

# Bringing Up the Wireless Charging Transmitter Board

Prevent issues with the Wireless Charging Transmitter board

## 1. Introduction

It is recommended to perform some tests before executing the wireless charging operation on the Wireless Charging Transmitter board. The tests described in this document expose issues that can completely block the wireless charging functionality (voltage levels, drivers, resonance curve check, and so on). Other tests prevent issues that can occur later on, even in the final stages of product development, such as FOD issues during Qi certification and issues during interoperability testing (3.3 V stability, noise analysis).

Redesigning the hardware is often the only solution for these issues. It is very important to identify such issues in early stages of product development.

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## 2. Disabling wireless charging functionality in software

It is recommended to disable the wireless charging functionality and perform the tests described below before you flash the software to the board for the first time. Otherwise, the wireless-charging state machine starts pinging immediately, and if there is a hardware issue, it can damage the board.

Disable the wireless charging functionality by setting the `bStop` variable in `main.c` to 1:

```
WORD wTemp;
WORD bNotified = 0;
WORD bStop = 1;
WORD bReset = 0;
WORD bWctStopStatus = 0;
```

## 3. Important voltage levels

All voltages must have the prescribed levels for a proper functionality of Wireless Charging Transmitter board.

### 3.1. 3.3 V and 5 V levels check

Check that the analog components work properly before you flash software to the Wireless Charging Transmitter board. Check the input voltage source (whether the connector is not soldered oppositely), and check that all 3.3 V and 5 V voltage levels on the board are correct, especially the 3.3 V power supply for the WCT controller.

If the voltage levels are not correct, check the analog DC/DC converters on the board.

### 3.2. DC/DC control check

If you control the amount of power transferred by changing the rail voltage (for example, on the A13 design), ensure that the DC/DC converter works properly before you enable charging.

To perform the DC/DC control check, take these steps:

1. Enter Debug mode.

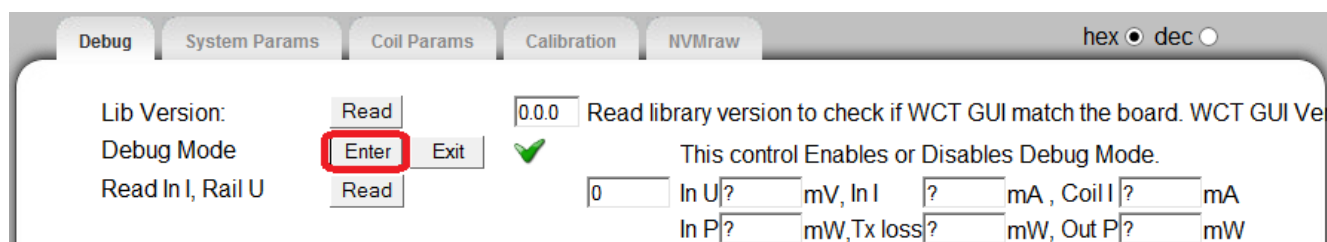


Figure 1. Entering Debug mode

2. Change the value of the DAC register in the DAC Control line, and check if the voltage is changing in the expected range using oscilloscope or voltmeter.

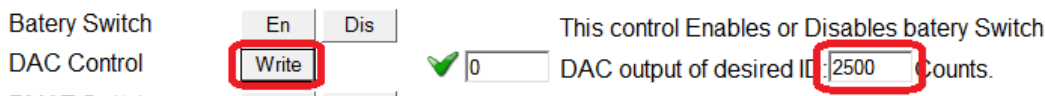


Figure 2. Changing the DAC value

If the DC/DC converter does not work properly, check if a proper value is written to the DAC register. If yes, check if the DAC voltage on the desired pin changed. If the voltage is correct, the DC/DC converter has issues. For more information on troubleshooting the DC/DC converter, contact the vendor of the DC/DC converter.

Check if the DC/DC converter handles substantial changes of voltage with the load connected. Perform the previous steps, and then turn on a coil by clicking the “Set” button in the Coil Frequency line to add the load. Change the DAC values in wide steps after turning on the coil.

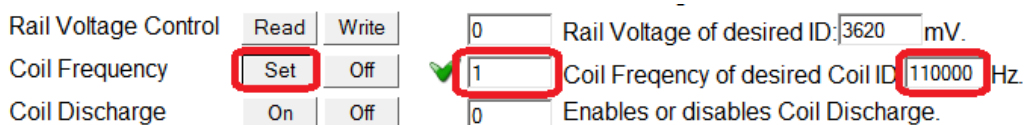


Figure 3. Turning on the coil

Turn off the coil by clicking on the Off button in the Coil Frequency line after the test.

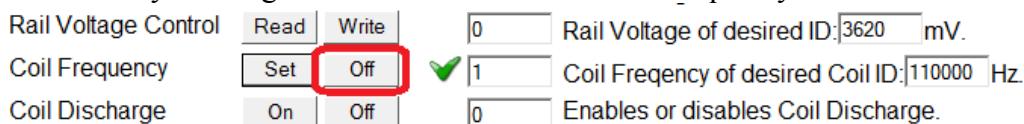


Figure 4. Turning off the coil

If the DC/DC converter fails during these wide voltage steps, the feedback circuit of the DC/DC converter has issues.

## 4. Frequency check

The frequency setting of the WCT device must have no issues for the wireless charging system to work properly.

To perform the frequency check, follow these steps:

1. On the **Debug** tab, enter the Debug mode.

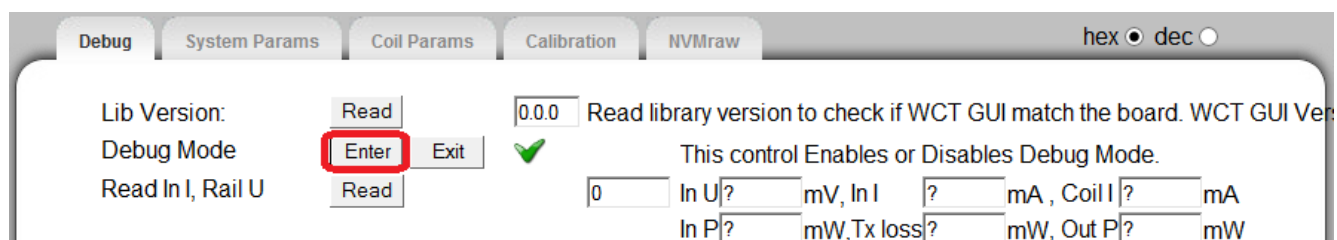


Figure 5. Entering Debug mode

- Set several frequencies from the operating range by typing to the last box in the Coil Frequency line, and turn on the coil by clicking the “Set” button. Using the oscilloscope, check if the frequency of the generated field corresponds to the given value.

Rail Voltage Control	Read	Write	0	Rail Voltage of desired ID:	3620	mV.
Coil Frequency	Set	Off	✓ 1	Coil Frequency of desired Coil ID:	110000	Hz.
Coil Discharge	On	Off	0	Enables or disables Coil Discharge.		

Figure 6. Turning on the coil

- Turn off the coil by clicking the “Off” button in the Coil Frequency line after the test.

Rail Voltage Control	Read	Write	0	Rail Voltage of desired ID:	3620	mV.
Coil Frequency	Set	Off	✓ 1	Coil Frequency of desired Coil ID:	110000	Hz.
Coil Discharge	On	Off	0	Enables or disables Coil Discharge.		

Figure 7. Turning off the coil

If the measured frequency does not correspond to the value in the box, then the PWM driver has issues. Verify that all settings in the graphical configuration tool, library configuration file, and the drivers are set properly.

## 5. Duty cycle/phase shift check

If the WCT uses duty cycle or phase shift to control the transferred power, check that these features work well by taking the steps below. If you do not use duty cycle or phase shift to control the transferred power, skip this section.

- On the **Debug** tab, enter the Debug mode.

Debug	System Params	Coil Params	Calibration	NVMraw	hex	dec
Lib Version:	Read	0.0.0	Read library version to check if WCT GUI match the board. WCT GUI Ver:			
Debug Mode	Enter	Exit	✓	This control Enables or Disables Debug Mode.		
Read In I, Rail U	Read	0	In U?	mV, In I ?	mA, Coil I ?	mA
			In P?	mW, Tx loss?	mW, Out P?	mW

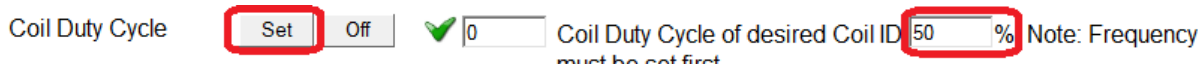
Figure 8. Entering the Debug mode

- Turn on the coil by clicking the “Set” button in the Coil Frequency line.

Rail Voltage Control	Read	Write	0	Rail Voltage of desired ID:	3620	mV.
Coil Frequency	Set	Off	✓ 1	Coil Frequency of desired Coil ID:	110000	Hz.
Coil Discharge	On	Off	0	Enables or disables Coil Discharge.		

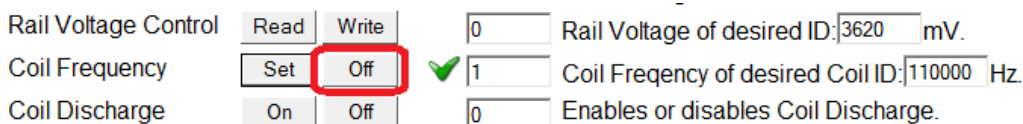
Figure 9. Turning on the coil

3. Change the value of the duty cycle/phase shift, and check if this feature works properly (using oscilloscope).



**Figure 10. Changing the duty cycle**

4. Turn off the coil by clicking the “Off” button in the Coil Frequency line after the test.



**Figure 11. Turning off the coil**

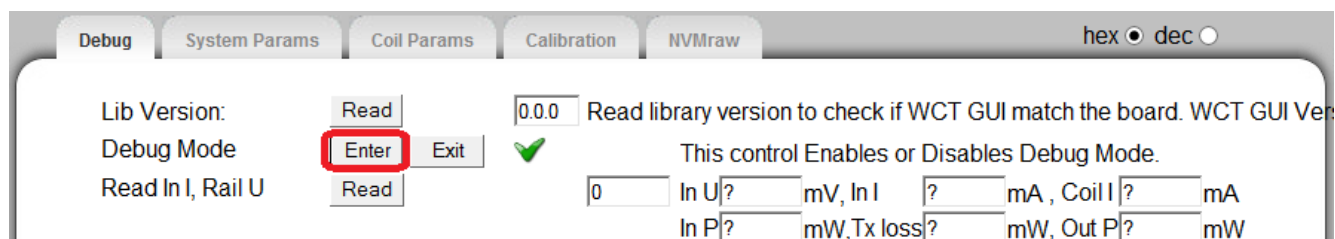
If the measured value of duty cycle/phase shift does not correspond to the value in the box, then there are issues with the PWM driver. Verify that all settings in the graphical configuration tool, library configuration file, and the drivers are set properly.

## 6. Resonance curve check

Resonance curve is a basic parameter of wireless power transfer. If the resonance curve has different shape than expected, then the efficiency radically decreases, and the receiver can be damaged during the identification phase.

To perform the resonance curve check, take these steps:

1. On the **Debug** tab, enter the Debug mode.



**Figure 12. Entering the Debug mode**

2. Set the lowest possible rail voltage (1000 mV) to prevent over-current condition on the resonance frequency.

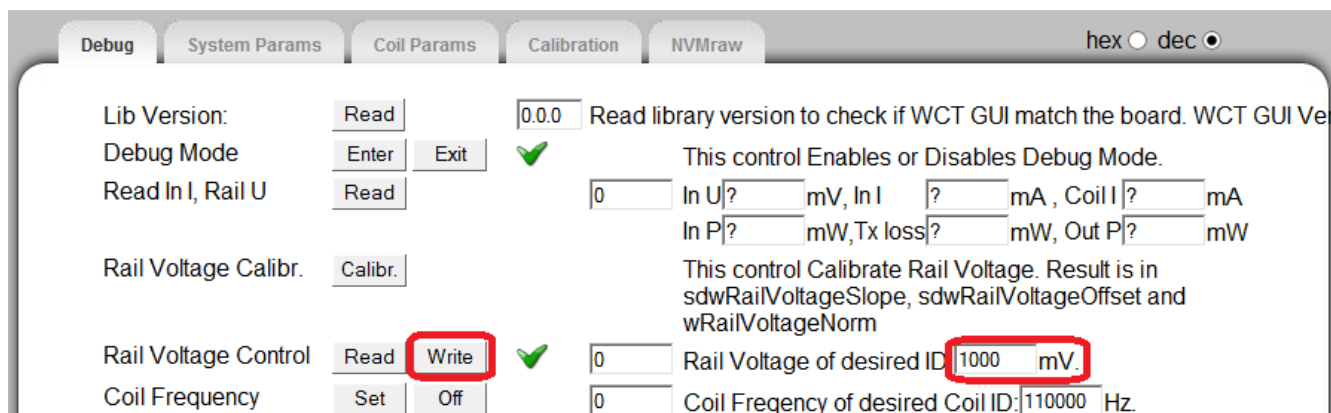


Figure 13. Changing the rail voltage

3. In the Frequency Sweep section on the **Debug** tab, set the frequency range for the sweep and click the “Start” button.

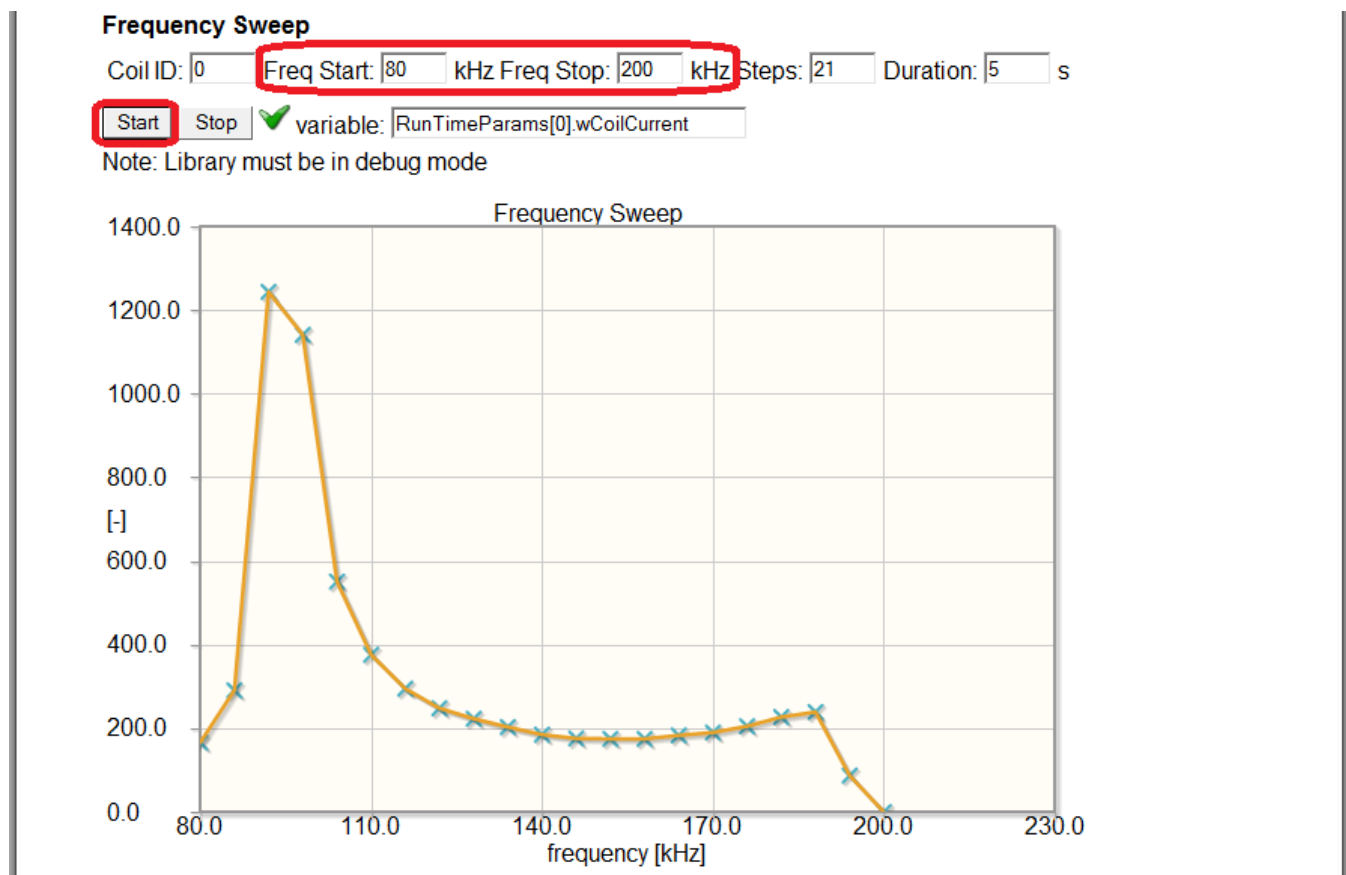


Figure 14. Frequency sweep

If the resonance curve does not have the expected shape, check the values of the resonance and filtering capacitors and inductors. If all values are correct, check if all MOSFETs driving the bridge and coils' discharging are switched properly (using oscilloscope). The PWM generation is already verified in this stage of testing, so there shall not be any issues with PWM generation. Note that different design types (A13, A11, and so on) have slightly different shape of resonance curve. Always make sure that the shape for the desired design is clear.

## 7. Multiplexer check

If you use multi-coil topology (for example A13), it is important to make sure that the multiplexer is switching each coil properly. The procedure is as follows:

1. On the **Debug** tab, enter the Debug mode.

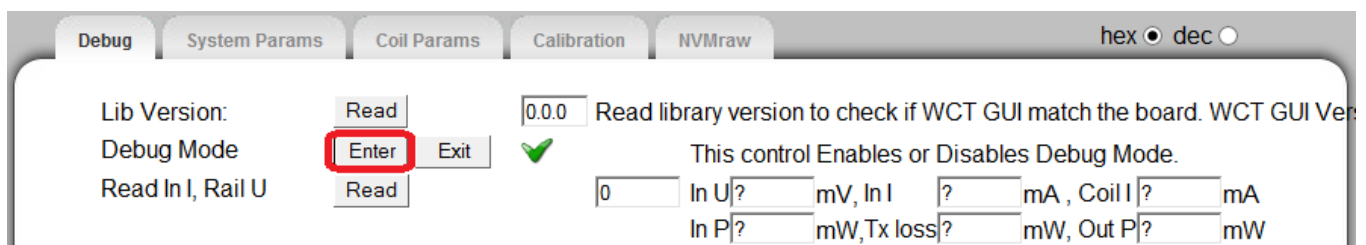


Figure 15. Entering the Debug mode

2. Set the desired coil and operating frequency by typing into the fields outlined in red (the first field represents the coil ID from 0 to number of coils, the second field sets the frequency in Herz). Turn on the desired coil by clicking the “Set” button in the Coil Frequency line.

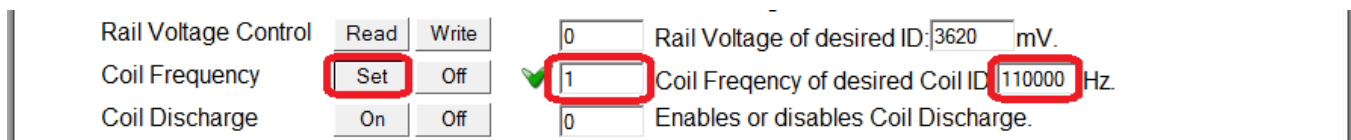


Figure 16. Turning on the coil

3. Check if there is a sinus signal in the desired coil (using an oscilloscope with a current probe).
4. Turn off the coil by clicking the “Off” button in the Coil Frequency line, and do the same with the next coil.

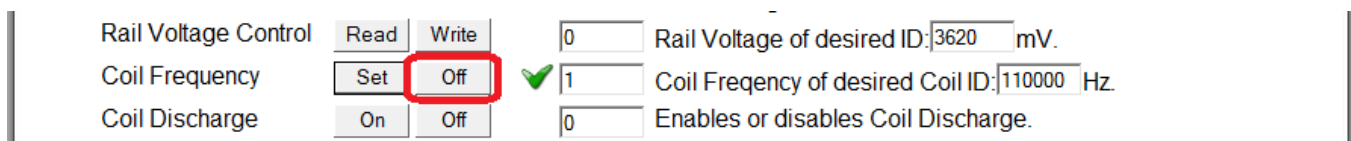


Figure 17. Turning off the coil

If the desired coil does not switch on properly, check if the ports are aligned properly in the library configuration file, and if the GPIOs are set properly in the graphical configuration tool. If these items are correct, check if the multiplexer MOSFETs are switched properly (using oscilloscope).

## 8. Noise analysis

One of the most common issues with wireless charging boards is the noise present in the communication signal. This is usually caused by incorrect PCB design of the communication signal path (proximity of digital signals, missing grounds, and so on). This test does not identify the source of the noise, but it provides an evidence of the noise itself. The test procedure is as follows:

1. Scroll to the bottom of the **Debug** tab, to the Noise Analysis section. Select the desired coil by typing the coil number (from 0 to number of coils) into the Coil ID box, and enter the Debug mode by clicking “Enter” in the Enter to Debug mode line.

### Noise Analyzis

- 1) Set Device ID:  and Coil ID:
- 2) Enter to debug mode:
- 3) Turn On desired coil:  ✓

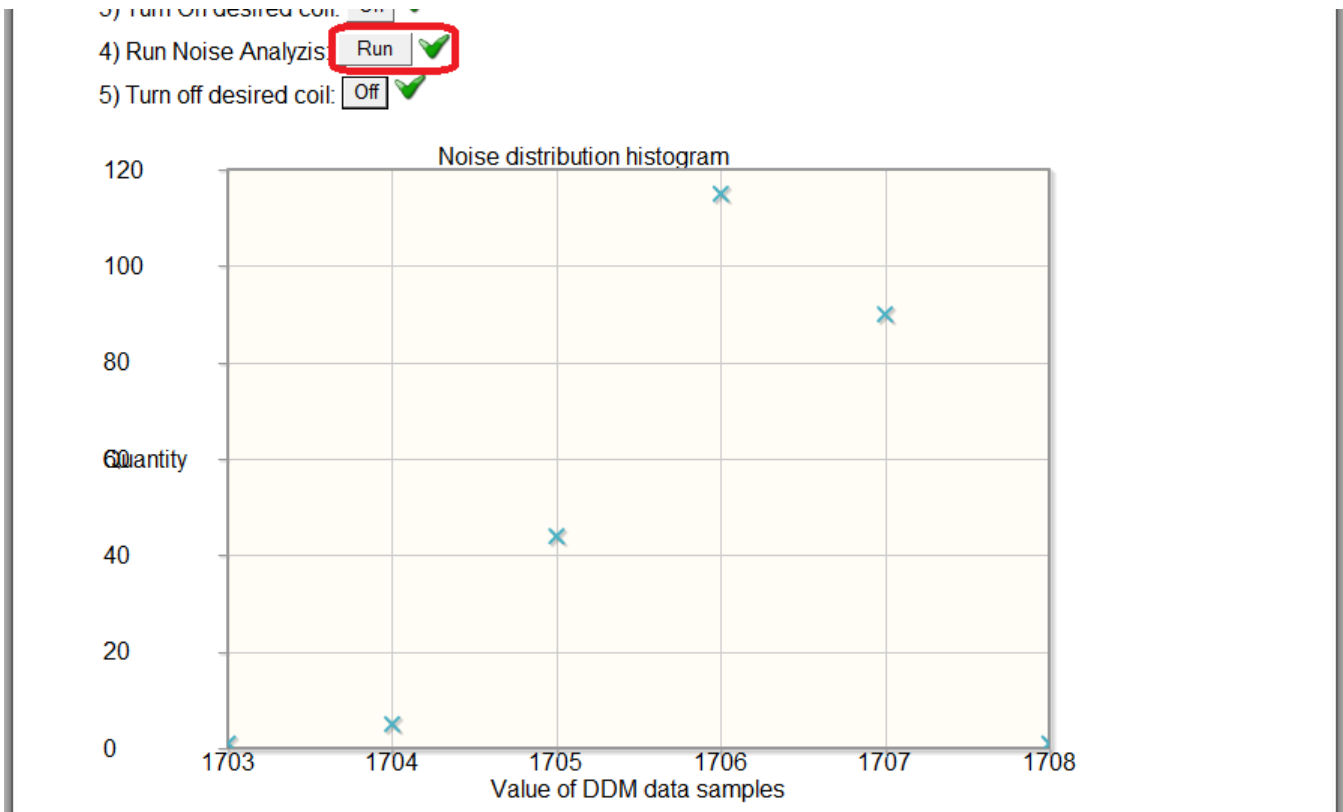
Figure 18. Entering the Debug mode

2. Turn on the desired coil by clicking the “On” button in the Coil Frequency line.

- 1) Set Device ID:  and Coil ID:
- 2) Enter to debug mode:
- 3) Turn On desired coil:  ✓

Figure 19. Turning on the coil

3. Click the “Run” button in the Run Noise Analysis line, and a histogram of data in the DDM buffer appears. The acceptable dispersion is shown in the following figure, with the biggest difference between data in the DDM buffer being  $1708 - 1703 = 5$ .



**Figure 20. Noise analysis**

- Switch off the coil by clicking the “Off” button in the Turn off desired coil line.

If the dispersion of data is greater than 10, identify the source of noise, and redesign the hardware. Otherwise, issues with charging receivers with low modulation depth can occur.

### 9.3.3 V noise and stability

Stable ADC reference voltage is important for proper functionality of analog measurement and Foreign Object Detection (FOD). There must be no noise and the voltage level must not change with the change of load on the Rx side. Check the 3.3 V reference voltage using oscilloscope, and compare it with the below figures.

The acceptable amount of noise is shown in this figure. The noise level is stable and there are only occasional spikes. The ADC measurement runs properly in such a case.

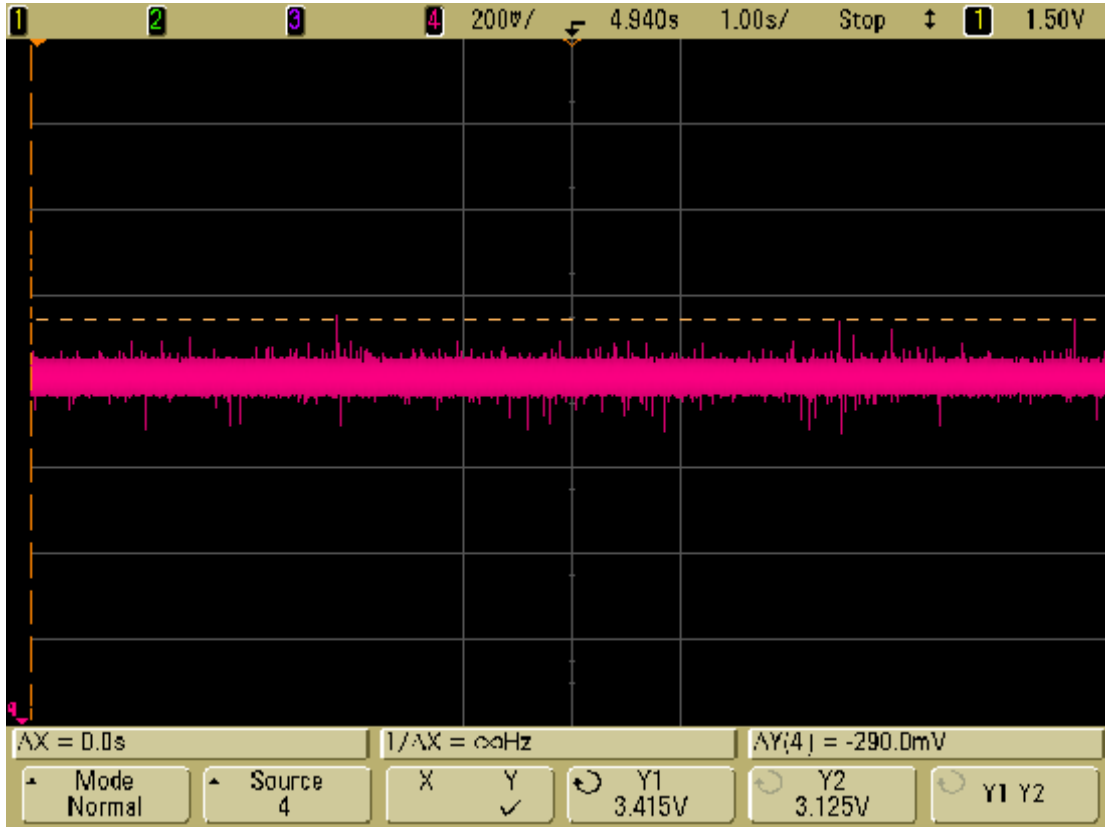


Figure 21. 3.3 V reference voltage with acceptable level of noise

The amount of noise shown in this figure is over the limit. The noise level is not constant, and there are a lot of spikes. This influences the ADC measurement, and the FOD results are incorrect.

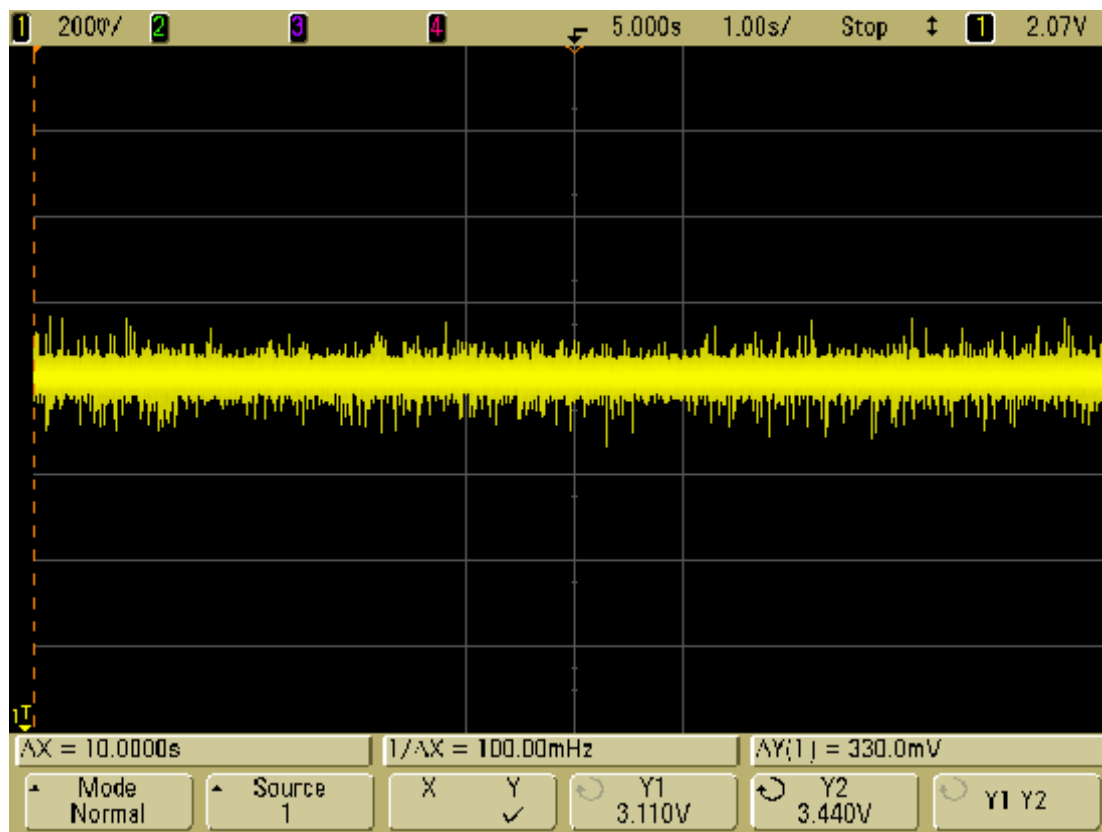


Figure 22. 3.3 V reference voltage with more noise

This figure shows the 3.3 V reference voltage during the change of Rx load. When the load changes, the 3.3 V level changes too. The 3.3 V level must be constant, otherwise the values measured during calibration (without load) and the values measured during charging are different, and FOD does not work properly.

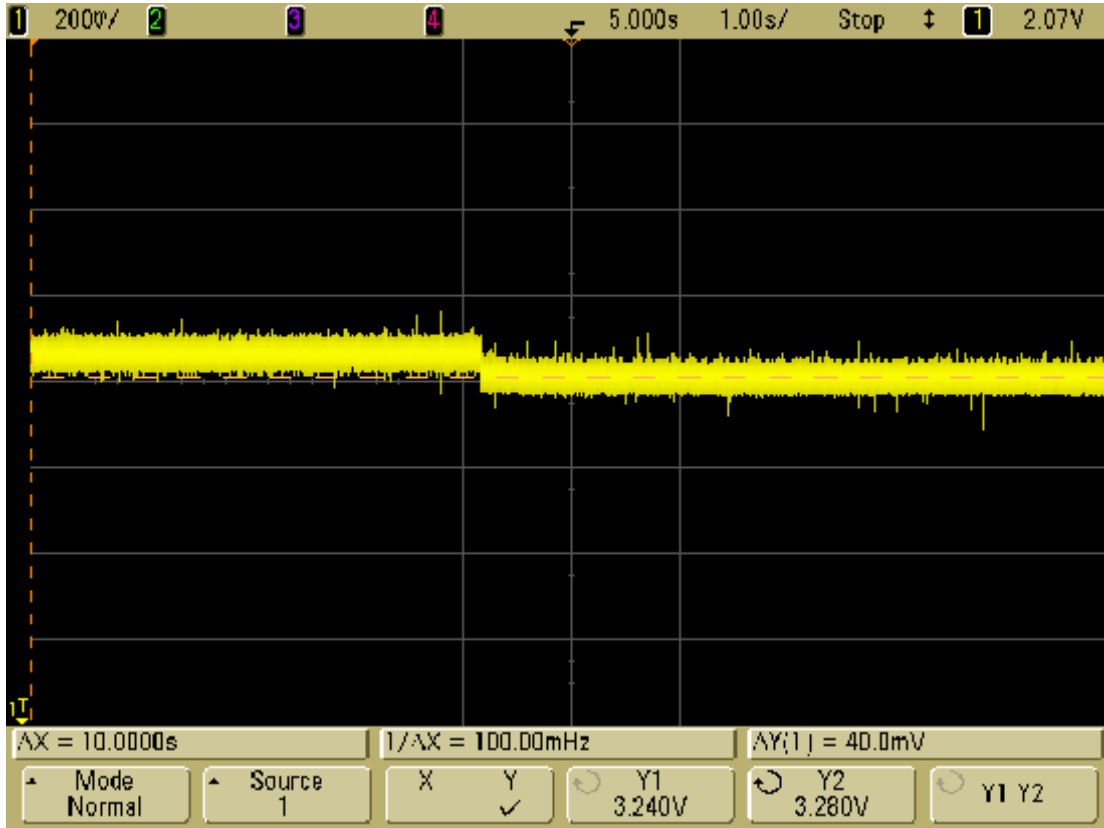


Figure 23. 3.3 V reference voltage during the change of Rx load

## 10. Conclusion

There are a lot of issues that can occur in the process of designing a wireless charging transmitter. This application note describes how to reveal them, and prevent the occurrence of these issues in latter stages of product development. In case of any questions and concerns, contact customer support at [www.freescale.com/support](http://www.freescale.com/support).

## 11. Revision history

The following table summarizes the changes made to this document since the initial release.

**Table 1. Revision history**

Revision number	Date	Substantive changes
0	08/2015	Initial release.

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