AN00000 NXQ1TXH5 – FOD configuration

The NXQ1TXH5/101 features FOD functionality according to the WPC 1.2 and WPC 1.1 standard. When the NXQ1TXH5/101 IC notices that too much power is lost in the wireless power transfer path (e.g. a metal object like a coin), the NXQ1TXH5/101 enters FOD fault state.

Fig 1. NXQ1TXH5/101 IC

Foreign Object Detection in an NXQ1TXH5/101 application is determined by the setting of 2 parameters: *FOD_E* (the equivalent AC loss resistance) and *FOD_T* (the power loss threshold margin that is considered acceptable).

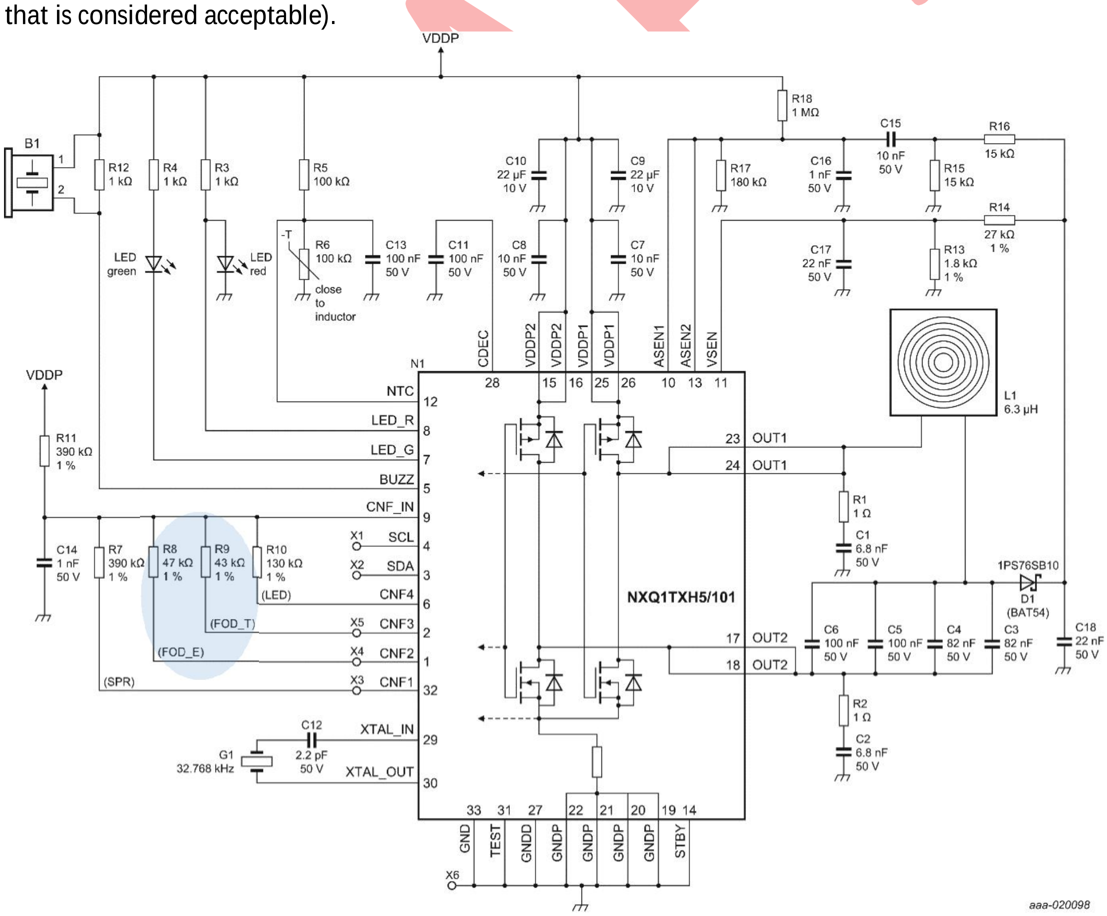

Figure 2 Typical NXQ1TXH5/101 application diagram – FOD_E and FOD_T settings indicated

FOD_E

The value of the FOD_E parameter is selected through the combination of the R8 and R11 resistors.

FOD_E represents the equivalent Ohmic AC resistance (in mΩ) that can be held responsible for the power loss in the NXQ1TXH5/101 wireless power transmitter application. This resistance consists of:

- The on-resistance ($R_{DS(ON)}$) of the power switches and related circuitry inside the NXQ1TXH5/101 IC. The value is around 195 mΩ.
- The AC resistance of the transmitter coil (typically measured at 150 kHz). For a typical coil that is used in the NXQ1TXH5/101 application that resistance is around 65 mΩ. For some commonly used coils a short table is given below.
- The resistance due to the traces and the soldered connections on the PCB. In a typical NXQ1TXH5/101 application is the value is approximately 20 mΩ. This part of the resistance can be held low by using short, wide and thick (i.e. 70µm / 2 Oz) copper traces for all power tracks on the PCB.

For the NXQ1TXH5DB1401 demo board application the total resistance sums-up to (~195 + ~65 + ~20 =) ~280 mΩ (= FOD_E). To set that value using a specific combination of R8 and R11, we must use the following formula:

$$R_8 = \frac{FOD\_E - 135}{1470 - FOD\_E} \cdot R_{11} \qquad (1)$$

By default R11 = 390 kΩ, and usually there no reason to deviate from that value, so substituting 280 for FOD_E and 390 kΩ for R11, results in R8 ≈ 47.5 kΩ (usually rounded to 47 kΩ).

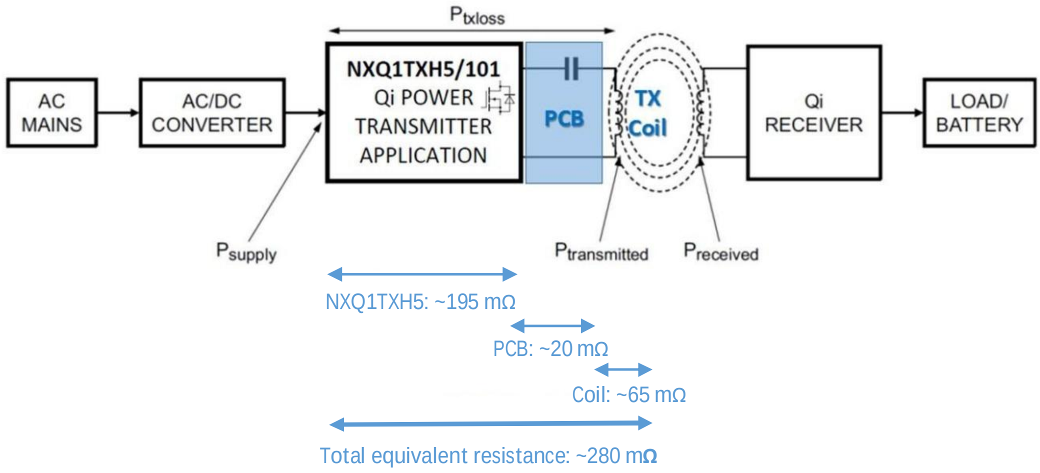

Figure 3 NXQ1TXH5 power transfer chain – FOD_E composition indicated

Manufacturer	Type	# of layers	Inner diameter	Outer diameter	Ferrite	AC R @150 kHz	Typical R8 value
Elec & Eltek	Y31-60055F	2	21 mm	43 mm	50x50mm x 2.6mm	65 mΩ	47 kΩ
Elec & Eltek	Y31-60081F	1	21 mm	44 mm	50x50mm x 0.8mm	64 mΩ	47 kΩ
Elec & Eltek	Y31-60187F	1	20 mm	43 mm	Ø 50mm x 3.8mm	60 mΩ	47 kΩ
Mingstar	31200043	2	20 mm	44 mm	53x53mm x 2.5mm	37 mΩ	39 kΩ
Mingstar	31200057	2	20 mm	44 mm	50x50mm x 1.0mm	38 mΩ	39 kΩ
Sunlord	SWA20N20H18C01B	2	6.3 mm	17.4 mm	20.4x20.4mm x 0.5 mm	135 mΩ	75 kΩ
Sunlord	SWA50N50H30C01B	1	21 mm	44 mm	Ø 50mm x 1.25mm	52 mΩ	43 kΩ
TDK	WT-505090-10K2-A11-G	1	21 mm	43 mm	Ø 50mm x 0.9mm	61 mΩ	47 kΩ
Würth	760308101103	1	17 mm	28 mm	Ø 30mm x 0.8mm	150 mΩ	82 kΩ
Würth	760308101104	2	11 mm	20 mm	Ø 20.5mm x 0.8mm	125 mΩ	68 kΩ
Würth	760308111	2	21 mm	43 mm	54x54mm x 2.5mm	76 mΩ	51 kΩ

Table 1 Typical parameters and R8 recommendations for some commonly used transmission coils

Proportionality factor

With the value of the equivalent Ohmic AC resistance (FOD_E) known to the NXQ1TXH5/101 IC, the power loss in the transmission system (P_{txloss}) can be calculated:

$$P_{txloss} = I^2_{RMS(coil)} \cdot FOD\_E \tag{2}$$

The value of $I_{RMS(coil)}$ is calculated internally but the calculation needs a proportionality factor. That proportionality factor is set externally by means of the voltage divider consisting of resistors R13 and R14. Generally R13 is kept fixed at 1.8 kΩ and R14 is adjusted (when needed). A suitable value for R14 can be obtained from formula 3.

$$R_{14} = \frac{k}{C_{res}} \tag{3}$$

Where

- k = 9.83 (mΩF)
- C_{res} = C3 + C4 + C5 + C6 (F)

Below is a table with typical R14 values (rounded to E24 or E96 range values) that correspond with commonly used resonant capacitor settings.

C_{res} (C3 + C4 + C5 + C6)	R14
328 nF (= 4 × 82 nF)	30 kΩ
346 nF (= 3 × 82 + 100 nF)	28.7 kΩ
364 nF (= 2 × 82 + 2 × 100 nF)	27 kΩ
382 nF (= 82 + 3 × 100 nF)	25.5 kΩ
400 nF (= 2 × 82 + 4 × 100 nF)	24.3 kΩ
420 nF (= 1 × 120 + 3 × 100 nF)	23.2 kΩ

Table 2 Typical R14 values for commonly used C_{res} settings

FOD_T

The value of the FOD_T parameter is selected through the combination of the R9 and R11 resistors.

FOD_T sets the power loss margin (in mW) that will be tolerated by the NXQ1TXH5/101 wireless transmitter application. When the FOD_T value is exceeded during operation, the NXQ1TXH5/101 application enters fault state.

With a high FOD_T value (say 700 mW), an object (typically a metal coin) that is placed in the power transfer path may heat-up excessively, but power transfer to the wireless power receiver is not interrupted.

When a low FOD_T value is selected (say 250 mW), every minimal disruption in the power transfer path (maybe even some friendly metal parts in the wireless power receiver) will cause the wireless power transmitter to halt. This usually makes the placement of wireless power receiver pretty critical. The system is also likely to be very sensitive to the type of wireless power receiver that is used. It must be taken into account that – due to component spread and limited accuracy of both the transmitter and the receiver unit – a spread of at least 150mW must be expected. Therefore the FOD setting needs to be evaluated for a small batch of boards; we advise to measure at least 10 sample boards of a batch.

An intermediate FOD_T value (around 330 mW) is generally recommended.

To set an FOD_T value using a specific combination of R9 and R11, we must use the following formula:

$$R_9 = \frac{FOD\_T}{3330 - FOD\_T} \cdot R_{11} \tag{4}$$

Substituting 330 for $P_{th(FOD)}$ and 390 kΩ for R11, results in R9 ≈ 42.9 kΩ (usually rounded to 43 kΩ).

For passing Qi certification in general selecting a FOD threshold value between 300 and 350 mW will allow the transmitter to meet the Qi specifications. It ensures detecting small metal objects, while still having sufficient margin to avoid false triggers by small metal parts in the phone ("friendly metals").

FOD_T	R9
250 mW	33 kΩ (31.6 kΩ)
350 mW	47 kΩ (45.8 kΩ)
500 mW	68 kΩ (68.9 kΩ)
700 mW	100 kΩ (103.8 kΩ)

Table 3 R9 values for a selection of FOD_T settings