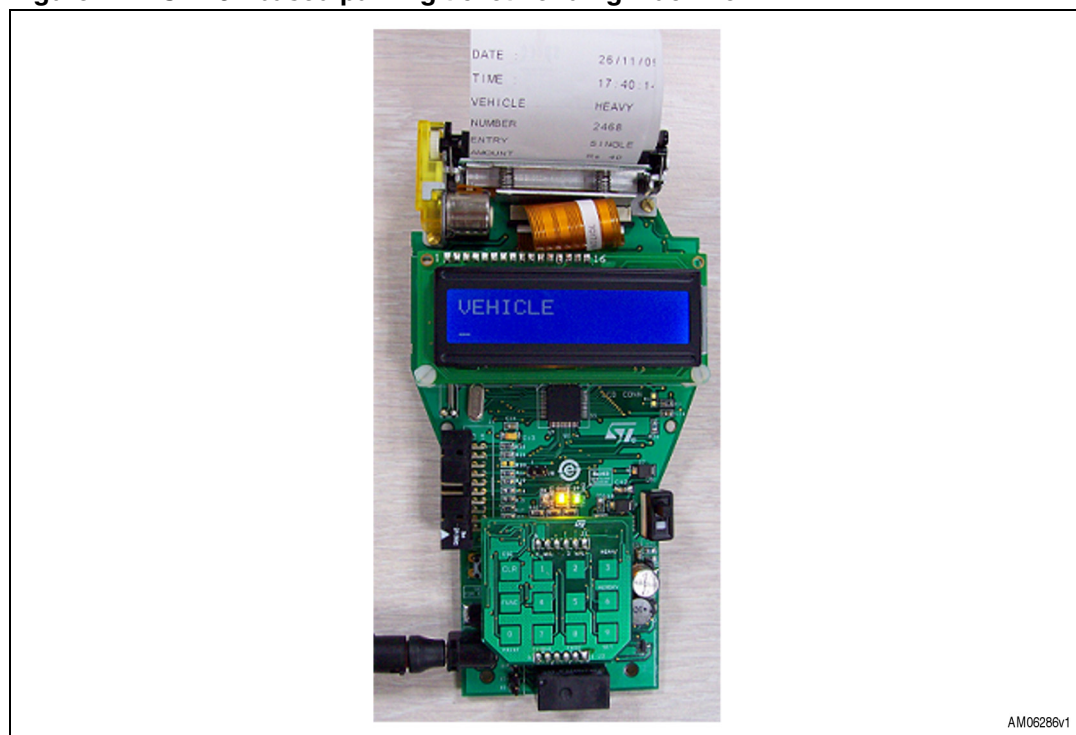


STEVAL-IPC002V1 demonstration board for parking ticket vending machine

Introduction

A parking ticket vending machine is a hand-held, battery operated device, inside of which a thermal printer is interfaced with the STM32 microcontroller from STMicroelectronics. This document focuses on the STEVAL-IPC002V1 demonstration board, whose objective is to print and generate parking tickets for different types of vehicles. The application can easily be modified to suit other applications where paper printing is to be managed directly by the microcontroller, such as POS-based applications, railway and bus ticket printing applications, standalone printers, and the like.

Figure 1. STM32-based parking ticket vending machine



The thermal printer has an in-built stepper motor for thermal paper feeding, paper movement, and so on. The stepper motor is controlled by a dedicated stepper-motor driver with an SPI interface. The system operates on two Li-Ion batteries and an optional DC adaptor. On-board battery chargers are available to charge the batteries from the DC adaptor. The data to be printed is entered by way of touch keys, and can be verified on an alphanumeric LCD.

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1 Definitions

Table 1. Definitions

Acronym	Definition
ESD	Electrostatic discharge
I2C	Inter-integrated circuit
JTAG	Joint test action group
LCD	Liquid crystal display
MCU	Microcontroller unit
POS	Point of sale
PTVM	Parking ticket vending machine
RTC	Real time clock
SPI	Serial peripheral interface

2 Features

The STM32-based demonstration board has the following key features.

- Thermal printer interfaced through SPI2.
- Stepper motor driver interfaced through SPI1 used to rotate the printer head while printing.
- S-Touch™-based keypad for user interfacing. The S-Touch™ controller device is interfaced through the I2C2. The keypad is used to enter the vehicle number and other parameters, and set the date and time.
- LED indication for battery status.
- On-board JTAG connector for firmware upgrades and changes.
- Alphanumeric LCD for displaying numbers and settings entered through the S-Touch™ keypad.
- SPDT switch for switching the system ON and OFF.
- Push button switch for resetting the system.
- Rechargeable battery circuit.
- On-board power supply. The entire system can be powered by either a DC adaptor (9 V, 2.5 A) or battery (2 batteries of 3.7 V each, 1.8 Ah ratings).
- Thermistor to monitor the temperature of the thermal head.
- STM32 in-built RTC (real time clock) that provides date and time of printing.
- EEPROM interfaced through I2C1. The last 20 vehicle numbers are stored in the EEPROM.

3 Getting started

3.1 Package

The STM32-based parking ticket vending machine demonstration board includes the following items.

- Hardware:
 - demonstration board
- Documentation:
 - this user manual
 - schematics, gerber files, BOM
- Firmware:
 - pre-programmed STM32 device soldered on the demonstration board
 - object files for the firmware

3.2 Hardware installation

The following instructions are for setting-up the STM32-based parking ticket vending machine demonstration board.

1. Connect the 9 V, 2.5 A DC adaptor or connect two Li-Ion batteries (3.7 V, 1800 mAh) to the connectors B1+, B1-, B2+ and B2-.
2. Feed the thermal paper (50 to 52 mm width) with the glossy (thermal printing) side up as shown in [Figure 2](#).

Note: Avoid running the demonstration board without inserting the thermal paper since this can cause the printer to overheat and cause permanent damage.

3. Switch on the board (SPDT ON/OFF power switch).
You should now see the word "VEHICLE" on the LCD.
4. Select the vehicle type by pressing one of the following key combinations.
 - 4 WHL: FUNC + 1
 - 2 WHL: FUNC + 2
 - HEAVY FUNC + 3

For example, to select a 4 WHL type vehicle, press "FUNC" (function key) and then "1".
The selected vehicle type is displayed on the LCD for 1 second.
5. The word "ENTRY" appears on the LCD. Press one of the following key combinations to select the entry type.
 - SINGLE: FUNC + 7
 - PASS: FUNC + 8

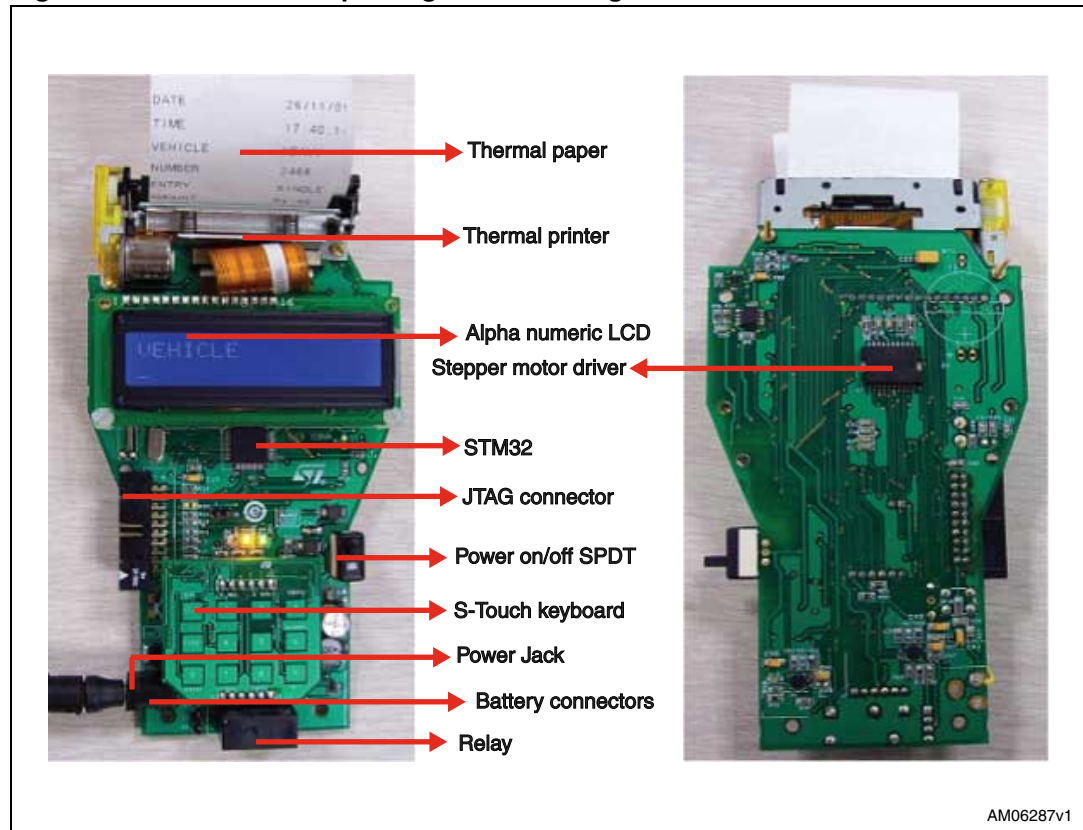
The selected entry type is displayed on the LCD for 1 second.
6. Enter the vehicle number (last 4 digits) by pressing the corresponding numeric keys on the keypad.
The number is now displayed on the LCD.
7. Send the print command by pressing the PRINT function (FUNC + 0).
The ticket is printed.

The time can be set by pressing the SET function (FUNC + 9).

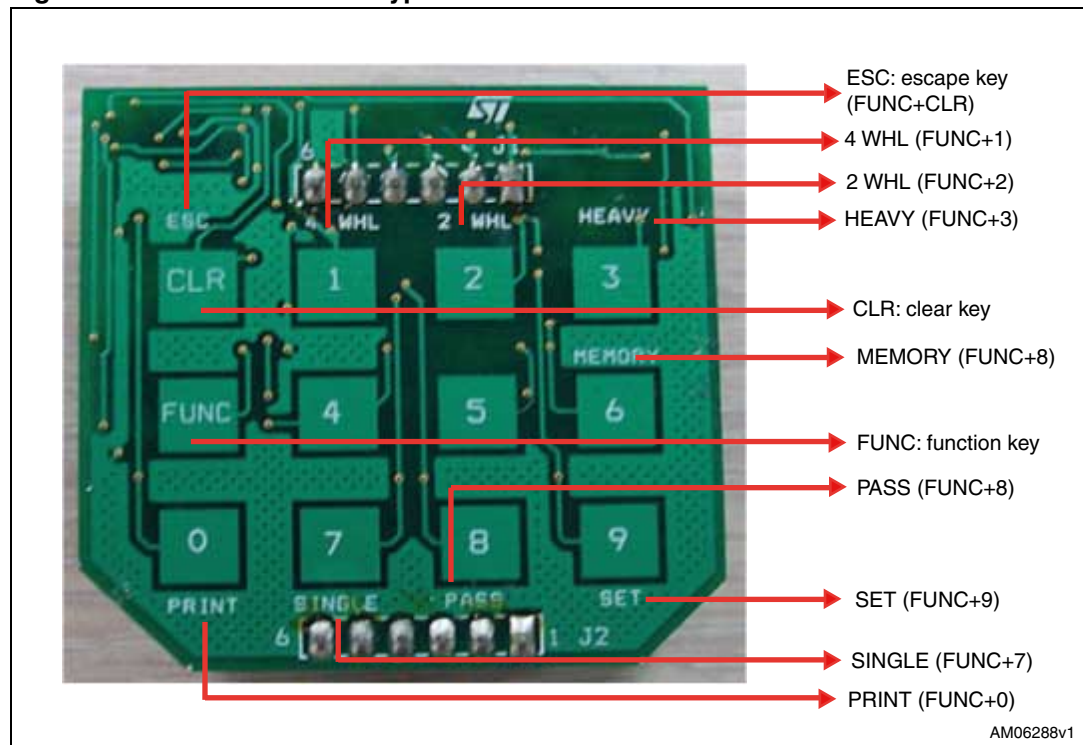
The 9 V adaptor is used to charge the batteries through the on-board battery charger.

To see the last 20 entries, press "FUNC" and then "6".

Figure 2. STM32-based parking ticket vending machine demonstration board



8. To replace the thermal paper, pull the black roll out of the printer. Place the paper (50 to 52 mm width) so that the glossy side faces up as shown in [Figure 2](#). Put the black roll back into place. If the paper is not inserted correctly the printout may not come out properly.

Figure 3. S-Touch-based keypad

The vehicles are categorized as follows:

- 4 WHL = 4-wheelers (cars)
- 2 WHL = 2-wheelers (bikes and scooters)
- HEAVY = heavy vehicles such as trucks or buses

The entry types are:

- Single = single entry/exit
- PASS = the user has a pass for multiple entries and exits.

Figure 4 shows a sample printed ticket generated from the PTVM.

Figure 4. Sample printed ticket

DATE	26 / 11 / 09
TIME	15 : 23 : 39
VEHICLE	4 WHL
NUMBER	0355
ENTRY	SINGLE
AMOUNT	Rs 20

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3.3 Hardware layout

The STM32-based parking ticket vending machine demonstration board is built using STMicroelectronics' ARM® Cortex-M3 core-based STM32F103RBT6 in a 64-pin LQFP64 package. The components used on this board are listed below. [Figure 5](#) and [Figure 6](#) provide the component layouts to assist you in locating the different component sections on the board.

- ST components:
 - STM32F103RBT6 (32-bit MCU)
 - L9935 (stepper motor driver)
 - STMPE1208S (S-Touch keypad)
 - M24C01-W (EEPROM)
 - L6924D (battery charger)
 - L5987A (step-down voltage regulator)
 - STM1061N31WX6F (low-power voltage detector for battery monitoring)
- Non-ST components:
 - FM205-HS (thermal printer)
 - 16X2 alphanumeric LCD

Refer to the bill of materials in [Chapter 5](#) for a detailed list of components.

Figure 5. Hardware layout: main board - top side

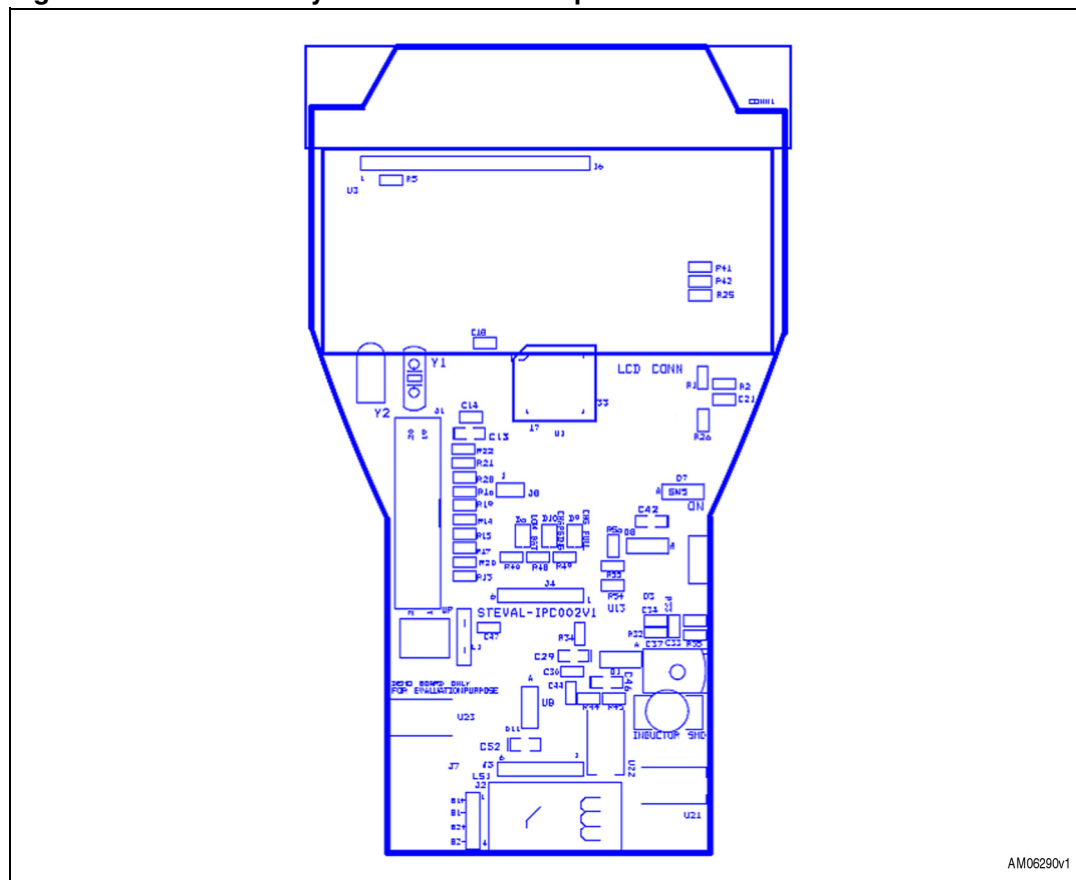


Figure 6. Hardware layout: main board - bottom side

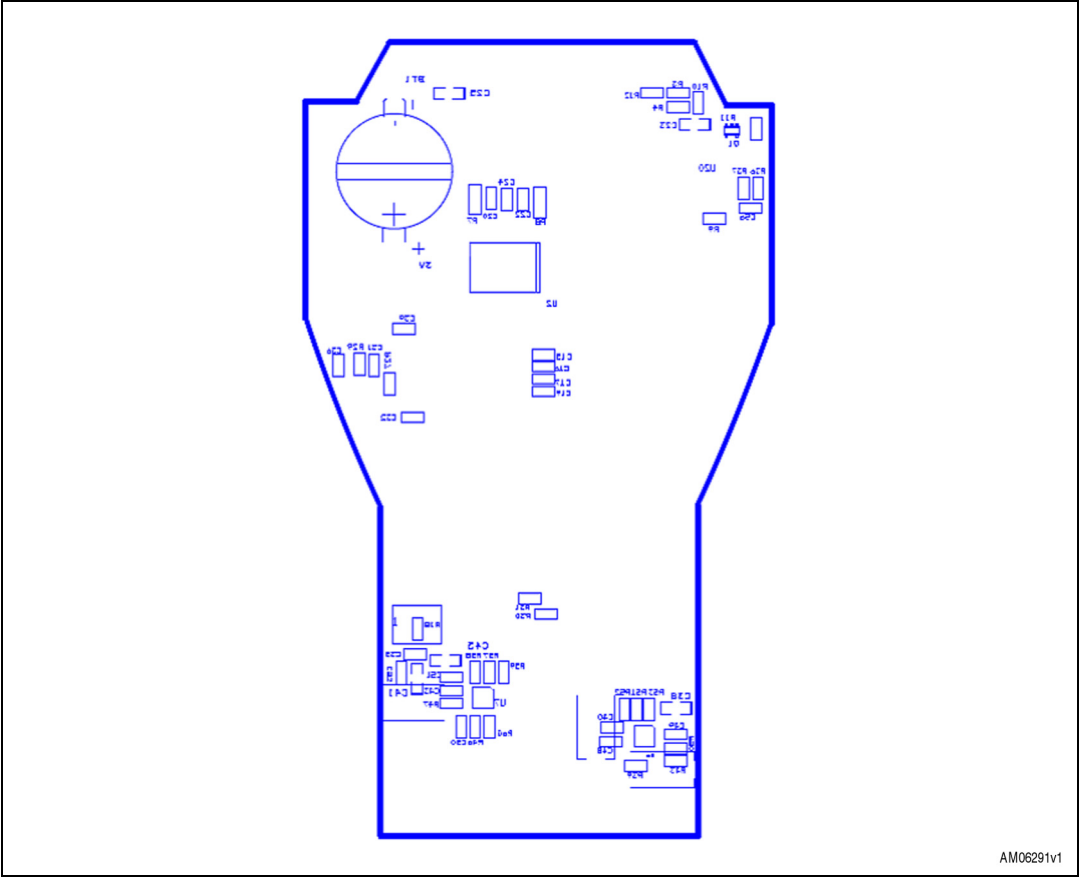


Figure 7. Hardware layout: daughterboard S-Touch keypad - top side

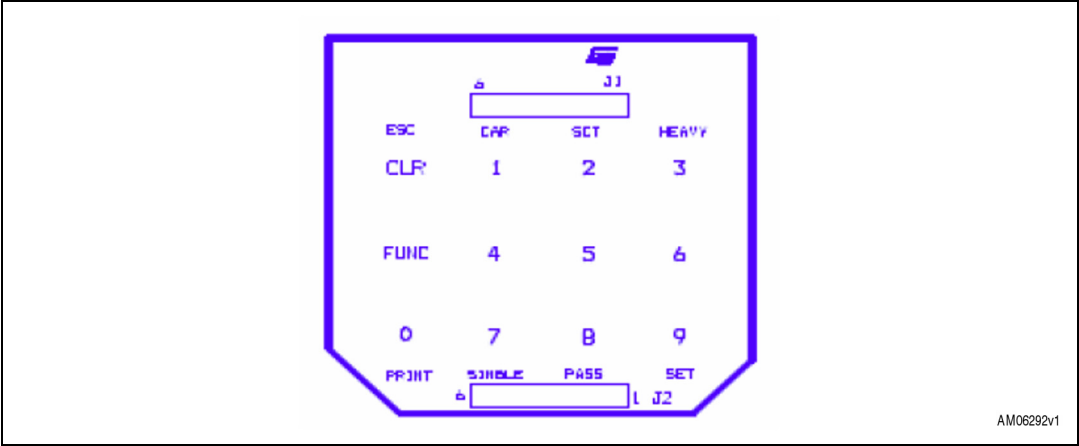
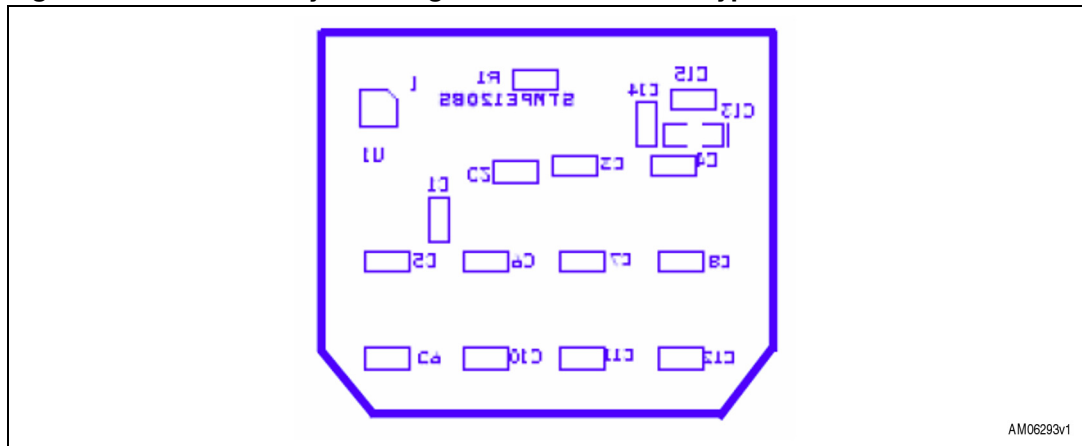
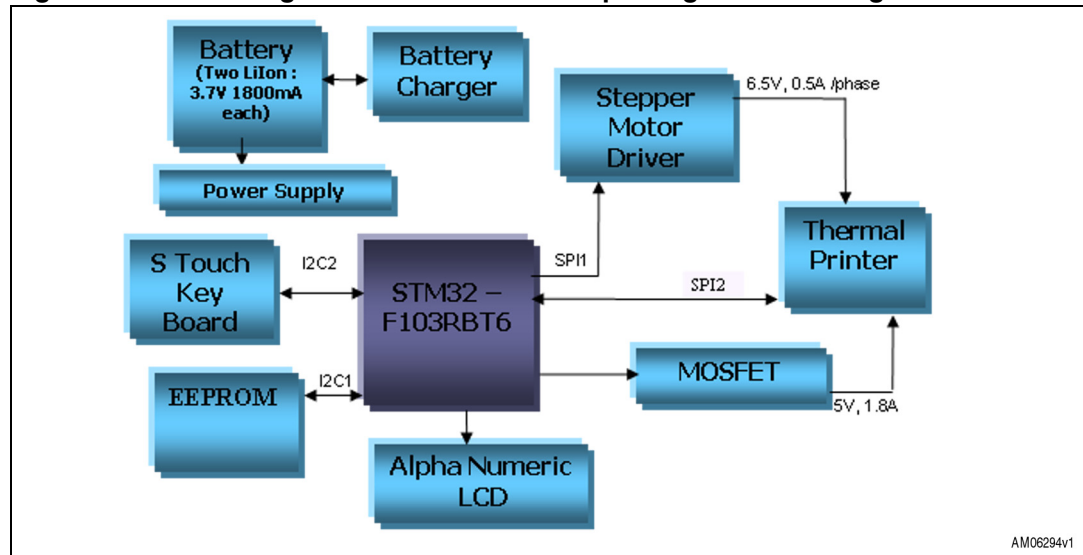


Figure 8. Hardware layout: daughterboard S-Touch keypad - bottom side

4 System overview

4.1 Hardware design

Figure 9. Block diagram of an STM32-based parking ticket vending machine



As shown in [Figure 9](#), the principal system controller is the STM32 microcontroller. [Figure 12](#) and [Figure 13](#) show the power management blocks in more detail.

4.1.1 Microcontroller(STM32)

The STM32 is a 32-bit MCU based on the popular ARM 32-bit Cortex™-M3 CPU running at 72 MHz with a performance of 90 DMIPS with 1.25 DMIPS/MHz. The microcontroller incorporates single-cycle multiplication and hardware division functions. It has 80 fast general-purpose I/Os to enhance the overall performance. The I/Os are 5-volt tolerant.

The microcontroller has several communication interfaces, including multiple I2Cs, USARTs (4.5 Mbps) and SPIs, a CAN 2.0B active interface and a USB 2.0 interface. For more information, go to <http://www.st.com>.

The microcontroller works on a single voltage ranging from 2 to 3.6 V, unlike some other microcontrollers that require a dual voltage. In this application the system operates at 3.3 V.

4.1.2 Battery connector

B1+ and B1-, B2+ and B2- are the four pins of the battery connector. Two Li-Ion batteries of 3.7 V and 1800 mAh are to be connected with correct polarity.

4.1.3 Thermal printer (FM205-HS)

The thermal printer is a compact, high-speed thermal line dot printing mechanism. It can be used with a measuring instrument and analyzer, a POS, a communication device or a data terminal device.

The paper is fed in a forward direction when the motor shaft is rotating in the normal direction (clockwise) as seen from the motor gear side. The motor is driven by a 2-2 phase excitation, constant-current chopper method and feeds 0.125 mm of paper (equivalent to a single dot pitch) every two steps of the motor drive signal. It is not possible to print while the motor is rotating in the reverse direction.

Excitation sequence

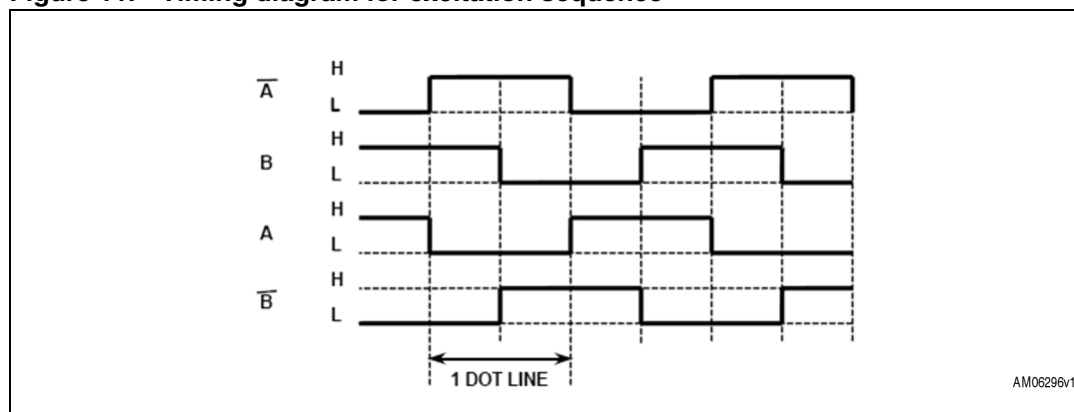
As shown in [Figure 10](#), the printer feeds the paper in the normal direction when the motor is excited in the order of step 1, step 2, step 3, step 4, step 1, step 2... On the other hand, to rotate the motor in the reverse direction, the motor must be driven in the reverse order: step 4, step 3, step 2, step 1, step 4, step 3, etc.

Figure 10. Truth table for excitation sequence

Signal Name	Sequence			
	Step 1	Step 2	Step 3	Step 4
$\overline{A}$	Low	High	High	Low
B	High	High	Low	Low
A	High	Low	Low	High
$\overline{B}$	Low	Low	High	High

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Figure 11. Timing diagram for excitation sequence



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4.1.4 Alphanumeric LCD

A 16 by 2 cm alphanumeric LCD displays the entries entered through the keypad.

4.1.5 EEPROM

The EEPROM maintains records and stores the last 20 entries.

4.1.6 S-Touch-based keypad

The demonstration board incorporates an S-Touch keypad based on the STMPE1208SQTR to navigate through the menus. This keypad is a 12-key daughterboard. [Figure 3](#) shows the placement of the keys.

4.1.7 Power supply unit

The power block is the main module of any hand-held system. This application requires several voltages (3.3 V, 5 V, 6.5 V) to drive the various board components. The board can be used in standalone/hand-held mode with two batteries. The circuit is implemented so that the batteries are charged individually and in parallel by dedicated battery chargers, and while discharging (application running on the batteries) they are connected in series. This switching is done through a relay.

If the DC adaptor is plugged in, the voltage from the voltage regulator output excites the relay, which changes the series connection of the batteries to a parallel connection and all the power is taken from the adaptor.

Figure 12. Power block of STM32-based parking ticket vending machine

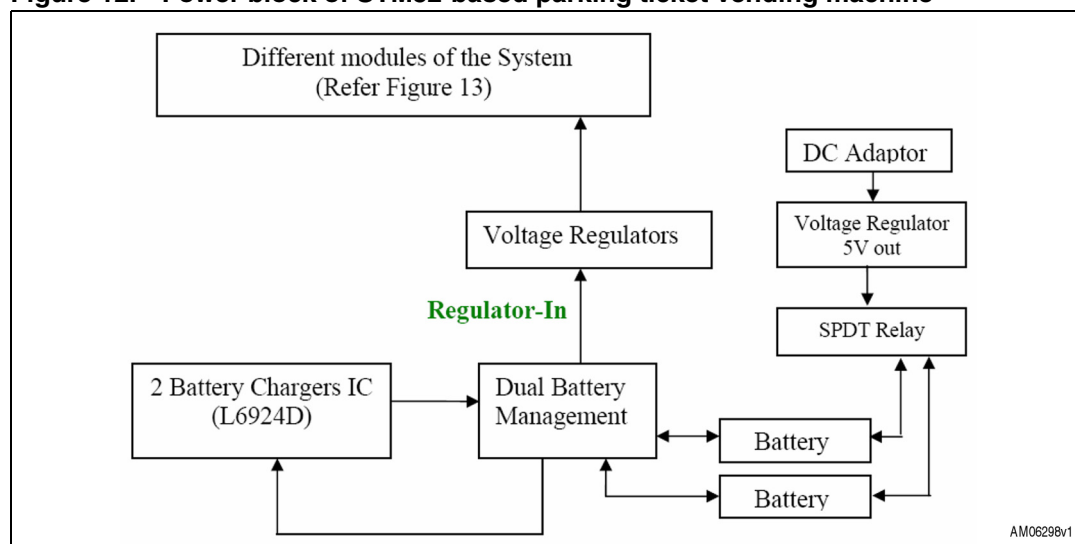
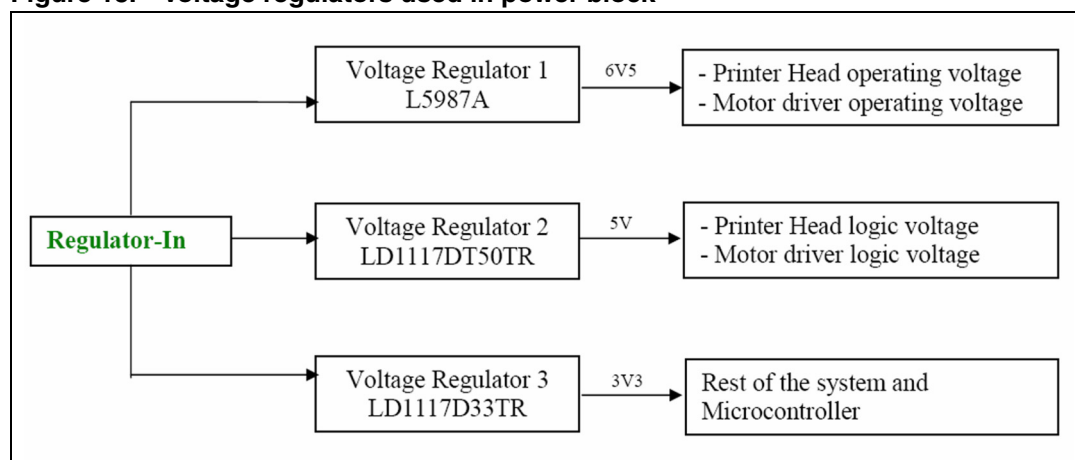


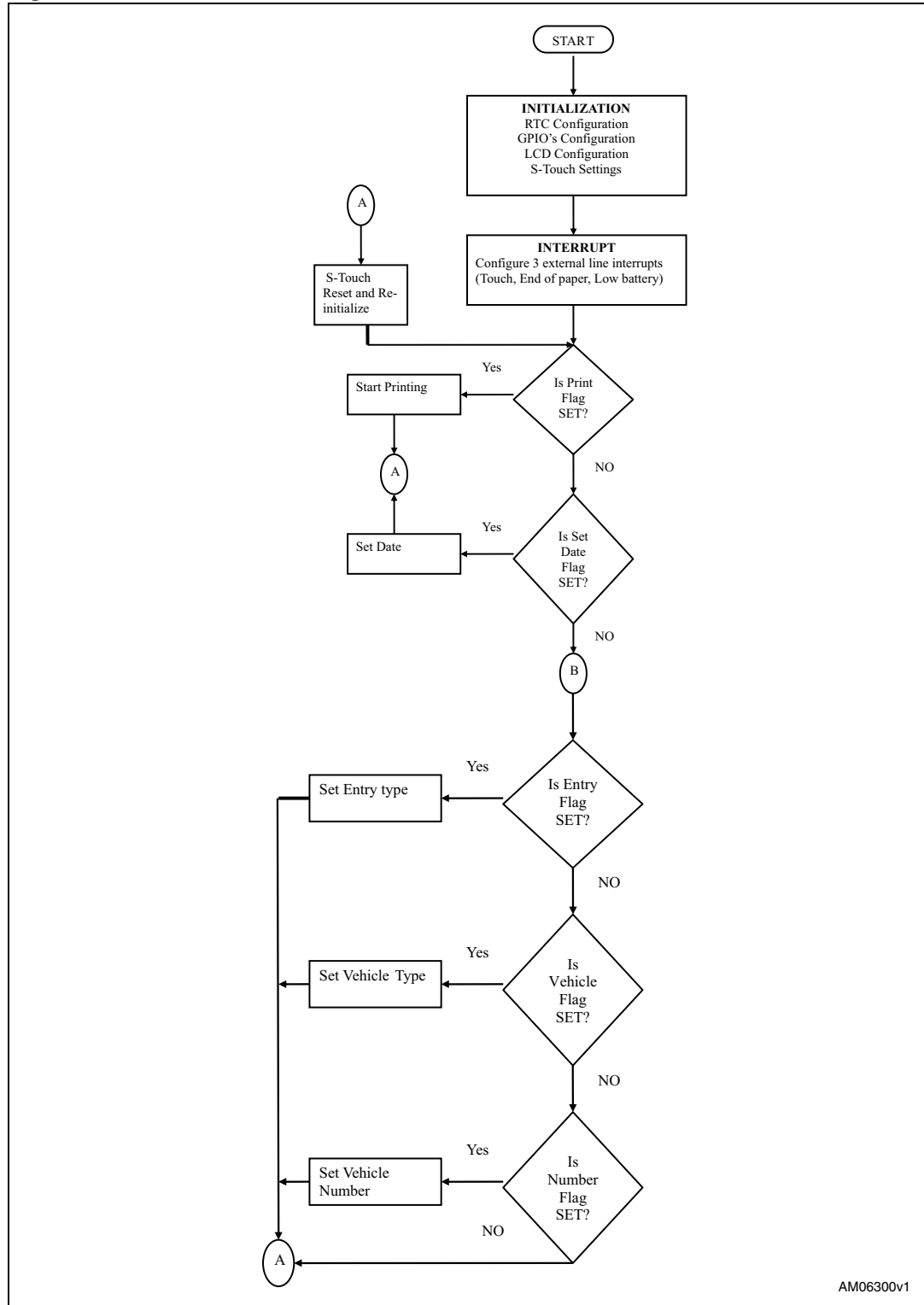
Figure 13. Voltage regulators used in power block



4.2 Flowchart

Figure 14 is a flowchart of the entire system.

Figure 14. Flowchart



- **Start printing:** the thermal printer starts printing stored data.
- **Set Date:** modify the date and time of the system.
- **Set Entry Type:** entry type 'Pass' or 'Single' is stored in the user buffer data.
- **Set Vehicle Type:** the vehicle type is 2 WHL, 4 WHL or Heavy, and is stored in the user buffer data.
- **Set Vehicle Number:** the system stores the last 4 digits of the vehicle number entered by the user.

Once all initializations are complete, various flag statuses are continuously checked within the main state machine. When a key is pressed on the keypad, an interrupt is generated and corresponding actions are taken by the firmware.

4.3 Hardware schematics

The following figures represent the schematic diagrams for the board.

Figure 15. Schematic: microcontroller section

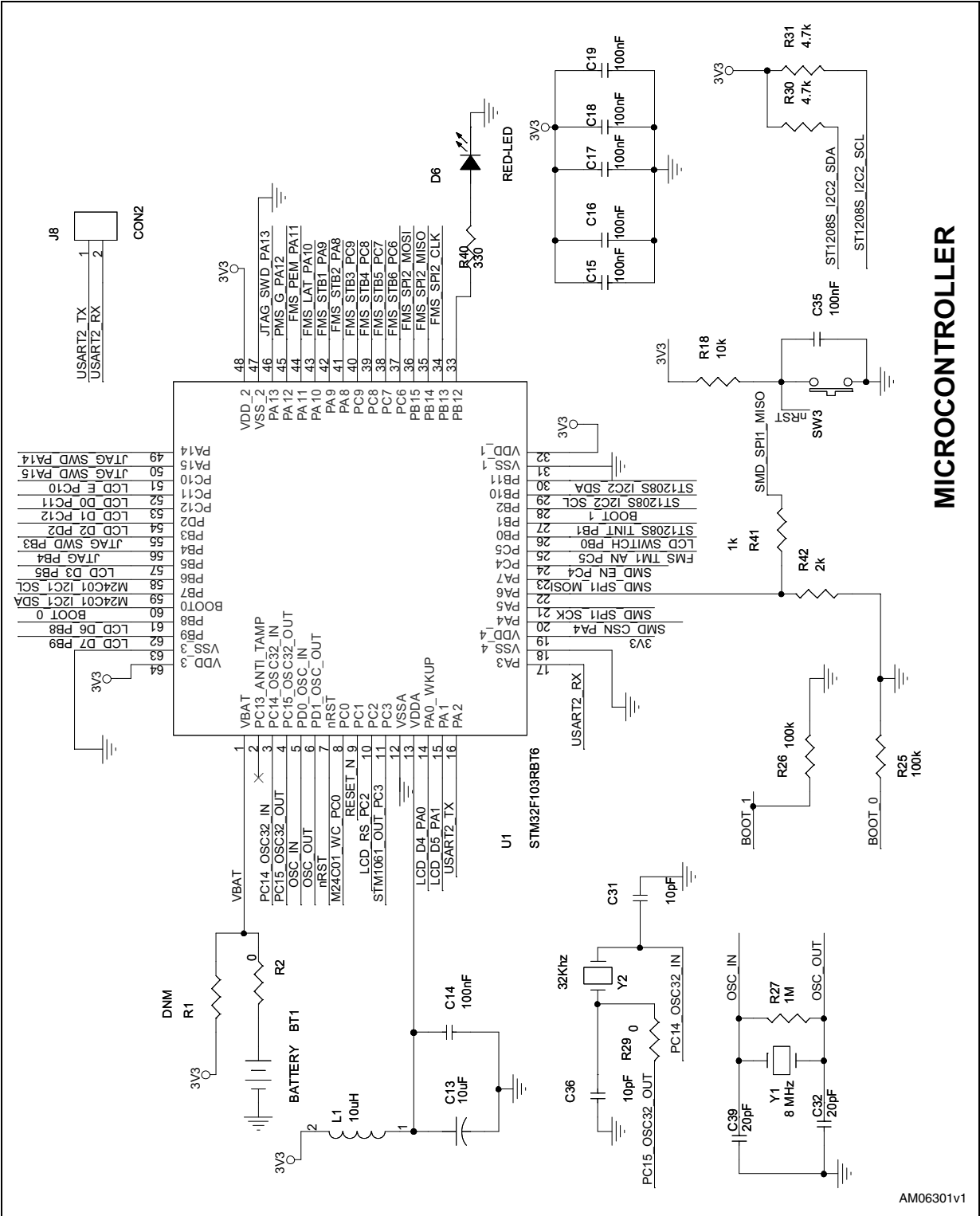


Figure 16. Schematic: motor driver

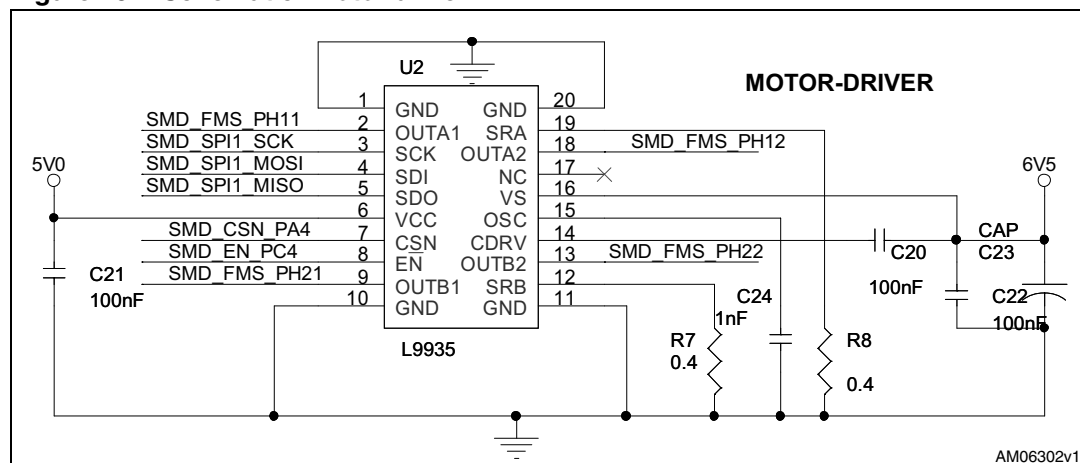


Figure 17. Schematic: connectors (printer, LCD and JTAG)

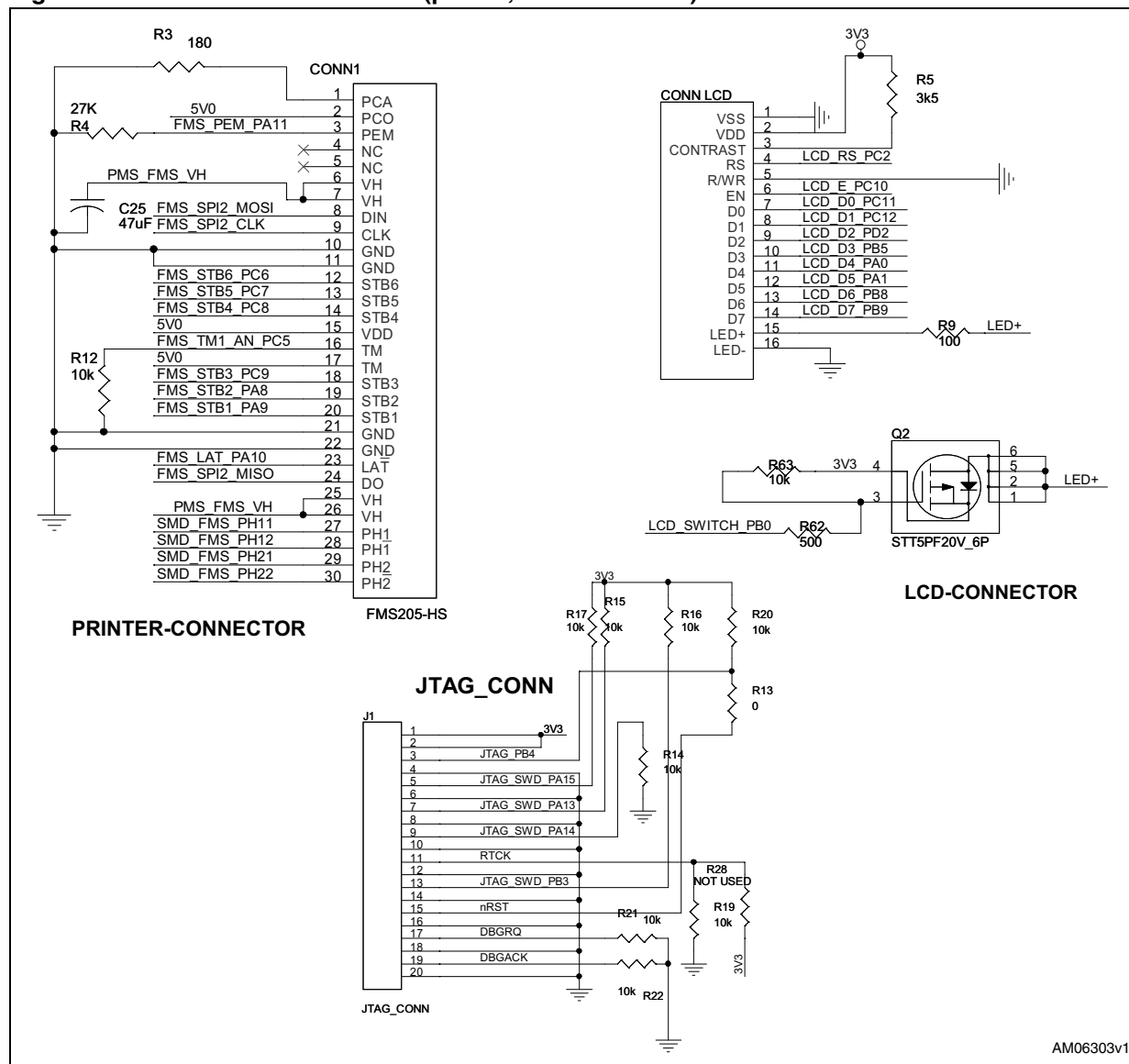
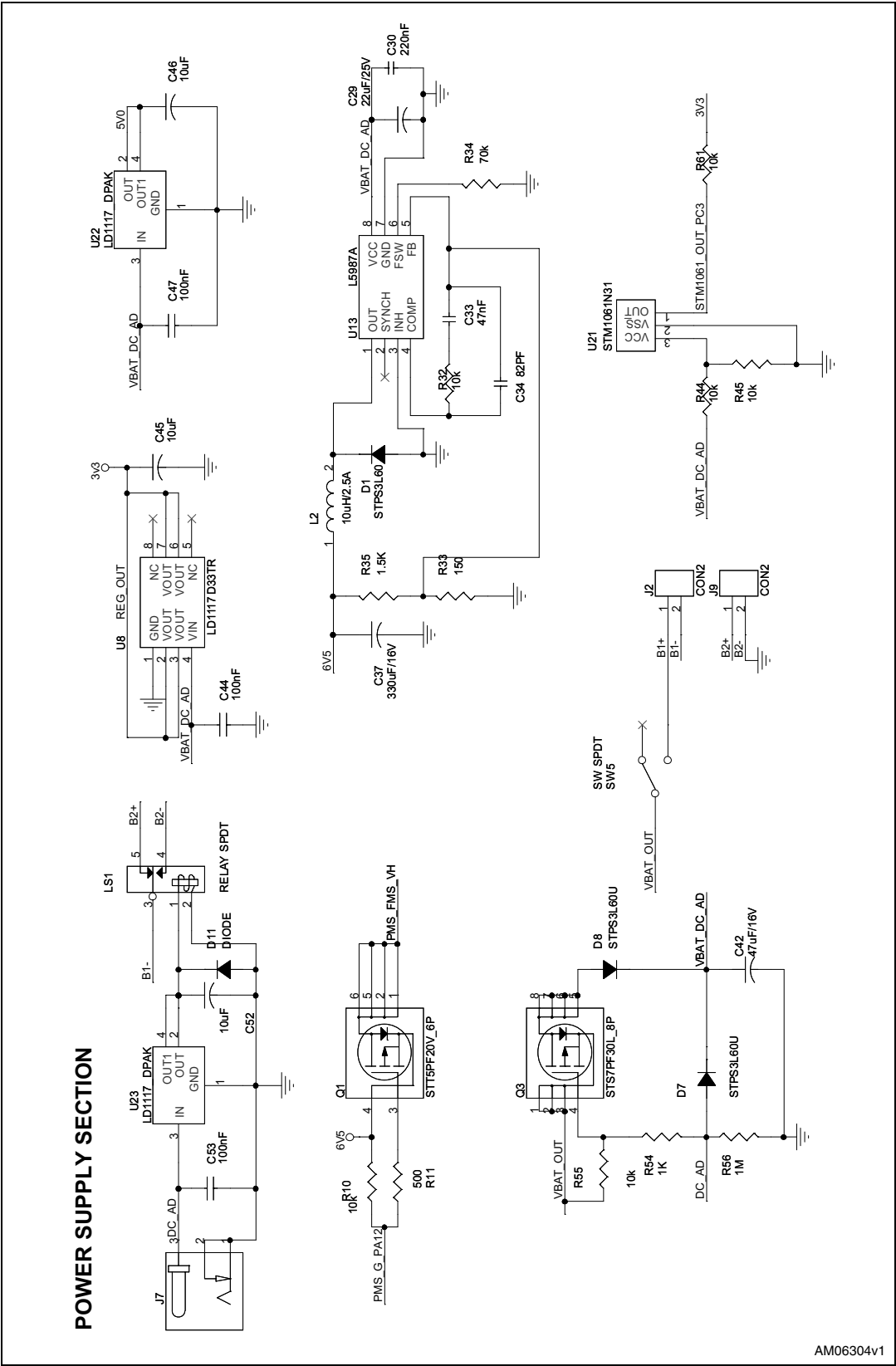
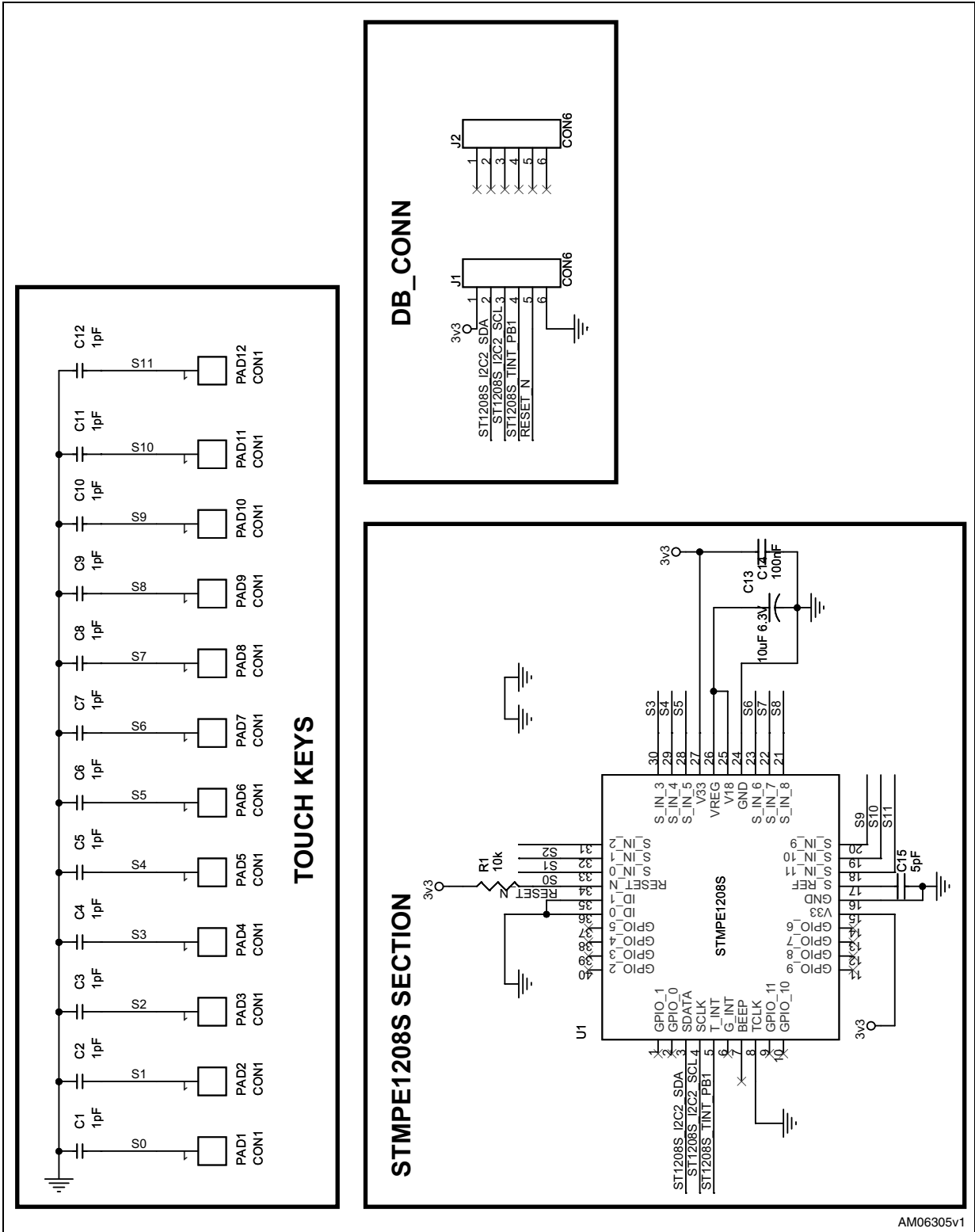


Figure 18. Schematic: power management section



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Figure 19. Schematic: S-Touch keypad



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5 Bill of materials

Table 2. STEVAL-IPC002V1 BOM

Category	Serial no.	Ref. description	Component description	Package	Manufacturer	Manufacturer's ordering code/orderable part number or equivalent	Supplier	Supplier ordering code
ST devices	1	U1	Microcontroller, ARM 32-bit Cortex™-M3 CPU, 128 kΩ Flash, 64 kΩ RAM	LQFP64	STMicroelectronics	STM32F103RBT6		
	2	U2	Two-phase stepper-motor driver	PowerSO-20	STMicroelectronics	L9935		
	3	U4	Xpander logic™ with 12-channel touchkey (S-Touch)	QFN40	STMicroelectronics	STMPE1208S		
	4	U6,U7	Battery charger system	VFQFPN16	STMicroelectronics	L6924D		
	5	U8	Voltage regulator	SO-8	STMicroelectronics	LD1117D33TR		
	6	U13	3 A step-down switching regulator	HSOP-8	STMicroelectronics	L5987A		
	7	U20	1 Kbit serial I²C bus EEPROM	SO8	STMicroelectronics	M24C01-WMN6TP		
	8	U21	Low-power voltage detector, 3.1 V threshold typical	SOT23-3 (WX)	STMicroelectronics	STM1061N31WX6F		
	9	U22,U23	Low-drop fixed and adjustable positive voltage regulators	DPAK	STMicroelectronics	LD1117DT50TR		
	10	Q1	P-Channel 20 V - 0.065 W - 5 A SOT23-6L 2.5 V-drive STripFET™ II power MOSFET	SOT23-6L	STMicroelectronics	STT5PF20V		

**Table 2. STEVAL-IPC002V1 BOM (continued)**

Category	Serial no.	Ref. description	Component description	Package	Manufacturer	Manufacturer's ordering code/orderable part number or equivalent	Supplier	Supplier ordering code
ST devices	11	Q3	P-Channel 30 V, 0.16 Ω , 7 A, SO8 STripFET™ II power MOSFET	SO8	STMicroelectronics	STS7PF30L		
	12	D1, D7, D8	Power Schottky rectifier	SMA	STMicroelectronics	STPS3L60U		
Crystal and Oscillator	1	Y1	Quartz crystal 8 MHz	11.35 x 4.35 mm, SS4	Jauch	Q 8.0-SS4-22-30/30		
	2	Y2	32 kHz		Jauch	Q 0.032768-MMTF32-12.5-30		
Connectors, jumpers and switches	1	SW5	SPDT slide switch	3-pin through hole	APEM	APEM 25136NAH6	Farnell	1082285
	2	SW3	Push button switch	(6 x 6 mm) push button, through hole	Tyco Electronics	FSM2JH	Farnell	Part# 1555981
	3	J1	JTAG connector	Box header, straight 20-way, 2 x 10 pin, 2.54 x 2.54 mm pitch	Protectron	P9603-20-15-1		
	4	CONN1	30-pin SMD connector	SMD	SAMTEC	ZF1-30-01-T-WT	SAMTEC	ZF1-30-01-T-WT
	5	J8, J2, J9	Header, pin, 2.54 mm, straight 2-WAY, single row, gold Flash	Single row straight, through hole, 2-pin	Protectron	P9101-02-12-1		
	6	J7	Socket, DC power JACK, 2.5 mm, right angle, locking type	Through hole	Protectron	PDCJ01-08		

**Table 2. STEVAL-IPC002V1 BOM (continued)**

Category	Serial no.	Ref. description	Component description	Package	Manufacturer	Manufacturer's ordering code/orderable part number or equivalent	Supplier	Supplier ordering code
Connectors, jumpers and switches	7	LCD CONN	Header, pin, 2.54 mm, straight 16-WAY, single row, Gold Flash	Single row straight, Through hole, 16pin	Protectron	P9101-16-12-1		
	8	BT1	Battery CR2032 holder	Through hole	Renata	HU2032-LF	Mouser	614-HU2032-LF
	9	J3,J4	HEADER, PIN, 2.54 mm, straight 6-WAY, single row, Gold Flash	Single row straight, through hole, 2pin	Protectron	P9101-06-12-1		
LEDs	1	D6	Yellow LED	SMD1206	OSRAM	LYN971-Z	Farnell	Part# 1226417
	2	D9	Green LED	SMD1206	OSRAM	LGN971	Farnell	Part# 1226371
	3	D10	Red LED	SMD1206	DIALIGHT Corporation	5988210107F	Farnell	Part# 1465997

Table 2. STEVAL-IPC002V1 BOM (continued)

Category	Serial no.	Ref. description	Component description	Package	Manufacturer	Manufacturer's ordering code/orderable part number or equivalent	Supplier	Supplier ordering code
Capacitors	1	C28	5 pF	SMD0805	Any			
	2	C31,C36	10 pF	SMD0805	Any			
	3	C32,C39	20 pF	SMD0805	Any			
	4	C34	82 pF	SMD0805				
	5	C24,C49, C51	1 nF	SMD0805	Any			
	6	C48,C50	22 nF	SMD0805				
	7	C33	47 nF	SMD0805				
	8	C14,C15, C16,C17, C18,C19, C20,C21, C22,C27, C35,C44, C47,C53, C56	100 nF	SMD0805	Any			

**Table 2. STEVAL-IPC002V1 BOM (continued)**

Category	Serial no.	Ref. description	Component description	Package	Manufacturer	Manufacturer's ordering code/orderable part number or equivalent	Supplier	Supplier ordering code
Capacitors	9	C30	220 nF	SMD0805	Any			
	10	C40,C41	1 μ F/16 V	SMD1206				
	11	C38,C43	4.7 μ F/16 V	EIA 3528-21/ size A				2
	12	C23	10 μ F	EIA 3528-21/ size A	Any			
	13	C13,C45, C46,C52	10 μ F	EIA 3528-21/ size A	Any			
	14	C29	22 μ F/25 V	EIA 3528-21/ size B	Any			
	15	C25, C42	47 μ F/16 V	EIA 3528-21/ size C	Any			
	16	C37	Aluminum electrolytic capacitors - SMD 330 μ F/ 10 V	SMD Electrolytic, 6.3 mm diameter x 11 mm L	Nichicon	UCD1A331MNL1GS	Mouser	647-UCD1A331MNL1GS
Inductors	1	L1	10 μ H	SMD	Any			
	2	L2	10 μ H/2.5 A	SMD	Bourns	SDR1005-100ML	Mouser	652-SDR1005-100ML
Resistors	1	R1	DNM	SMD0805	Any			
	2	R2,R13,R29, R39,R47	0	SMD0805	Any			
	3	R3	180 Ω	SMD0805	Any			
	4	R4	27 k Ω	SMD0805	Any			

**Table 2. STEVAL-IPC002V1 BOM (continued)**

Category	Serial no.	Ref. description	Component description	Package	Manufacturer	Manufacturer's ordering code/orderable part number or equivalent	Supplier	Supplier ordering code
Resistors	6	R6,R10, R12,R14, R15,R16, R17,R18, R19,R20, R21,R22, R32,R44, R45,R55	10 k Ω	SMD0805	Any			
	7	R7,R8	0.4 Ω	SMD0805	Any			
	8	R9	100 Ω	SMD0805	Any			
	9	R11,R50,R60	500 Ω	SMD0805	Any			
	10	R25,R26	100 k Ω	SMD0805	Any			
	11	R27,R56	1 M Ω	SMD0805	Any			
	12	R28	DNM	SMD0805	Any			
	13	R30,R31, R36,R37	4.7 k Ω	SMD0805	Any			
	14	R33	150 Ω	SMD0805	Any			
	15	R34	70 k Ω	SMD0805	Any			
	16	R35	1.5 k Ω	SMD0805	Any			
	17	R40	330 Ω	SMD0805	Any			
	18	R41,R48, R49,R54	1 k Ω	SMD0805	Any			
	19	R42	2 k Ω	SMD0805	Any			
	20	R43,R46	470 Ω	SMD0805	Any			
	21	R51,R57	13.5 k Ω	SMD0805	Any			

**Table 2. STEVAL-IPC002V1 BOM (continued)**

Category	Serial no.	Ref. description	Component description	Package	Manufacturer	Manufacturer's ordering code/orderable part number or equivalent	Supplier	Supplier ordering code
Resistors	22	R5, R52,R58	3.5 k Ω	SMD0805	Any			
	23	R53,R59	12 k Ω	SMD0805	Any			
Misc	1	Thermal printer	Thermal printer	Modular	APS	FM 205 – HS	Evolute	FM 205 – HS
	2	U3	Oriole LCD, 16 x 2 alpha-numeric LCD	Modular	Oriole			
	3	Relay	Relay, SPDT	5-pin through hole	Tyco electronics	PCH-105D2H,000	Digikey	PB890-ND

Note: *Not mounted: R1, R28. An equivalent term has been used where the exact part number from the mentioned vendor may not have been used.*

**Table 3. STEVAL-IPC002V1 touch daughterboard BOM list**

Category	Serial no.	Ref. description	Component description	Package	Manufacturer	Manufacturer's ordering code/orderable part number or equivalent	Supplier	Supplier ordering code
ST devices	1	U1	S-Touch	QFN40	STMicroelectronics	STMPE1208SQTR	-	-
Capacitors	1	C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,C11,C12	1 pF	SMD0805	Any		-	-
	2	C15	5 pF	SMD0805	Any		-	-
	3	C14	100 nF	SMD0805	Any		-	-
	4	C13	10 μ F 6.3 V	EIA 3528-21/Size A	Any		-	-
Resistors	1	R1	10 k Ω	SMD0805	Any		-	-
Connectors	1	J1 and J2	6 pin socket, 2.5 mm pitch	Through hole	Any		-	-

Note: As per the capacitor tuning of the STMPE1208SQTR, C3-C12 are not mounted. An equivalent term has been used where the exact part number from the mentioned vendor may not have been used.

6 Revision history

Table 4. Document revision history

Date	Revision	Changes
17-Jun-2010	1	Initial release.

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