MFRD52x

Mifare® Contactless Smart Card Reader Reference Design

Rev. 2.1 — 17. April 2007 **Preliminary Data Sheet**

Document information

Info	Content
Keywords	MFRC522, MFRC523, MFRC52x, MFRD522, MFRD523, MFRD52x Mifare Contactless Smart Card Reader Reference Design, Mifare Reader IC
Abstract	

Revision history

Rev	Date	Description
2.1	2007-04-17	modifications to PCB Add MFRD523 designs new NXP layout
2.0	2005-12-13	Changed Status to Preliminary Specification
1.0	2005-11-09	Initial Draft

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1. Introduction

1.1 Scope

This document describes the functionality of the reference reader PCB based on the MFRC52x. It includes the functional and electrical specifications and gives the needed details to use this reader as a reference design.

This reference reader implementation is based on the HVQFN32 package of the MFRC52x device.

The MFRC52x it self is described in the corresponding data sheet:

- “Product Data Sheet - MFRC522 Contactless Reader IC”.
- “Product Data Sheet - MFRC523 Contactless Reader IC”.

Antenna design and tuning is described in following application notes:

- “Application Note - Micore Reader IC family Directly Matched Antenna Design”
- “Application Note - 13.56 MHz RFID Proximity Antennas”

1.2 Features

- Single 5 V up to 12 V unregulated external power supply
- RS232 DSUB9 connector for easy connection to a host PC
- Regulated voltage supply for all supply voltages
- Variable Supply Voltage
  - TVDD = AVDD = DVDD: adjustable, 3.3V or 2.8 V
  - PVDD: adjustable, 1.8V or equal to DVDD
  - SVDD: adjustable, 1.8V, 2.8V or 3.3V
- NRESET, IRQ signals externally accessible
- Support of S2C interface
- Analog test signal pins AUX1 and AUX2
- Digital test signal pins D6, D5, D4, D3, D2 and D1 depending on the interface
- Breakable line between serial RS232 and MFRC52x section
- Breakable line between serial MFRC52x and antenna matching section
- Breakable line between antenna matching and antenna section
- MFRC52x reader section can be connected via:
  - Serial UART
  - I2C
  - SPI
- Antenna size: 33.5 mm x 51.0 mm

2. Functional Description

The MFRD52x reference reader PCB is a complete Mifare® reader reference design based on the MFRC52x. The reader PCB itself is divided in 4 parts:

Table 1. PCB sections

Measure	Reason
Interface section	Enables the direct connection to an RS 232 interface via a DSUB9 socket connector.
Reader section	MFRD52x reader module. This module is the basic PCB including the MFRC52x Reader IC and all required components for a Mifare® reader plus the filter circuitry.
Antenna matching section	Matching circuit for single ended or complementary driver operation
Antenna section	Antenna coil PCB including the resistor R_Q for quality factor adjustment.

Three areas to break the PCB are foreseen for easy adaptation of the reference reader PCB:

- Between the interface section and MFRC52x section
- Between the MFRC52x section and the antenna matching section
- Between the antenna matching section and the antenna section

The default configuration uses pins and jumpers to connect the PCB sections. It is also possible to use 0 Ohm resistors instead of the pin and jumper connection.

The MFRD52x reference reader PCB offers the possibility to be directly connected to microcontroller with serial UART, SPI or I2C interface.

Note: In case of a direct connection to a microcontroller, the input and output voltage levels must be observed.

For a detailed view of all different layers of the MFRD52x reference reader PCB, refer to Section “Schematic & Layout”.

3. PCB Marking

Depending on the reader IC version and some external modifications, the PCB is labeled on the reader and antenna section

Table 2. Laser Marking

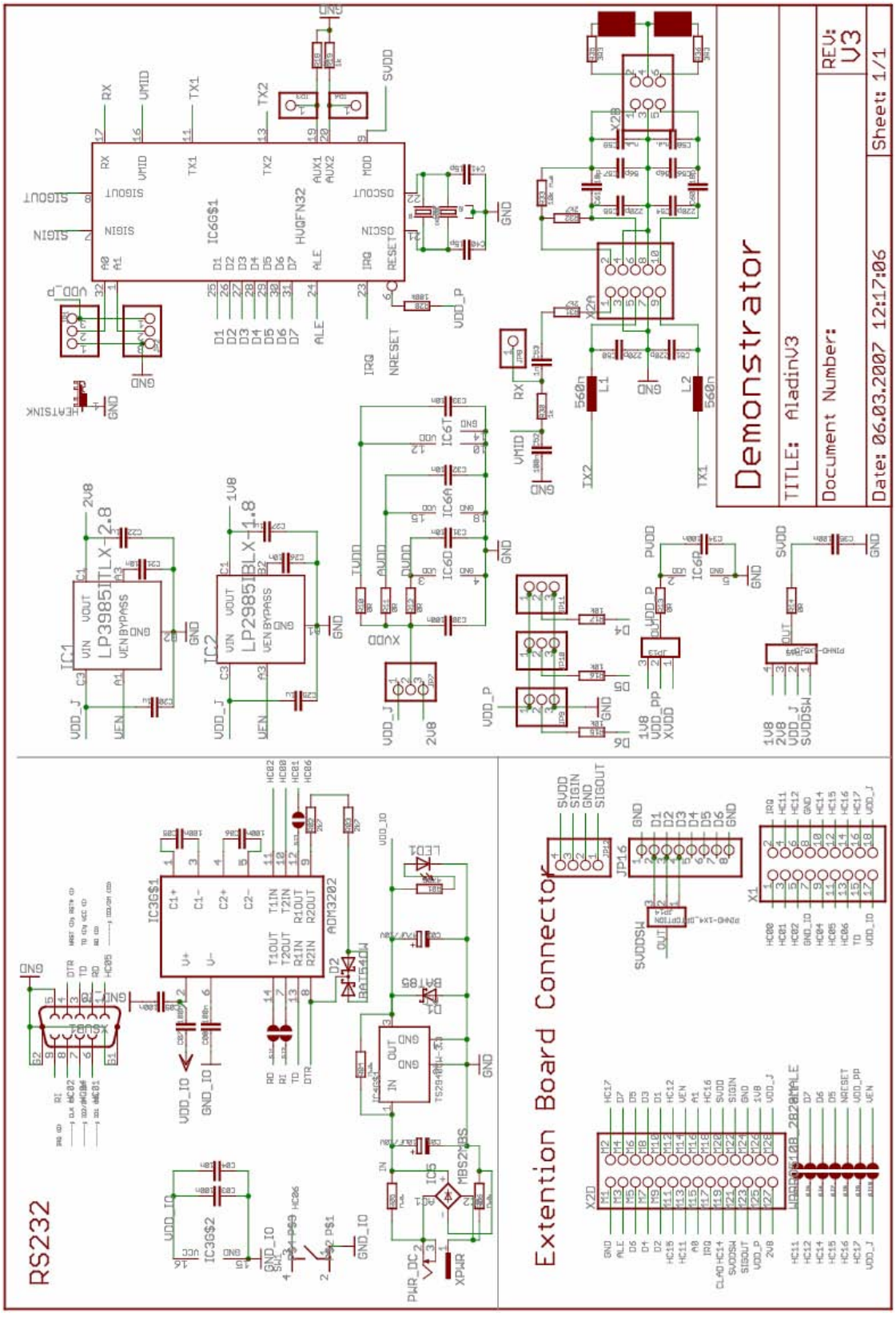
Label	Description
	MFRC522 reference reader design
	MFRC523 reference reader design
	Assembly option for MFRC523 reference reader for Mifare® SAM add-on board usage

4. Schematic Description

4.1 Schematic Overview

The following parts describe the MFRD52x reference reader PCB schematic, the part list and the layout of the PCB completely in order to give the user the possibility to take the evaluation reader as a reference design for an own Mifare® integration.

Table 3. Schematic Overview

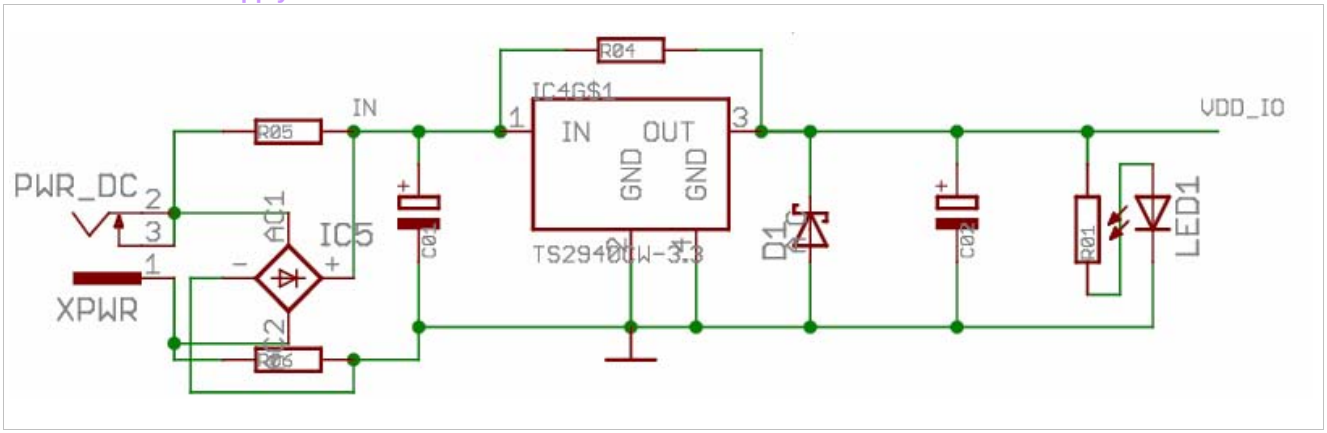


Note: The Antenna part and the antenna matching section shows the basic schematics only. The actual values used circuit and the relevant parts are described in following chapters.

4.2 Interface Section

4.2.1 Power Supply

Table 4. Power Supply



The power supply can be connected with a 2.5 mm dc plug. According default configuration the resistors R04, R05 and R06 are not assembled. With these resistors the PCB can be adjusted to customer needs. The polarity of the plug is managed automatically on the PCB. The supplied voltage should be in a range of 5.0V up to 12.0V and can be unregulated. The power supply should be able to provide at least 200 mA.

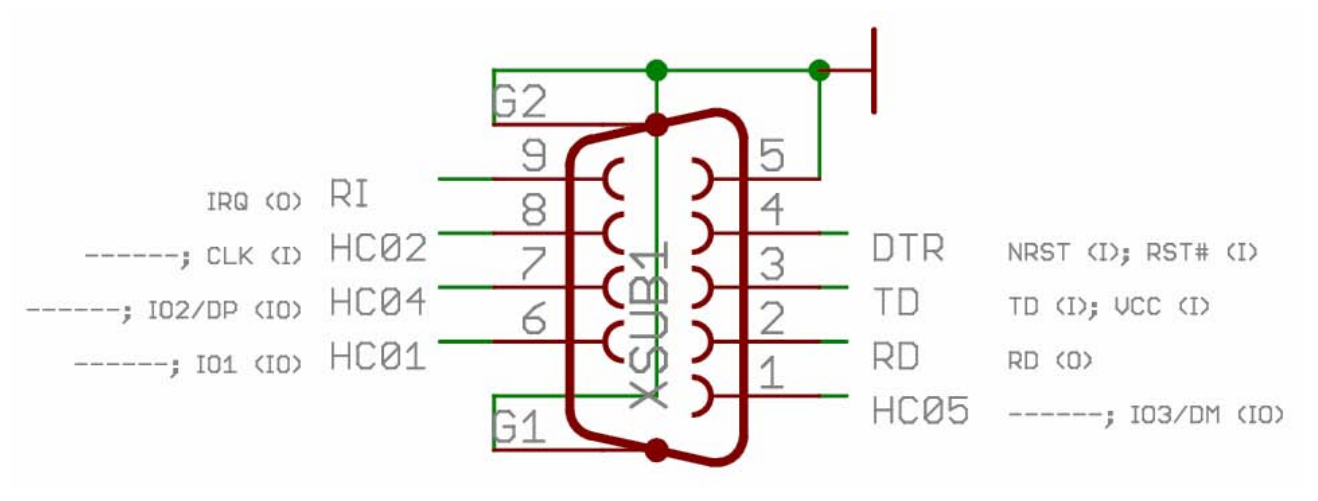
The main supply voltage on the interface section is 3.3 V regulated.

After plugging in the voltage supply, the LED on the PCB should light up.

In the special case of using Mifare® SAM add-on board and PC/SC smart card reader connection, the power is provided by this external supply. The supply from the PC/SC reader is only used to generate a cold reset. Please refer to Document “xxx” .

4.2.2 Host Interface

Table 5. DSUB-9 Connector Pinning



The DSUB-9 socket is used on one side for a standard RS232 connection to the PC or other host controller and on the other side for as a connection to a PC/SC smart card reader if Mifare® SAM add-on board is used. Therefore each pin has several use cases depending on the application.

Table 6. DSUB-9 Pinning Assignment

Pin	RS232 (DCE)			PC/SC Smart Card Interface		
	Signal	D	Voltage [V]	Signal	D	Voltage [V]
1	DCD (Data Carrier Detect)	O	± 3 - 12	IO3/DM (ISO IO3, USB D-)	IO	0 - 5
2	RD (Receive Data)	O	± 3 - 12	-		
3	TD (Transmit Data)	I	± 3 - 12	VCC (ISO VCC)	Pwr	0 - 5
4	DTR (Data Terminal Ready)	I	± 3 - 12	RST (ISO RST)	I	0 - 5
5	GND	Pwr		GND	Pwr	
6	DSR (Data Set Ready)	O	± 3 - 12	IO1 (ISO IO1)	IO	0 - 5
7	RTS (Ready To Send)	I	± 3 - 12	IO2/DP (ISO IO2, USB D+)	IO	0 - 5
8	CTS (Clear To Send)	O	± 3 - 12	CLK (ISO CLK)	I	0 - 5
9	RI (IRQ)	O	± 3 - 12	-		

4.2.3 Connection Schemes

In RS232 configuration, the DSUB-9 socket is used to connect demo board to standard PC or other host controller.

In PC/SC smart card interface configuration, the DSUB-9 socket is used to connect to PC/SC smart card reader. This configuration will only function if Mifare® SAM add-on board is used.

Different usage will result in mal-function but will not harm the devices or reader PCB:

PC connection in PC/SC Smart Card Interface configuration

The PC expects voltage levels of ± 5 to 12 V, whereas the output voltage levels are 0 to 2.8V and the expected Input voltage levels are in a range of 0 to 5 V. The output voltage levels should not harm the PC interface. On the other side the higher PC voltage levels would influence the VCC pin. Since this voltage level is only used to switch the onboard voltage regulator - the influence is not critical.

The other critical Pin RST is protected by a diode and will not damage the reader board.

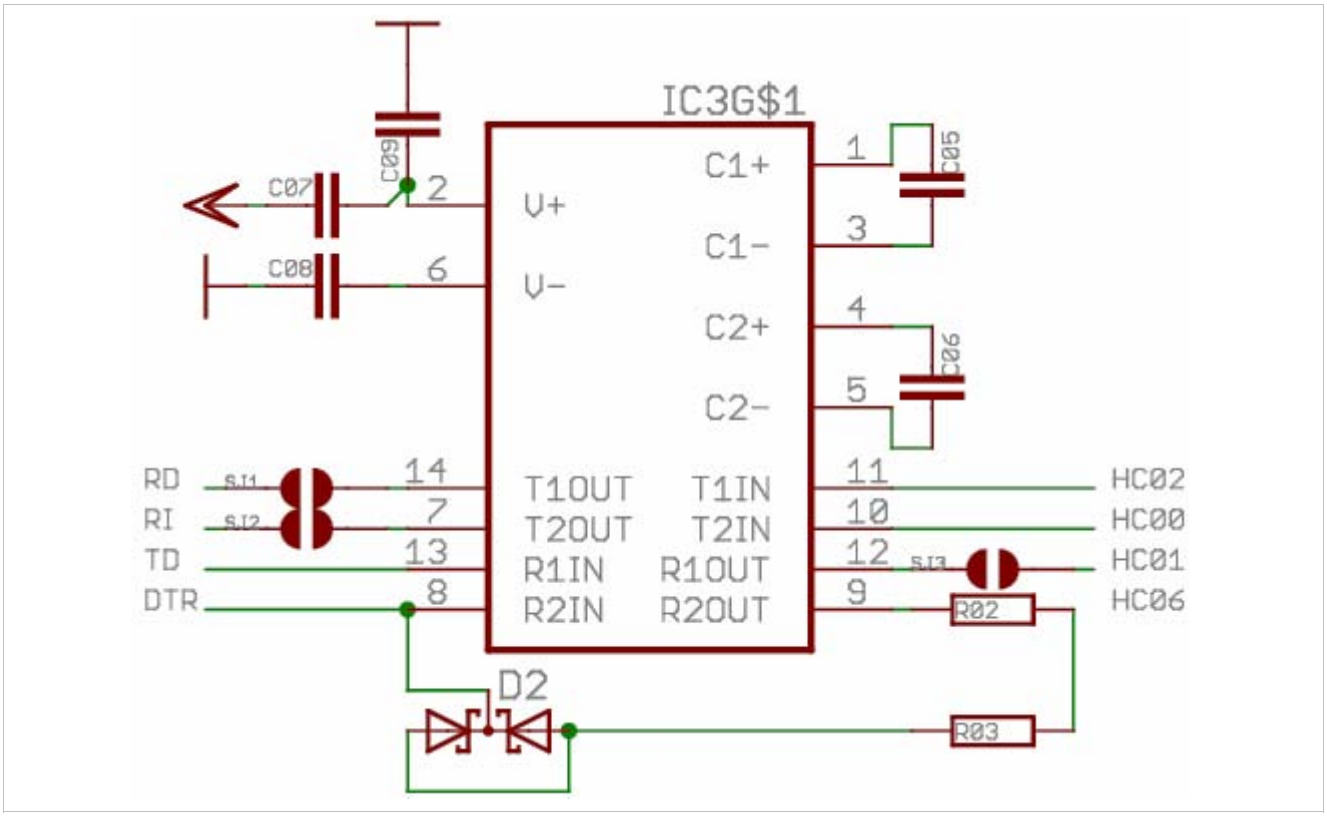
Signal RTS is not connected in this configuration and as therefore no influence.

PC/SC Smart Card reader connection in RS232 Interface configuration

The expected voltage levels on PC/SC smart card reader are 0 to 5 V. whereas the output voltage levels are ± 5 to 12 V. The input voltage levels will not harm the reader PCB. Output signals are only available on pin RD / RI, but in this case there is no signal connection to the PC/SC smart card reader device. There is no harm expected.

4.2.4 RS232 Transceiver IC

Table 7. RS232 Transceiver IC



Capacitor C09 and C07 are assembled, dependent on the type of IC3.

4.2.5 Configuration Settings RS232 vs. PC/SC Smart Card Reader interface

Table 8. Configuration Setting

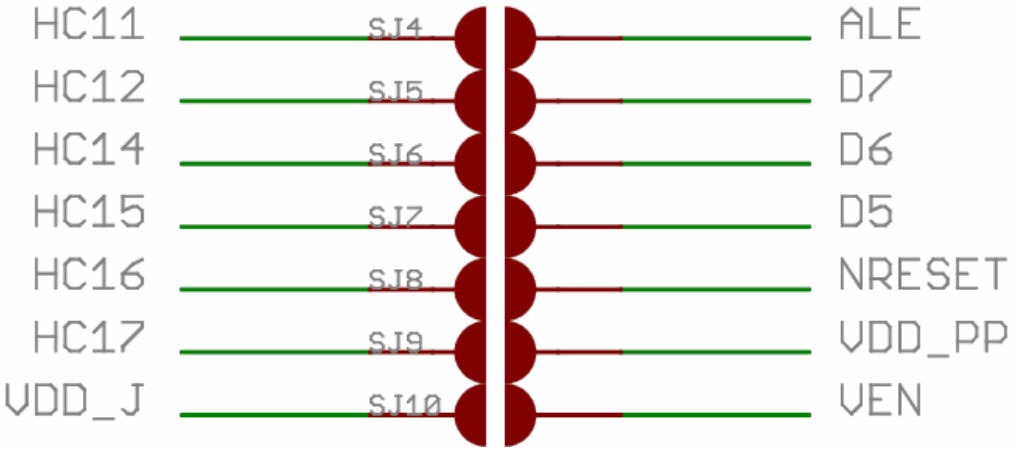
Device	RS232	PC/SC
JP1	Solder bridge between 1 – 2	Open
JP2	Solder bridge between 2 – 3	Open
R02	Optional - Not assembled	Not assembled
R03	Not assembled	100R
SJ1	Closed	Open
SJ2	Closed	Open
SJ3	Open	Open
SJ4	Closed	Open
SJ5	Closed	Open
SJ6	Closed	Open
SJ7	Closed	Open
SJ8	Closed	Open
SJ9	Closed	Open
SJ10	Closed	Open

JP … Solder Jumper

R … Resistor – value given

SJ … Solder Jumper

Table 9. Jumper Settings



4.2.6 Connector to reader section

This connector can be assembled either with pin heads, sockets or simple solder bridges. The wire holes are on a 2.54 mm grid. Between these wire holes there is a milling line. If you remove the solder bridges, you can easily break the PCB along the milling line. In this case you can operate the reader section with a microcontroller with various interfaces.

Table 10. Connector to Reader Section

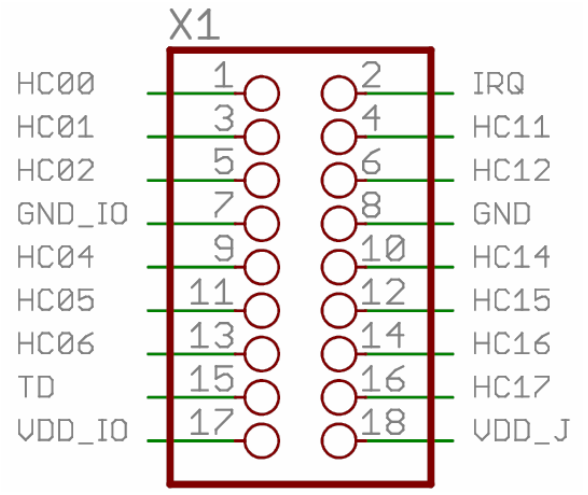


Table 11. Connector to reader section pin description

Interface Section		Reader Section			
Description	Pin	Description			
		UART	I2C	SPI	PC/SC
HC00	1	IRQ	IRQ	IRQ	-

Interface Section		Reader Section			
Description	Pin	Description			
		UART	I2C	SPI	PC/SC
HC01	3	RXD	SDA	NSS	IO1
HC02	5	TXD	SCL	MISO	CLK
GND_IO	7	GND	GND	GND	GND
HC04	9	D6	D6	MOSI	IO2 / DP
HC05	11	D5	D5	SCK	IO3 / DM
HC06	13	NReset	NReset	NReset	RST
TD	15	VDD_PP	VDD_PP	VDD_PP	VCC
VDD_IO	17	VDD_J	VDD_J	VDD_J	VDD_J

Please note to supply valid voltage range of VDD_J (main power supply for the reader section) and VDD_PP (pad power supply for the reader IC).

The voltage levels for pins 2, 4, 6, 10, 12, and 14 are related to the selected VDD_P (Pad VDD).

On pin 16 an additional pad VDD for the MFRC52x IC can be provided. An input voltage on this pin is not mandatory, if another pad voltage is selected. In this case the pin can be left open.

4.2.7 Parameter Selection on PCB

Table 12. Parameter Selection Top Layer

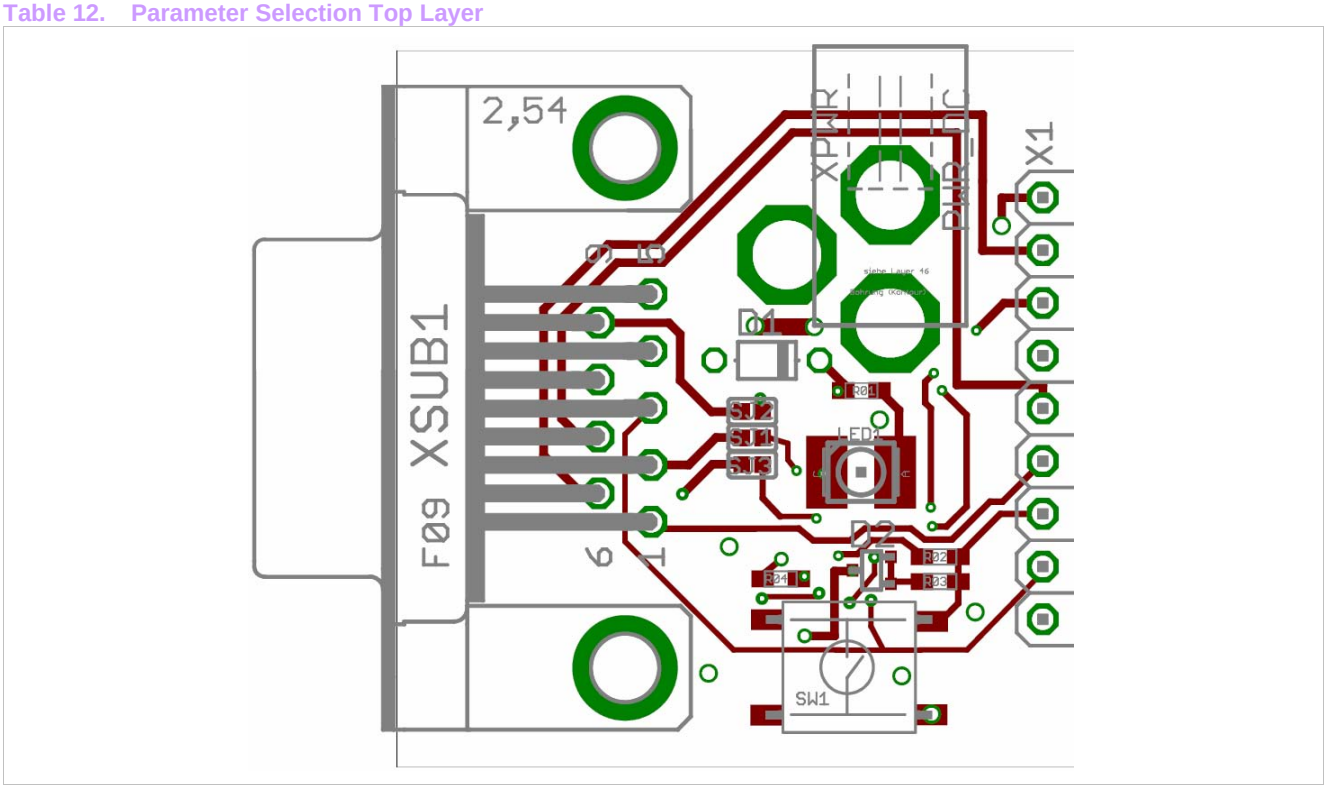


Table 13. Parameter Selection Placement Top Layer

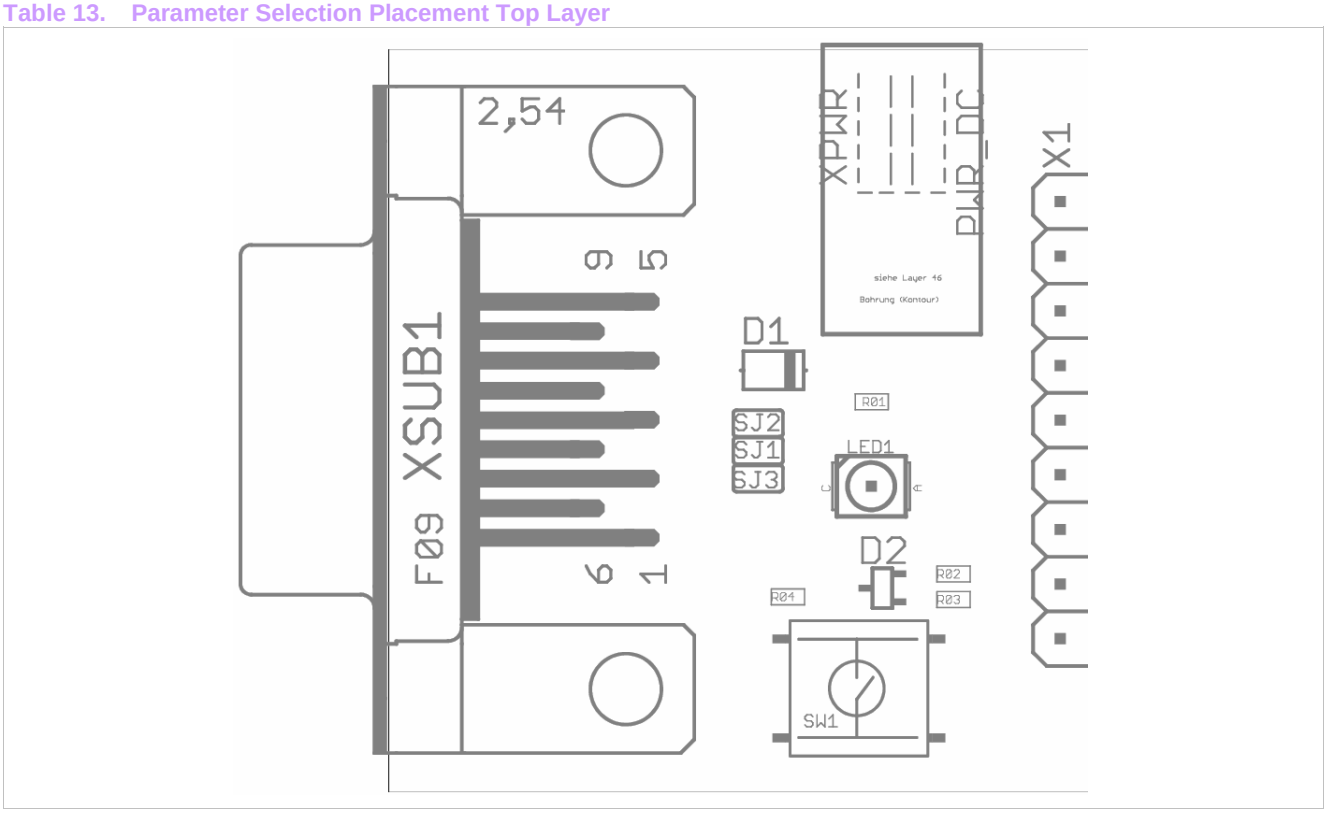


Table 14. Parameter Selection Bottom Layer

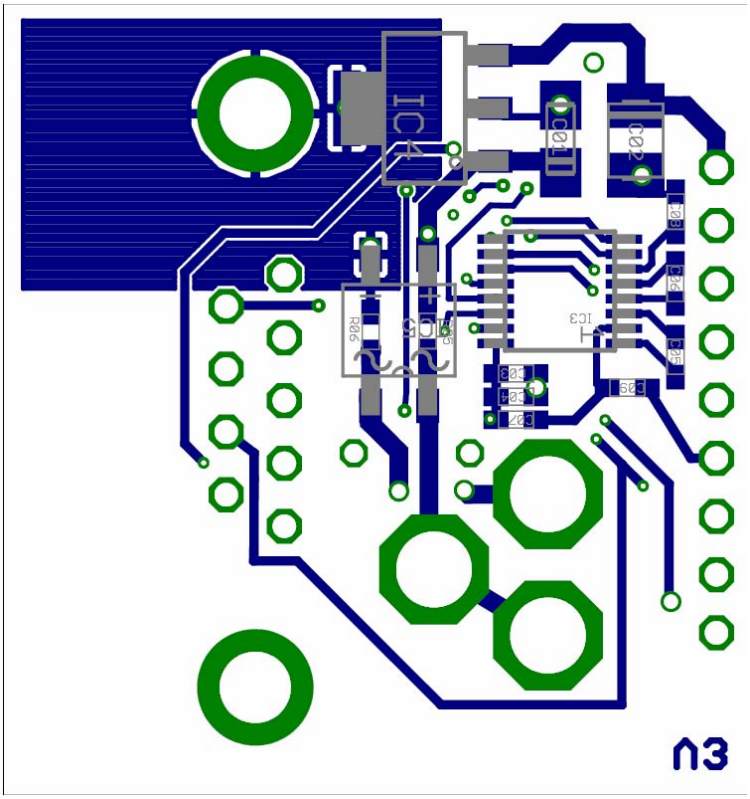
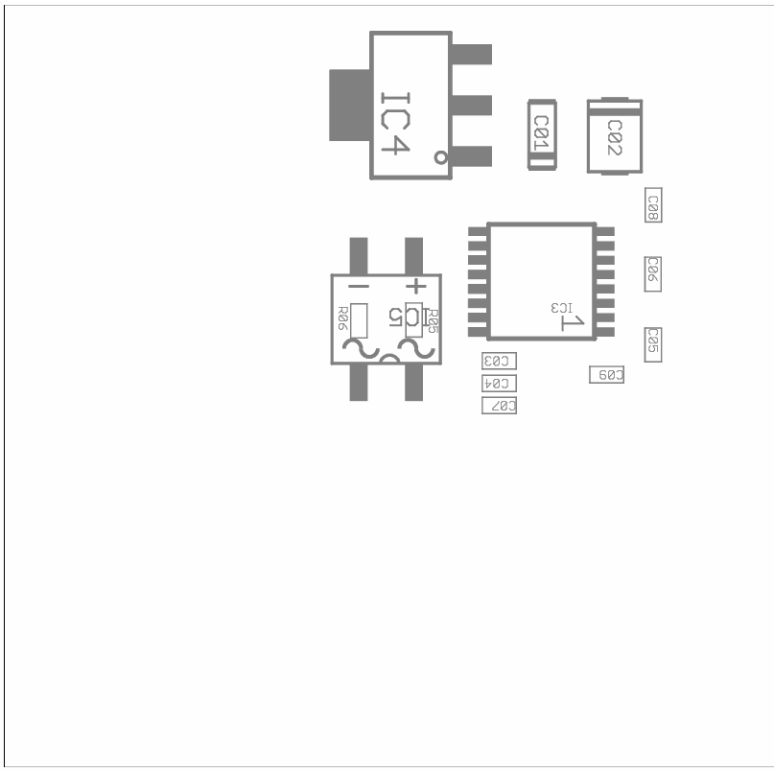


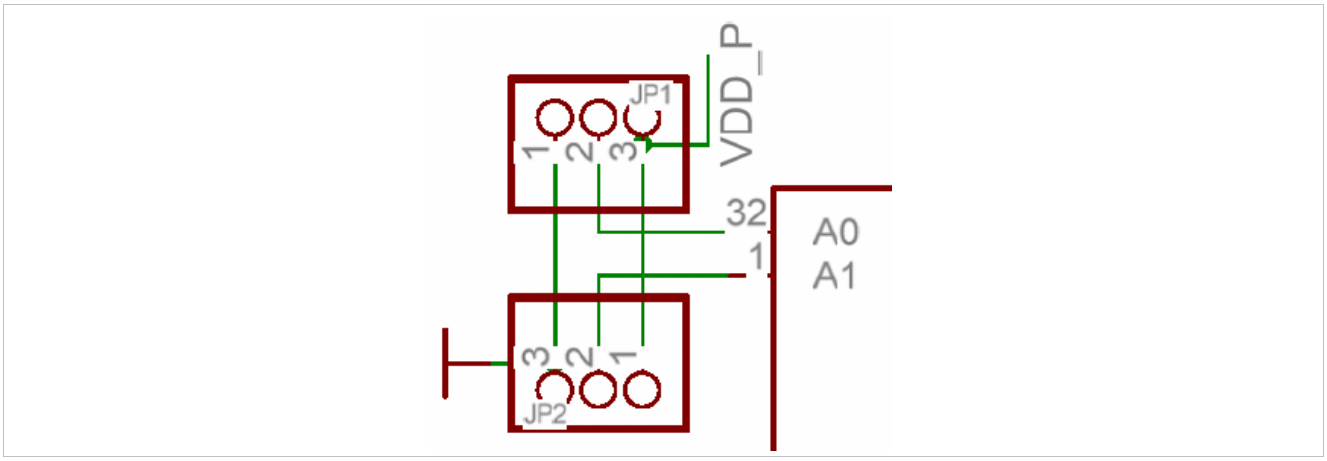
Table 15. Parameter Selection Placement Bottom Layer



4.3 Reader Section

4.3.1 Interface Selection

Table 16. Interface Selection



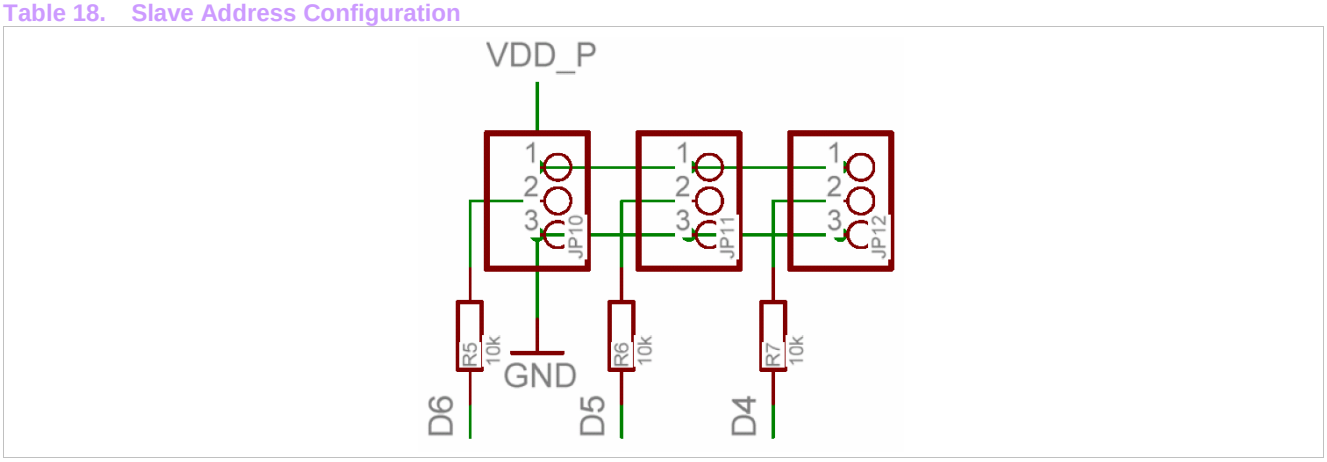
The interface selection of the reader section is made by two solder jumpers. Low means GND potential at the input pin and HIGH means PVDD at the input pin. The factory default value is indicated by a “*”.

Table 17. Interface Options

Pin	UART* (default)	SPI	I^2C
A0	LOW	HIGH	LOW
A1	LOW	LOW	HIGH

4.3.2 I²C Slave Address Configuration

Table 18. Slave Address Configuration



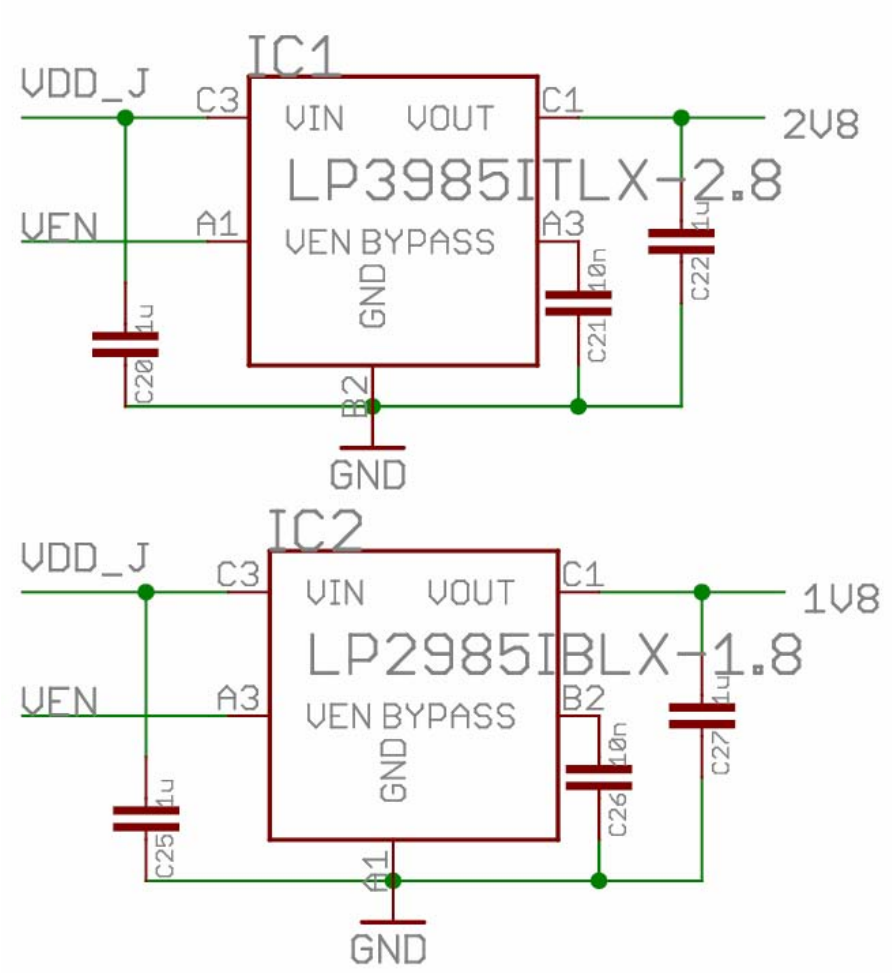
In order to use the I²C bus, the bus slave address has to be selected. The slave address consists of 7 bits, where 4 bits (slave address bit 6, 5, 4, 3) are fixed to 0101. The remaining 3 bits (slave address bit 2, 1, 0) can be selected externally. Please pay attention, by default these jumpers are not configured at all.

Table 19. I²C slave address selection

Slave Address	D4 (S2)	D5 (S1)	D6 (S0)
0101 XXX (default)	NC	NC	NC
0101 **000**	LOW	LOW	LOW
0101 **001**	LOW	LOW	HIGH
0101 **010**	LOW	HIGH	LOW
0101 **011**	LOW	HIGH	HIGH
0101 **100**	HIGH	LOW	LOW
0101 **101**	HIGH	LOW	HIGH
0101 **110**	HIGH	HIGH	LOW
0101 **111**	HIGH	HIGH	HIGH

4.3.3 Supply Voltage Generation

Table 20. Generation of 2.8V and 1.8V supply voltages



The main section supply (VDD_J) is used to generate two additional supply voltages, which can be selected for various purposes.

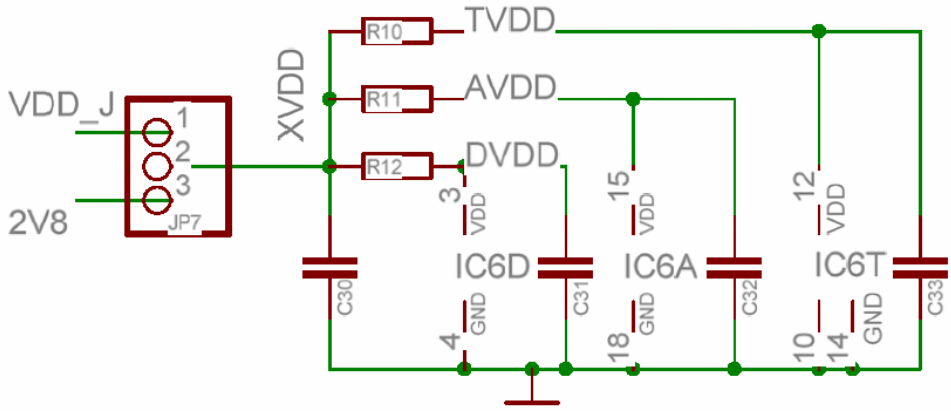
If you are using these voltage regulators, the supply range of VDD_J should be between 3.0 V and 6.0 V.

If the voltage on VDD_J is directly used to supply the reader IC, the supplied voltage on the VDD_J interface pin should be in a range of 2.5 V to 3.6 V.

As default option VEN should be connected directly to VDD_J by means of solder jumper SJ10. VEN is controlled differently in combination with Mifare® SAM add-on board.

4.3.4 Voltage selection

Table 21. Voltage selection JP7



The supply VDD for driver, analog and digital part can be selected between the direct pin voltage VDD_J and the output of the onboard voltage regulator of 2.8 V.

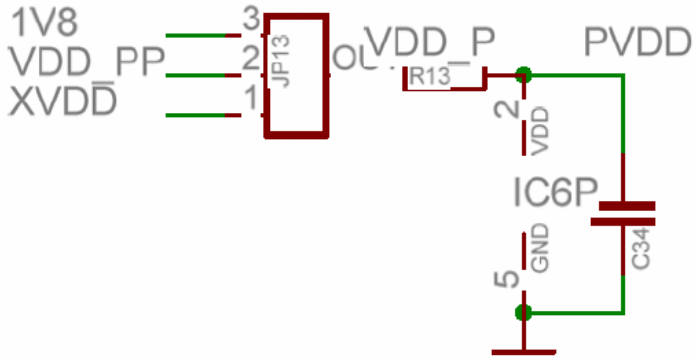
The serial resistors in power supply line can be used for current measurement. By default zero ohm resistors are used.

Table 22. Reader IC supply voltages

TVDD, AVDD, DVDD	On board voltage (default)	External voltage
XVDD	2V8	VDD_J

4.3.5 Pad Supply Voltage selection

Table 23. Voltage selection



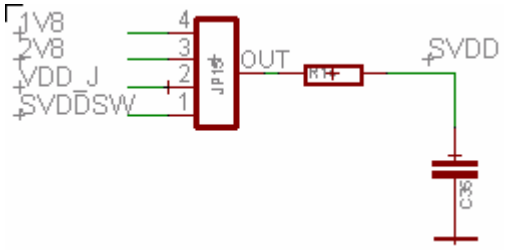
The pad supply voltage has to be selected according the interface voltage of the external microcontroller or level shifters.

Table 24. Pad supply voltage selection JP13

Pad VDD	Reader supply voltage XVDD (default)	External voltage	On board voltage
PVDD	XVDD	VDD_PP	1V8

4.3.6 SVDD voltage selection

Table 25. SVDD voltage selection



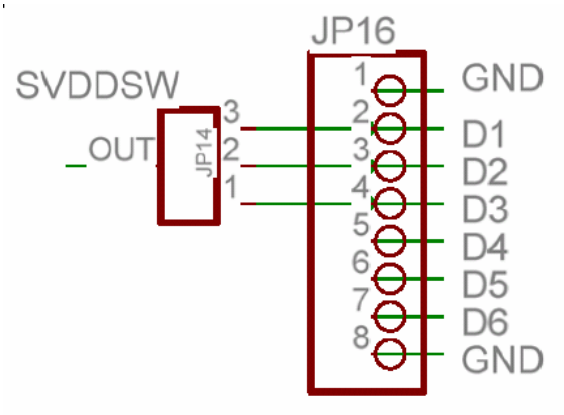
The SVDD supply voltage depends on the selected supply voltage for the external controller. Even if no external MFIN/MFOUT (SIGIN/SIGOUT) is used, this voltage should be selected.

Table 26. SVDD supply voltage selection JP15

MFIN/MFOUT VDD	External voltage	On board voltage (default)	On board voltage	switched pin voltage
SVDD	VDD_J	2V8	1V8	VDD_P

4.3.7 Switched Supply Voltage

Table 27. Switched supply voltage JP14

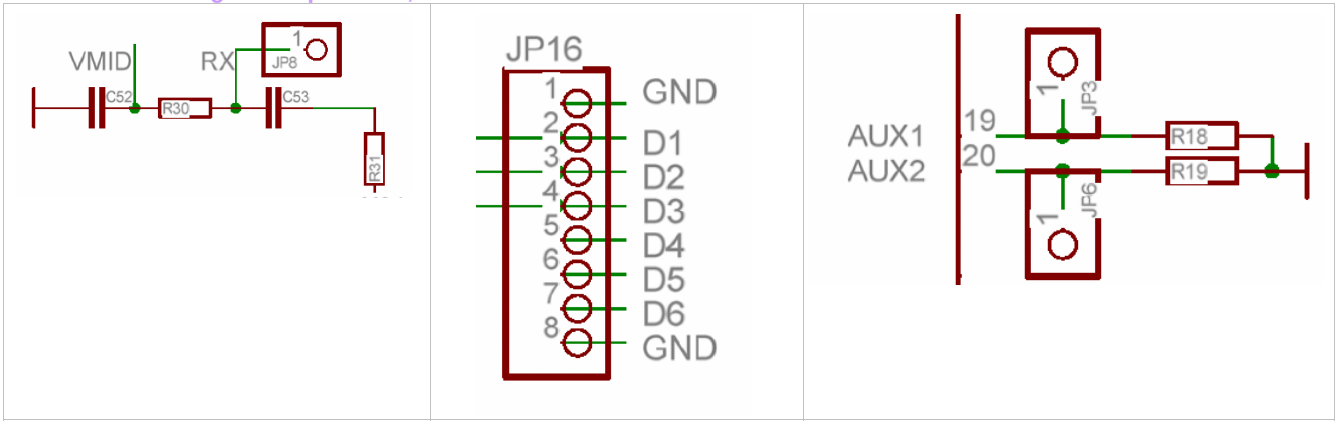


For low power applications the output ports of the reader IC can be used as supply pins. Each pin is able to provide up to 4 mA. Please encounter the resulting voltage drop at the pins. For applications, where only a small voltage drop compared to PVDD is acceptable,

more than one pin can be used in parallel. As a consequence these pins are no longer available as debug pins. The selection can be made by means of jumper JP14. According to the default configuration, this jumper is not assembled, that means, this option is also not valid during SVDD selection.

4.3.8 Test Signal Output

Table 28. Test Signal Output JP16, JP6



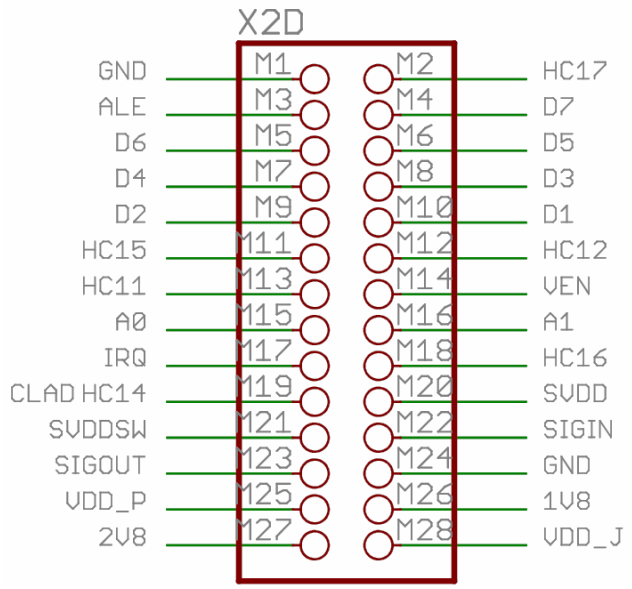
In order to qualify the performance of the reader and detect a potential weakness, several test signals are available.

For digital test signals the digital test bus is available on the separate debug connector.

Two analog test signals are available on solder pads at the bottom side of the PCB. For measurements directly on the RX pin a separate solder pad is available. Please pay attention that measurements at the RX pad should be preferred done with a differential probe.

4.3.9 Extension Board Connector

Table 29. Extension Connector X2D



Depending on the application, a more powerful extension connector is necessary.

4.3.10 Parameter Selection on PCB

Table 30. Parameter Selection Top Layer

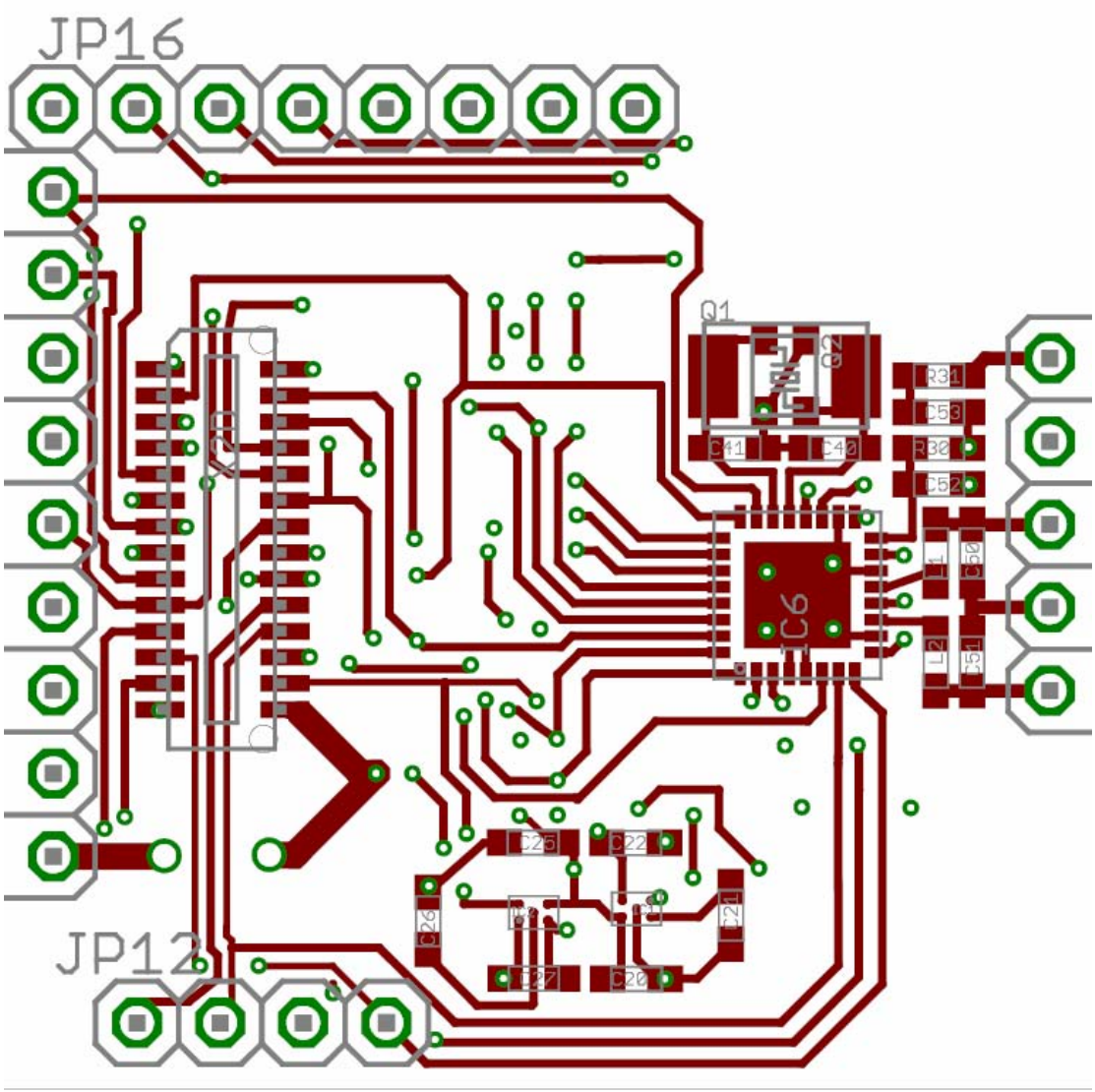


Table 31. Parameter Selection Placement Top Layer

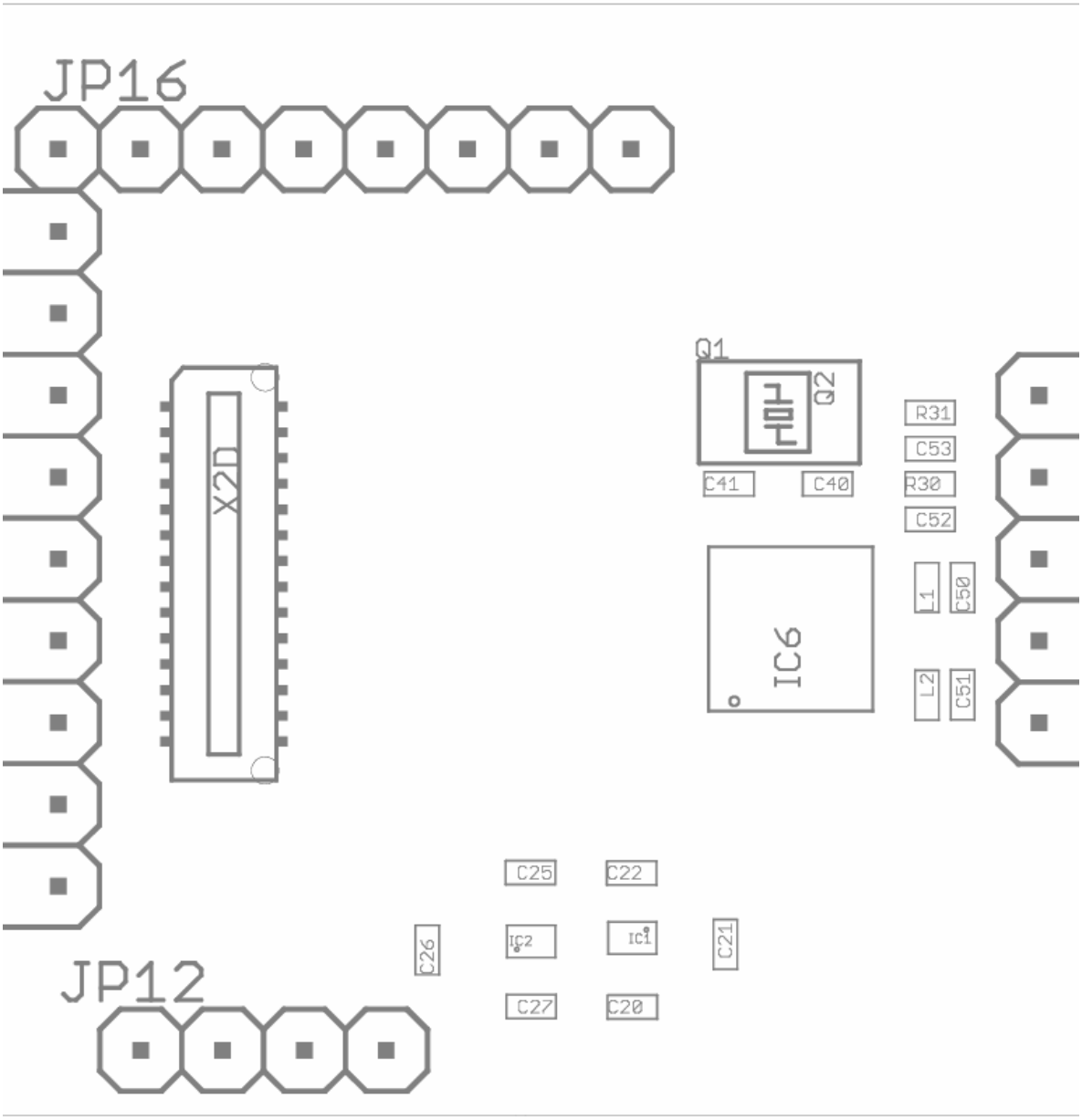


Table 32. Parameter Selection Bottom Layer

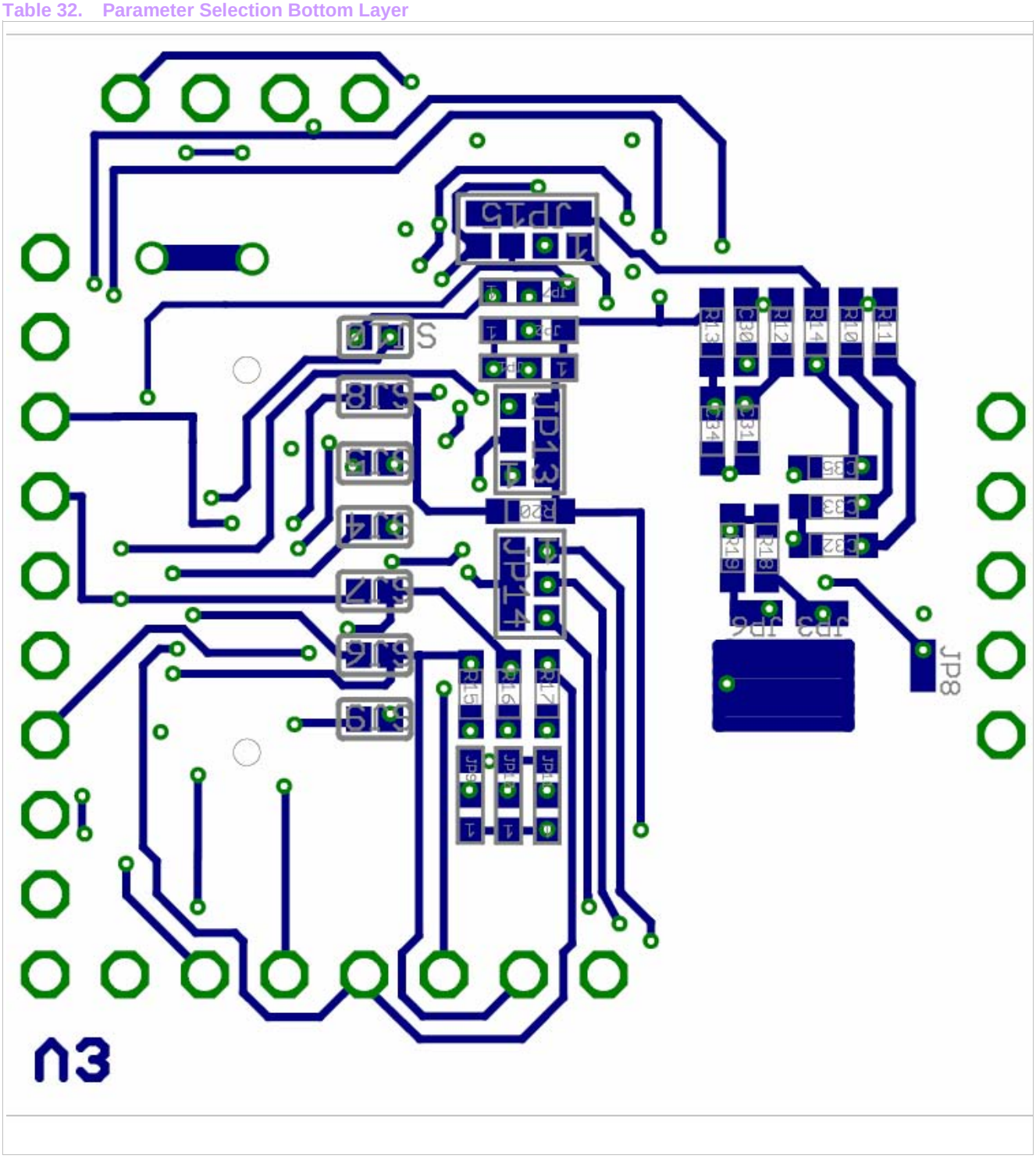
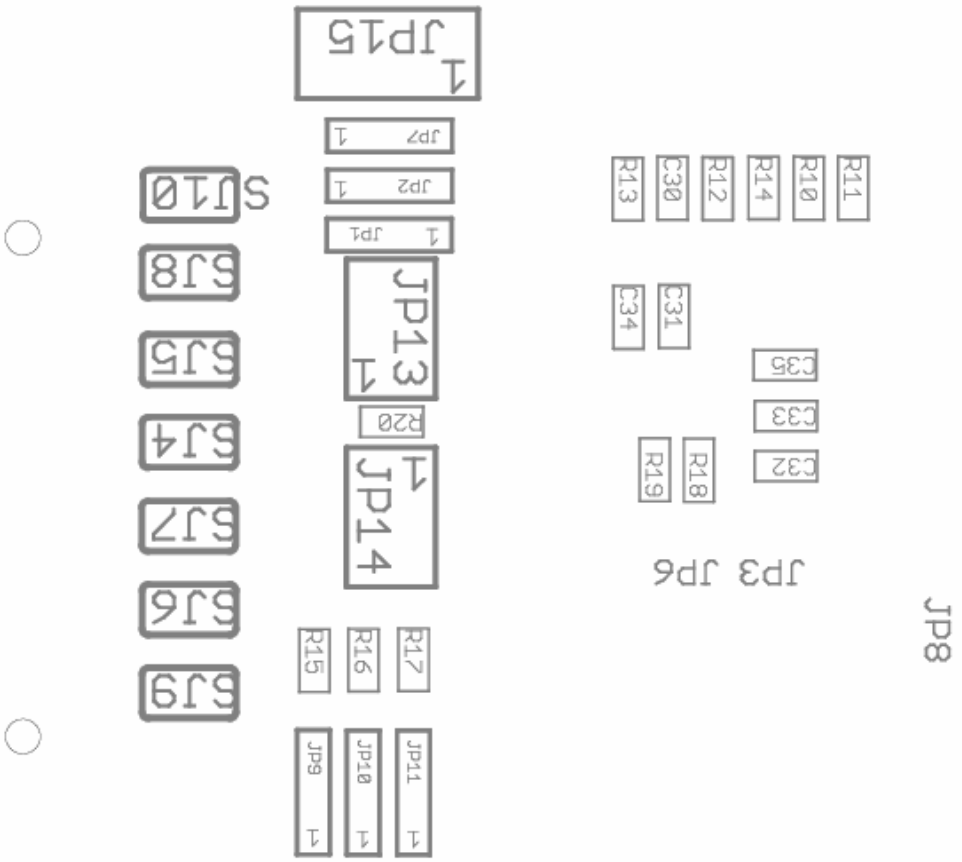
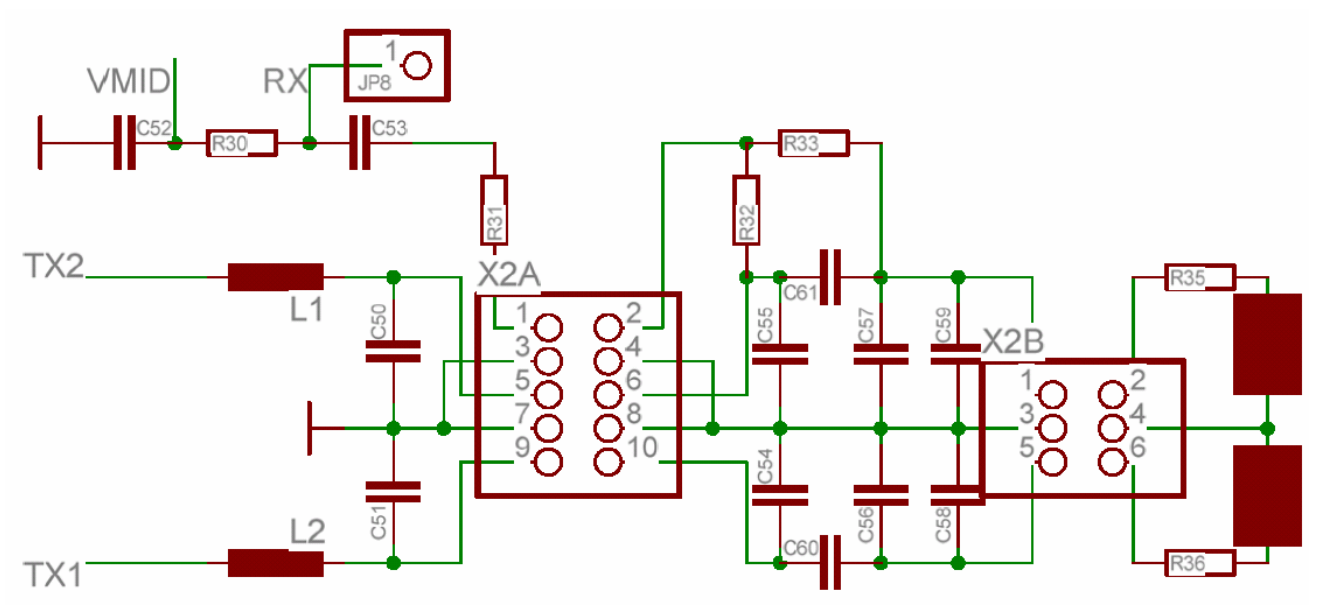


Table 33. Parameter Selection Placement Bottom Layer



4.4 Antenna Matching Section

Table 34. Antenna matching and antenna section



The connector between the reader section and the antenna matching section as well as the connector between the antenna matching section and the antenna itself can be assembled either with pin heads, sockets or simple solder bridges. The wire holes are on a 2.54 mm grid. Between these wire holes there is a milling line. If you remove the solder bridges, you can easily break the PCB along the milling line.

The driver stage of the reader IC is connected to the signals TX1 and TX2. The receiver input is connected to the signal RX. All the necessary external circuitry is located at the reader section. The filter is dimensioned for a resonance frequency of about 14.3 MHz and also located on the reader section.

4.4.1 Complementary Output Stage

MFRD52x reference reader design uses a complementary antenna. The following schematic drawing shows all the necessary devices and their values.

Table 35. Complementary antenna circuit

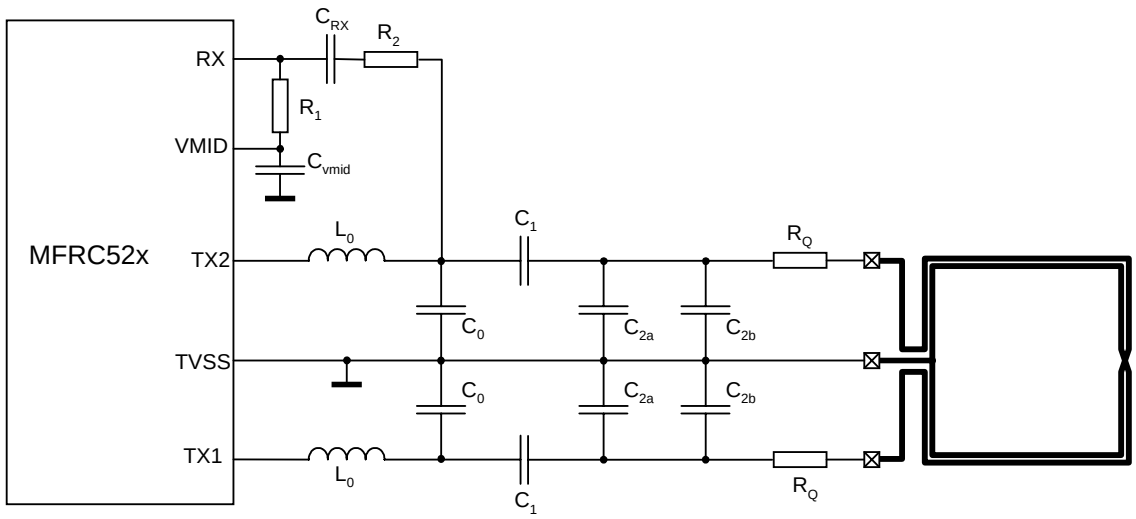
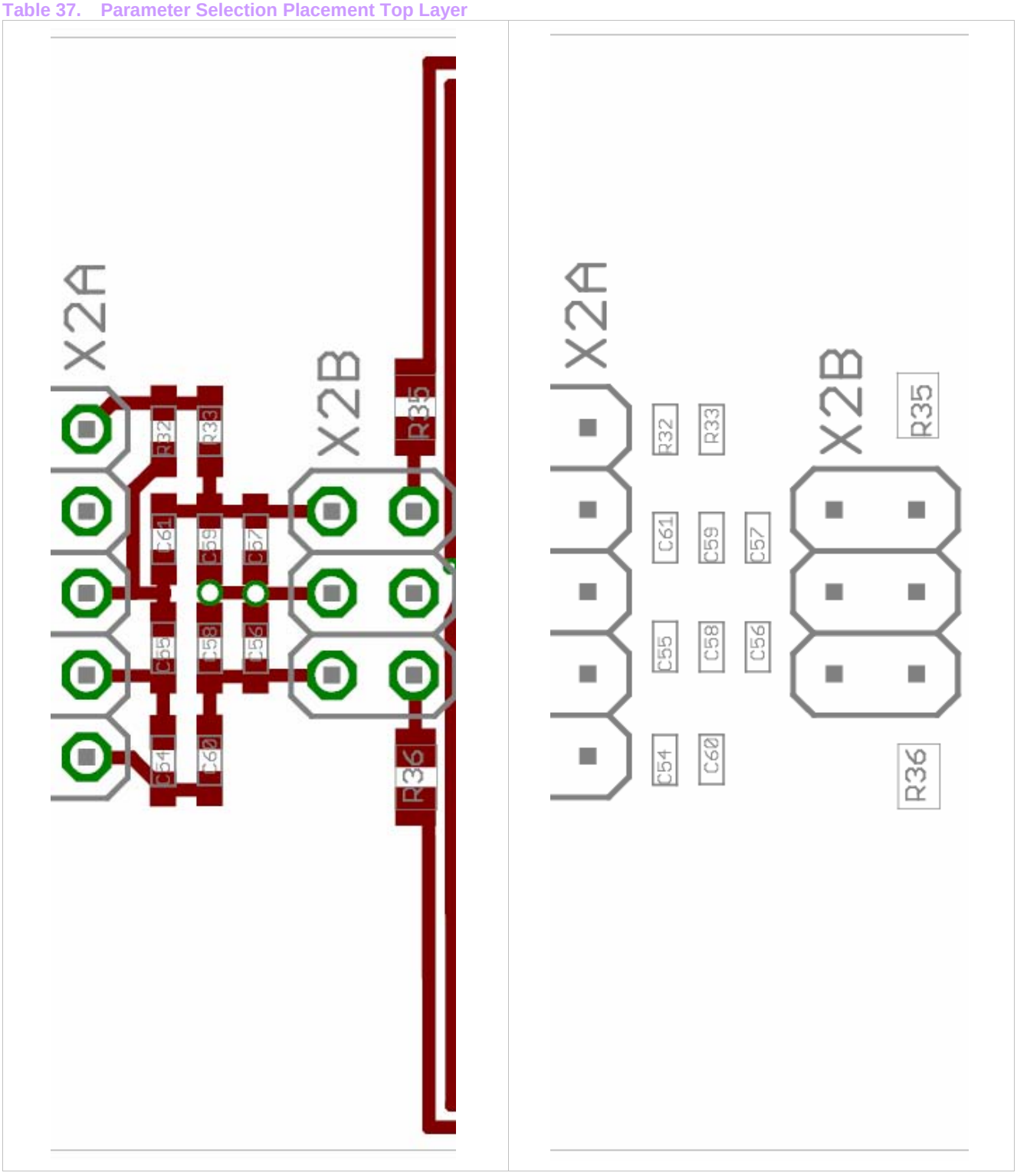


Table 36. Assembly list for complementary antenna circuit

Part	Part No. in schematics	Value	Package	Type
L_0	L1, L2	560 nH	0603	TDK MLF1608J
C_0	C50/C51, C54/C55	220 pF	0603	COG, 1%, 25V
C_1	C60, C61	18 pF	0603	COG, 1%, 25V
C_{2a}	C58, C59	47 pF	0603	COG, 1%, 25V
C_{2b}	C56, C57	6p8	0603	COG, 1%, 25V
C_{Rx}	C53	1 nF	0603	X7R, 5%, 25V
C_{vmid}	C52	100 nF	0603	X7R, 5%, 6V
R_1	R30	1 kOhm	0603	5%
R_2	R31 + R32	2.7 kOhm	0603	5%
R_Q	R35, R36	3.3 Ohm	0805	5%, 100mW

4.4.2 Parameter Selection on PCB

Table 37. Parameter Selection Placement Top Layer



5. Schematic & Layout

Table 38. Schematic

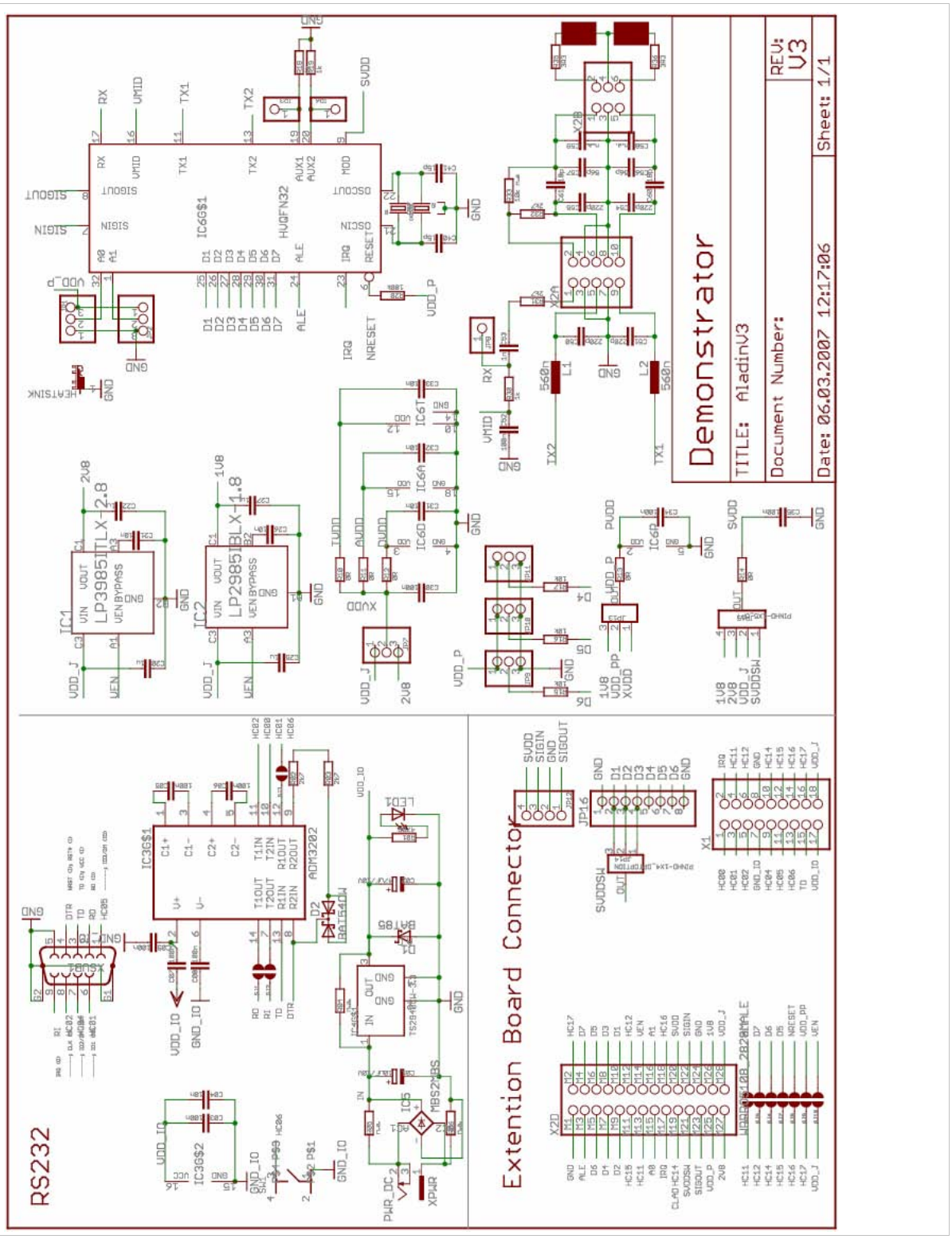


Table 39. Layout

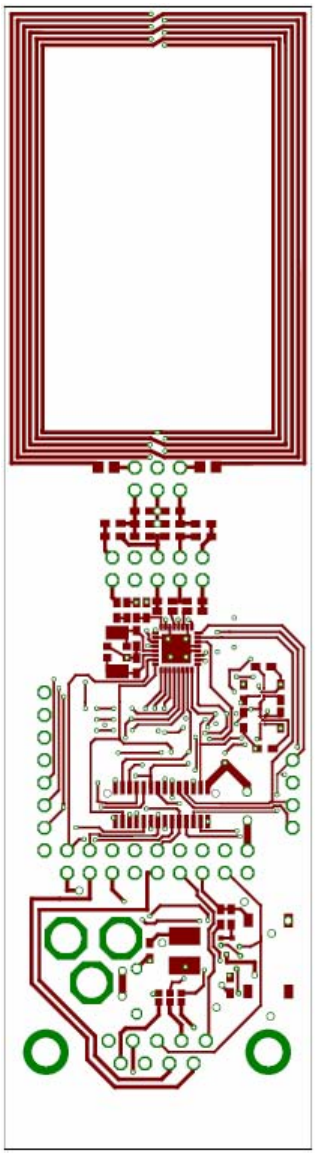
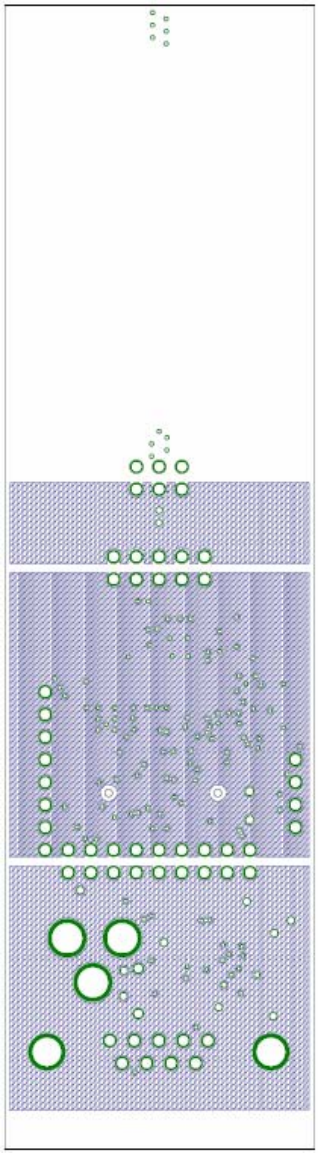
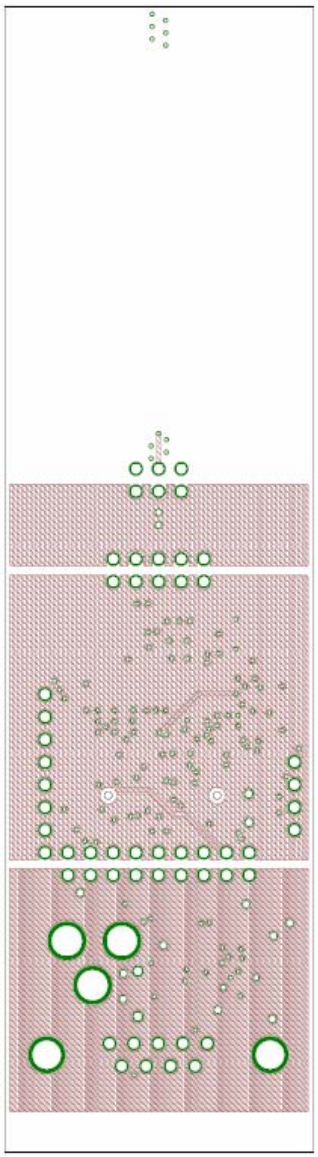
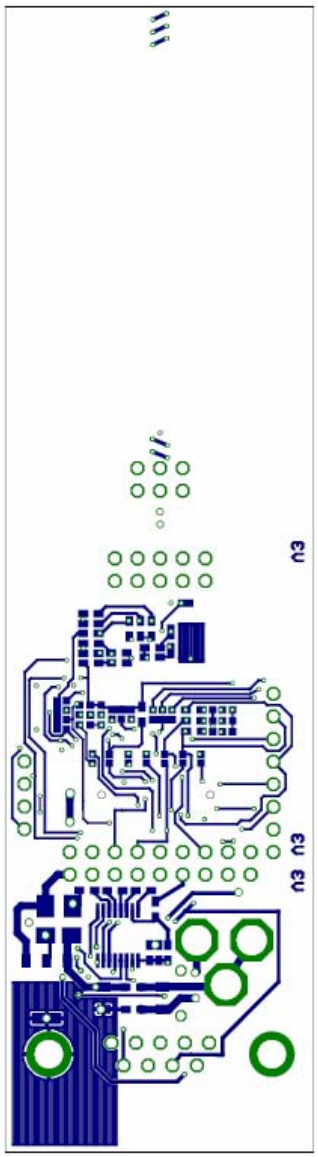
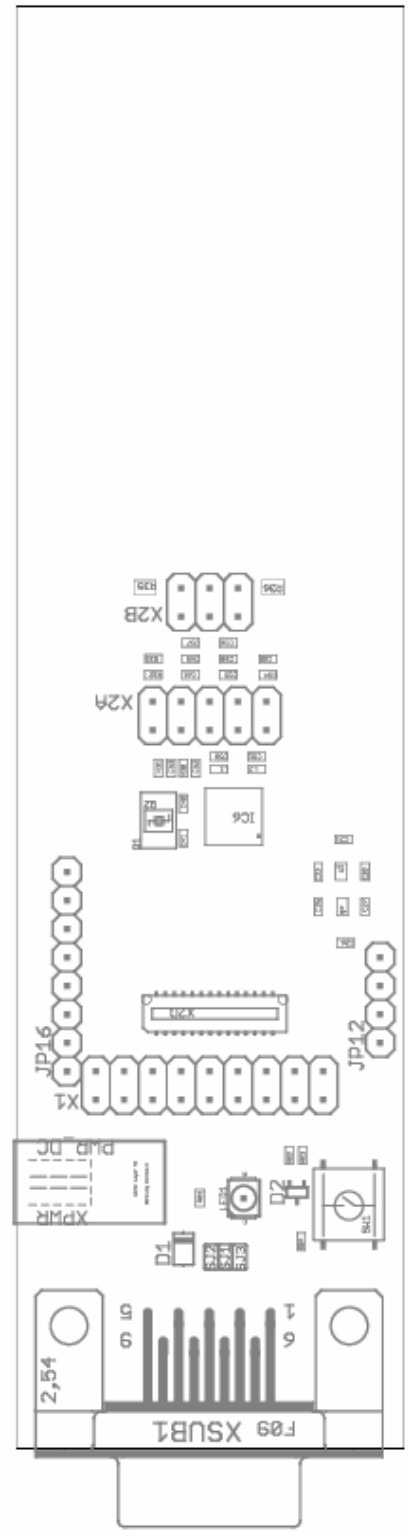
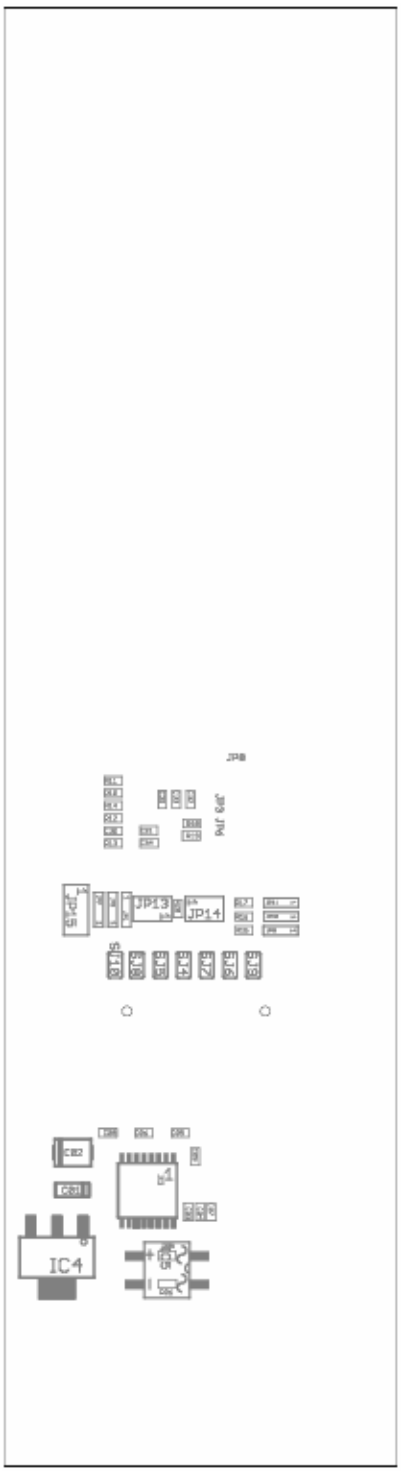
Top	Layer 2	Layer 3	Bottom
Signal	*GND*	*Supply*	*Signal*
			

Table 40. Component

Top	Bottom
	

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continued >>

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Date of release: 17. April 2007
Document identifier: 119321