AN5233
Application note

Energy harvesting with ST25DV-I2C series Dynamic NFC Tags

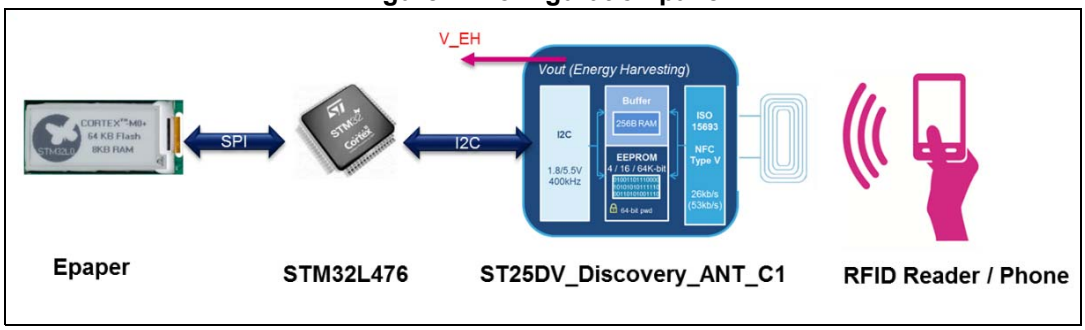
Introduction

The ST25DV-I2C series Dynamic NFC Tags offer the possibility of harvesting energy from an external RF field, and to delivery it onto their V_EH output pin. The non-regulated DC voltage on V_EH is generated by means of RF signal rectification. This function is mainly intended to supply very low power applications.

The purpose of this document is to show how to use the ST25DV-I2C energy harvesting feature in an ESL application based on the ST25DV-I2C-04K in combination with an STM32L476 MCU.

Additional details can be found in the ST25DV-I2C datasheets and in application note AN4913, available on *www.st.com*.

Figure 1. Configuration panel



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1 Acronyms

Table 1. List of acronyms

Acronym	Definition
BOM	Bill of materials
EEPROM	Electrically Erasable Programmable Read-Only Memory
EH	Energy harvesting
ESL	Electronic label shield
IEC	International electro technical commission
ISO	International organization for standardization
I2C	Inter-integrated circuit
MCU	Microcontroller unit
RF	Radio frequency

2 Energy harvesting

2.1 Benefits

Upon application of an RF field to the antenna of an ST25DV-I2C device plugged on a Discovery_ANT_Cxx board, the chip transforms the inducted energy into electrical current to supply the tag IC and the MCU.

The components can then operate as long as the RF field is present and strong enough to supply them. ST25DVxxx devices offer the possibility to automatically activate energy harvesting after boot, when entering an RF field able to automatically power the application.

2.2 Usage limitations

2.2.1 Target antenna size

Antenna design has to be studied carefully to ensure optimum values.

As the ST25DV-I2C is compliant with NCF Type 5 and ISO/IEC 15693 specifications, the standardized large class-1 antenna provides the best performance. It is recommended to use the available card (ST25DV_Discovery_ANT_C1) to start trials. Then an antenna perfectly turned for the custom application (number of turns, capacitances, resonance frequency) can provide more energy.

2.2.2 Initiator RF electromagnetic field

In an NFC exchange the initiator dialogs with the target. In this application, the target is the ST25DVI2C-04K tag and the initiator can be an RFID reader or a smartphone.

The initiator creates an inductive coupling between two loop antennas. The initiator antenna size, the antenna position, the distance between the devices are the key factors that influence the energy provided.

The ST25DV-I2C will deliver enough current if the electromagnetic field is strong enough. When the initiator is a smart phone, depending on the embedded NFC controller solution and the other mentioned parameters the available energy can be insufficient to operate the MCU.

3 Setup

3.1 Introduction

To verify the ST25DV-I2C energy harvesting capability a set-up based on standard NFC STMicroelectronics cards has been prepared. The ST25DV DISCOVERY MBOARD is associated with the ST25DV_Discovery_ANT_C1. On top of these two boards, an Epaper daughter card had been designed.

The solution proposed is the simplest possible one, with the lowest BOM cost. It is intended as a project guideline, from this base the final customer can easily improve it to address the target application.

3.2 ST25 discovery board

The MB1396 (ST25_Discovery_Mboard) is designed to help the user explore the features of the ST25DV-I2C-04K product with the support of the STM32 Nucleo ecosystem. This motherboard uses a 32-bit Arm®(a) Cortex®-M4 CPU with FPU high-performance microcontroller.

The MB1396 is a ready-to-use printed circuit board (PBC). In this version it includes:

- an STM32L476GT6 LQFP100 32-bit microcontroller with 1 Mbyte of Flash memory and 192 + 4 Kbytes of SRAM
- a User push button
- a Reset button
- a joystick
- an on-board ST link for microcontroller firmware upgrade and debug
- an ST-LINK mini USB

3.3 ST25DV-I2C antenna daughter board

The MB 1285 (ST25DV_Discovery_ANT_C1) is a ready-to-use PCB that includes:

- an ST25DV-I2C-04K Dynamic NFC/RFID tag IC with 4-Kbit EEPROM, which provides a buffering data-transfer capability
- a Class 1 single-layer inductive antenna etched on the PCB (ANT C1)

3.3.1 Epaper board features

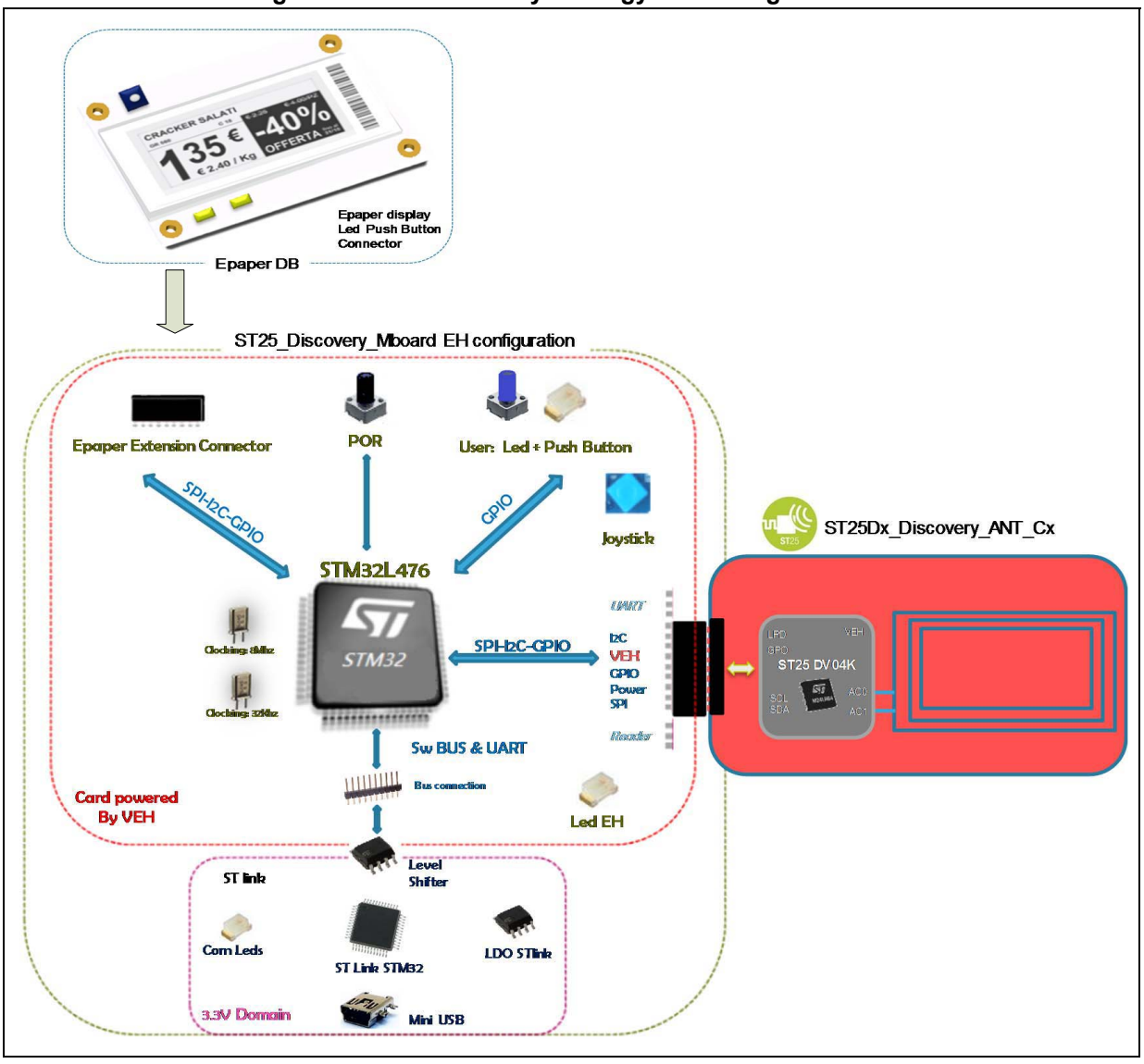
The Epaper daughter board is a ready-to-use PCB that includes an active matrix electrophoretic display with its controller.

a. Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

The 2.13” active area contains 122x250 pixels, black and white color.

- A connector makes it possible to power the DB, the link to an SPI and the control signals coming from the motherboard.
- A tank capacitor stores the necessary energy for a complete refresh of the display. No another added circuitry is needed, the BOM corresponds to the manufacturer recommendations.

Figure 2. ST25 Discovery - Energy harvesting overview



4 Operation

4.1 Start-up sequence

Without Epaper the STM32L476 operates immediately, if the current supplied by the ST25DV-I2C is higher than 2 mA.

If the Epaper daughter board is connected the STM32L476 power-on is delayed due to the capacitor added on the power line. Depending on the initiator performances, the first the boot time can be longer than 20 s.

4.2 Epaper limitation

During a refresh sequence, the Epaper requires a large amount of energy, and, without a buffer, the system powered only by harvesting cannot deliver it.

In the described setup the current storage is available in the tank capacitor. Its availability depends upon the harvested energy, with the limitations described in *Section 2.2*.

5 BOMs

Table 2. Epaper daughter board

ID	Quantity	Description	Manufacturer
C1	1	Supercap FCS0H104ZFTBR24 0.1 F, 5.5 V	KEMET
C2, C3, C8, C9, C10, C11, C12	7	Capacitor 1 µF, 25 V, 10% X5R 0603	Multi source
C4	1	Capacitor 4.7 µF, 50 V, 10% X5R 0805	
C5	1	Capacitor 100 nF, 25 V, 10% X5R 0603	
C6, C13	2	Capacitor 1 µF, 50 V, 10% X5R 0805	
C7	1	Capacitor 4.7 µF 25 V, 10% X5R 0805	
C14	1	Capacitor 100 nF, 16 V, 0603	
D1, D2, D3	3	Diode MBR0530 SOD123	ON Semiconductor
J1	1	Connector FH34SRJ-24S-0.5SH(50)	Hirose
J2	1	Connector TSM-107-01-L-DV-A 2x7 pts	Samtec
J3	1	Connector CES-110-01-L-D	
L1	1	Inductor NLCV32T-100K-PF	TDK
LCD1	1	LCD module GDEH0213B1	Dalian Good Display
LD1, LD2	2	LED Yellow TLMY1000-GS08	Vishay
Q1	1	Transistor SI1304BDL SC70	
Q2	1	Transistor STR2P3LLH6 SOT23(1)	STMicroelectronics
R1, R2, R3, R7, R8	5	Resistor 0R 0603	Multi source
R4	1	Resistor 10 kΩ, 1% 0603	
R5	1	Resistor 3 Ω, 1% 0603	
R6	1	Resistor 0.47 Ω, 1% 0603	
R9	1	Resistor 4.7 kΩ, 5% 0603	
R10, R11	2	Resistor 360R, 5% 0603	
R12	1	Resistor 100R, 5% 0603	
SW1	1	Push button TD-0341X BLUE BUTTON	WEALTH METAL
Additional parts for mounting on ST25DX Discovery Mboard			
-	4	M2.5x11 Threaded spacer REF: 05.02.113 (Farnell 1466760)	Ettinger
-	8	Cross-head screw M2.5x6	-
-	8	Washer diameter 2.5	-

1. Not fitted.

Table 3. ST25 DV Discovery - ANT_C1

ID	Quantity	Description	Manufacturer
C1, C8	2	Capacitor 0603(1)	Multi source
C2, C6	2	Capacitor 0402(1)	
C3	1	Capacitor 4.7 µF, 25 V, 10% X7R 0603	
C4	1	Capacitor 100 nF, 16 V, 10% X7R 0402	
C5, C7	2	Capacitor 10 nF, 16 V, 10% X7R 0402	
J1	1	Connector TSW-114-08-G-S-NA	Samtec
PEG1, PEG2, PEG3, PEG4	4	Self adhesive rubber bumper SJ5306	3M
R1	1	Resistor 20 KΩ, 1% 0402	Multi source
R2, R3	2	Resistor 1.5 KΩ, 1% 0402	
R4	1	Resistor 0R, 0402	
R5	1	Resistor 0402(1)	
R6, R7	2	Resistor 0R, 0603	
ST1, ST2	2	C TSW-103-07-G-S 1x3Pts	Samtec
ST3	1	Connector TSW-102-07-G-S 1x2 pts	
TP1	1	Connector TSW-101-07-G-S 1 pt	
U2	1	ST25DV64K-JMR6D3 UFDFPN12	STMicroelectronics
C2, C6	2	Capacitor 0402(1)	Multi source
C3	1	Capacitor 4.7 µF, 25 V 10% X7R 0603	
C4	1	Capacitor 100 nF, 16 V 10% X7R 0402	
C5, C7	2	Capacitor 10 nF, 16 V 10% X7R 0402	

1. Not fitted.

Table 4. ST25 Discovery - MB1396

ID	Quantity	Description	Manufacturer
C1, C8	2	Capacitor 1 µF, 25 V, 10% X5R 0603	Multi source
C2, C6	2	Capacitor 2.2 µF, 16 V, 10% X7R 1206	
C3	1	Capacitor 10 nF, 16 V, 10% X7R 0402	
C4, C5, C6, C7, C8, C11, C12, C14, C15, C16, C19, C22, C23, C24, C25, C26, C27, C28, C31, C35, C36, C38, C42, C43, C44, C45, C46, C47, C50, C51	30	Capacitor 100 nF, 16 V, 10% X7R 0402	
C9, C37, C48, C49, C54, C55	6	Capacitor 10 µF, 25 V, 10% X7R 0603	
C18, C33	2	Capacitor 4.7 nF, 50 V, 5% NPO 0402	
C20, C21, C30, C32	4	Capacitor 10 pF, 50 V, 5% NPO 0402	
C29	1	Capacitor 20 pF, 0402(1)	
C34	1	Capacitor 4.7 µF, 25 V, 10% X7R 0603	
C39, C40	2	Capacitor 100 nF, 0402(1)	
C52, C53	2	Capacitor 4.7 pF, ±0.25 pF 50 V, NPO 0402	
D1, D2, D3, D4, D5	5	Diode BAT60JFILM	STMicroelectronics
J1	1	Micro-USB AB 47590-0001	Molex
J2	1	Mini-USB B 5075BMR-05-SM	Neltron
J4	1	Connector SSW-114-02-G-S-RA	Samtec
J5, J6	2	Connector SSW-105-02-G-S-RA	
JP1, JP2, JP3, JP10, JP13, JP15	6	Connector TSW-102-07-G-S 1x2 pts	
JP4	1	Connector TSW-104-07-G-S 1x4 pts	
JP5	1	Connector TSW-105-07-G-S(1)	
JP6, JP7, JP8, JP9	4	Connector TSW-101-07-G-S 1Pt	
JP11	1	Connector TSW-104-07-G-D 2x4 pts	
JP12	1	Connector CES-107-01-L-D	
JP14	1	Connector TSW-1xx-07-G-S 1x3 pts and 1x1 pt	
JP16	1	Connector TSW-103-07-G-S 1x3 pts	
L1, L3	2	EMI ferrite bead 600 Ω 742792042	Wurth Elektronik
L2, L6, L8	3	Common mode filter 744232090	
L4, L7	2	EMI ferrite bead 300 Ω 742792641	

Table 4. ST25 Discovery - MB1396 (continued)

ID	Quantity	Description	Manufacturer
L5	1	Ferrite chip bead FCM1608KF-601T03	TAI-TECH
L9	1	SELF BLM18EG471SN1D	Murata
LCD1	1	LCD module FRD24048TP(1)	Shenzen Frida
LD1	1	LED Green 19-21SYGC/S530-E1/TR8	EVERLIGHT
LD2	1	LED Yellow TLMY1000-GS08	Vishay
LD3	1	LED Orange 19-217/S2C-AM2N2VY/3T	EVERLIGHT
LD4	1	LED bicolor HSMF-A201-A00J1	AVAGO
LD6, LD7, LD8	3	LED Green 19-21SYGC/S530-E1/TR8(1)	EVERLIGHT
PEG1, PEG2, PEG3, PEG4, PEG5	5	Self adhesive rubber bumper SJ5306	3M
Q1	1	Transistor MMBT9013L-G-AE3 SOT23	UNISONIC TECHNOLOGIES
Q2	1	Transistor STR2P3LLH6 SOT23	STMicroelectronics
R1, R3, R9, R12, R13, R14, R15, R20, R21, R23, R27, R41, R42, R46, R47, R49, R50, R53, R54, R56, R71, R72, R77, R78, R86, R104, R113	27	Resistor 0R 0402	Multi source
R2, R110	2	Resistor 510R 1% 0402	
R4, R25, R33, R39, R43, R48, R51, R52, R62, R65, R67, R70, R74, R75, R83, R97, R109, R122	18	Resistor 0402(1)	
R5, R7, R36, R37, R103	5	Resistor 10R 1% 0402	
R6	1	Resistor 47R 1% 0402	
R8, R40, R118, R119, R120, R121	6	Resistor 0R 0402(1)	
R10, R38	2	Resistor 1 MΩ, 1% 0402	
R11	1	Resistor 360R 1% 0402	
R16, R105, R106, R107, R108, R114	6	Resistor 1.5 kΩ,1% 0402	
R17, R90, R91, R93	4	Resistor 680R 1% 0402	

Table 4. ST25 Discovery - MB1396 (continued)

ID	Quantity	Description	Manufacturer
R18, R24, R26, R63, R64, R66, R68, R69, R73, R76, R79, R80, R81, R82, R89, R112	16	Resistor 4.7 KΩ, 1% 0402	Multi source
R19, R28, R30, R117	4	Resistor 100R, 1% 0402	
R22	1	Resistor 4.3 Ω, 1% 0402(1)	
R29	1	Resistor 100R 0402(1)	
R31, R32, R35, R55, R84, R85, R87, R88	8	Resistor 100 KΩ, 1% 0402	
R34, R94, R95, R98, R99, R100, R101, R102, R115	9	Resistor 10 KΩ, 1% 0402	
R44, R96	2	Resistor 47 KΩ, 1% 0402	
R45	1	Resistor 15 KΩ, 1% 0402	
R92	1	Resistor 4.7kΩ, 1% 0402(1)	
R111	1	Resistor 2.7 kΩ,1% 0402	
R116	1	Resistor 36 KΩ, 1% 0402	
SB1, SB2, SB3, SB4, SB5, SB6, SB7, SB8, SB9, SB10, SB11, SB12, SB13, SB14	14	Solder bridge open size 0603	-
SW1	1	Push button TD-0341X BLUE BUTTON	WEALTH METAL
SW2	1	Push button TD-0341X BLACK BUTTON	
SW3	1	Push button TD-0341X BLACK BUTTON(1)	
SW4	1	Joystick MT-008A	
TP1, TP2, TP3, TP4, TP5	5	Plated hole diameter 1.0 mm	-
TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP17, TP18, TP19, TP20, TP21, TP22, TP23, TP26	17	Testpoint copper land diameter. 0.8 mm	-
U1	1	Regulator LD39050PUR	STMicroelectronics
U2	1	STM32L476VGT6	
U3	1	Digital pot AD5112BCPZ10(1)	Analog Devices
U4	1	Level shifter SN74LVC2T45DCUT VSSOP8	TI

Table 4. ST25 Discovery - MB1396 (continued)

ID	Quantity	Description	Manufacturer
U5	1	STM32F103CBT6	STMicroelectronics
U6	1	Touchscreen controller STMPE811QTR(1)	
U7	1	WiFi® module SPWF01SA.11(1)	
U8	1	Bluetooth® module SPBTLE-RF(1)	
Y1, Y2	2	SMD Crystal NX3225GD 8 MHZ EXS00A-CG04874	NDK
Y3	1	SMD Crystal NX3215SA 32.768 KHZ	

1. Not fitted.

6 Schematics

Figure 3. Epaper daughter board

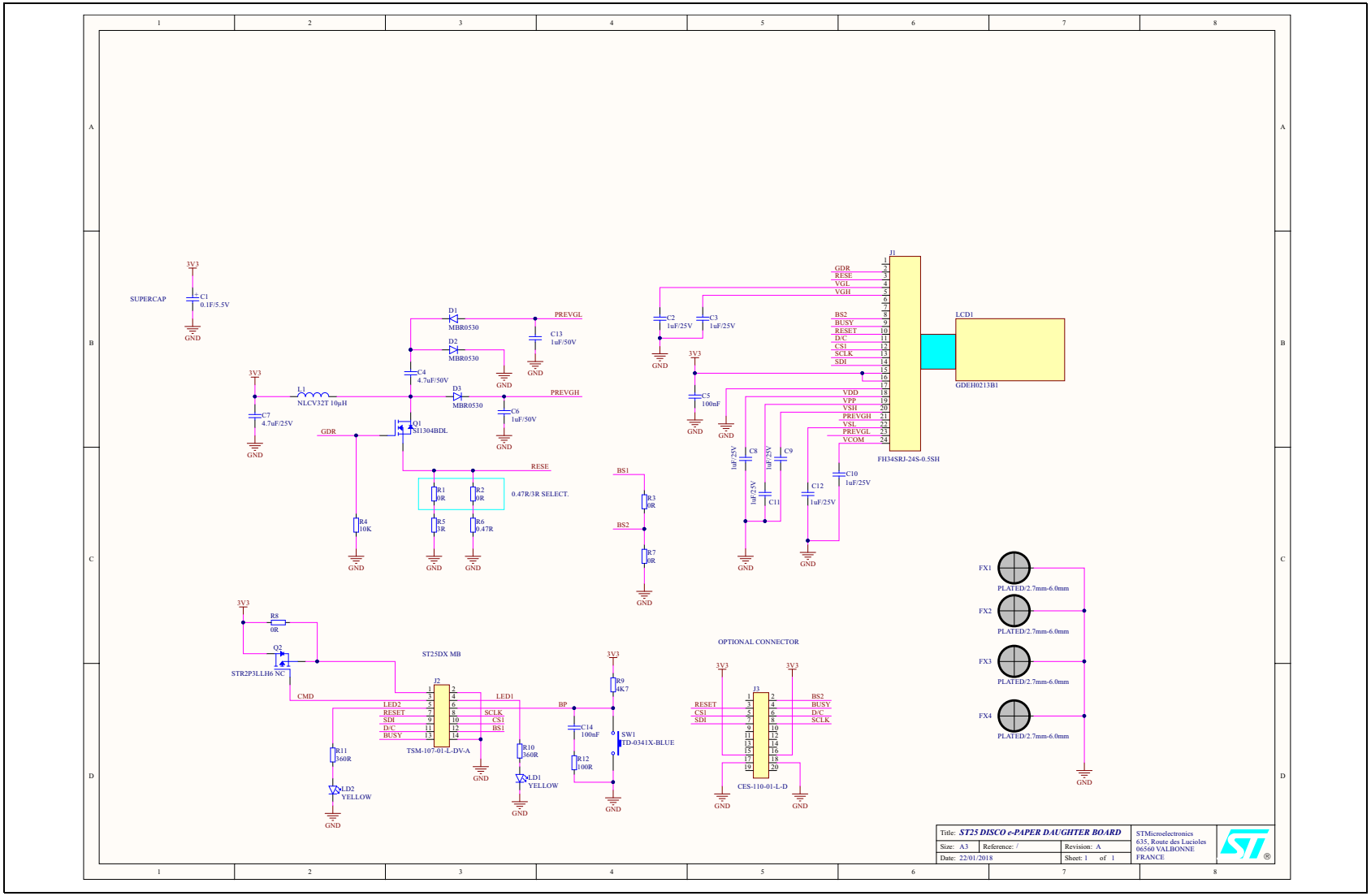


Figure 4. ST25 Discovery ANT_C1

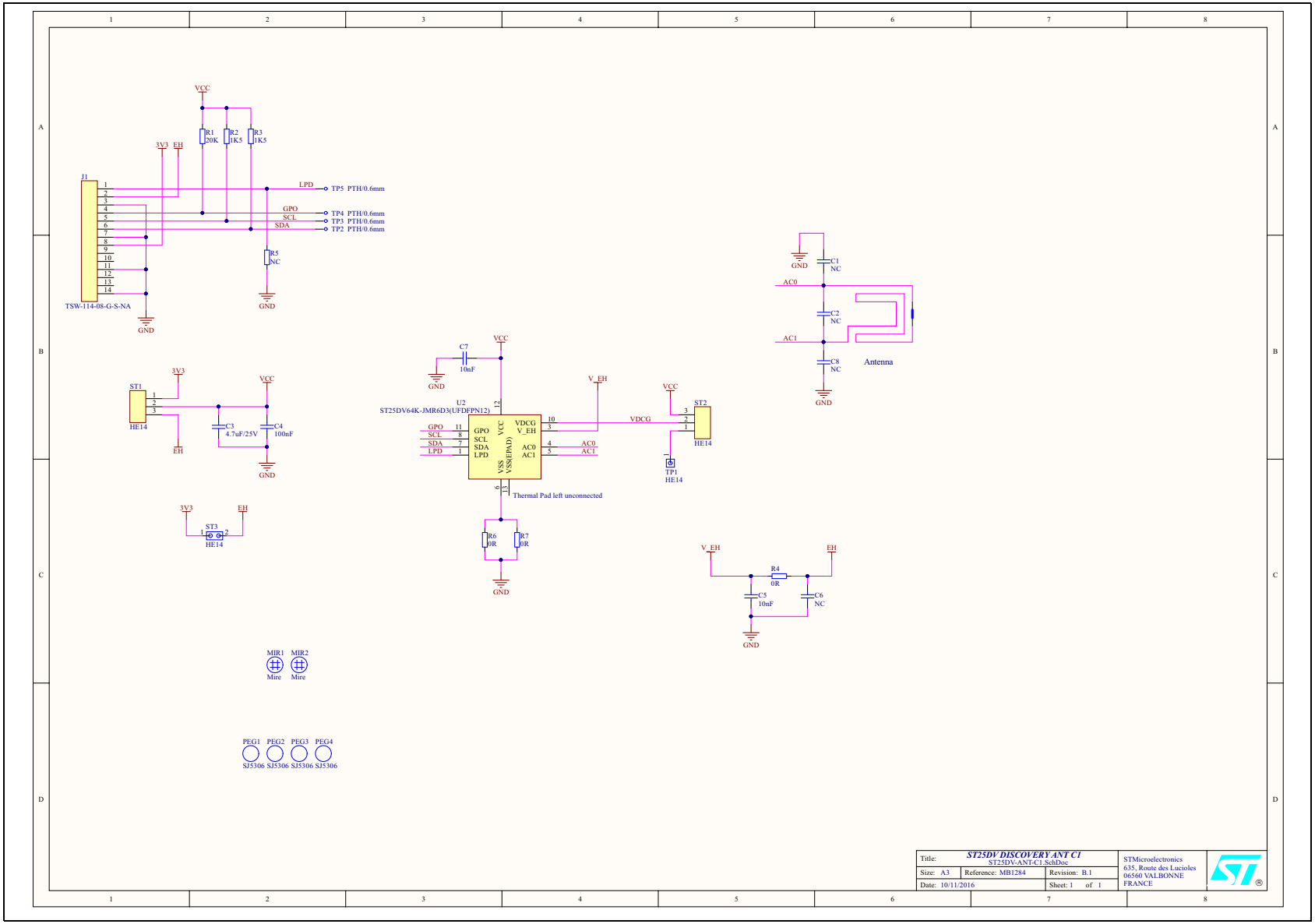


Figure 5. ST25 Discovery MB1396 - Top level

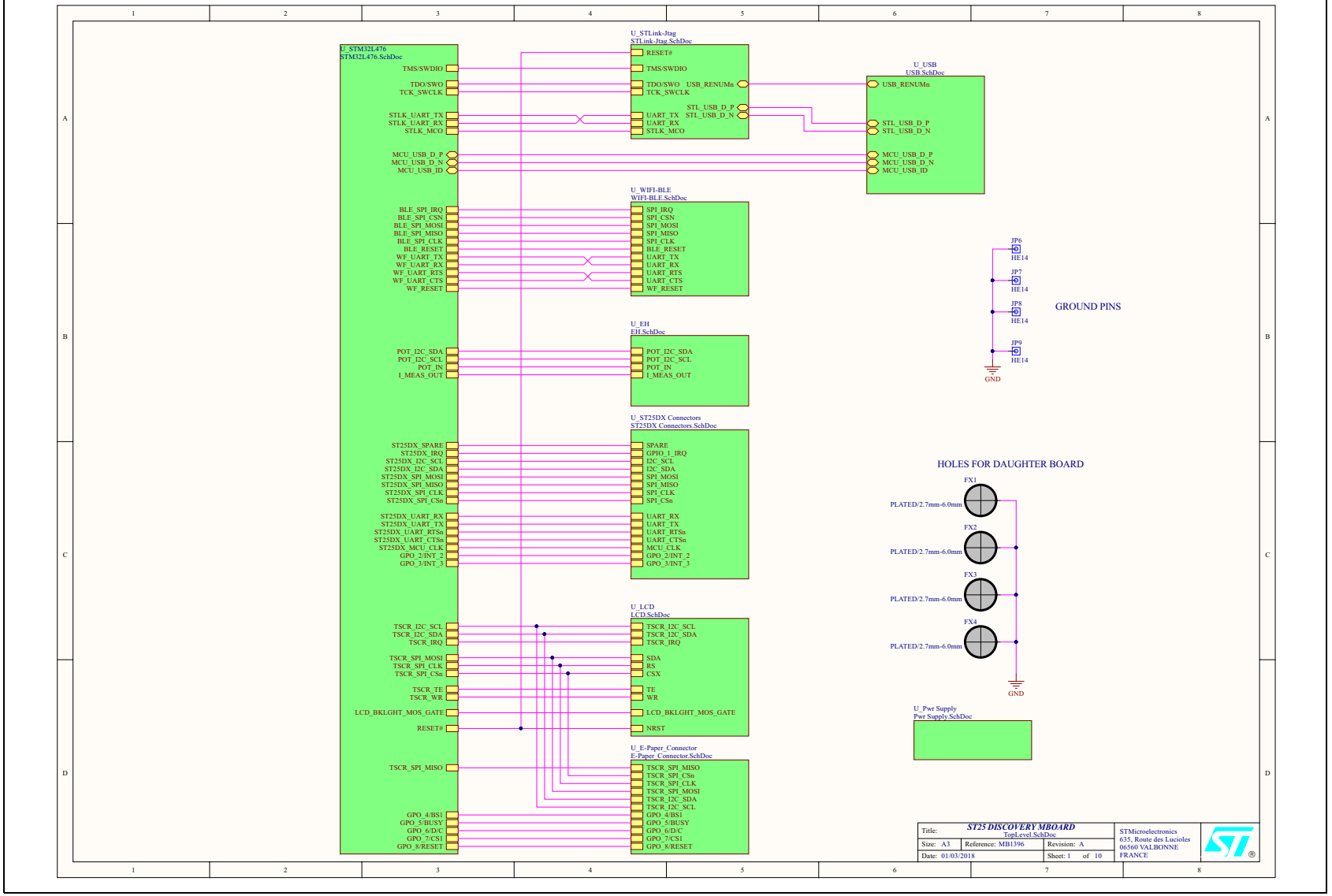


Figure 6. ST25 Discovery MB1396 - Power supply

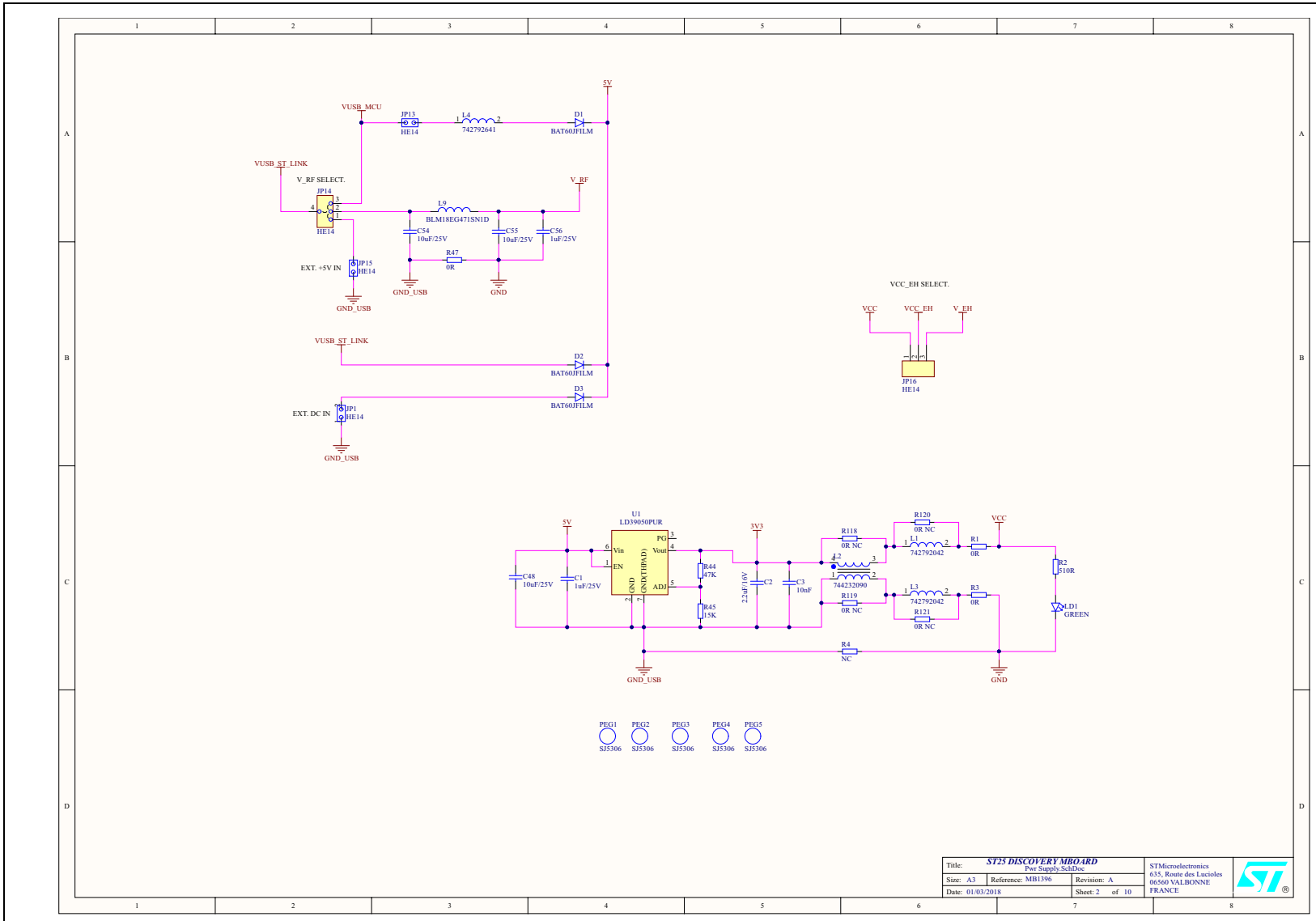


Figure 7. ST25 Discovery MB1396 - STM32L476 block

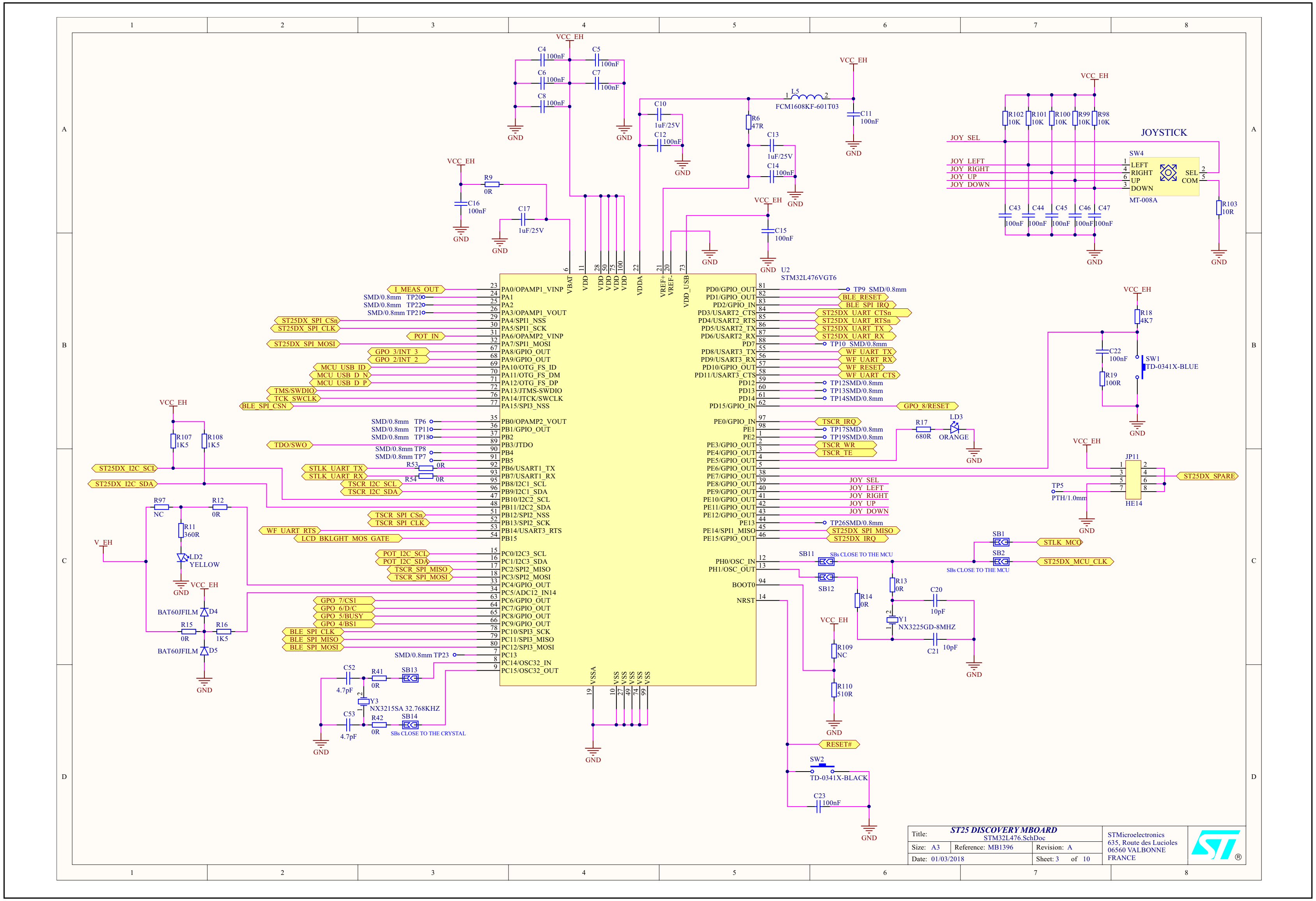


Figure 8. ST25 Discovery MB1396 - Energy harvesting

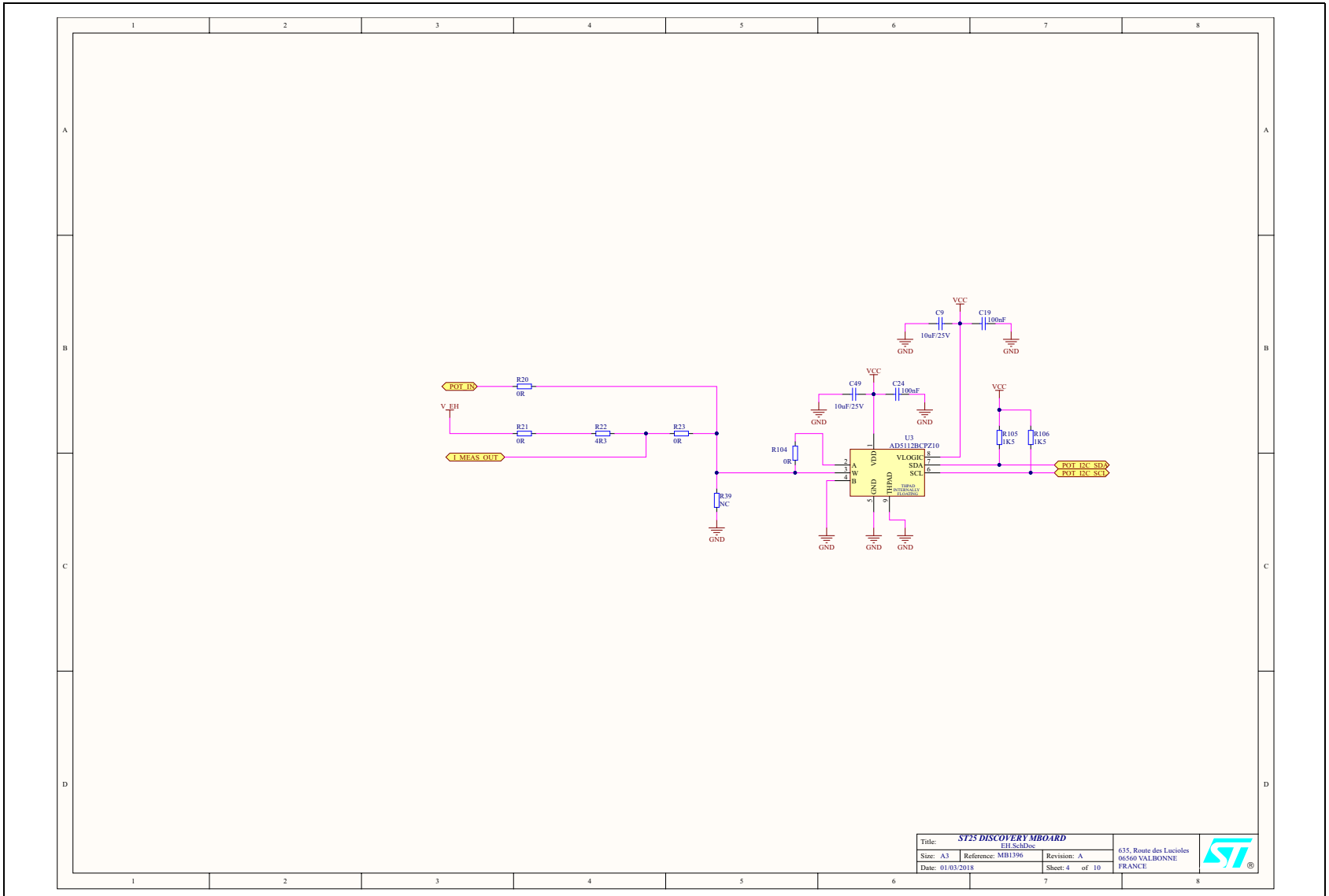


Figure 9. ST25 Discovery MB1396 - ST Link

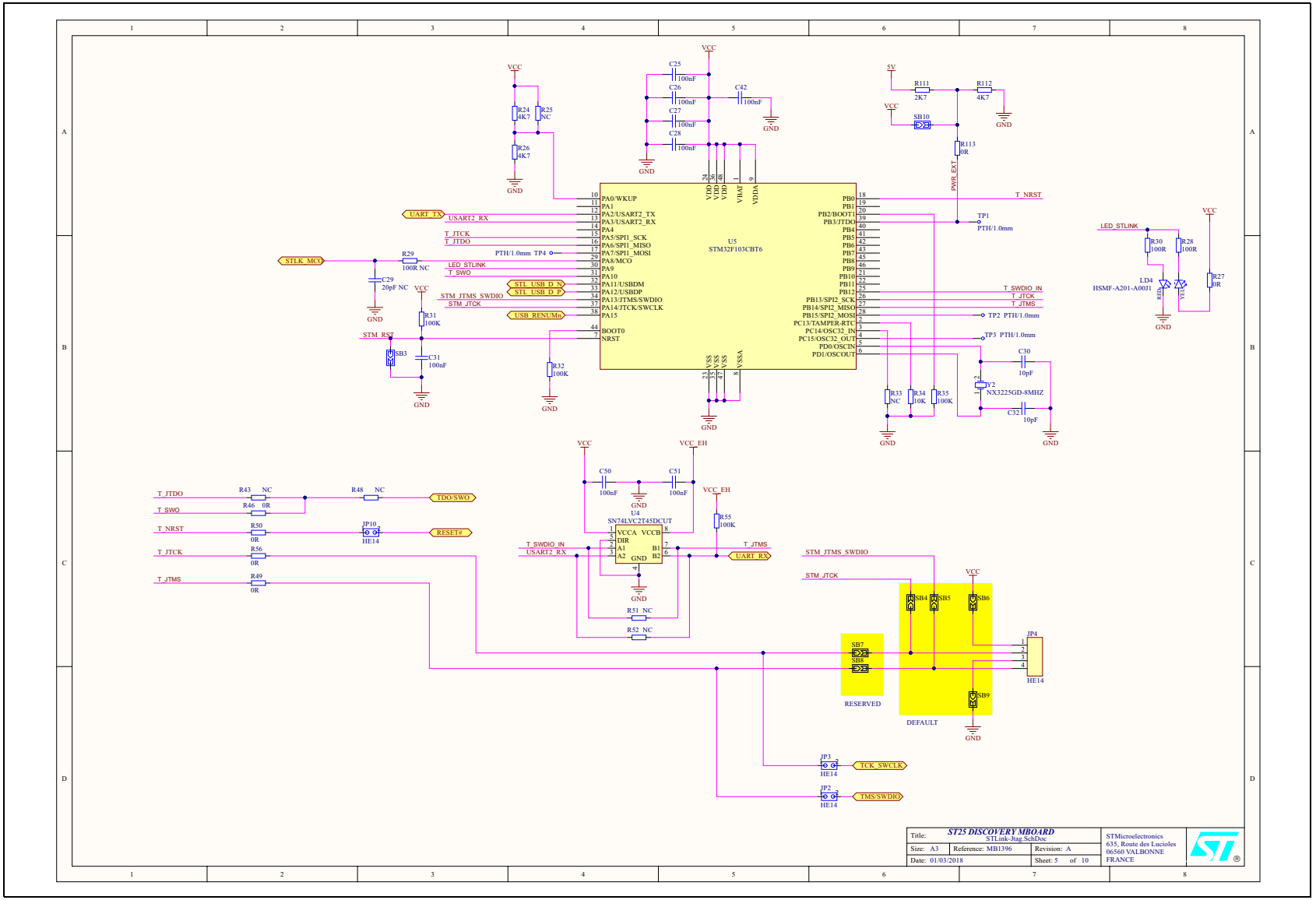


Figure 10. ST25 Discovery MB1396 - LCD

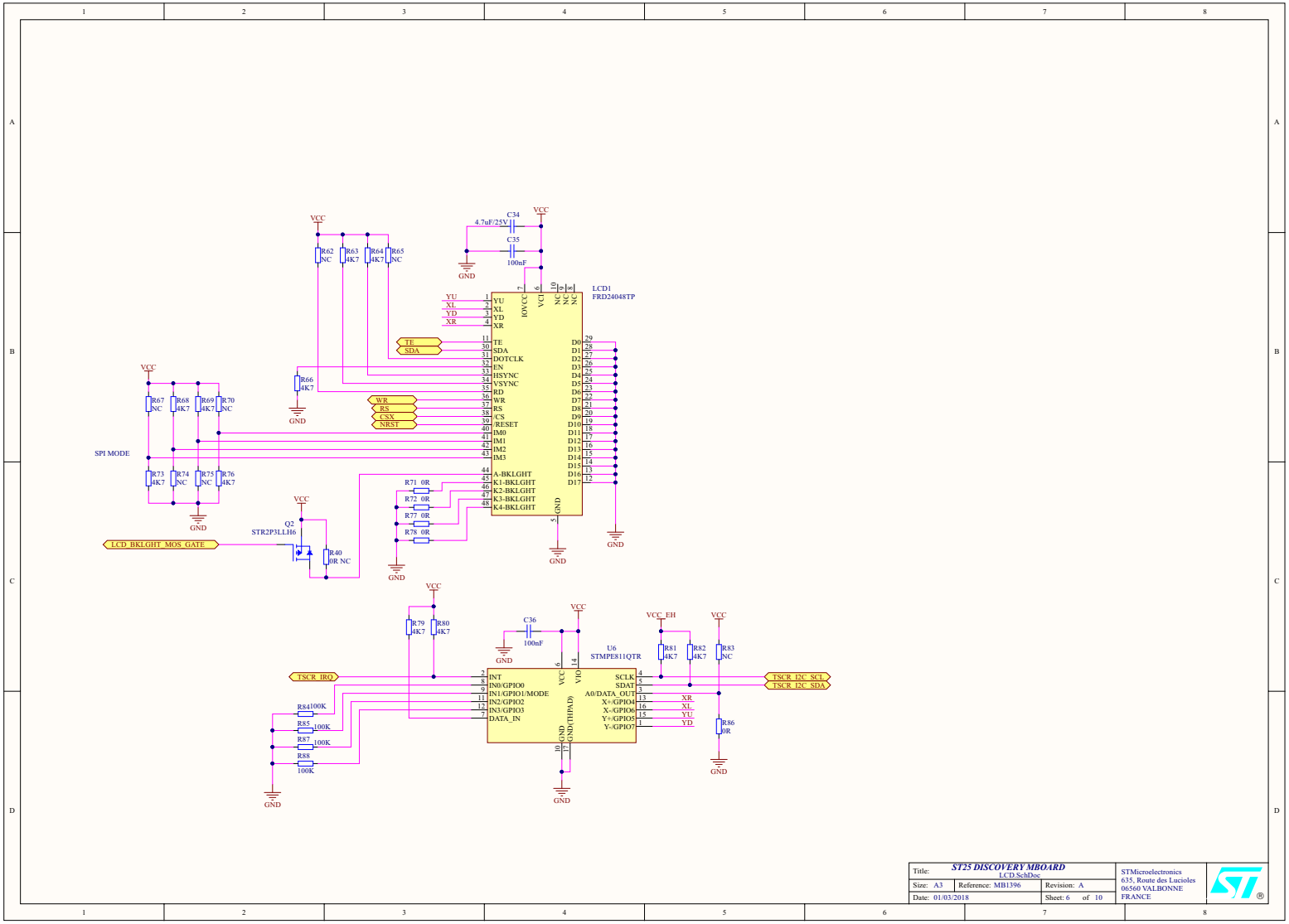


Figure 11. ST25 Discovery MB1396 - WiFi® and Bluetooth® Low Energy

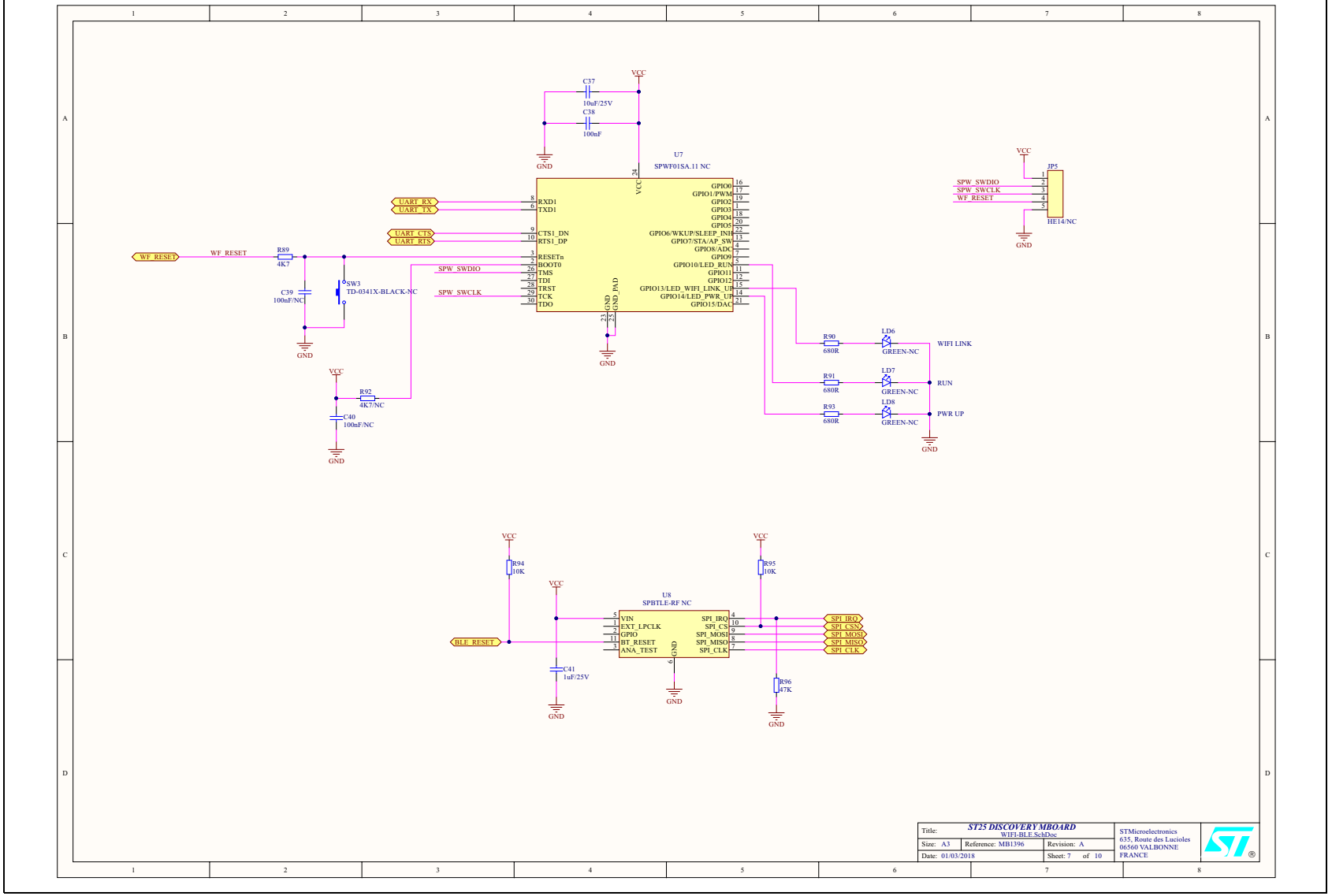


Figure 12. ST25 Discovery MB1396 - ST25 connector

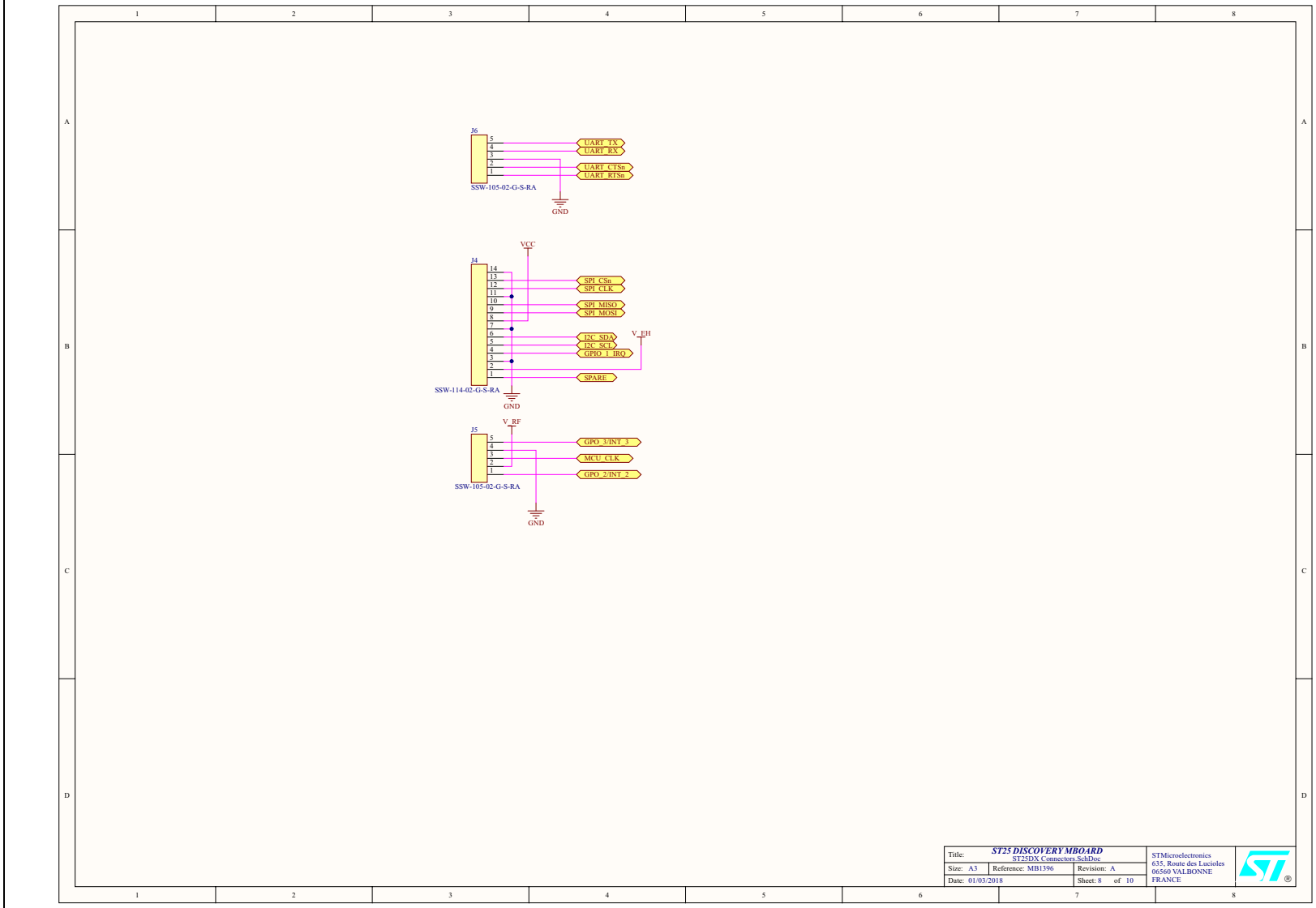
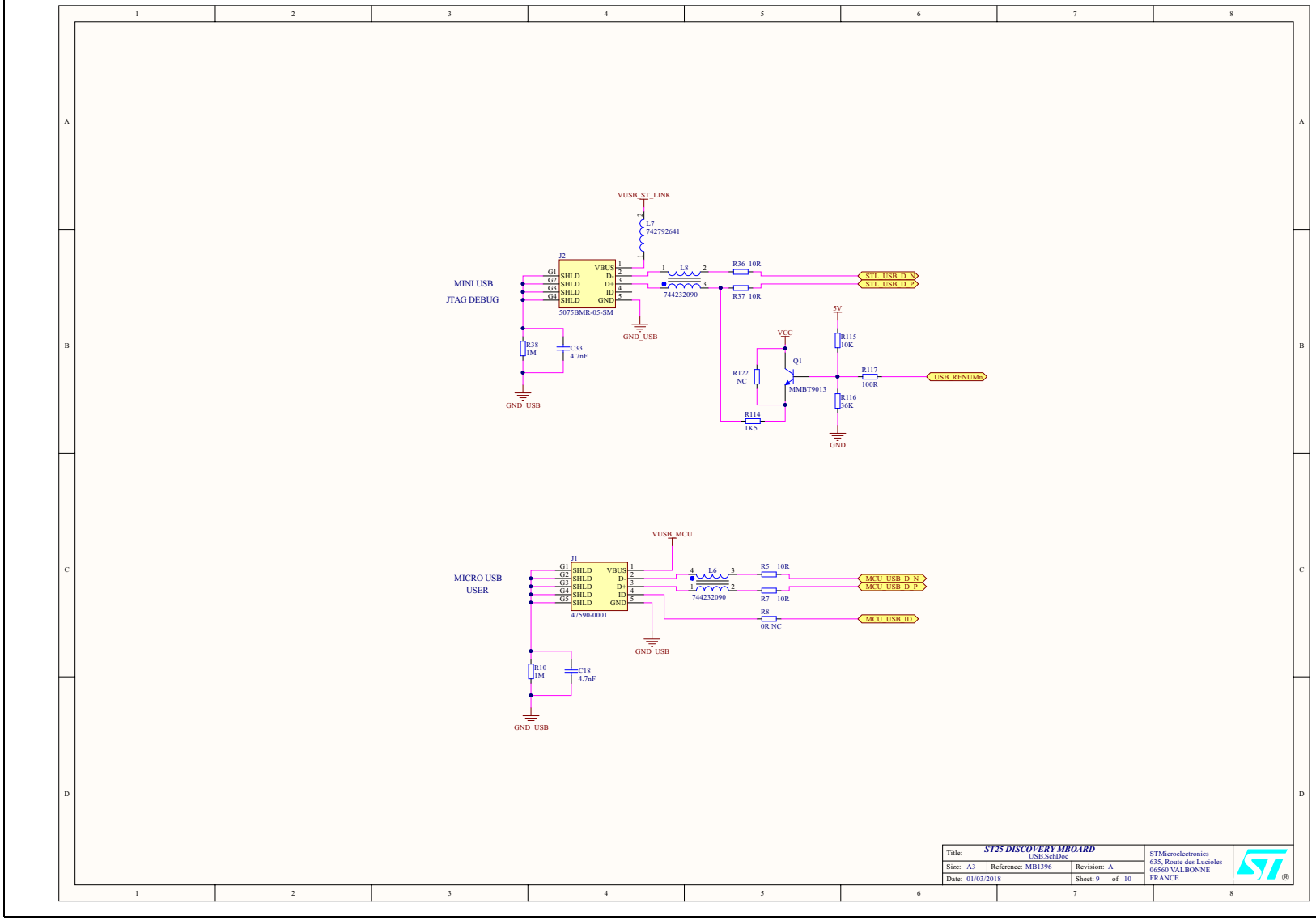


Figure 13. ST25 Discovery MB1396 - USB



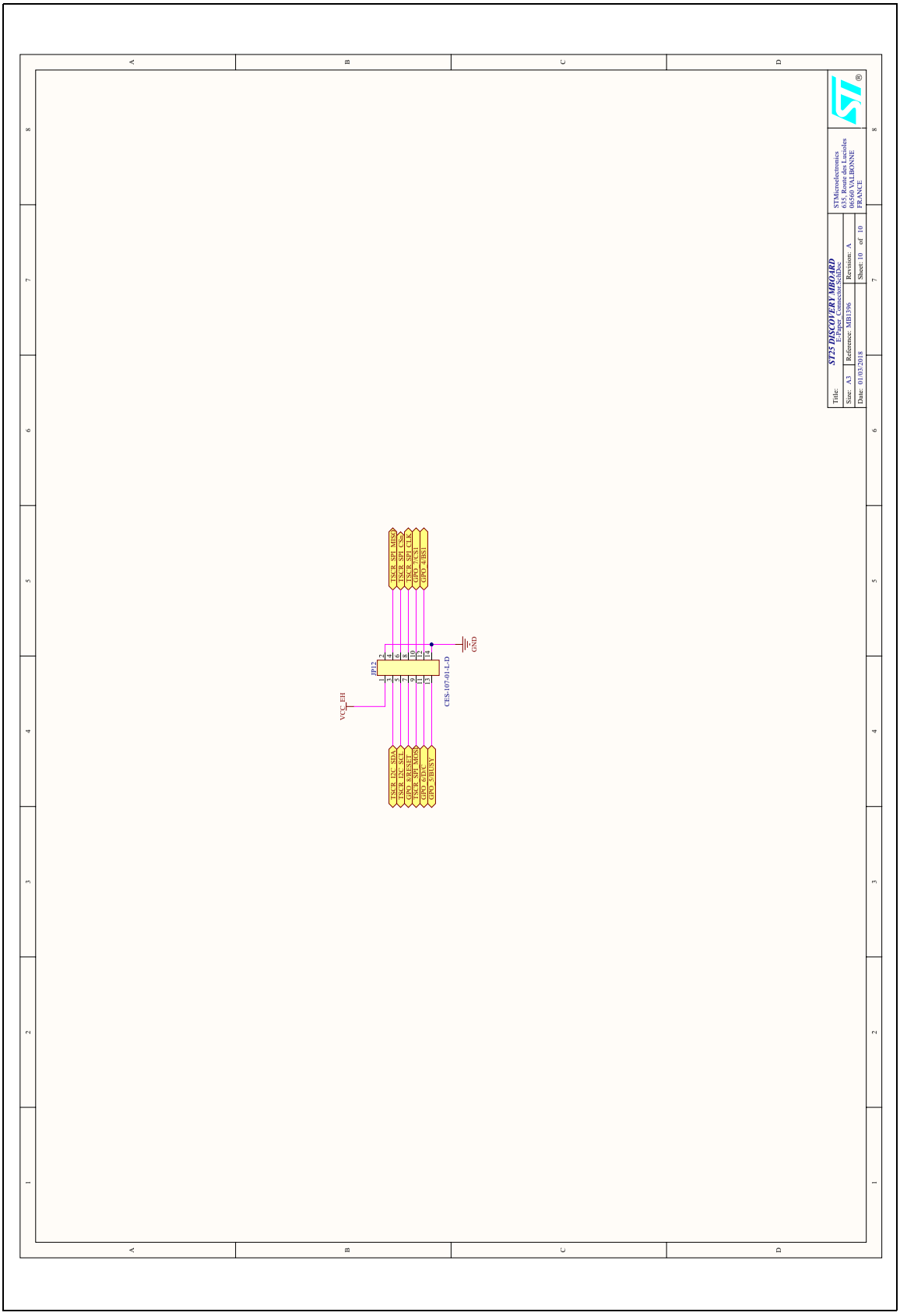


Figure 14. ST25 Discovery MB1396 - E-paper connector

7 Revision history

Table 5. Document revision history

Date	Revision	Changes
24-Sep-2018	1	Initial release.