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ARTIC evaluation board

Description and reference design

Table of Contents

Revision history

V	Date	Sections concerned	Info
1v0	2016-09-12	all	first version
1v1	2016-09-27	1, 2.4	Added warning about antenna matching.

References

[1] AnSem NV, "ARTIC User Datasheet 1v0," Leuven, 2016.

[2] AnSem NV, "ARTIC_evaluation_board_software_1v0," Leuven, 2016.

1. Introduction

This document describes the ARTIC evaluation board and its features. The evaluation board is built around the ARTIC ASSP and is created to provide a reference design and to function as a development platform. The board can be connected to a PC or can be used in combination with an external SPI master. The ARTIC evaluation board contains all required components to transmit ARGOS 2/3 messages and to receive ARGOS 3 downlink messages.

The board features a single antenna connection and uses an ARTIC controlled RF switch to alter between transmitting and receiving. The power amplifier can be configured to transmit at 500mW or 1W output power.

Important:

Always connect a matched antenna to the TX/RX connector when transmitting. See the datasheet of the RFPA0133 for more information about the maximum VSWR and current consumption. Failing to meet these specifications can result in permanent damage of the power amplifier.

2. Functional description

The different building blocks of the evaluation board can be seen in Figure 1. Each block is explained into detail. The schematic of the evaluation board is located in section 4.

Multiple jumpers are present to allow an optimal usage of the evaluation board. Using the different jumpers the user can:

- Use a different SPI master
- Record / analyze SPI data
- Use different power supplies
- Measure current consumption
- Change the transmit output power
- Capture INT1 / INT2 signals

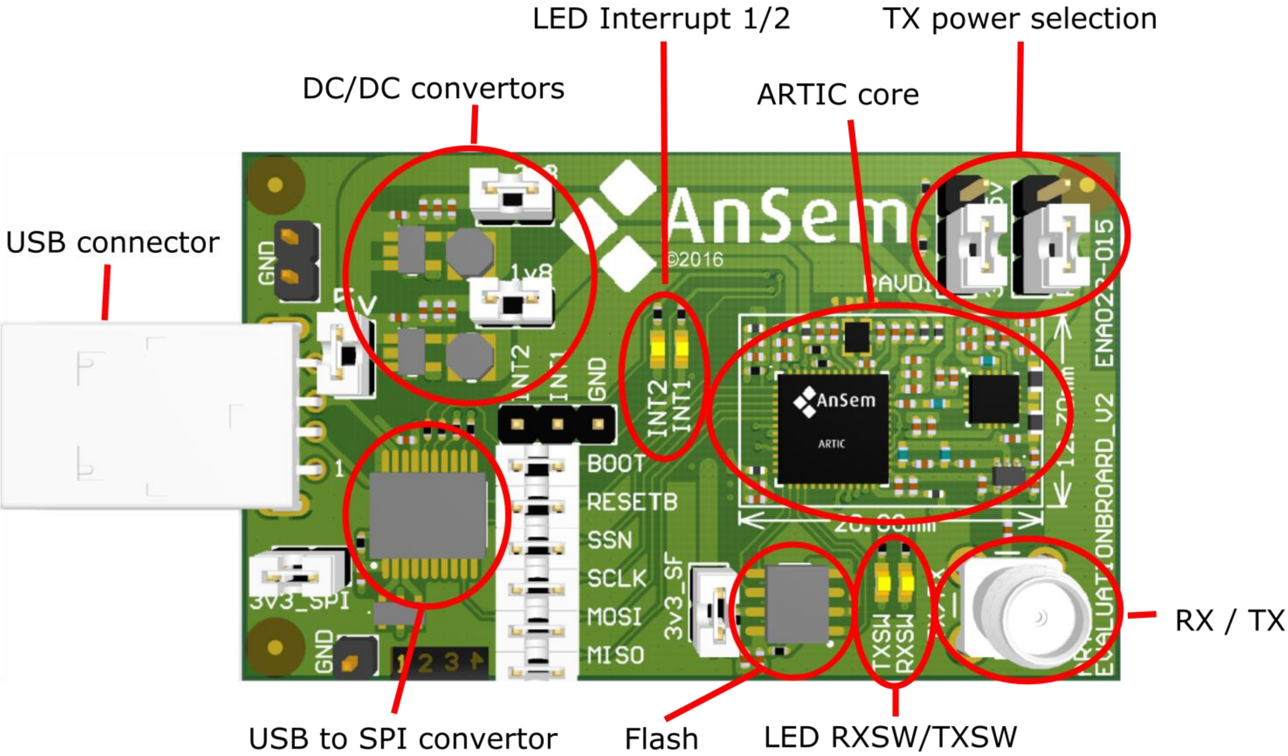


Figure 1 PCB overview

2.1 DC/DC convertors

Two DC/DC convertors are placed on the evaluation board to provide the required 1.8V and 3.3V supply voltages. Both use the 5V USB as input power. The user can use different power supplies by removing the jumpers on the supply lines. The evaluation board is also equipped with a few GND header pins to ease this process.

The user can provide 5V, 3.3V and 1.8V supply signals by removing the corresponding jumpers. The red squares in Figure 2 indicate the position where the user supply signals should be connected. The blue squares indicate GND connections. By placing a current meter over the jumpers the current consumption can be measured.

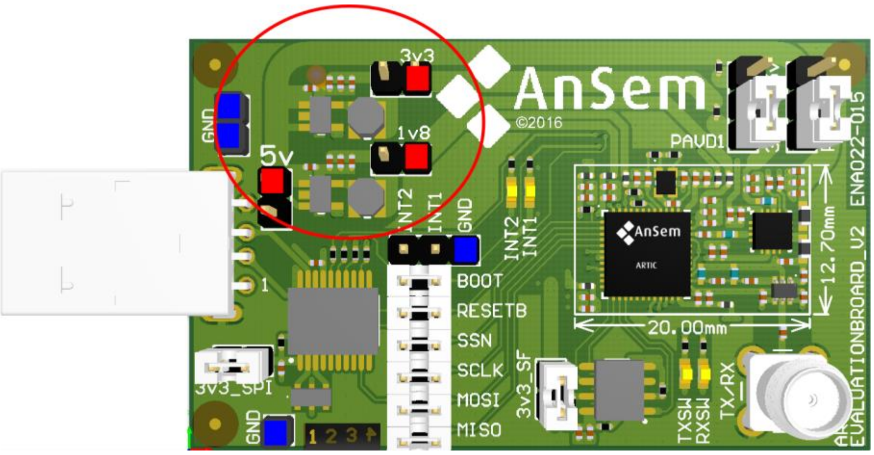


Figure 2 Custom power supply connections

2.2 USB to SPI convertor

The evaluation board is equipped with an MCP2210 USB to SPI convertor which is connected to the ARTIC. This convertor also controls the BOOT and RESETB signals and can monitor the INT1, INT2, RXSW and TXSW signals. When connected to a PC, the USB to SPI convertor is registered as a standard human interface device (HID). No special software is required.

2.3 User SPI

The user can connect SPI signals on the marked pins in Figure 3. The corresponding jumpers need to be removed.

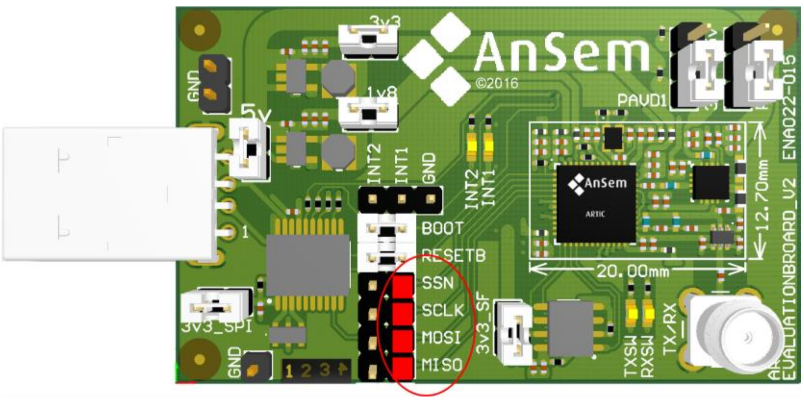
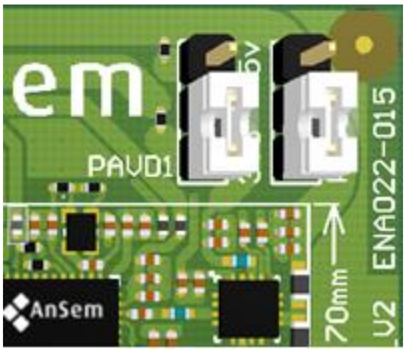


Figure 3 User SPI connections

2.4 Transmission output power selection

The PCB includes the RFPA0133 power amplifier to boost the 0dBm ARTIC transmission output [TXOUT]. The output of the power amplifier can be selected to be ~500mW or ~1W using 2 jumpers.

~500mW jumper configuration [default]



~1W jumper configuration

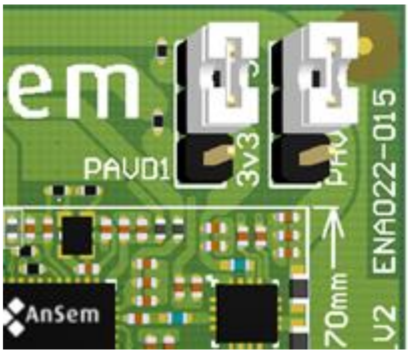


FIGURE 4 TX OUTPUT POWER CONFIGURATIONS

Important:

Always connect a matched antenna to the TX/RX connector when transmitting. See the datasheet of the RFPA0133 for more information about the maximum VSWR and current consumption. Failing to meet these specifications can result in permanent damage of the power amplifier.

2.5 ARTIC essential

The essential ARTIC components use only a very small region of 12.70mm x 20.0 mm. This region contains all required components to perform ARGOS transmissions and ARGOS 3 reception. Outside this region the DC/DC power supplies and other interfacing components are placed. This essential region contains:

- ARTIC chip
- TCXO
- Receiver filter
- Power amplifier
- RF switch
- Decoupling capacitors

2.6 Boot / reset

The ARTIC boot and reset pin are controlled by the USB 2 SPI convertor. By removing 2 jumpers the user can connect their own signals. See Figure 5

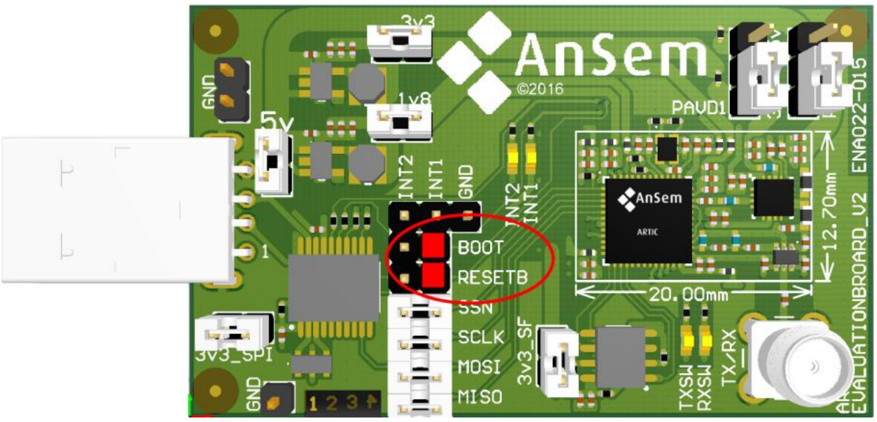


Figure 5 User boot/reset connections

2.7 Interrupt signals

The user can capture the INT1 and INT2 signals using the indicated header pins in Figure 6

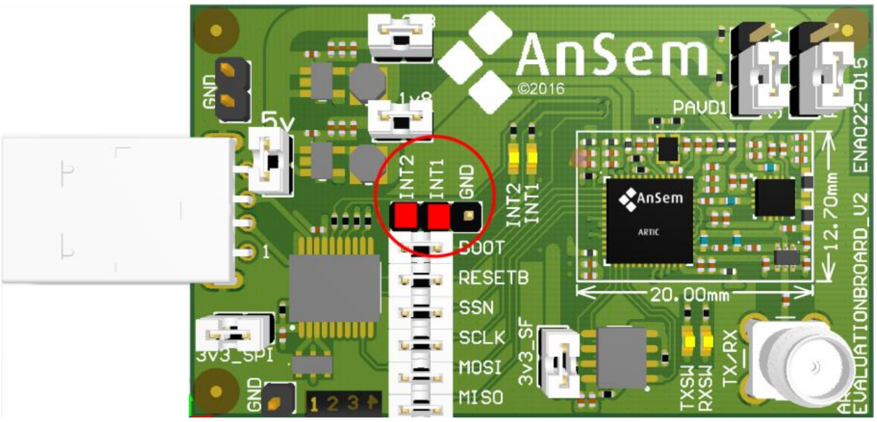


Figure 6 interrupt connection pins

3. Reference design

The essential core circuit within the ARTIC evaluation board can be replicated and used as reference for other designs. The design of the core is critical to meeting the performance of the ARTIC device so it is vital that this circuit is laid out as per this reference. To aid understanding important areas of the PCB layout are explained in detail.

3.1 PCB buildup

The reference design uses a 4 layer PCB. The top layer is used for all components. Layer 2 and 3 are GND planes and the bottom layer is used for additional routing. The middle layers create a very low impedance GND plane to avoid any ground issues.

3.2 PCB layout

The ARTIC requires 2 supply voltages being 3.3V and 1.8V. The 3.3V is used for all IO pins/signals and the power amplifier. The 1.8V is used for all internal ARTIC blocks. The ARTIC core area of the PCB has multiple connections to the different power supplies. The importance of each supply line is explained alongside worse case current consumption estimations.

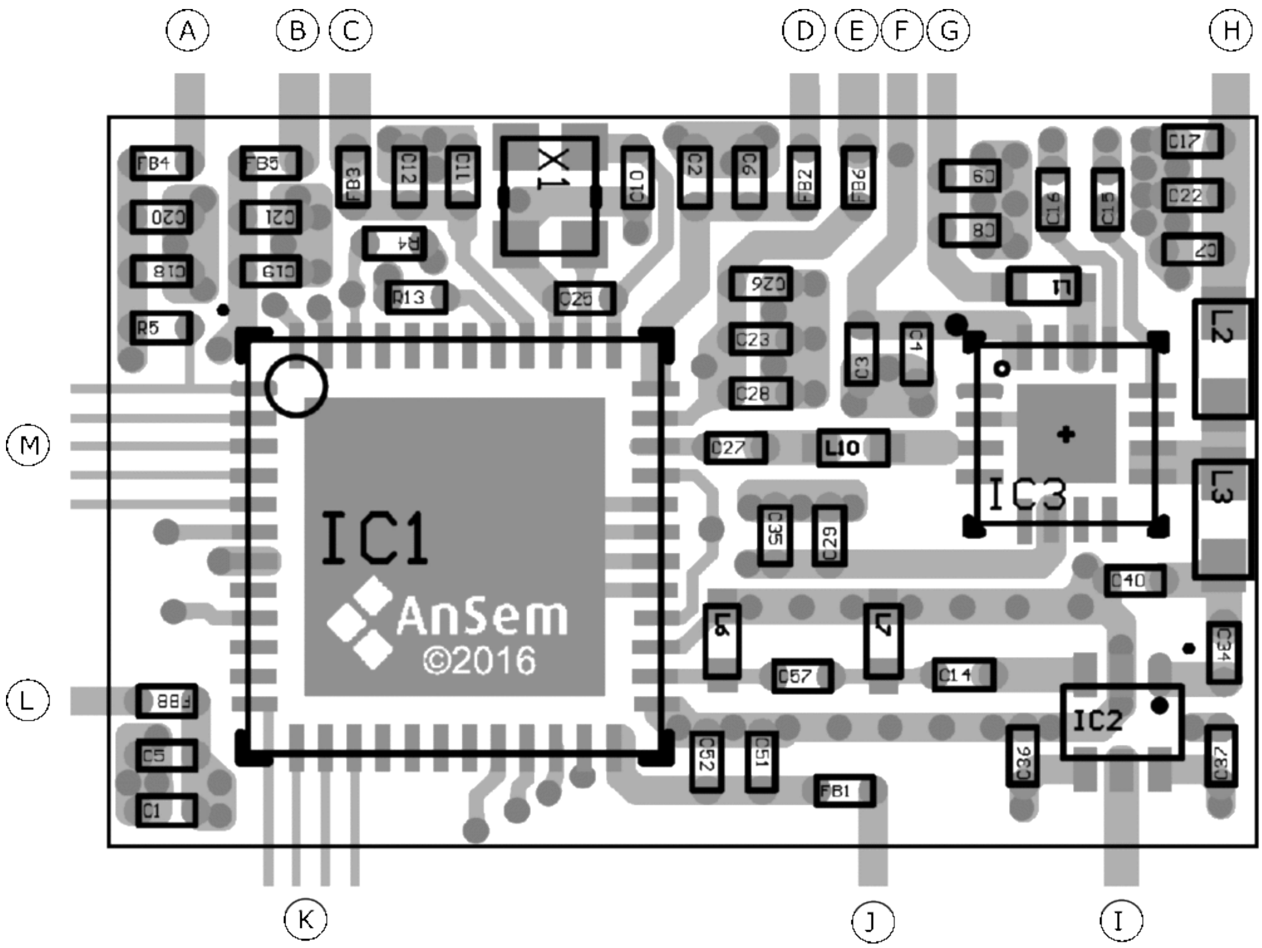


Figure 7 ARTIC essential connections

TABLE 1 ARTIC ESSENTIAL CONNECTIONS

Identifier	Supply voltage [V]	Max current [mA]	Description
A	3.3	5	ARTIC Power supply
B	1.8	10	ARTIC Power supply
C	1.8	10	ARTIC Power supply
D	3.3	2	ARTIC Power supply
E	1.8	20	ARTIC Power supply
F	3.3/5	230 [Typ.]	Bias power amplifier
G	3.3/5		EXTPAVD1
H	3.3/5		EXTPAVD2
I	-	-	TX / RX
J	1.8	10	ARTIC Power supply
K	-	-	Flash interface signals
L	3.3	1	ARTIC Power supply
M	-	-	SPI interface signals

3.3 MCU interface

The following pins make up the interface to the MCU:

3.3.1 SPI

The ARTIC uses a standard SPI interface containing the following signals: SSN, SCLK, MISO and MOSI and are 3.3V tolerant. See the Artic user datasheet [1] for more information about SPI functionality and SPI specifications.

3.3.2 Reset

The reset is active low. Use a 100kΩ pullup resistor to activate the ARTIC at power-up.

3.3.3 Interrupt lines

Two interrupt signals are used by the ARTIC to signal different events: INT1 and INT2. Both output signals are active high.

3.4 Boot

The ARTIC will boot from the [onboard] external flash memory (see 3.11) when the boot pin is high and reset is released. If the boot pin is held low at reset the ARTIC will wait for the MCU to upload the Firmware. The boot pin must be connected either through GND or VCC using a pulldown or pullup resistor.

3.5 BIAS

Use a 33kΩ 1% tolerance resistor as bias reference for the ARTIC.

3.6 TCXO

The ARTIC needs a 26MHz clipped sine TCXO for the onboard synthesizer. This TCXO is powered by the FREFVD and FREFVS signals. A 1µF decoupling capacitor must be placed as close possible to the ARTIC for decoupling, see C25 in Figure 8. On the evaluation board the KT1612ACW26000TAN TCXO from Kyosera is placed. The PCB layout however also allows the usage of the KT2016ACW26000Txx which is slightly larger. A 47nF decoupling capacitor is placed close to the TCXO as required by Kyosera.

The FREFVS signal must be connected to GND as close possible to the GND connection of the TCXO.

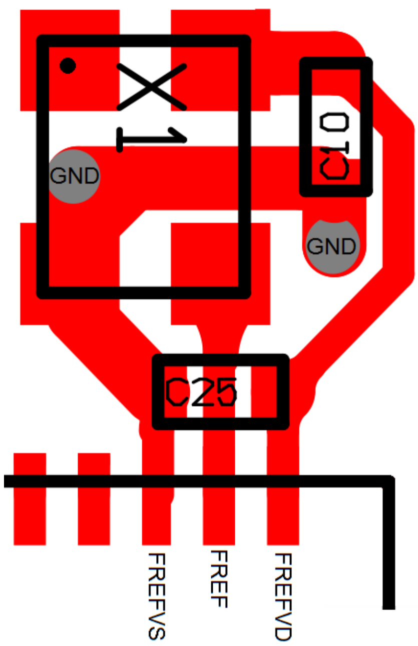


Figure 8 - TCXO PCB layout

3.7 Transmitter

At the TXOUT of the ARTIC a 100pF DC cut capacitor must be placed close to the pin.

3.8 Power amplifier

The power amplifier is an RFPA0133 from RFMD. The schematic and components are explained in detail in the datasheet of the RFPA0133.

3.9 Receiver

The RX filter circuit is the most sensitive part of the ARTIC as it must cope with input signals of -130dBm. Therefore all switching signals [DC/DC convertors, oscillators,…] must be placed far away.

The filter circuit components must be placed as close possible to the ARTIC. The PCB layout of the RX signal should be completely routed in the top layer [No via's]. The 2 RXVS pins surrounding the RXIN pin should be used to form a guard ring around the matching circuit and should be connected to ground. The GND layer under the RX components must be cut away to minimalize coupling effects. See Table 2 for the recommended components.

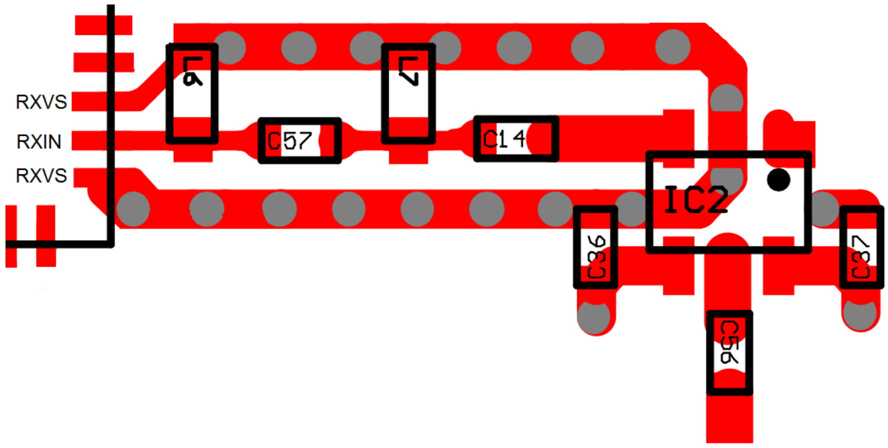


Figure 9 - Top PCB layer with RX path, guard ring and RF switch

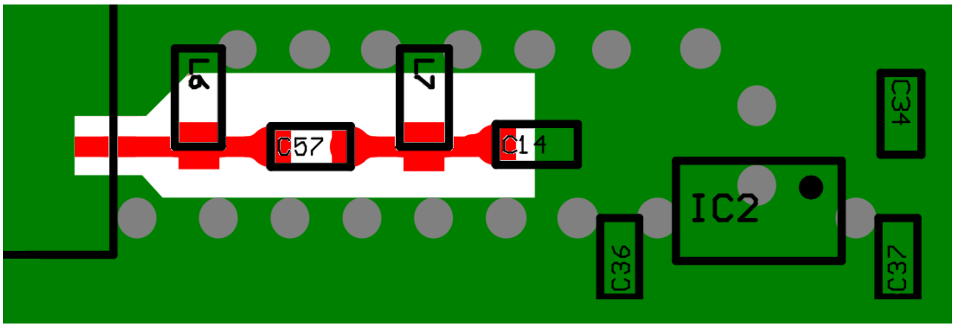


Figure 10 - PCB layer 2 with cut-out underneath RX path

TABLE 2 - RX COMPONENTS

Designator	Value	Package	Manufactory	Manufactory Number
C57	2.2pF	0402	MULTICOMP	MC000282
C14	47pF	0402	KEMET	CBR04C470F3GAC
L6	30nH	0402	COILCRAFT	0402HP-30NXGLU
L7	51nH	0402	COILCRAFT	0402HP-51NXGLU

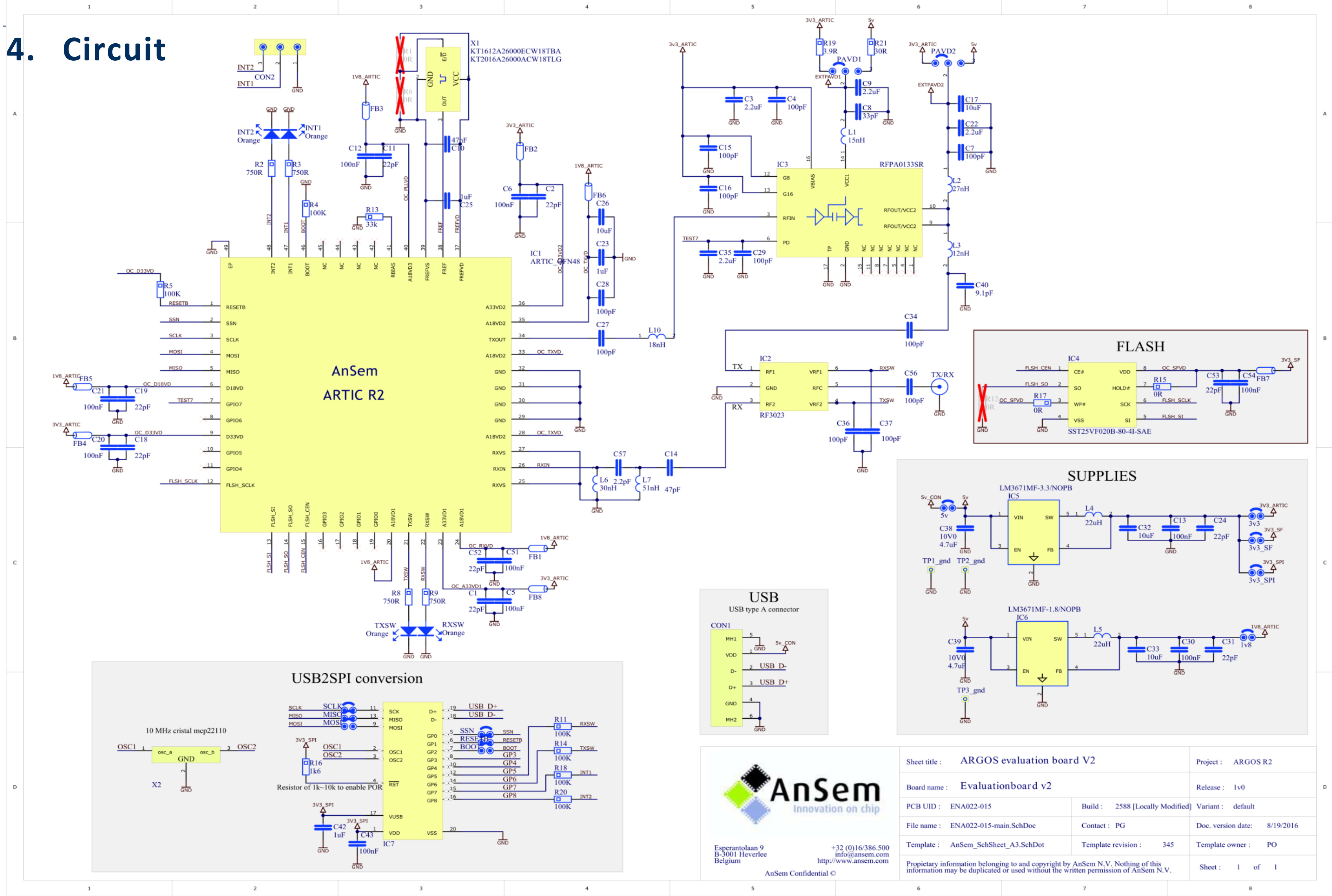
3.10 RF switch

The RF3023 is used to switch between TX and RX for usage with a dual band antenna. The switch can be removed if separate antennas for TX and RX are used. The switch is controlled by the RXSW and TXSW signals from the ARTIC. The ARTIC will raise the corresponding signals to 3.3V during TX or RX. In IDLE state both signals are low. See the datasheet of the RF3023 for more information.

3.11 Flash interface

The ARTIC is able to boot from a flash memory chip. This chip must have the same register interface as the SST25VF020B from MICROCHIP. The flash memory is connected to the ARTIC through a dedicated SPI interface. By default the flash is pre-programmed with the ARTIC firmware.

4. Circuit


AnSem
ARTIC R2
USB2SPI conversion
USB
USB type A connector
FLASH
SUPPLIES
10 MHz cristal mcp22110
Resistor of 1k~10k to enable POR
Sheet title : ARGOS evaluation board V2
Board name : Evaluationboard v2
Project : ARGOS R2
Release : 1v0
PCB UID : ENA022-015
File name : ENA022-015-main.SchDoc
Template : AnSem_SchSheet_A3.SchDot
Esperantolaan 9
B-3001 Heverlee
Belgium
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Build of material:

Designator	Qty.	Manufacturer	Manufacturer Number
FB1, FB2, FB3, FB4, FB5, FB7, FB8	7	MURATA	BLM15AG221SN1D
FB6	1	MURATA	BLM15EG221SN1D
IC2	1	RFMD	RF3023
IC3	1	RFMD	RFPA0133SR
IC4	1	MICROCHIP	SST25VF020B-80-4I-SAE
IC5	1	Texas Instruments	LM3671MF-3.3/NOPB
IC6	1	Texas Instruments	LM3671MF-1.8/NOPB
IC7	1	MICROCHIP	MCCP2210
X1	1	KYOCERA	KT1612A26000ACW18TBA
C5, C6, C12, C13, C20, C21, C30, C43, C51, C54	10	MULTICOMP	MC0402B104K160CT
C4, C7, C15, C16, C27, C28, C29, C34, C36, C37, C56	11	MULTICOMP	MC000274
C17, C26, C32, C33	4	AVX	C1005X5R0J106M050BC
C23, C25	2	'MURATA	GRM155R60J105KE19D
C42	1	AVX	04026D105KAT2A
C57	1	MULTICOMP	MC000282
C3, C9, C22, C35	4	MURATA	GRM155R60J225ME15D
C1, C2, C11, C18, C19, C24, C31, C52, C53	9	MULTICOMP	CBR04C220J5GAC
C8	1	JOHANSON TECHNOLOGY	500R07S330JV4T
C38, C39	2	TDK	C1005X5R1A475K050BC
C10	1	MURATA	GRM155R71C473KA01D
C14	1	MULTICOMP	CBR04C470F3GAC
C40	1	JOHANSON TECHNOLOGY	500R07S9R1CV4T
L1	1	COILCRAFT	0402HP-15NXGLU
L2	1	COILCRAFT	0603HP-27NXGLU
L3	1	COILCRAFT	0603HC-12NXGLU
L4, L5	2	WURTH ELEKTRONIK	744025002
L6	1	COILCRAFT	0402HP-30NXGLU
L7	1	COILCRAFT	0402HP-51NXGLU
L10	1	MURATA	LQG15HN18NJ02D
R13	1	YAGEO	RC0402FR-0733KL