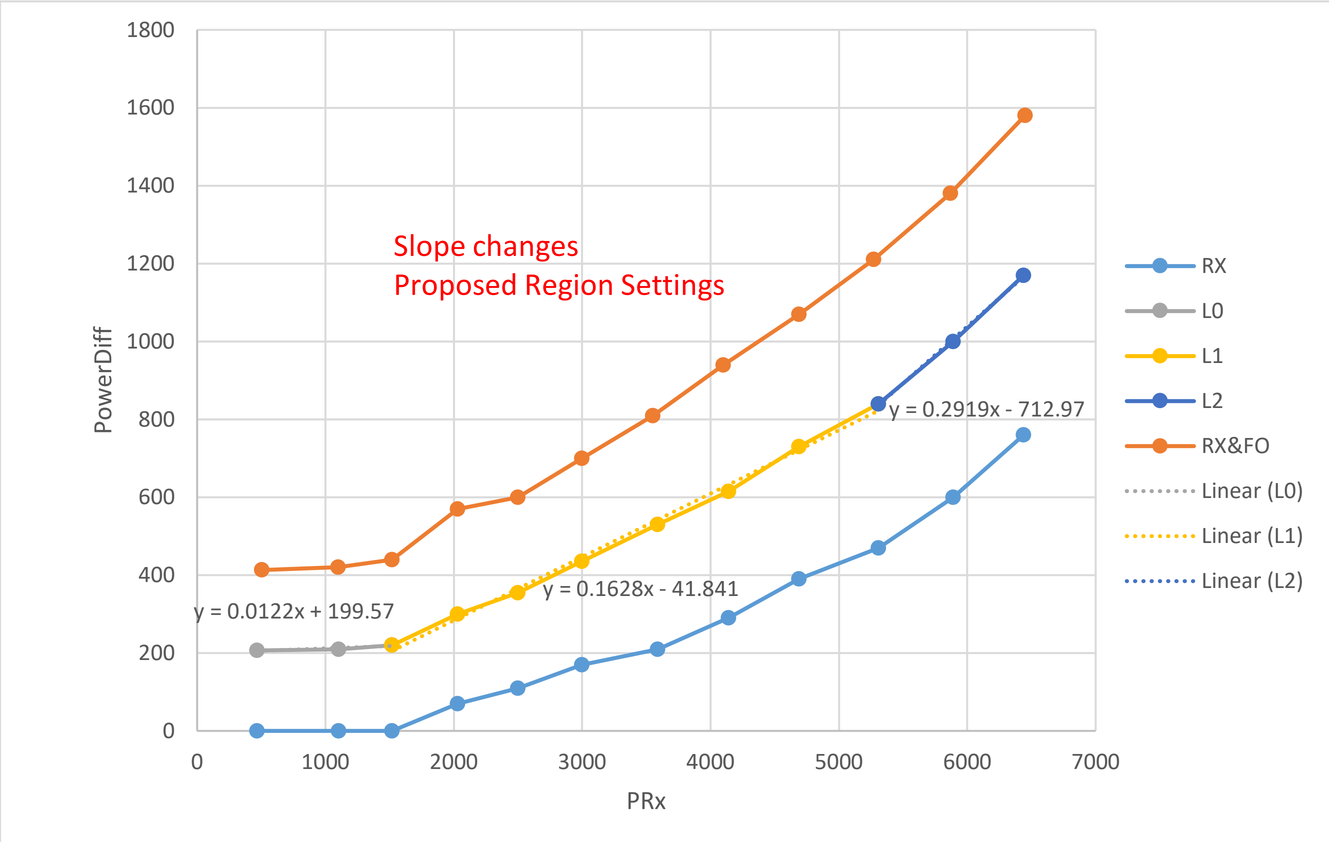

Figure 2. Measurements Needed to Tune FOD with P9261

6. After obtaining all the FOD parameters, they can then be written to the 9261 via the GUI (see Figure 3).

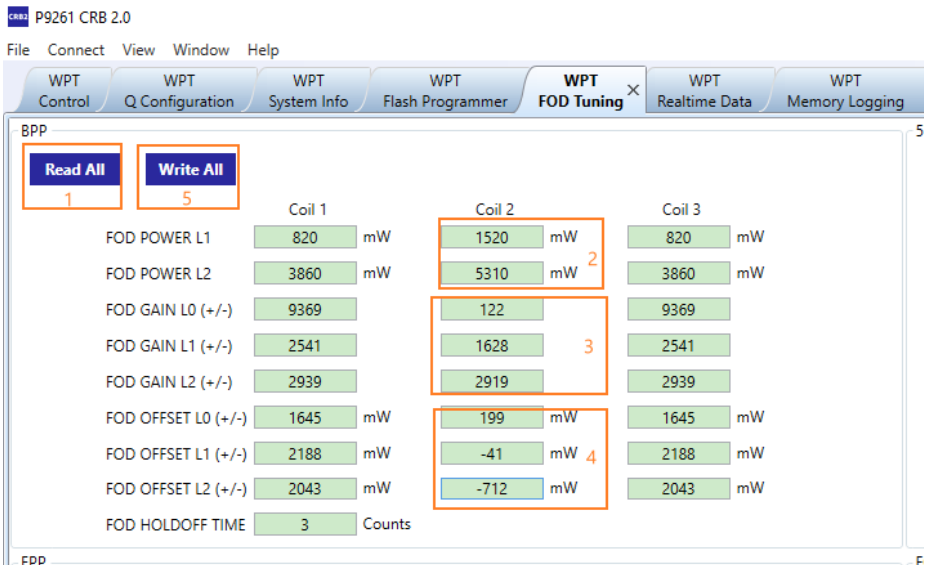

Figure 3. Set the FOD Parameters via the GUI for BPP Coil 2

7. By putting Rx and FO together on Tx, see how the new parameters have taken effect. RPP 3750 is in the region L1, so the threshold should be 3750 * 0.1628 – 41 = 569mW.

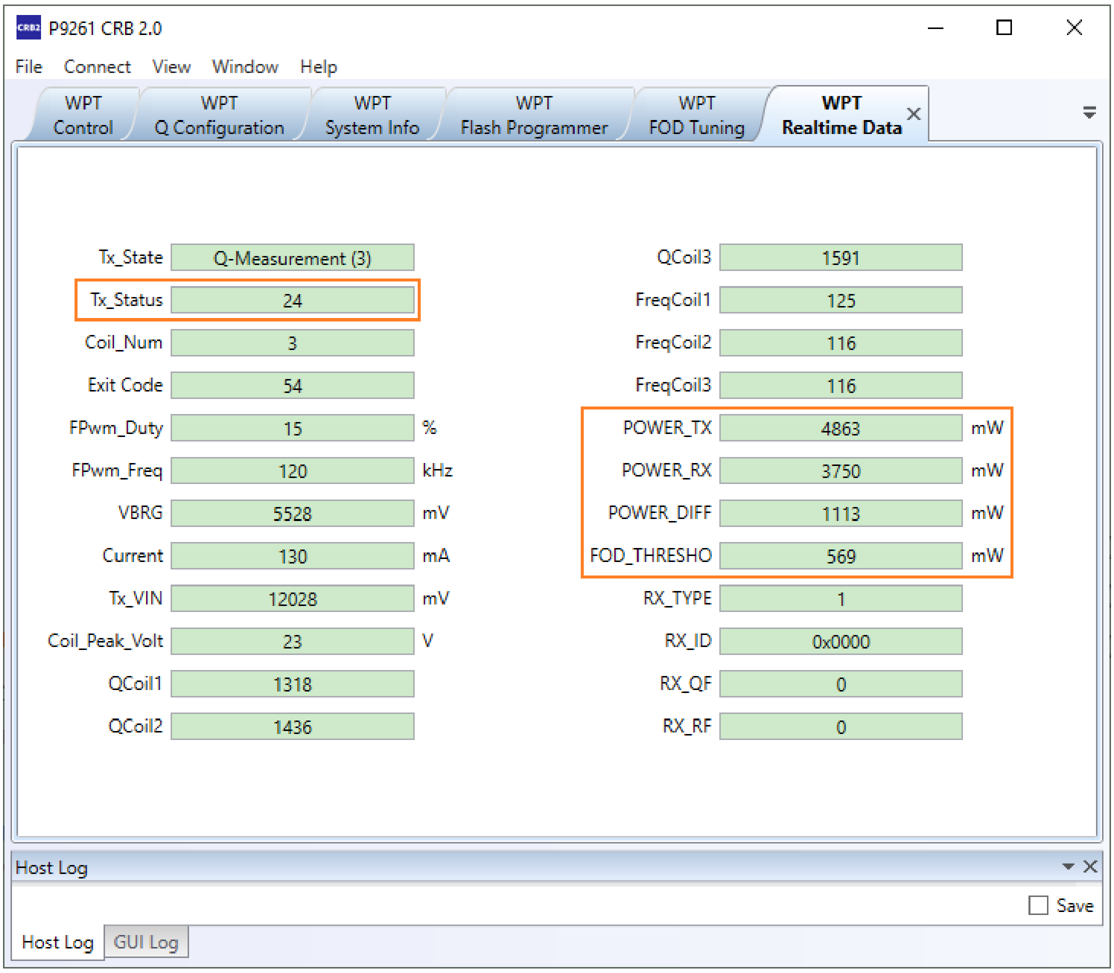

Figure 4. Verify the New Parameters

8. Save the FW onto a new hex file. Go to the “WPT Flash Programmer” tab and click on “Save to hex file” (see Figure 5). A dialog box will be open. Choose the name of the file and the location to save it.

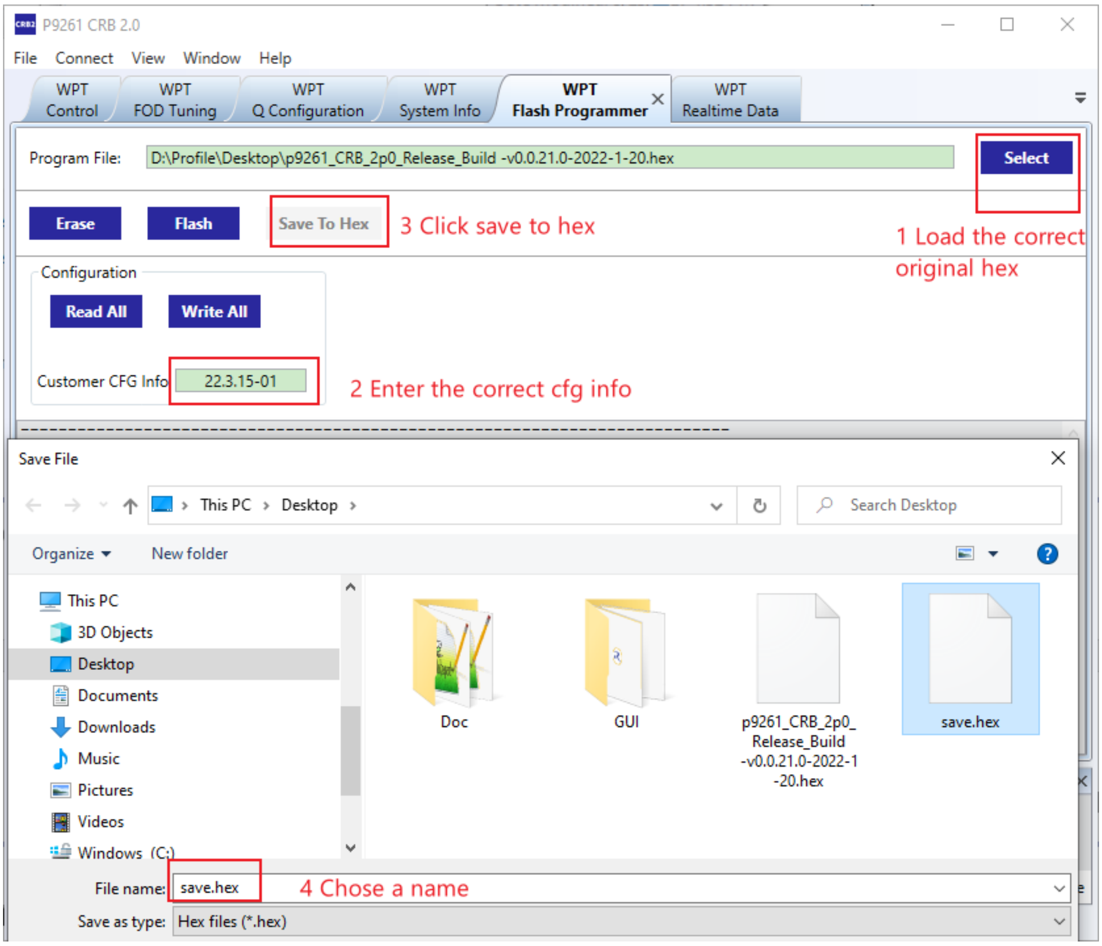

Figure 5. Windows Dialog Box to save.hex File under New User Defined Name

9. Repeat steps 1 through 7 to obtain the parameters for coils 1 and 3. Then use the same methods to obtain the parameters for 5W EPP and EPP; 5W EPP is similar to BPP. EPP is similar as well, with the only difference being EPP's power range is 0 to 15W, so EPP uses 5 regions.

4. P9261 Power-Loss FOD Applicable Registers

Refer to document *P9261-3C-CRB2.0 Command/Status Registry*, "Table 9. Power Loss FOD' in section "4.6 Power Loss FOD".

5. Revision History

Revision	Date	Description
1.00	May 2, 2022	Initial release.

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