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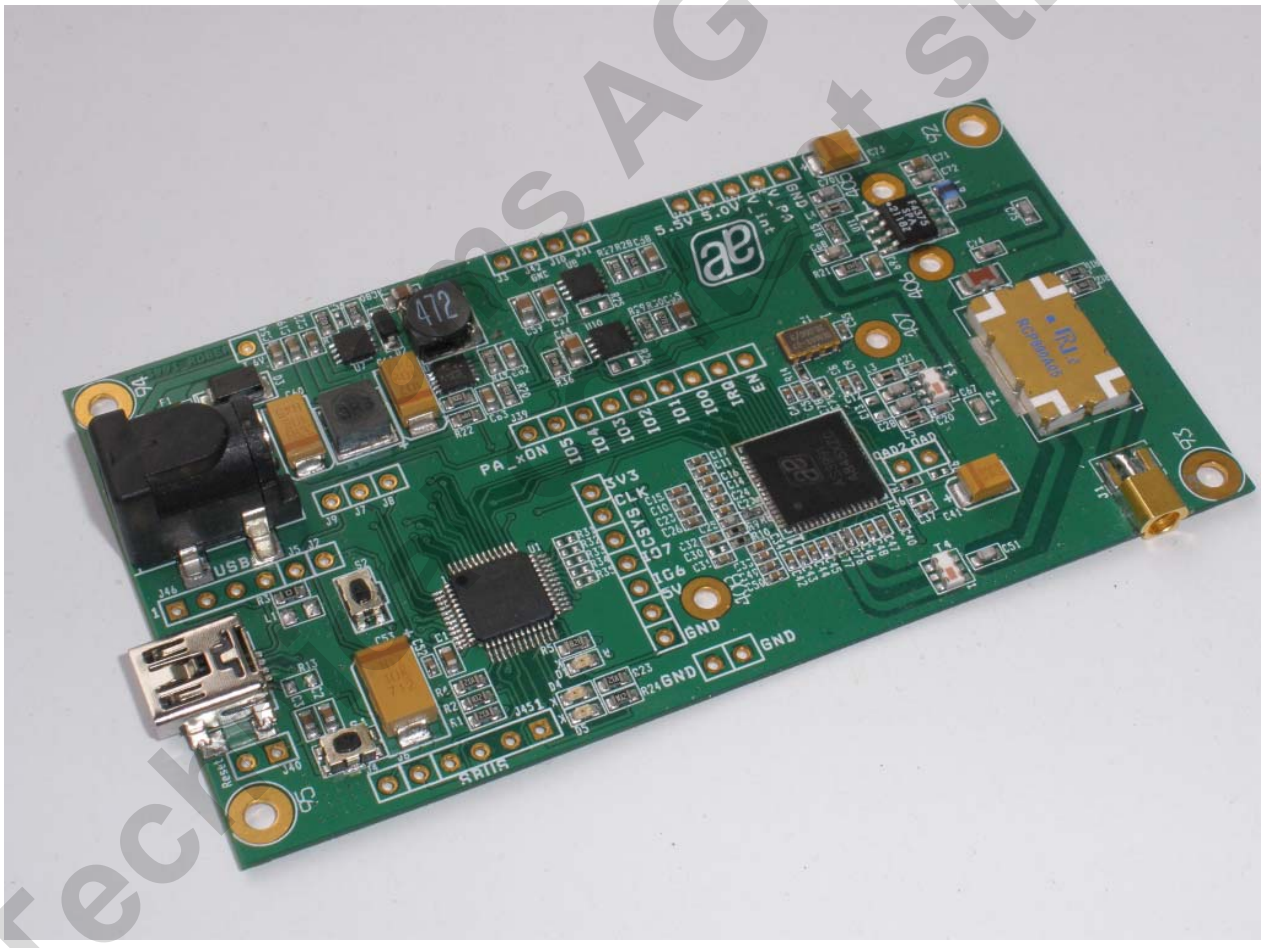
Hardware Description of AS399x "ROGER" - UHF RFID Reader System



Demo Kit Reference
Rev 1.5 March 2010

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1 Introduction

The AS399x UHF RFID Reader System Demo Kit supports the **ISO 18000-6b** and **EPC Generation 2** standards. The aim of the development kit is to demonstrate the performance and the features of the AS399x UHF RFID reader chip and to enable customers to develop their own application fast.

The AS399x UHF RFID Reader System is a single PCB solution offering two configurations:

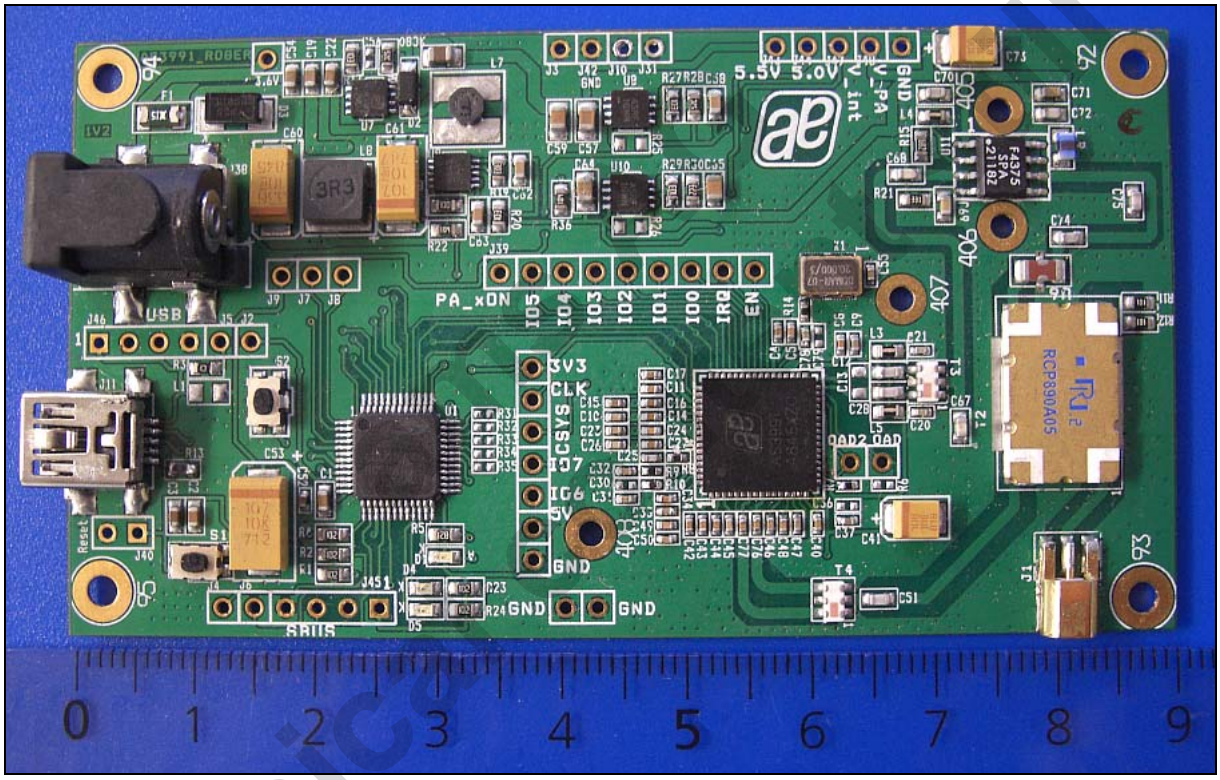
- A UHF RFID reader stand alone operation aided by the on board microcontroller
- A direct access operation for development purposes with disabled MCU where the host system directly controls the AS399x using a pin header interface. The operational RF part can be used to develop customized software for controlling the AS399x. An access to the IO pins for an external microcontroller is provided to speed up the design phase of an UHF RFID reader application.

1.1 Key Features

- Reading and writing UHF RFID tags
- Communication with host computer using the USB-HID or UART interface
- USB HID device (automatically installed on host side)
- Low cost 8- bit micro controller is used
- Controller software written in C which can easily ported to a different controller type.
- Host software (AS399x Reader Suite) written in C++ and MFC

2 Short Description

The “ROGER” UHF RFID Reader System is designed for medium range tag detection and is optimized regarding PCB area and power consumption. To minimize costs no special RF connectors are required. The connection to the antenna is established by a MMCX connector.
For powering up the UHF RFID Reader System an auxiliary power supply is used. For the communication with the host system the USB interface is used. After power up the internal registers of the reader chip are configured with default values which enables the reader system to be functional right from the beginning.



Picture 1: ROGER – PCB

2.1 Port Definitions

2.1.1 Detailed Description

Pin	Signal	Description
P0.0	-	Not used
P0.1	-	Not used
P0.2	-	Not used
P0.3	IRQ	External Interrupt Input
P0.4	TX	UART Transmit Pin
P0.5	RX	UART Receive Pin
P0.6	-	Not used
P0.7	SCLK	System Clock Input

Table 1: Port 0

Pin	Signal	Description
P1.0	IO0	IO Data, Address and Ctrl Bit
P1.1	IO1	IO Data, Address and Ctrl Bit
P1.2	IO2	IO Data, Address and Ctrl Bit
P1.3	IO3	IO Data, Address and Ctrl Bit
P1.4	IO4	IO Data, Address and Ctrl Bit
P1.5	IO5	IO Data, Address and Ctrl Bit
P1.6	IO6	IO Data, Address and Ctrl Bit
P1.7	IO7	IO Data, Address and Ctrl Bit

Table 2: Port 1

Pin	Signal	Description
P2.0	CLK	Interface CLK Output
P2.1	EN	Device Enable Output
P2.2	LED	LED Output
P2.3	-	Not used
P2.4	-	Not used
P2.5	-	Not used
P2.6	-	Not used
P2.7	-	Not used

Table 3: Port 2

Note: Port 3 is not used.

Pin	Signal	Description
P4.0	-	Not used
P4.1	-	Not used
P4.2	-	Not used
P4.3	-	Not used
P4.4	-	Not used
P4.5	-	Not used
P4.6	-	Not used
P4.7	RESET	Output for resetting the MCU

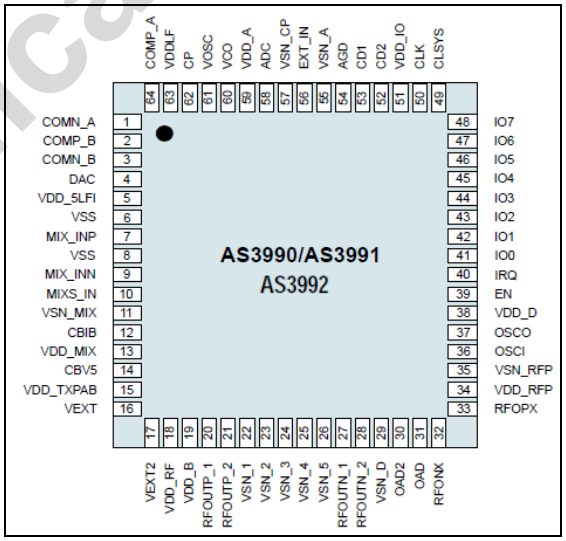
Table 4: Port 4

Pin	Signal	Description
7	GND	GND Pin
8	D+	USB Data + Signal
9	D-	USB Data - Signal
10	VDD	VDD Pin
11	REGIN	Not used
12	VBUS	USB Power In
13	RST	Reset Pin
14	C2D	Debugging Interface

Table 5: Other uC Pins

2.2 *AS399X Pinout:*

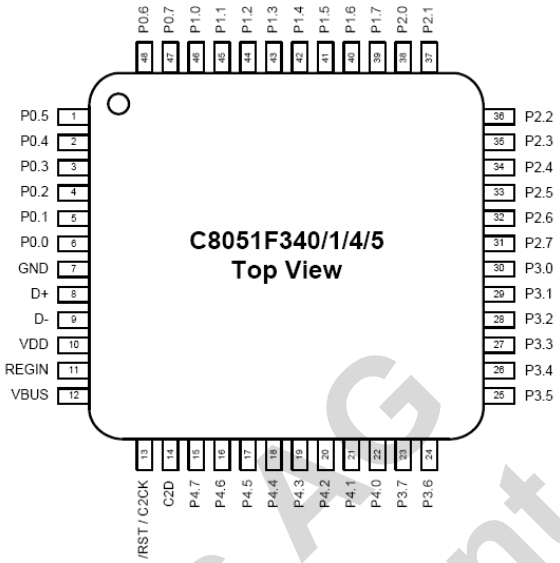
Pinout of AS399x



Picture 2: AS399x Pinout

2.3 C8051F340 Pin out

The pinout from Silabs microcontroller C8051F340 is shown below.



Picture 3: C8051F340 Pin out [Silabs 2006]

2.4 Power Supply

3.6 V power jack (2.1X5.5MM). The supply is guarded by a polyswitch (1.5A).

2.5 USB Connector

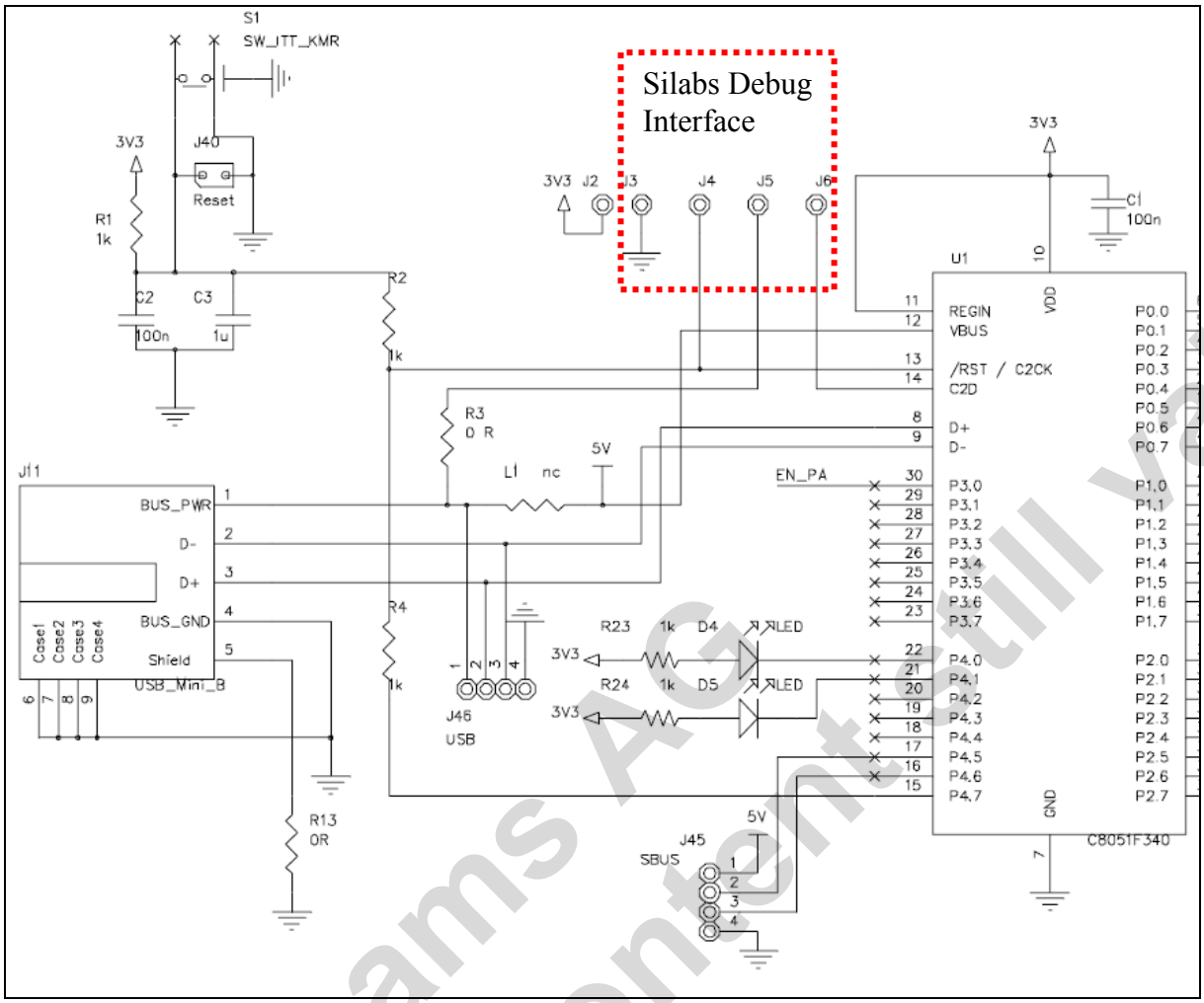
USB is used for communication with the host. No external matching and pull down resistors are needed, since all parts are integrated in the microcontroller.

2.6 RS232 Connector

For debugging, the controller board has solder pads to connect an external RS232 circuit. Power for the external circuit is delivered through the connector.

2.7 Debugging Connector

In the following picture a special interface is highlighted which is used to directly connect the Silabs USB Debug Adapter. The circuit is taken from the Silabs Development Kit data sheet [SilabsDK 2006].
The resistor R3 can be used to supply the board via the debugging connector.



Picture 4: Schematic - Debug Interface

2.8 Supply Concept

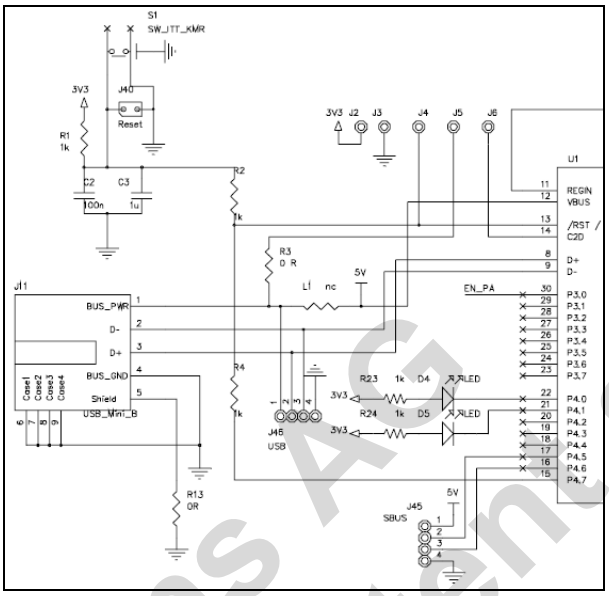
To filter out noise on the USB supply voltage a ferrite (*L1*) and two capacitors (*C52*, *C53*) are used. Additionally, each AS399X V_{DD} pin is featured with two capacitors (10 nF & 2.2 µF). The microcontroller supply *VDD* (pin 10) only needs one 100nF capacitor (*C1*).
During power down mode the majority of the AS399x reader chip is switched off but still generates a 3.3V supply voltage (*VDD_D* = pin 38) which supplies the microcontroller unit (MCU). This mode is configured by the resistor *R7* (10kΩ) at *OAD2* (pin 30) to GND. After start up the microcontroller has to pull the AS399X enable pin (*EN* = pin 39) to high in order to start the operation of the AS399X finalizing the power up sequence.

4 different voltages are generated on the ROGER Demo Kit:

1. 3.3 V (generated by Silabs MCU)
2. 4.5 V (generated by AMS AS1364 LDO)
3. 5.0 V (generated by AMS AS1326A DCDC Step Up Converter)
4. 5.5 V (generated by AMS AS1340 Boost Converter)

2.9 Microcontroller Reset Circuit

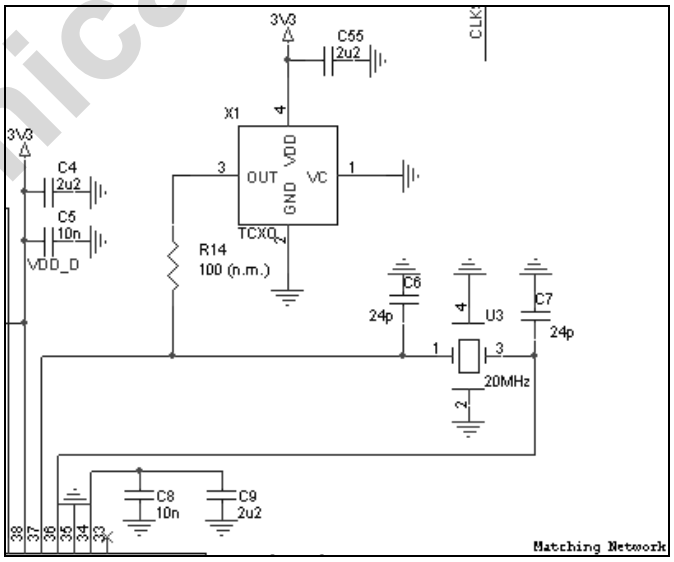
The reset circuit needs only two capacitors (*C2, C3*) for power on reset. A pull- up resistor (*R1*), a series resistor (*R2*) and a push button (*S1*) for resetting during normal operation is used (see Picture 5). To enable a reset trough the software, resistor *R4* is connected between port pin *P4.7* and the reset pin (*/RST* = pin 13). If the microcontroller needs to be reset, the software has to write a logic zero to *P4.7*.



Picture 5: Reset Circuit

2.10 Oscillator Circuit

The AS399X can be used with a conventional quartz crystal or a TCXO. The crystal should have an accuracy of 10ppm. Most crystals do not provide this high accuracy for this reason a TCXO is recommended. Besides good frequency stability a TCXO inherently provides better temperature stability.



Picture 6: Schematic - Oscillator Circuit

2.11 VCO Concept.

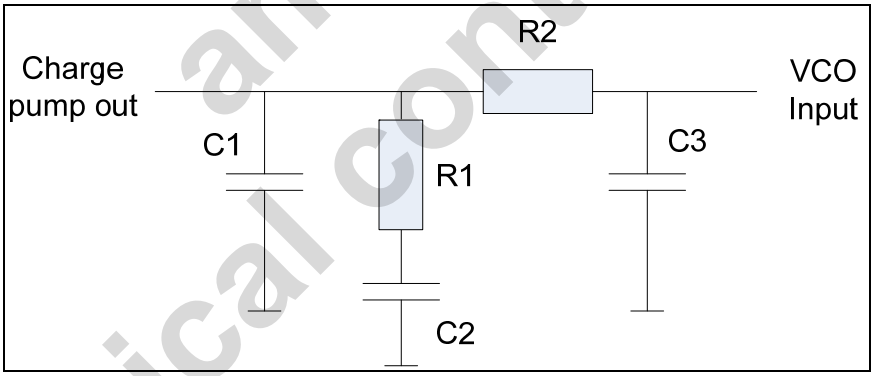
To generate the high frequency carrier signal for the communication with the tag (840 MHz – 960 MHz) the internal VCO is used and thus only a few passive components are needed. The external loop filter components need to be calculated for each parameter set of loop filter current, reference frequency and charge pump current. For this particular reference design following settings was used:

- 915 MHz
- 1.2 mA charge pump current
- 50 kHz reference frequency
- Internal VCO

In following table, one can also find other settings for reference:

VCO	Reference Frequency [kHz]	Charge Pump Current [mA]	C1 [pF]	R1 [kΩ]	C2 [nF]	R2 [kΩ]	C3 [pF]
20 MHz / V	50	1.2	220	27	3.3	56	110
20 MHz / V	50	0.6	120	56	1.5	110	56
20 MHz / V	100	1.2	150	27	1.8	47	68

Table 6: Loop Filter Reference Settings



Picture 7: Loop Filter Circuit

2.12 LED

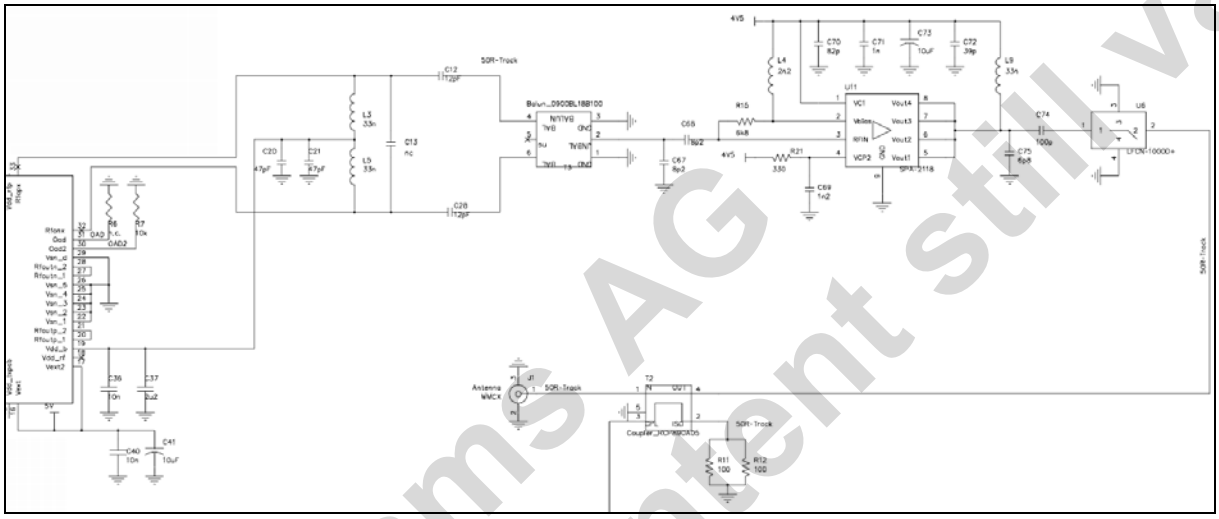
For an easy and fast functional check, an external LED with a current limitation resistor is included. During normal operation, the LED is continuously flashing.

2.13 Serial RS232 Interface

For debugging an external RS232 interface may be used.

2.14 High Frequency RFID Output

The 0 dBm differential outputs (Rfopx, Rfonx) are used. The differential outputs need to be converted to single- ended outputs. This is done by a Balun (Balanced/ Unbalanced). The output signal is then routed to the external GaAs power amplifier (U11) SPA-2118. In order to attenuate high order intermods a ceramic low pass filter (U6) is placed in the Tx path.



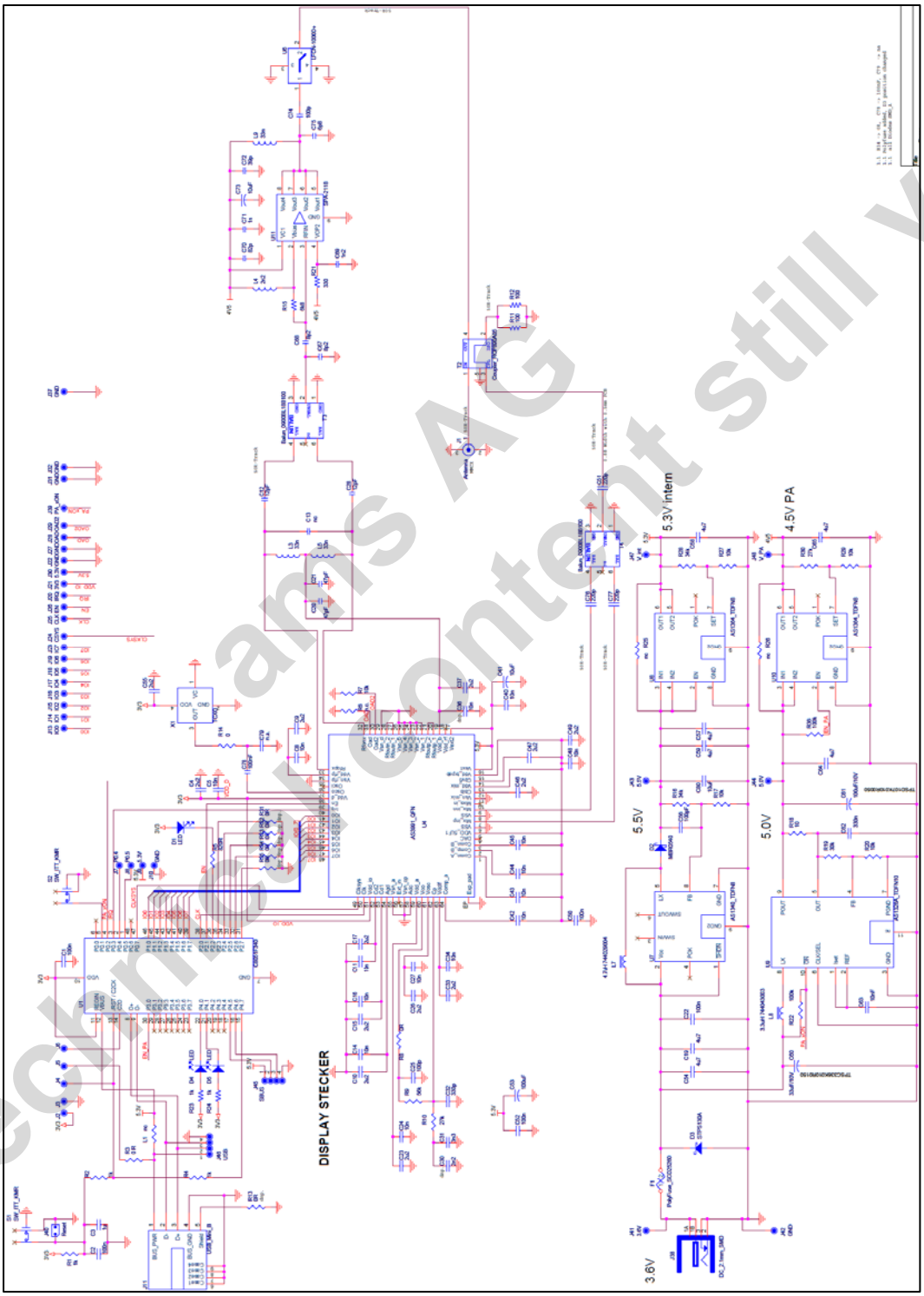
Picture 8: Schematic - UHF RFID Output Path

2.15 Decoupling Tx/Rx

To separate transmit and receive path a directional coupler (RCP890A05) is used.

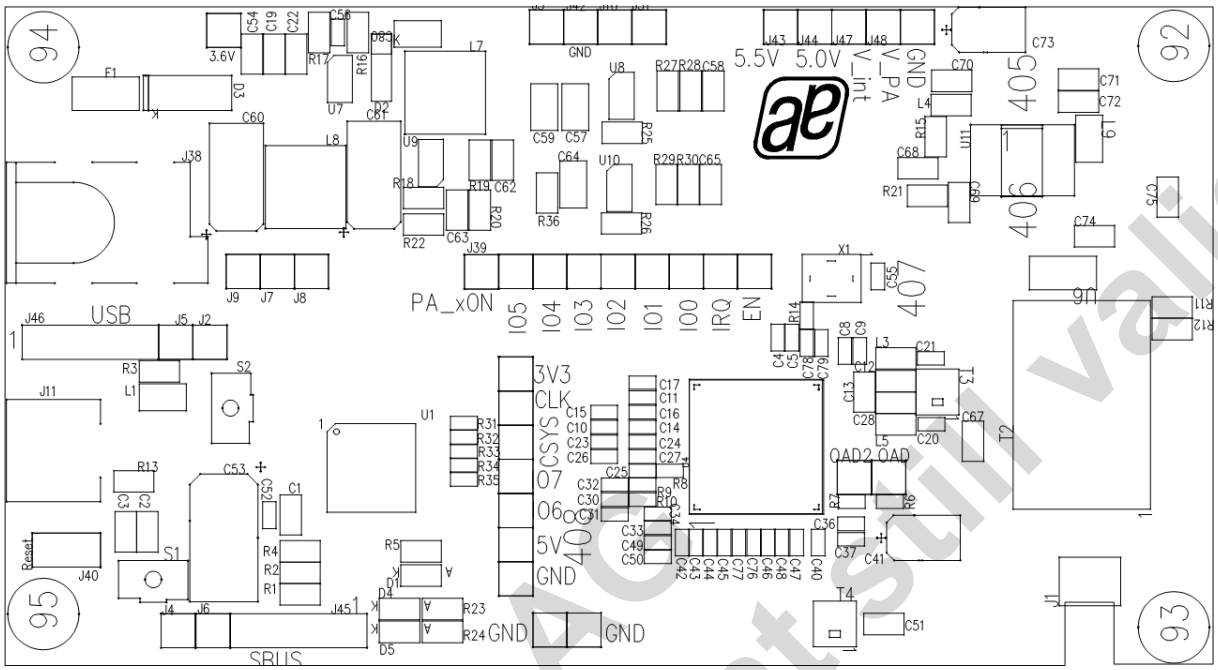
3 Hardware Description UHF board

3.1 Schematic



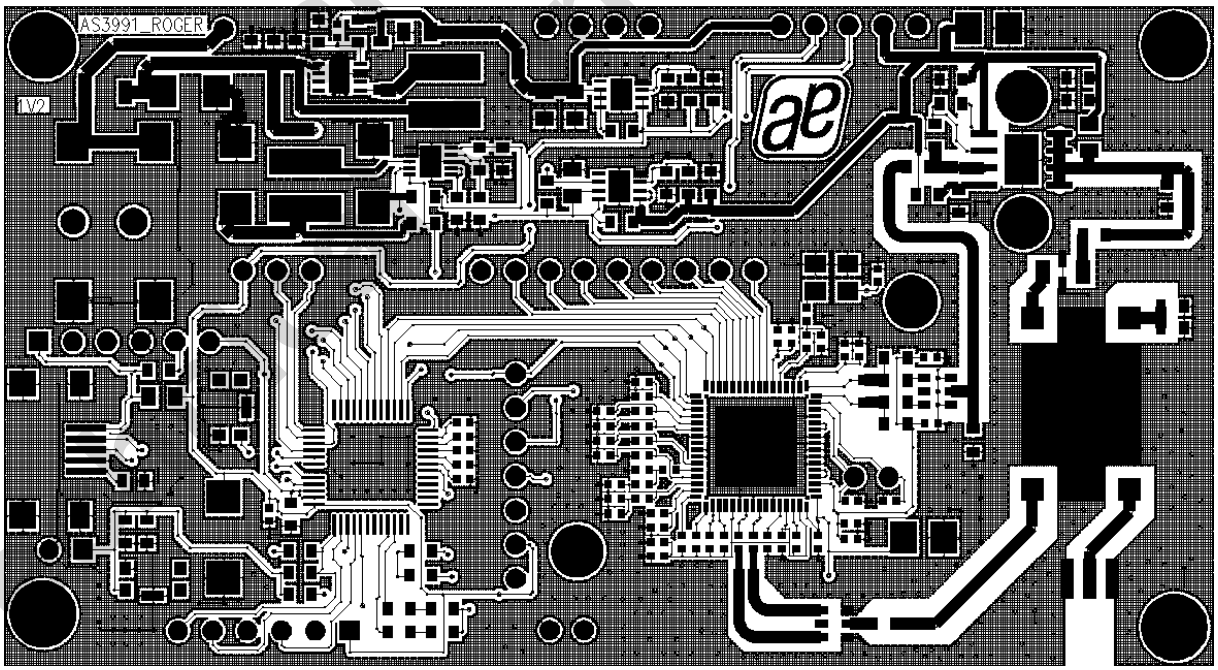
Please note that the components may change. Please review the BOM for latest Information

Top Mounted



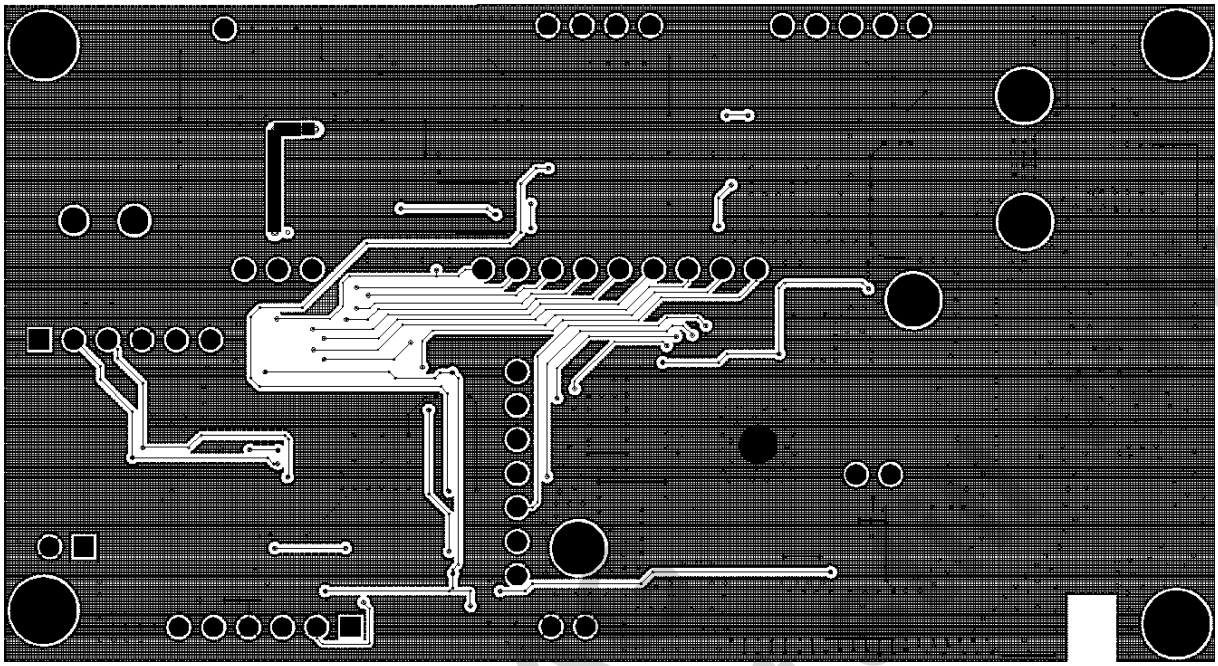
Picture 9: Assembly Top

3.2 Top Layer



Picture 10: Top Layer

3.3 Bottom Layer



Picture 11: Bottom Layer

3.4 Bill of Material

Part Info	Reference	Footprint	ordering information
Integrated Circuits (IC)			
AS3991	U4	QFN 64 9x9	AS3991-BQFT
AS1364-AD_TDFN8	U8, U10	0	austriamicrosystems
SPA-2118	U11	0	austriamicrosystems
AS1340_TDFN8	U7	0	austriamicrosystems
AS1326A_TDFN10	U9	0	austriamicrosystems
20 MHZ TCXO	X1	3.2x2.5	Digikey/ 631-1073-1-ND Degtron KDS
C8051F340	U1	TQFP 48	Digikey: 336-1298-ND
Other semiconductors			
LED	D1, D4, D5	0805	Digikey/160-1423-1-ND
MBR0540	D2	SOD123_MM	Digikey/MBR0540T1GOSCT-ND
S2KA-13	D3	D_SMA	Digikey/S2KADICT-ND
SMD resistor			
1k	R1, R2, R4, R23, R24	1608_0603_MM	Standard part
100	R11,R12	1608_0603_MM	Standard part
0R	R14	1005_0402_MM	Standard part
6k8	R15	1608_0603_MM	Standard part
34k	R16;R28	1608_0603_MM	Standard part
10k	R17, R20, R27, R29	1608_0603_MM	Standard part
10	R18	1608_0603_MM	Standard part
30k	R19	1608_0603_MM	Standard part
330	R21	1608_0603_MM	Standard part
100k	R22, R36	1608_0603_MM	Standard part
nc	R25,R26, R6	1608_0603_MM	Standard part
0 R	R3	1608_0603_MM	Standard part
27k	R30, R10	1608_0603_MM	Standard part
820R	R5	1608_0603_MM	Standard part
10k	R7	1005_0402_MM	Standard part
0R	R8	1005_0402_MM	Standard part
56k	R9	1005_0402_MM	Standard part
SMD capacitors			
12pF	C12, C28	1608_0603_MM	Standard part
nc	C13	1608_0603_MM	Standard part
4u7	C19; C54, C58	1608_0603_MM	Digikey/490-3303-1-ND
10u	C80		
4u7	C57, C59,C64, C65	0805	
47pF	C20, c21	1005_0402_MM	Standard part
110p	C25		
100p	C56	1005_0402_MM	Standard part
1u	C3	1608_0603_MM	Standard part
3n3	C31	1005_0402_MM	Standard part
220p	C32	1005_0402_MM	Standard part
2u2	C4, C9, C10, C15, C17, C23, C26, C33, C37, C46, C47, C49, C55	1005_0402_MM	Standard part
10uF	C41;C73	CPMP3528_B_MM	Standard part
10n	C5;C8, C11, C14, C16, C24, C27, C34, C40, C42, C43, C44, C45, C48	1005_0402_MM	Standard part
100n	C50, C52, C1, C2, C22	1005_0402_MM	Standard part
220p	C51	1608_0603_MM	Standard part
100uF	C53	CPMP7243_D_MM	Standard part
33uF/10V	C60	CPMP6032_C_MM	Digikey/PCE3164DKR-ND
100uF/10V	C61	CPMP6032_C_MM	Digikey/478-3320-1-ND
330n	C62	1608_0603_MM	Standard part
10nF	C63	1608_0603_MM	Standard part
8p2	C67, C68	1608_0603_MM	Standard part
1n2	C69	1608_0603_MM	Standard part
82p	C70	1608_0603_MM	Standard part
1n	C71	1608_0603_MM	Standard part
39p	C72	1608_0603_MM	Standard part
100p	C74	1608_0603_MM	Standard part
6p8	C75	1608_0603_MM	Standard part
220p	C76, C77	1005_0402_MM	Standard part
100n	C78	1005_0402_MM	Standard part
n.m.	C79, C30	1005_0402_MM	Standard part
SMD inductor			
nc	L1	2012_0805_MM	0
33n	L3, L5	1608_0603_MM	Würth/744902133
2n2	L4	1608_0603_MM	Würth/744902022
4.7uH	L7	Würth	Digikey/732-1097-1-ND
3.3uH (4.1µ)	L8	Würth	Würth/74476013C
33n	L9	2012_0805_MM	Würth/74476013C
Coupler_RCP890..	T2	COUPLER_RCP890A05	Degtron Richardson/BFI-Optilas
Balun 50/100	T3,T4	BALUN-0900BL18B100	Würth/748431090 0
Mechanical components			
Switch	S1,S2	SMD Type	Farnell: 1201424
USB Connector	J11		Buerklin:72F2280
Power Jack	J38		Digikey/CP-002AHPJCT-ND
MMCX Connector	J1		Samtec:MMCX-J-P-H-ST-EM1
Other componets			
Low pass Filter	U6		Würth/748131009
Polyswitch	F1		Digikey/NANOSMDC150FTR-ND
not mounted	J10, J13, J14, J15,J16,J17,J18,J19;2,J20,J21;J22,J23, J24,J25,J26,J27,J28,J29;3,J30,J31,J32,		not mounted

Table 7: BOM

4 PCB Layer Information

Name		AS399x UHF Board
Dimensions		90 x 49 mm
Edges		milled
PCB Material		FR4 **Dielectric** DE117
PCB Strength		0.51 mm
Layer Count		2
Attached files		
Format		Gerber RS274x / Excellon
Gerber files	Top Side Layer: Layer 01	ROGER_1V2.top
	Bottom Side Layer: Layer 04	ROGER_1V2.bot
	Solder Stop Top	ROGER_1V2.smt
	Solder Stop Bottom	ROGER_1V2.smb
	Silk Screen Top	ROGER_1V2.sst
	Dimension, Print Info	ROGER_1V2.drd
	Drill Files	Data for Drills und Holes
	Thruhole	thruhole.tap
PCB layer setup	Top Side Layer 01	(36) 43µm thickness
	Core Material	500µm thickness Dielectric Constant 4.7
	Bottom Side Layer 4	(36) 43µm thickness

Material	Thickness [µm]	Layer	Layer Name	Comments
Copper Plated	36 (43 final thickness)		*.top	Top Side Layer 1
Pre Preg	500			DE117 Dielectric constant 4,7
Copper plated	36 (43 final thickness)		*.bot	Bottom Side Layer 4

Table 8: PCB Layer Properties

5 Disclaimer

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