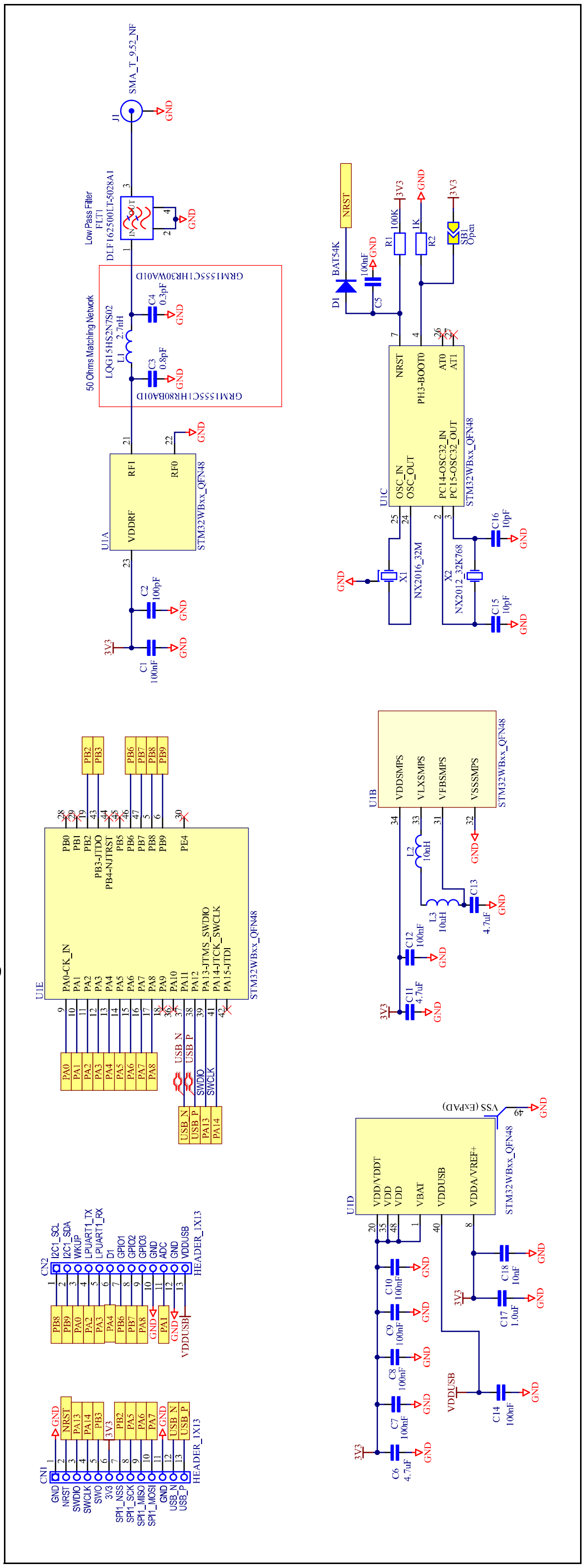
Figure 8. UFQFPN48 reference board



For RF matching, multilayer ceramic capacitors offer linear temperature coefficients, low losses and stable electrical properties over time, voltage, and frequency. SMD (surface mount device) is used with a 0402 package, a good compromise between performance and handling.

For RF decoupling, the capacitance value must be chosen so that the frequency to be decoupled is close to or just above the self-resonant frequency of the capacitor.

For DC-DC converter, as the quality factor of a capacitor is inversely proportional to its ESR, a capacitor with low insertion loss and a good quality factor is recommended. The capacitor requires either an X7R or X5R dielectric.

Table 2. Capacitor temperature ranges

Minimum temperature		Maximum temperature		Variation over the temperature range	
Code	**Temperature**	**Code**	**Temperature**	**Code**	**Variation (%)**
X	-55 °C (-67 °F)	4	+65 °C (+149 °F)	P	±10
		5	+85 °C (+185 °F)	R	±15
Y	-30 °C (-22 °F)	6	+105 °C (+221 °F)	S	±22
		7	+125 °C (+257 °F)	T	+22 / -33
Z	+10 °C (+50 °F)	8	+150 °C (+302 °F)	U	+22 / -56
		9	+200 °C (+392 °F)	V	+22 / -82

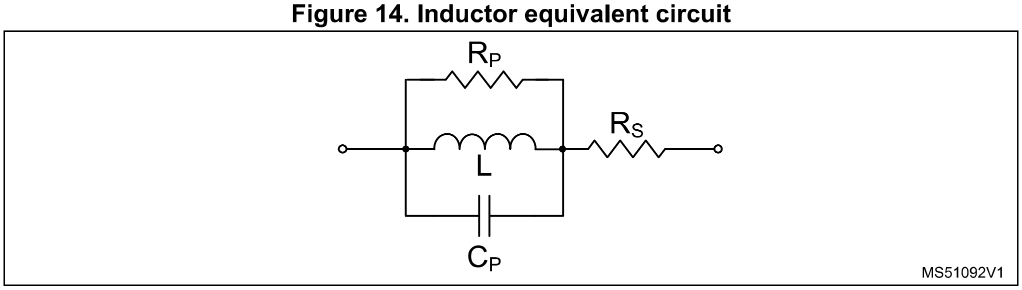
3.2 Inductor

An inductor is a passive electrical component used to store energy in its magnetic field. Inductors differ from each other for construction techniques and used materials.

For RF design, where a high Q (quality factor = Im[Z] / Re[Z]) is required to reduce insertion loss, it is generally recommended to use air core inductors. Those inductors do not use a magnetic core made of ferromagnetic material, but are wound on plastic, ceramic, or other nonmagnetic materials. SMD is also used with a 0402 package.

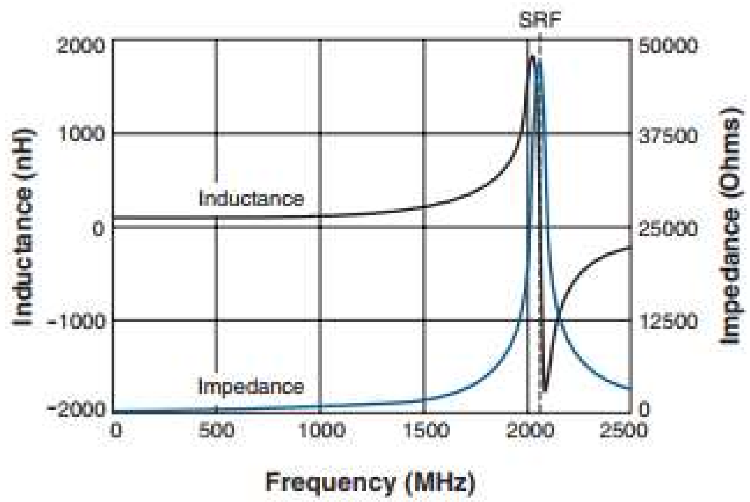
The equivalent circuit of an inductor is shown in *Figure 14*. The resistor R_s represents the losses due to the winding wire and terminations, its value increases with temperature. The resistor R_p represents the magnetic core losses, it varies with frequency, temperature and current. The capacitor C_p is associated with the windings.

Figure 14. Inductor equivalent circuit



As shown in *Figure 15*, at SRF the impedance and inductance are at their maximum. At lower/higher frequencies impedance and inductance increase/decrease with frequency.

Figure 15. Inductor impedance vs. frequency



For RF matching and decoupling, a good compromise between application cost and RF performance is to use an inductor with medium Q.

For DC-DC converter, the nominal value is 10 µH. The inductor value affects the peak-to-peak ripple current, the output voltage ripple and the efficiency. The selected inductor has to be rated for its DC resistance and saturation current.

It is important to use the components shown in the schematics to obtain the best RF performance with the given PCB layout of the reference boards.

3.3 SMPS

Some STM32WB microcontrollers (check the product datasheet available on *www.st.com*) embed an SMPS (switched-mode power supply) that can be used to improve power efficiency when V_{DD} is high enough.

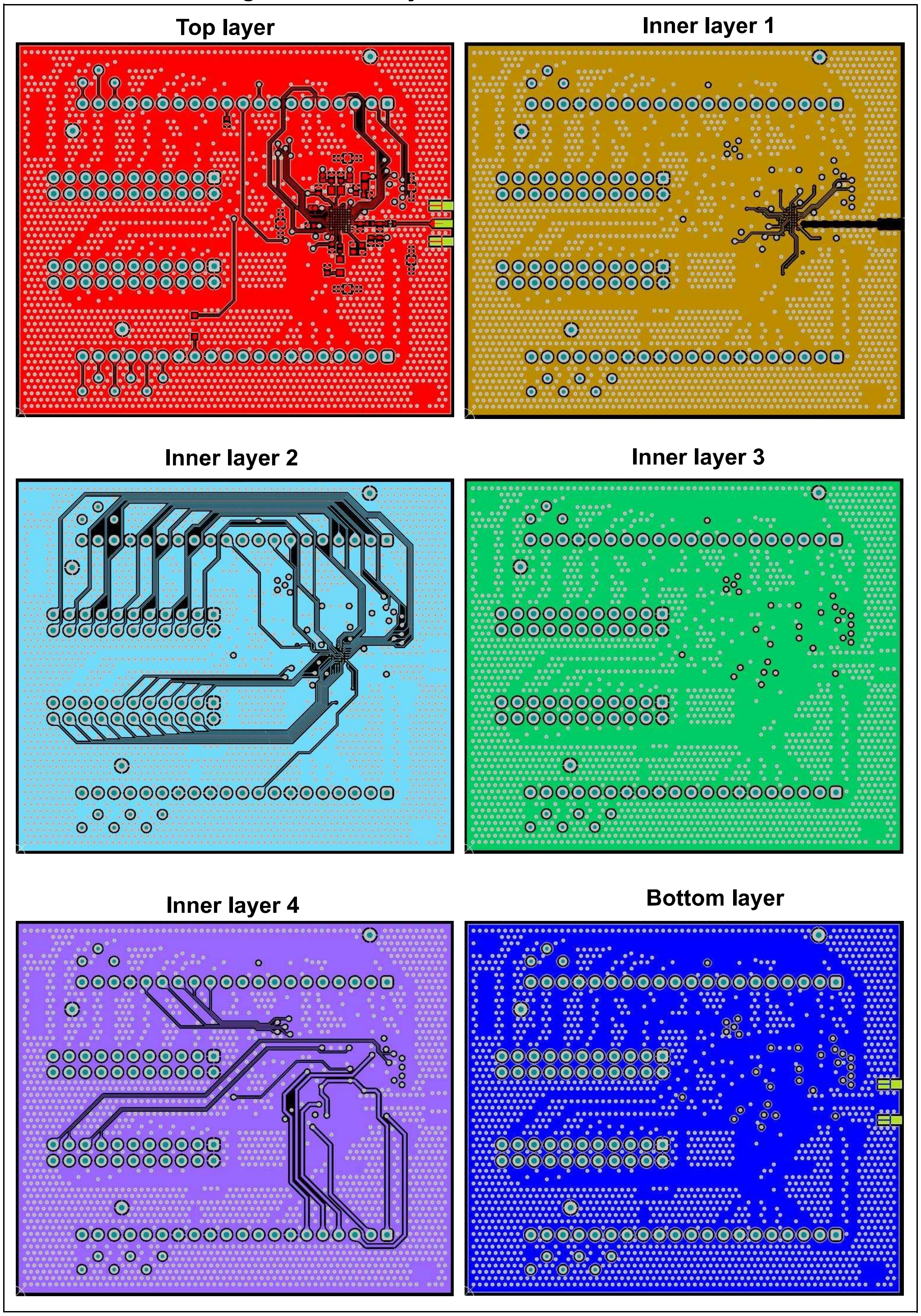
In order not to disturb the RF performances, this SMPS has its switching frequency synchronous with the RF main clock source HSE. The allowed frequencies for the SMPS are 4 or 8 MHz. During RF startup phases from low power modes, the HSI is used, to allow a faster wake-up time compared to waiting from the HSE stabilization before starting the SMPS and the digital logic.

Two specific features have been added to this step down SMPS in association with all the low power modes supported by the STM32WB microcontrollers.

To operate properly the SMPS needs two inductors and two capacitors, whose values depend upon the targeted performance, and upon the PCB area and total height allowed in the mechanical design.

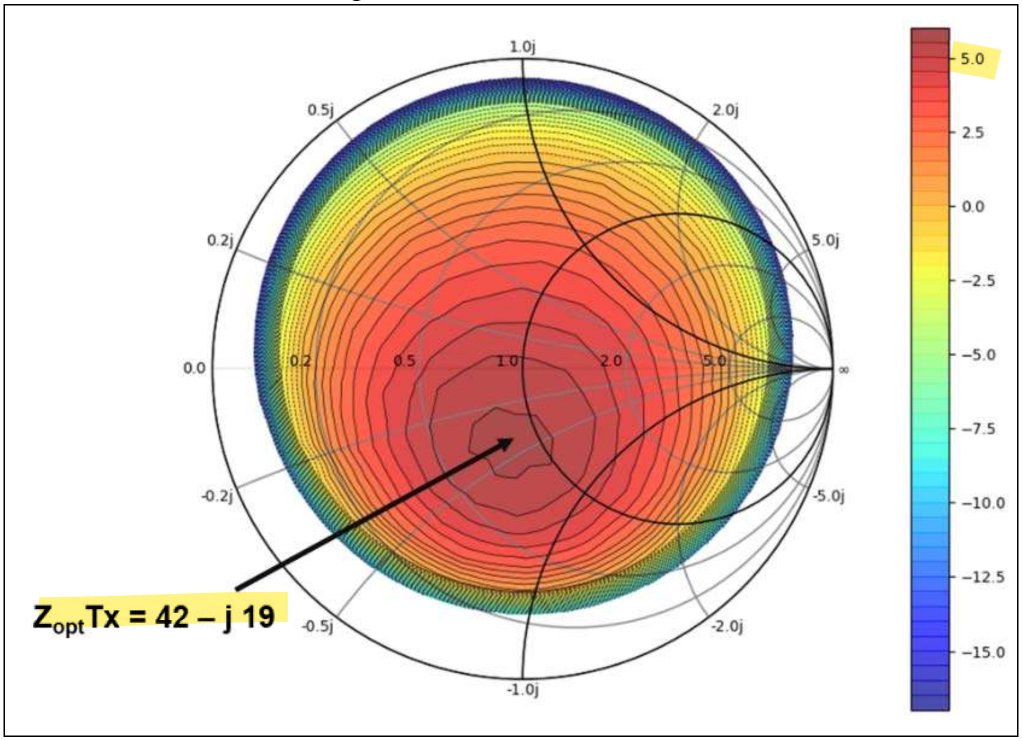
For best power performance, 4 MHz should be selected, leading to a 10 µH inductor associated with a 4.7 µF bulk capacitance. For smaller footprint, and especially to use very

Figure 22. PCB layout for WLCSP100 - Detail



The last step is to analyze the measurement results. The maximum power measured in the Smith chart corresponds to the impedance to present to the RF chip (see *Figure 44*).

Figure 44. Extraction of results



Once the impedance to present to the RF device is known, a simulation tool is needed to determine the value of the components for the corresponding matching network (in this example the ADS simulation tool has been used).

Figure 45. Network simulation