
STWLC68JRH - FOD calibration**Introduction**

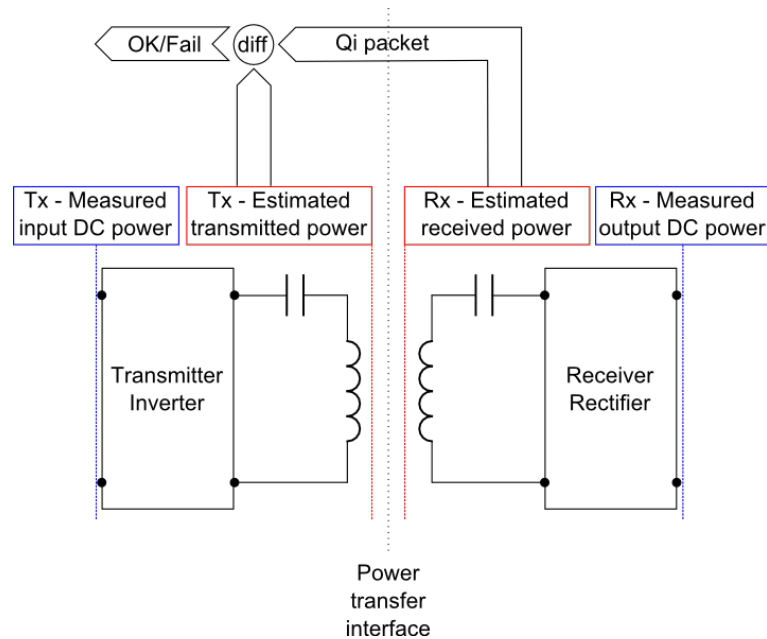
The aim of the document is to provide instructions and a step by step example how to fine-tune **STWLC68JRH** parameters to comply Qi 1.2.4 requirements regarding foreign object detection.

1 Purpose

Whenever the STWLC68JRH operates in Qi-mode, it has to calculate and report the received power level to the transmitter as defined in Qi specification. The STWLC68JRH uses precise A/D converter to perform the measurements and 32-bit arithmetic to ensure adequate calculation precision.

The actual received power from the transmitter is inherently not accounting losses taking place outside the STWLC68JRH, like the ones in the receiving coil (winding DCR and core) or in the RF shielding. For this reason a mathematical model of the transmitter-to-receiver system has to be used in the estimation of the received power. Such a model is clearly application-dependent and determining the optimal set of parameters is the key of the FOD tuning process.

Figure 1. Block diagram of the transmitter-to-receiver power transfer



The STWLC68JRH computes the estimated received power using measurement of the rectifier output voltage and current.

Note: The FOD tuning procedure requires a calibrated, Qi-compliant transmitter (like AVID, MP-500, Nok9 system, etc) capable of reporting both the transmitted power and received power (sent back from the receiver under test) without terminating the power transfer in case a FOD condition is detected.

2 Compensation method

The compensation method is one of the possible ways to achieve FOD tuning for a given wireless power receiver application. The key concept is estimating the received power by introducing a compensation for the external power losses.

In other words, the received power is estimated as the result of a linear correction (equation 1): the external losses are accounted as a fixed baseline (offset) plus a variable amount proportional (gain) to the power delivered at the STWLC68JRH input terminals.

The total received power is given by equation 1:

$$P_{RX_EST} = FOD_A + FOD_B \cdot (P_{RECT} + P_{LOSS_INT})$$

The two parameters, FOD_A and FOD_B are the offset and the gain of the above mentioned linear correction. A third FOD tuning parameter, R_{SER} , is specifically used in the calculation of the internal power loss and will be explained later.

In summary, the FOD tuning parameters are:

- FOD_A : compensation offset
- FOD_B : compensation gain
- R_{SER} : parameter accounting for all the “current-dependent” contributions to the external power losses, although the DCR of the coil is the most relevant.

The STWLC68JRH stores the FOD parameters in the internal configuration sector of the OTP Non-Volatile Memory (NVM) and retrieves them at power-up.

3 FOD calibration parameters selection: step-by-step procedure

From a practical point of view, the FOD calibration can be performed through a simple procedure that involves the user application with STWLC68JRH including the final position of the coil, shielding, surrounding friendly metal objects, etc. GUI (available on www.st.com) and optionally a set of monitoring instruments.

As already mentioned a calibrated, Qi-compliant transmitter with special features is mandatory to successfully calibrate the FOD, since the whole FOD calibration procedure relies on reporting the difference between the transmitted power and the received power as a function of the measured current (spanning over a pre-defined range).

FOD calibration should be achieved easily by changing of the FOD tuning parameters of STWLC68JRH mentioned above using FOD Tuning tool in the GUI.

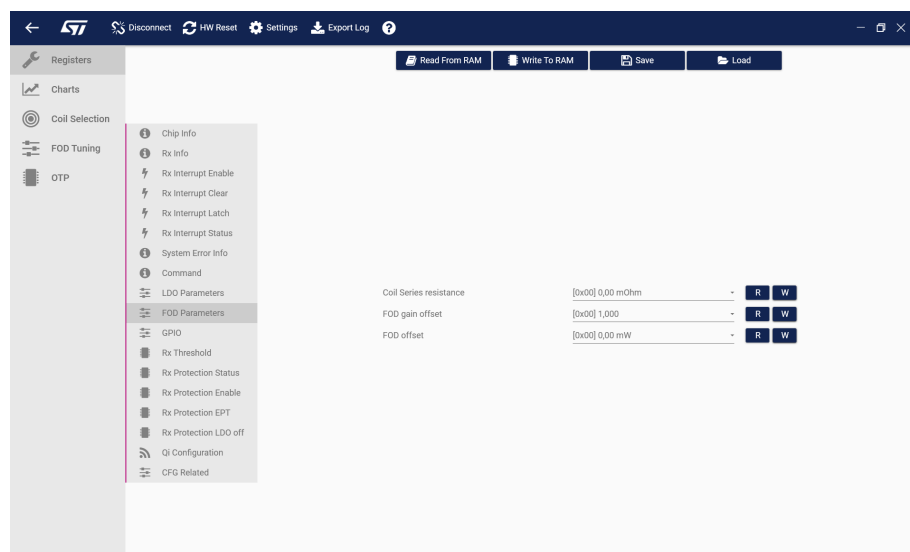
All FOD tuning parameters are always initialized from the stored configuration in OTP after each boot up of the device. As well as other configuration also FOD tuning parameters can be changed on fly using I²C registers through GUI. Change is valid until next reset of the device.

Step 1: reset FOD tuning parameters

Put the device on the FOD reference transmitter for FOD tuning and disable the FOD compensation through the GUI by setting FOD parameters setting as listed below:

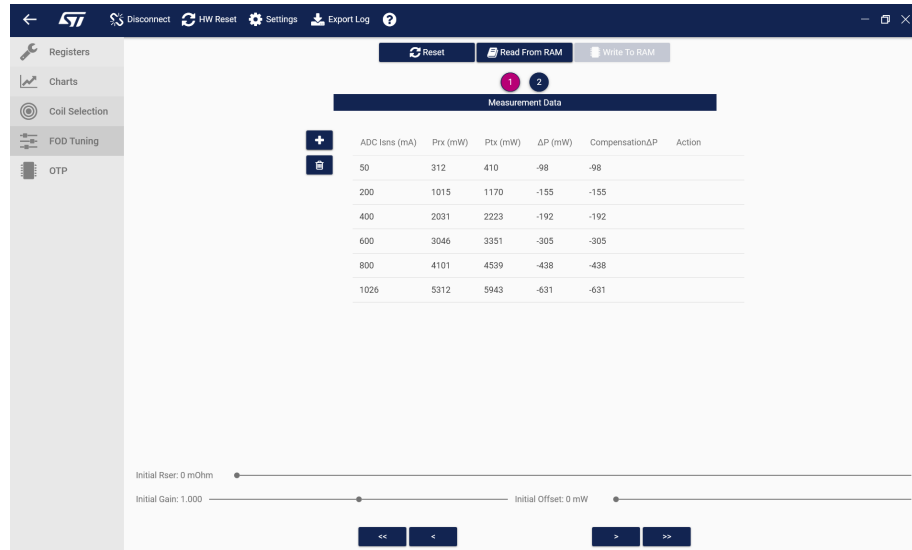
- $FOD_A = 0 \text{ mW}$
- $FOD_B = 1,0$
- $R_{SER} = 0 \text{ mOhm}$

Figure 2. Initial setting for FOD tuning parameters



Step 2: Initial measurement

As a second step in the FOD calibration procedure, the load at the output of the receiver is gradually increased and the corresponding values for both the transmitted and the received power are collected. The number of calibration points is not critical, but of course a minimum of three points is needed for linear compensation. For most of applications, 5 to 10 calibration points is a good choice. It must be noted that for each calibration point the reference current is actually the internally measured one, not the output one. For this reason, it could be easier defining the target values for I_{SNS} and adjusting the load current accordingly: once the desired value for I_{SNS} is read on the GUI, the corresponding values for the transmitted and the received power are reported in the FOD tuning Page 1. Figure 4 shows an example using six, non-equally spaced values for I_{SNS} and the corresponding power levels values (first three columns). For each set of three values (I_{SNS} , P_{TX} and P_{RX}), the GUI calculates the original power difference ΔP and the final ΔP after applying of the compensation. It is required to set the Initial FOD parameters which corresponds to these data. This can be done manually using sliders below the table or by "Read from RAM" button which automatically read the actual FOD parameters from RAM.

Figure 3. Initial Measurement data (FOD Tuning – Page 1)


For clarity of operation, it is good practice aligning the final FOD compensation FOD Page 2 with the initial FOD parameters on FOD Page 1. This is done easily by reset push-button on both FOD pages.

Step 3: determining the optimal value for FOD_A, FOD_B and R_{SER}

The third and final step is aimed to finalize the **FOD_A, FOD_B and R_{SER}** tuning parameters. As already mentioned, the final goal is getting a nearly constant over-estimation of the power loss on receiver side and this is achieved by keeping constant the overall P_{TX} - P_{RX} difference over the whole output power range when no foreign object is present (equation 1).

Such an over-estimation (ΔP) is dictated by Qi specifications (actual to Qi 1.2.4 ver) and depends on the output power level. As shown in Table 1, the over-estimation has to be lower than 350 mW for an output power up to 5 W. In this FOD calibration example the over-estimation is set to 200 mW (see related input box "Target ΔP ").

Table 1. Max ΔP tolerance define in Qi spec

Received Power [W]	Max ΔP [mW]
0 .. 5	350
> 5 .. 10	500
> 10 .. 15	750

Once the target over-estimation level is defined, it is a matter of adjusting the gain, the offset and the R_{SER} values through the related sliders in order to match trace which is showing the final compensation result ("After compensation" trace in Figure 5) to the target trace ("Target" trace in figure). A top reference ("Tolerance" trace) provides a maximum level that should not be crossed (Qi specifications), while the RMS error (fitting indicator) should be minimized.

Figure 4. FOD tuning completed (FOD Tuning – Page 2)



The final FOD tuning parameters shall be written into the RAM using a button in GUI. It is also needed to use these values for generation of the final OTP configuration for the final customer application together with other customized application dependent configuration.

Revision history

Table 2. Document revision history

Date	Version	Changes
6-Mar-2020	1	Initial release.

Contents

1	Purpose	2
2	Compensation method.....	3
3	FOD calibration parameters selection: step-by-step procedure	4
	Revision history	7
	Contents	8
	List of tables	9
	List of figures.....	10

List of tables

Table 1.	Max ΔP tolerance define in Qi spec	5
Table 2.	Document revision history	7

List of figures

Figure 1.	Block diagram of the transmitter-to-receiver power transfer	2
Figure 2.	Initial setting for FOD tuning parameters	4
Figure 3.	Initial Measurement data (FOD Tuning – Page 1)	5
Figure 4.	FOD tuning completed (FOD Tuning – Page 2).	6

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