STM32-MICRIUM
evaluation board for MICRIUM operating system

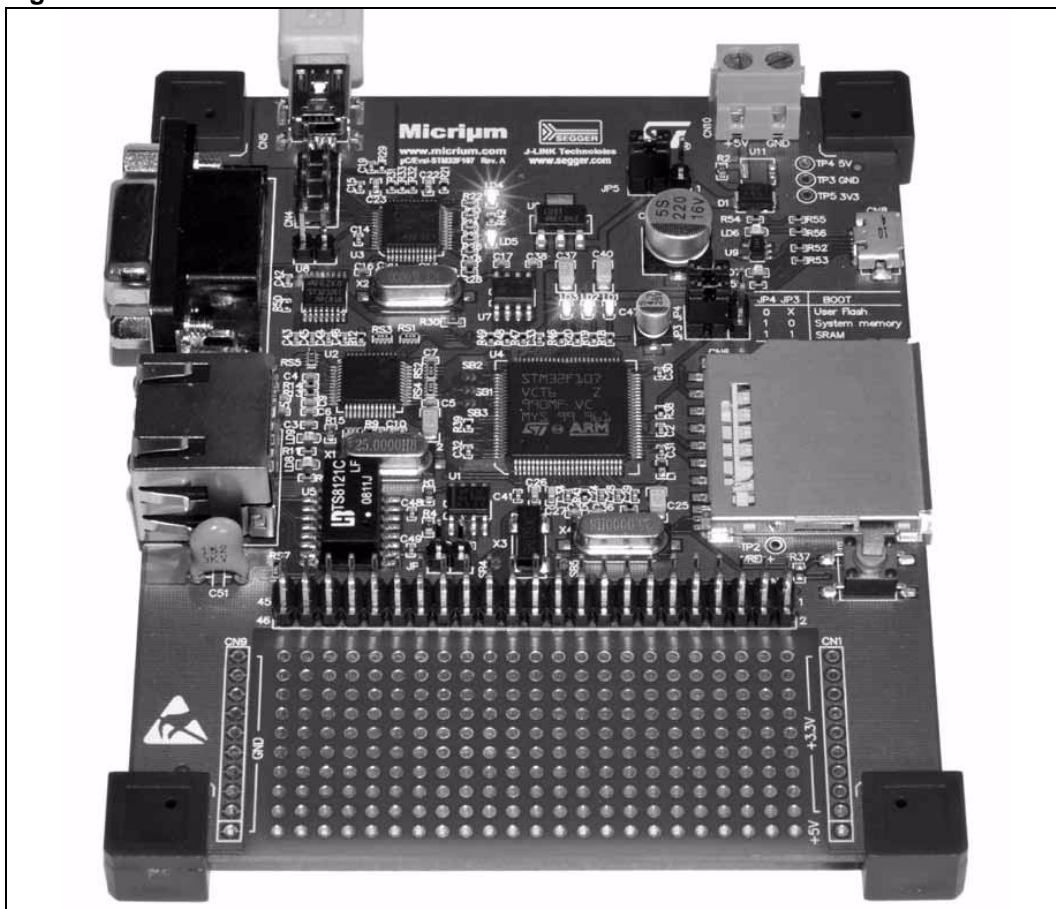## Introduction

The STM32-MICRIUM evaluation board is a complete development platform for STMicroelectronic's ARM Cortex™-M3 core-based microcontroller with full-speed USB-OTG, Ethernet MAC, two channels of CAN2.0A/B compliant interface, two I2S channels, two I2C channels, five USARTs with smartcard support, three SPIs, 64 KB internal SRAM and 256 KB Flash, JTAG and SWD debugging support.

The full range of hardware features on the board help you to evaluate all types of peripherals (USB-OTG FS, Ethernet, CAN, SD/MMC card, USART, temperature sensor, etc.) and develop your own applications. Extension pin headers and wire wrapping area make it possible to easily add your own components/interface on the board for a specific application.

Figure 1 shows a picture of the STM32-MICRIUM evaluation board.

Figure 1.   STM32-MICRIUM evaluation board

Contents

1 Overview

1.1 Features

- 72 MHz STM32F107 Cortex™-M3 based microcontroller with:
  - 256 Kbytes of Flash
  - 64 Kbytes of SRAM
- 10/100 Ethernet connector
- USB-OTG full-speed connector
- RS-232C connector
- CAN interface connected to pin headers
- SD/MMC socket
- STLM75 temperature sensor
- 3 user LEDs (red, yellow and green)
- Reset button
- Free I/O ports connector (pin headers)
- Prototyping area
- On-board J-Link SWD for debugging
- Powered by J-Link USB connector or 5V external power supply on screw terminal
- RoHS compliant

1.2 Software example

- Example #1 described in the µC/OS-III book is preloaded in the board's Flash memory showing the LD1, DL2 & DL3 blinking. For more information on this demonstration example, please refer to Chapter 3 of the µC/OS-III book .

1.3 Order code

- To order the µC/OS-III book and the STM32-MICRIUM evaluation board, use the order code STM32CMICOS-EVAL.

1.4 Hardware layout

The STM32-MICRIUM evaluation board is designed around the STM32F107VCT in a 100-pin TQFP package.

Figure 2 illustrates the connection between the STM32F107VCT and peripherals (USB-OTG, Ethernet, SD/MMC, RS-232, CAN temperature sensor).

Figure 3 helps you to locate these features on the actual evaluation board.

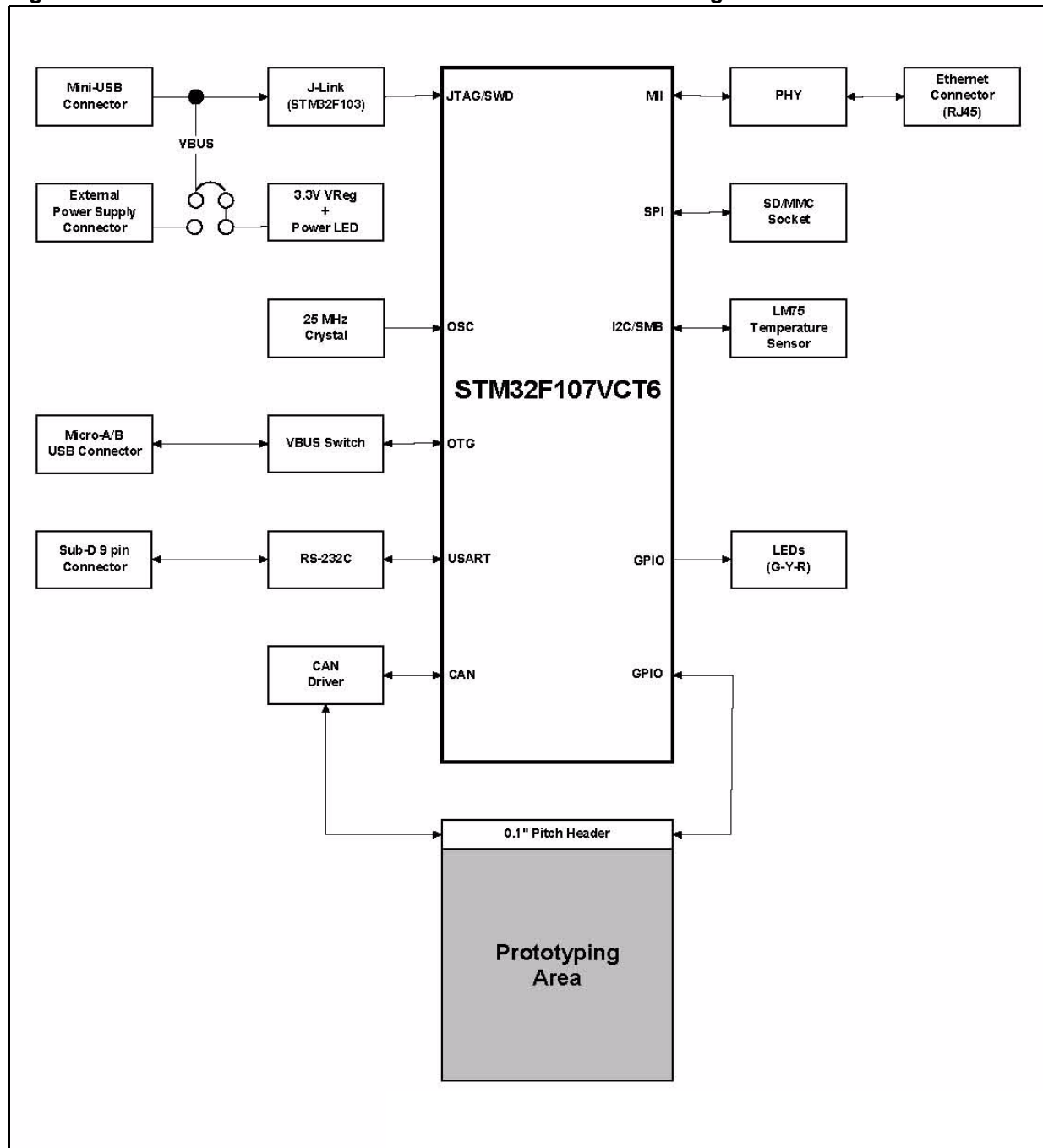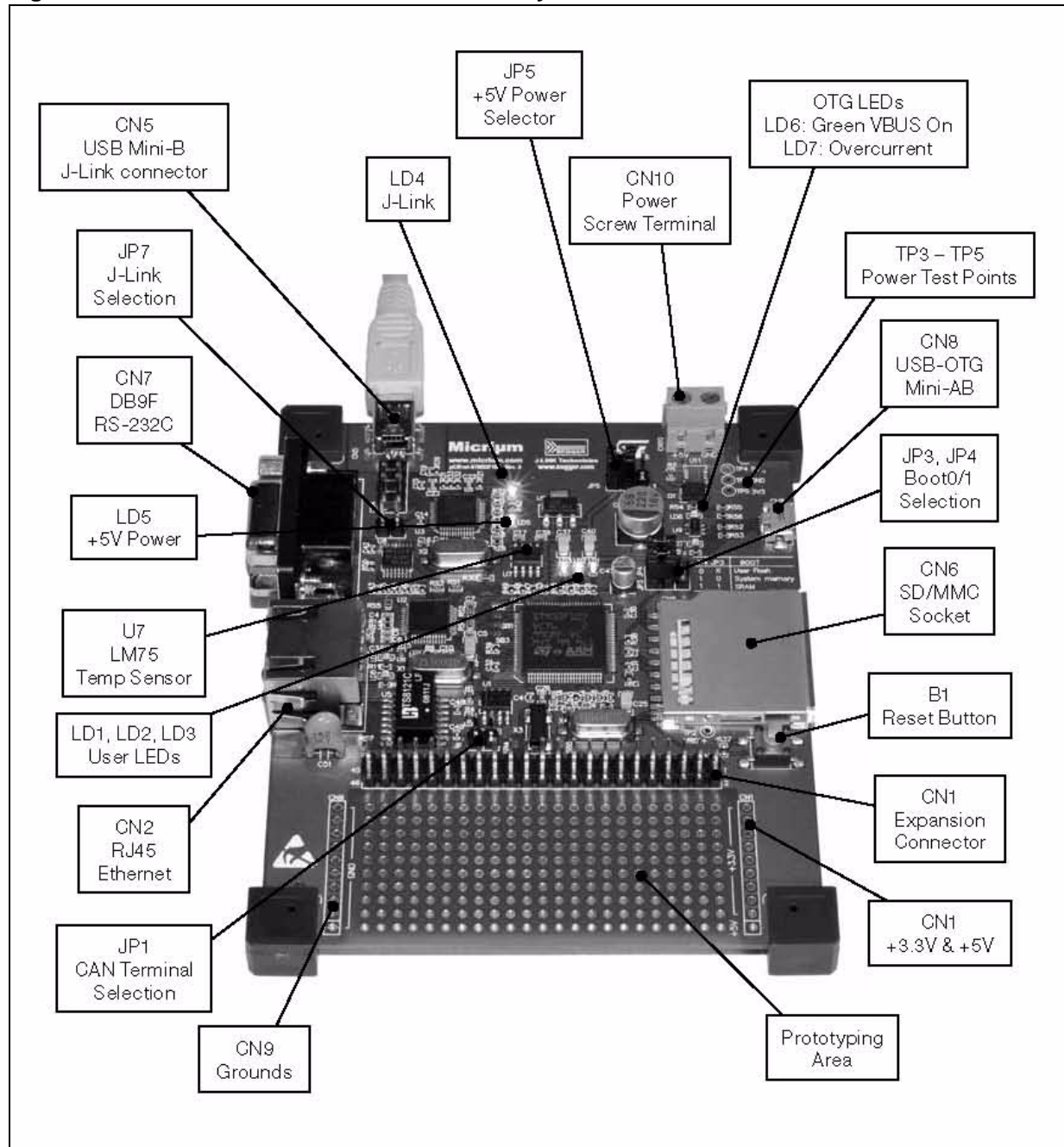**Figure 2.   STM32-MICRIUM evaluation board hardware block diagram**
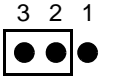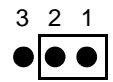
Figure 3.   STM32-MICRIUM evaluation board layout

2 Configuration

2.1 Power supply

The STM32-MICRIUM evaluation board is powered by a 5V DC power supply. It is configured via JP5 to use the following power supply sources:

● 5V DC power adapter connected to CN10, the power screw terminal on the board.

● 5V VBUS power (500 mA limitation from CN5), the mini-B USB of embedded J-Link.

Table 1.   STM32-MICRIUM evaluation board power supply jumper

Jumper	Description	Switch configuration
JP5	The board is powered by VBUS of the embedded J-Link input CN5 when JP5 is set as shown on the right: (Default setting).	3 2 1
	The board is powered by 5V DC input CN10 when JP5 is set as shown on the right:	3 2 1
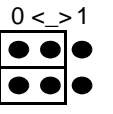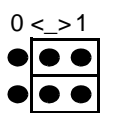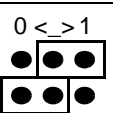
Note: *1   The board cannot be powered by VBUS on CN8 when USB-OTG is used as a USB device.*

   2   The LED LD5 is lit when the STM32CMICOS-EVAL board is powered by the 5V correctly.

   3   Three test points TP4 (5V), TP3 (GND), and TP2 (3.3V) are available on the top right of the board to check power supply.

2.2 Boot options

The boot option is configured by setting switch JP3 (BOOT1) and JP4 (BOOT0). The STM32-MICRIUM evaluation board can boot from:

● Embedded user Flash.

● System memory.

● Embedded SRAM for debugging.

Table 2.   STM32-MICRIUM evaluation board boot options jumpers

Jumper	Description	Configuration
JP3 & JP4	STM32-MICRIUM evaluation board boots from user Flash when JP4 is set as shown to the right. JP3 is not relevant in this configuration. (Default setting).	0 <_> 1
	STM32-MICRIUM evaluation board boots from embedded SRAM when JP3 and JP4 are set as shown to the right.	0 <_> 1
	STM32-MICRIUM evaluation board boots from system memory when JP3 and JP4 are set as shown to the right.	0 <_> 1

2.3   Reset sources

The reset signal of the STM32-MICRIUM evaluation board is active low.
The reset source may come from:

●   Reset button B1 in bottom right of the board.
●   Embedded J-Link.
●   Extension connector CN3 pin 45 (pin header).

2.4   CAN (controller area network)

The STM32-MICRIUM evaluation board supports one channel of CAN2.0A/B-compliant
CAN bus communication based on a 3.3V CAN transceiver.
The CAN transceiver (U1) is configured for high-speed mode.
The CAN bus is available on extension connector CN3 pin 28 (CAN_L) and pin 30 (CAN_H).
The CAN interface is connected to CAN1 remapped (PD0, PD1) of the STM32F107VCT.
The CAN terminal (120 ohm), available on the board, can be connected on the bus by the
jumper JP1.

Table 3.   STM32-MICRIUM evaluation board CAN related jumper

Jumper	Description
JP1	CAN terminal resistor is enabled when JP1 is fitted. Default setting: Not fitted.

2.5   RS-232C

The RS-232 communication with hardware flow control is supported by CN7 (a 9-pin D-type
RS-232 connector) and the transceiver U8, which is connected to USART2 remapped on
PD3 to PD6 of STM32F107VCT on STM32-MICRIUM evaluation board.

2.6   SD/MMC card

An SD/MMC card (Secure Digital/Multi-Media Card) connector (CN6) is available on the
board, but the card is not provided by default with the product. The SD/MMC card is
connected to SPI1 of STM32F107VCT (PA5 to PA7 without remap) with chip select on PA8
and card detection on PE6.

2.7   USB-OTG (USB ON-THE-GO)

The STM32-MICRIUM evaluation board supports USB-OTG full-speed communication via a
USB Micro-AB connector (CN8) and USB power switch (U9) connected to VBUS. The
evaluation board cannot be powered by this USB connector.

The green LED LD6 turns on when the power switch (U9) is ON, which corresponds to USB-
host mode. In this case, the 5V VBUS is provided by the board to a USB device connected
on CN8. The red LED LD7 turns on when an over-current condition is detected.

2.8   LM75 temperature sensor

A 10-bit temperature sensor, STLM75M2E (U7), is connected to the I2C1 bus of the
STM32F107VCT without remap (PB5 to PB7).

2.9   Debug interface

An embedded J-Link (JTAG/SWD development tool from IAR) is available on the STM32-
MICRIUM evaluation board as the default debugger/programmer interface. The mini-B USB
connector CN5 is used to interface the embedded J-Link (U3) using the IAR Embedded
Workbench for ARM toolchain. The SWD port of the embedded J-Link is directly connected
to the STM32F107VCT debug port and optionally, through solder bridges, to all other JTAG
signals, as detailed in *Table 5*.

Other debugger/programmer hardware can be supported by the JTAG/SWD signals
available on extension connector CN3. The debug tool used can be selected by the jumper
JP2, as mentioned in *Table 4*.

Table 4.   STM32-MICRIUM evaluation board J-Link related jumper

Jumper	Description
JP2	Open: embedded J-Link is selected as debugger/programmer tool (Default setting).
	Closed: external debugger/programmer tool connected on CN3 is used.

Table 5.   STM32-MICRIUM evaluation board J-TAG solder bridges

Jumper	Description
SB1	Open: J-Link TDO/SWO is not connected to the TDO of the STM32F107VCT. J-Link supports SWD communication only.
	Closed: J-Link TDO/SWO is connected to the TDO of the STM32F107VCT. J-Link supports JTAG and SWD communication (Default setting).
SB2	Open: J-Link TDI is not connected to the TDI of the STM32F107VCT. J-Link supports SWD communication only.
	Closed: J-Link TDI is connected to the TDI of the STM32F107VCT. J-Link supports JTAG and SWD communication (Default setting).
SB3	Open: J-Link TRST is not connected to the TRST of the STM32F107VCT. J-Link supports SWD communication only.
	Closed: J-Link TRST is connected to the TRST of the STM32F107VCT. J-Link supports JTAG and SWD communication (Default setting).

2.10   Ethernet

The STM32-MICRIUM evaluation board supports a 10/100 Ethernet communication
interface with a 'PHY' (DP83848CVV, U2) and integrated RJ45 connector (CN2). MII
interface mode is also supported.

The 25 MHz Ethernet clock is provided by crystal X1 connected to the PHY.

Note: *Test point TP1 can be used to check the PHY clock frequency.*

2.11 Clock sources

Two clock sources are available on the STM32-MICRIUM evaluation board for the STM32F107VCT, and also include an embedded RTC:

● X3, 32.768 KHz crystal for embedded RTC connected to PC14, PC15.

● X2, 25 MHz crystal for the STM32F107VCT microcontroller.

The PC14 and PC15 are available on extension connector CN3 depending on SB4 and SB5 configuration as mentioned in *Table 6*.

Table 6.   STM32-MICRIUM evaluation board 32 KHz crystal X3 solder bridges

Jumper	Description
SB4	Open: PC14 is connected to 32 KHz crystal (Default setting). Closed: P14 is connected to extension connector CN3.
SB5	Open: PC15 is connected to 32 KHz crystal (Default setting). Closed: P15 is connected to extension connector CN3.

2.12 Connectors

2.12.1 RS-232C connector (CN7)

Figure 4.   STM32CMICOS-EVAL DB-9F RS-232C CN6 with ISP support (front view)
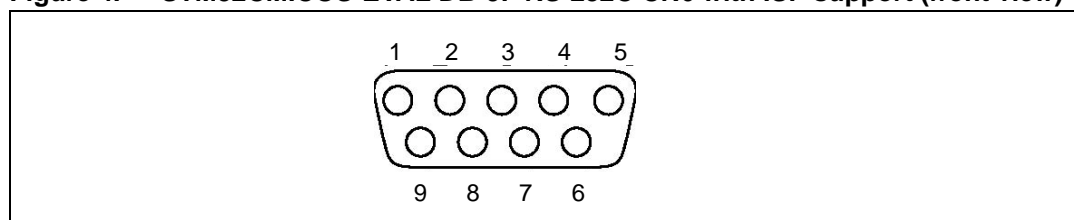
Table 7.   RS-232C connector CN6 with ISP support

Pin number	Description	Pin number	Description
1	NC	6	NC
2	RS232_TXD (PD5)	7	RS232_CTS (PD3)
3	RS232_RXD (PD6)	8	RS232_RTS (PD4)
4	NC	9	NC
5	GND		

2.12.2 Power connectors (CN1 and CN9)

The nine pins of connector CN9 on the left side of the wrapping area are connected to the board's ground.

The eight higher pins of connector CN8 are connected to the 3.3V power. and the lower pin is connected to the 5V power of the board.

2.12.3 Extension connector (CN3)

Table 8. CN3 pinout

Description	Pin name	Pin number of CN3		Pin name	Description
IO port	PA4	1	2	PE3	IO port
IO port	PB0	3	4	PE4	IO port
IO port	PB1	5	6	PB3	IO port or TDO (SB1)
IO port	PB9	7	8	PB4	IO port or TRST (SB3)
IO port	PB14	9	10	PE7	IO port
IO port	PB15	11	12	PE8	IO port
IO port	PC0	13	14	PE9	IO port
IO port	PC4	15	16	PE10	IO port
IO port	PC5	17	18	PE11	IO port
IO port	PC6	19	20	P12	IO port
IO port	PC7	21	22	PE13	IO port
IO port	PC8	23	24	PE14	IO port
IO port	PC9	25	26	PE15	IO port
IO port	PC10	27	28	CAN_L	CAN bus L
IO port	PC11	29	30	CAN_H	CAN bus H
IO port	PC12	31	32	PD6	IO port
IO port	PC13	33	34	PD5	IO port
IO port (SB4)	PC14	35	36	PD4	IO port
IO port (SB5)	PC15	37	38	PD3	IO port
IO port	PD2	39	40	PA15	IO port or TDI (SB2)
IO port	PD7	41	42	PE2	IO port
IO port	PE0	43	44	PA13	IO port or TMS
Board reset	RESET	45	46	PA14	IO port or TCK

Note: *(SBx) means that a corresponding solder bridge must be set to enable the signal on the connector.*

3   I/O assignments

Table 9.   I/O assignments

Pin No.	Pin name	STM32-MICRIUM evaluation board processor I/O assignments
1	PE2	IO PORT PE2
2	PE3	IO PORT PE3
3	PE4	IO PORT PE4
4	PE5	MII_INT
5	PE6	SDCard_Detection
6	VBAT	
7	PC13-ANTI_TAMP	IO PORT PC13
8	PC14-OSC32_IN	OSC32K or IO PORT PC14
9	PC15-OSC32_OUT	OSC32K or IO PORT PC15
10	VSS_5	
11	VDD_5	
12	OSC_IN	
13	OSC_OUT	
14	NRST	RESET
15	PC0	IO PORT PC0
16	PC1	ETHER_MDC
17	PC2	ETHER_TXD2
18	PC3	ETHER_TX_CLK
19	VSSA	
20	VREF	
21	VREF+	
22	VDDA	
23	PA0-WKUP	ETHER_CRS
24	PA1	ETHER_RX_CLK
25	PA2	ETHER_MDIO
26	PA3	ETHER_COL
27	VSS_4	
28	VDD_4	
29	PA4	IO PORT PA4
30	PA5	SPI_SCK_MMC
31	PA6	SPI_MISO_MMC
32	PA7	SPI_MOSI_MMC

Table 9.   I/O assignments (continued)

Pin No.	Pin name	STM32-MICRIUM evaluation board processor I/O assignments
33	PC4	IO PORT PC4
34	PC5	IO PORT PC5
35	PB0	IO PORT PB0
36	PB1	IO PORT PB1
37	PB2	BOOT1
38	PE7	IO PORT PE7
39	PE8	IO PORT PE8
40	PE9	IO PORT PE9
41	PE10	IO PORT PE10
42	PE11	IO PORT PE11
43	PE12	IO PORT PE12
44	PE13	IO PORT PE13
45	PE14	IO PORT PE14
46	PE15	IO PORT PE15
47	PB10	ETHER_RX_ER
48	PB11	ETHER_TX_EN
49	VSS_1	
50	VDD_1	
51	PB12	ETHER_TXD0
52	PB13	ETHER_TXD1
53	PB14	IO PORT PB14
54	PB15	IO PORT PB15
55	PD8	ETHER_RX_DV
56	PD9	ETHER_RXD0
57	PD10	ETHER_RXD1
58	PD11	ETHER_RXD2
59	PD12	ETHER_RXD3
60	PD13	LED0
61	PD14	LED1
62	PD15	LED2
63	PC6	IO PORT PC6
64	PC7	IO PORT PC7
65	PC8	IO PORT PC8
66	PC9	IO PORT PC9
67	PA8	SPI_CS_MMC

Table 9.   I/O assignments (continued)

Pin No.	Pin name	STM32-MICRIUM evaluation board processor I/O assignments
68	PA9	VBUS
69	PA10	ID
70	PA11	DM
71	PA12	DP
72	PA13	Debug TMS
73	NC	
74	VSS_2	
75	VDD_2	
76	PA14	Debug TCK
77	PA15	Debug TDI
78	PC10	IO PORT PC10
79	PC11	IO PORT PC11
80	PC12	IO PORT PC12
81	PD0	CAN_RX
82	PD1	CAN_TX
83	PD2	IO PORT PD2
84	PD3	USART_CTS
85	PD4	USART_RTS
86	PD5	USART_TX
87	PD6	USART_RX
88	PD7	IO PORT PD7
89	PB3	Debug TDO
90	PB4	Debug TRST
91	PB5	INT_Temperature
92	PB6	I2C_SCL_Temperature
93	PB7	I2C_SDA_Temperature
94	BOOT0	BOOT0
95	PB8	ETHER_TXD3
96	PB9	IO PORT PB9
97	PE0	IO PORT PE0
98	PE1	USB_PowerSwitchOn
99	VSS_3	
100	VDD_3	

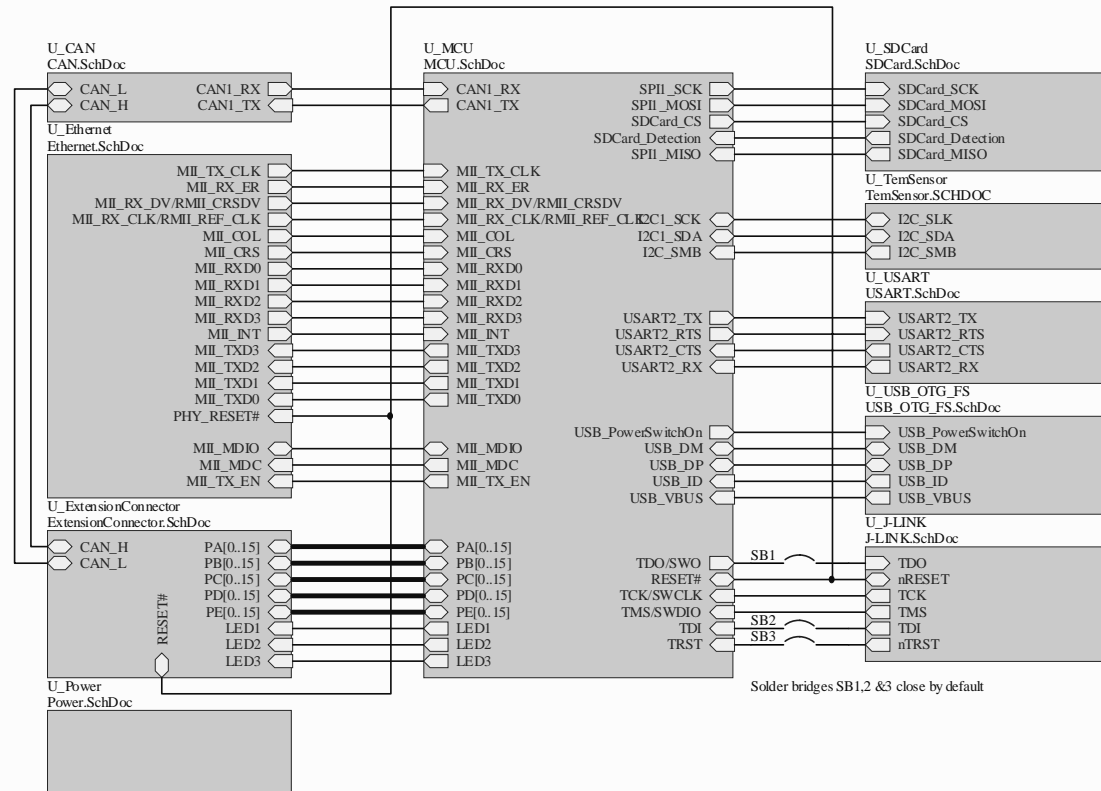# 4 Schematics

This section provides the design schematics for the STM32-MICRIUM evaluation board board key features, to help you implement these features in your applications.

The following schematics are provided:

Figure 5.   Block diagram

1	2	3	4

U_CAN
CAN.SchDoc

CAN_L
CAN_H
CAN1_RX
CAN1_TX

U_Ethernet
Ethernet.SchDoc

MII_TX_CLK
MII_RX_ER
MII_RX_DV/RMII_CRSDV
MII_RX_CLK/RMII_REF_CLK
MII_COL
MII_CRS
MII_RXD0
MII_RXD1
MII_RXD2
MII_RXD3
MII_INT
MII_TXD3
MII_TXD2
MII_TXD1
MII_TXD0
PHY_RESET#

MII_MDIO
MII_MDC
MII_TX_EN

U_ExtensionConnector
ExtensionConnector.SchDoc

CAN_H
CAN_L
PA[0..15]
PB[0..15]
PC[0..15]
PD[0..15]
PE[0..15]
LED1
LED2
LED3
RESET#

U_Power
Power.SchDoc

U_MCU
MCU.SchDoc

CAN1_RX
CAN1_TX
SPII_SCK
SPII_MOSI
SDCard_CS
SDCard_Detection
SPII_MISO

MII_TX_CLK
MII_RX_ER
MII_RX_DV/RMII_CRSDV
MII_RX_CLK/RMII_REF_CLK
MII_COL
MII_CRS
MII_RXD0
MII_RXD1
MII_RXD2
MII_RXD3
MII_INT
MII_TXD3
MII_TXD2
MII_TXD1
MII_TXD0

I2C1_SCK
I2C1_SDA
I2C_SMB

USART2_TX
USART2_RTS
USART2_CTS
USART2_RX

MII_MDIO
MII_MDC
MII_TX_EN

USB_PowerSwitchOn
USB_DM
USB_DP
USB_ID
USB_VBUS

PA[0..15]
PB[0..15]
PC[0..15]
PD[0..15]
PE[0..15]
LED1
LED2
LED3

TDO/SWO
RESET#
TCK/SWCLK
TMS/SWDIO
TDI
TRST

U_SDCard
SDCard.SchDoc

SDCard_SCK
SDCard_MOSI
SDCard_CS
SDCard_Detection
SDCard_MISO

U_TemSensor
TemSensor.SCHDOC

I2C_SLK
I2C_SDA
I2C_SMB

U_USART
USART.SchDoc

USART2_TX
USART2_RTS
USART2_CTS
USART2_RX

U_USB_OTG_FS
USB_OTG_FS.SchDoc

USB_PowerSwitchOn
USB_DM
USB_DP
USB_ID
USB_VBUS

U_J-LINK
J-LINK.SchDoc

SB1
SB2
SB3

TDO
nRESET
TCK
TMS
TDI
nTRST

Solder bridges SB1,2 &3 close by default

Note1: only default setting of SB1,2 &SB3 was updated to be close from Versioin B.1 to B.2.

STMicroelectronics

Title: uC/eval-STM32F107

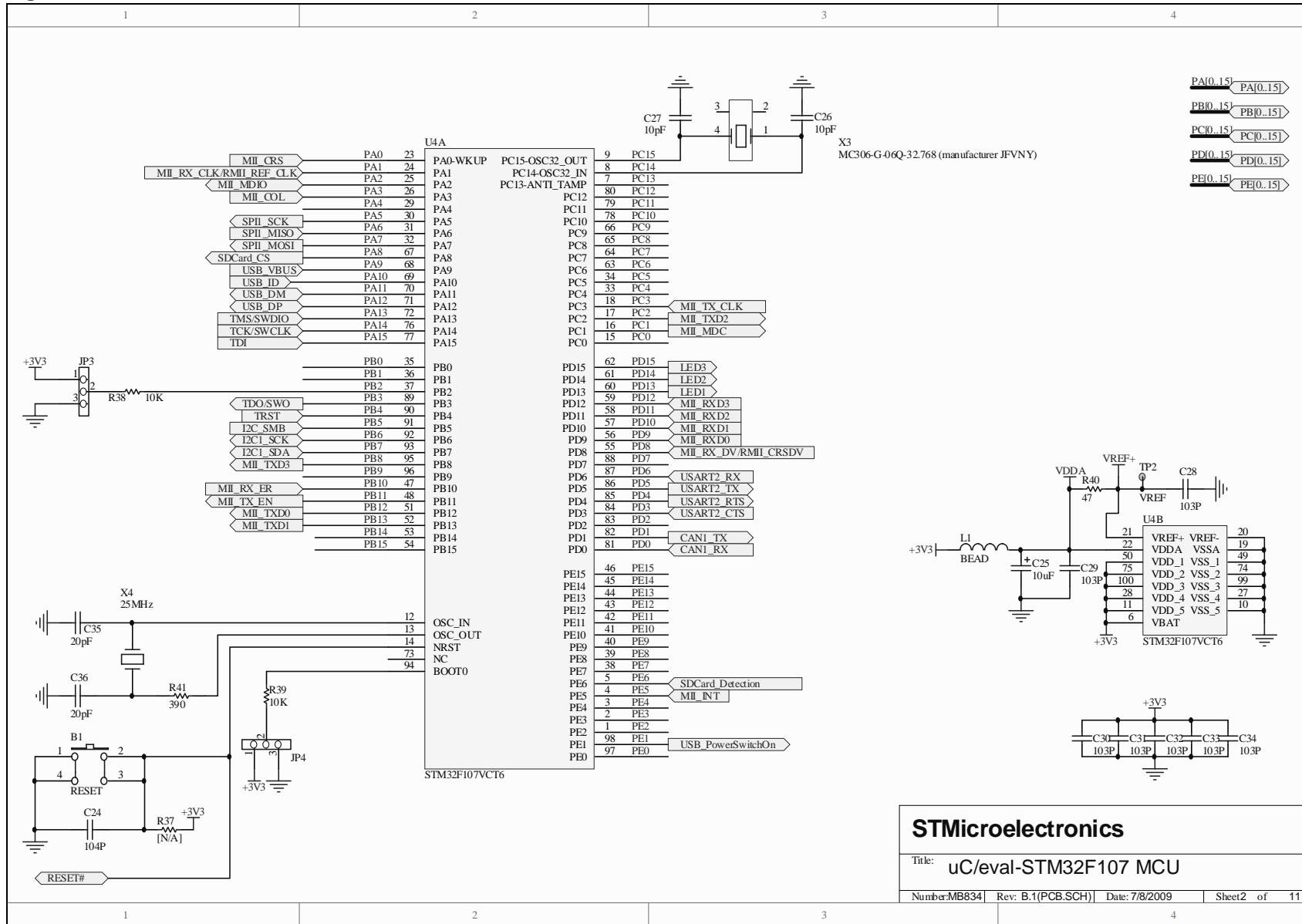| Number:MB834	Rev: B.2(PCB.SCH)	Date: 10/9/2009	Sheet1 of 11

Figure 6.   STM32F107VCT6

U4A

Pin	Signal
MII_CRS	PA0 23 PA0-WKUP
MII_RX_CLK/RMII_REF_CLK	PA1 24 PA1
MII_MDIO	PA2 25 PA2
MII_COL	PA3 26 PA3
	PA4 29 PA4
SPI1_SCK	PA5 30 PA5
SPI1_MISO	PA6 31 PA6
SPI1_MOSI	PA7 32 PA7
SDCard_CS	PA8 67 PA8
USB_VBUS	PA9 68 PA9
USB_ID	PA10 69 PA10
USB_DM	PA11 70 PA11
USB_DP	PA12 71 PA12
TMS/SWDIO	PA13 72 PA13
TCK/SWCLK	PA14 76 PA14
TDI	PA15 77 PA15

PC15-OSC32_OUT 9 PC15
PC14-OSC32_IN 8 PC14
PC13-ANTI_TAMP 7 PC13
PC12 80 PC12
PC11 79 PC11
PC10 78 PC10
PC9 66 PC9
PC8 65 PC8
PC7 64 PC7
PC6 63 PC6
PC5 34 PC5
PC4 33 PC4
PC3 18 PC3 — MII_TX_CLK
PC2 17 PC2 — MII_TXD2
PC1 16 PC1 — MII_MDC
PC0 15 PC0

PB0 35 PB0
PB1 36 PB1
PB2 37 PB2
TDO/SWO PB3 89 PB3
TRST PB4 90 PB4
I2C_SMB PB5 91 PB5
I2C1_SCK PB6 92 PB6
I2C1_SDA PB7 93 PB7
MII_TXD3 PB8 95 PB8
PB9 96 PB9
MII_RX_ER PB10 47 PB10
MII_TX_EN PB11 48 PB11
MII_TXD0 PB12 51 PB12
MII_TXD1 PB13 52 PB13
PB14 53 PB14
PB15 54 PB15

PD15 62 PD15 — LED3
PD14 61 PD14 — LED2
PD13 60 PD13 — LED1
PD12 59 PD12 — MII_RXD3
PD11 58 PD11 — MII_RXD2
PD10 57 PD10 — MII_RXD1
PD9 56 PD9 — MII_RXD0
PD8 55 PD8 — MII_RX_DV/RMII_CRSDV
PD7 88 PD7
PD6 87 PD6 — USART2_RX
PD5 86 PD5 — USART2_TX
PD4 85 PD4 — USART2_RTS
PD3 84 PD3 — USART2_CTS
PD2 83 PD2
PD1 82 PD1 — CAN1_TX
PD0 81 PD0 — CAN1_RX

PE15 46 PE15
PE14 45 PE14
PE13 44 PE13
PE12 43 PE12
PE11 42 PE11
PE10 41 PE10
PE9 40 PE9
PE8 39 PE8
PE7 38 PE7
PE6 5 PE6 — SDCard_Detection
PE5 4 PE5 — MII_INT
PE4 3 PE4
PE3 2 PE3
PE2 1 PE2
PE1 98 PE1 — USB_PowerSwitchOn
PE0 97 PE0

OSC_IN 12
OSC_OUT 13
NRST 14
NC 73
BOOT0 94

STM32F107VCT6

C27 10pF   C26 10pF
X3
MC306-G-06Q-32.768 (manufacturer JFVNY)

PA[0..15] — PA[0..15]
PB[0..15] — PB[0..15]
PC[0..15] — PC[0..15]
PD[0..15] — PD[0..15]
PE[0..15] — PE[0..15]

+3V3 JP3
R38 10K

X4 25MHz
C35 20pF
C36 20pF
R41 390
R39 10K
JP4

B1
RESET
C24 104P
R37 [N/A] +3V3

RESET#

VREF+ TP2 C28
VDDA R40 47 VREF 103P

U4B
VREF+ VREF- 21 20
VDDA VSSA 22 19
VDD_1 VSS_1 50 49
VDD_2 VSS_2 75 74
VDD_3 VSS_3 100 99
VDD_4 VSS_4 28 27
VDD_5 VSS_5 11 10
VBAT 6

+3V3 L1 BEAD
C25 10uF C29 103P
+3V3 STM32F107VCT6

+3V3
C30 103P C31 103P C32 103P C33 103P C34 103P

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Title: uC/eval-STM32F107 MCU

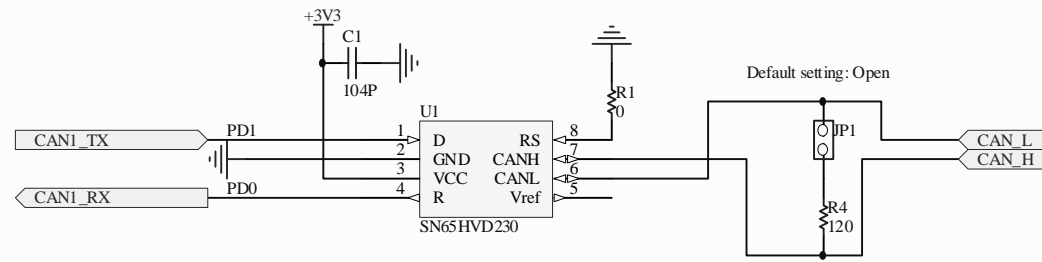Number: MB834 | Rev: B.1(PCB.SCH) | Date: 7/8/2009 | Sheet2 of 11

Figure 7. CAN

+3V3

C1
104P

CAN1_TX

PD1

CAN1_RX

PD0

U1

1	D	RS	8
2	GND	CANH	7
3	VCC	CANL	6
4	R	Vref	5

SN65HVD230

R1
0

Default setting: Open

JP1

R4
120

CAN_L
CAN_H

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Title: uC/eval-STM32F107 CAN

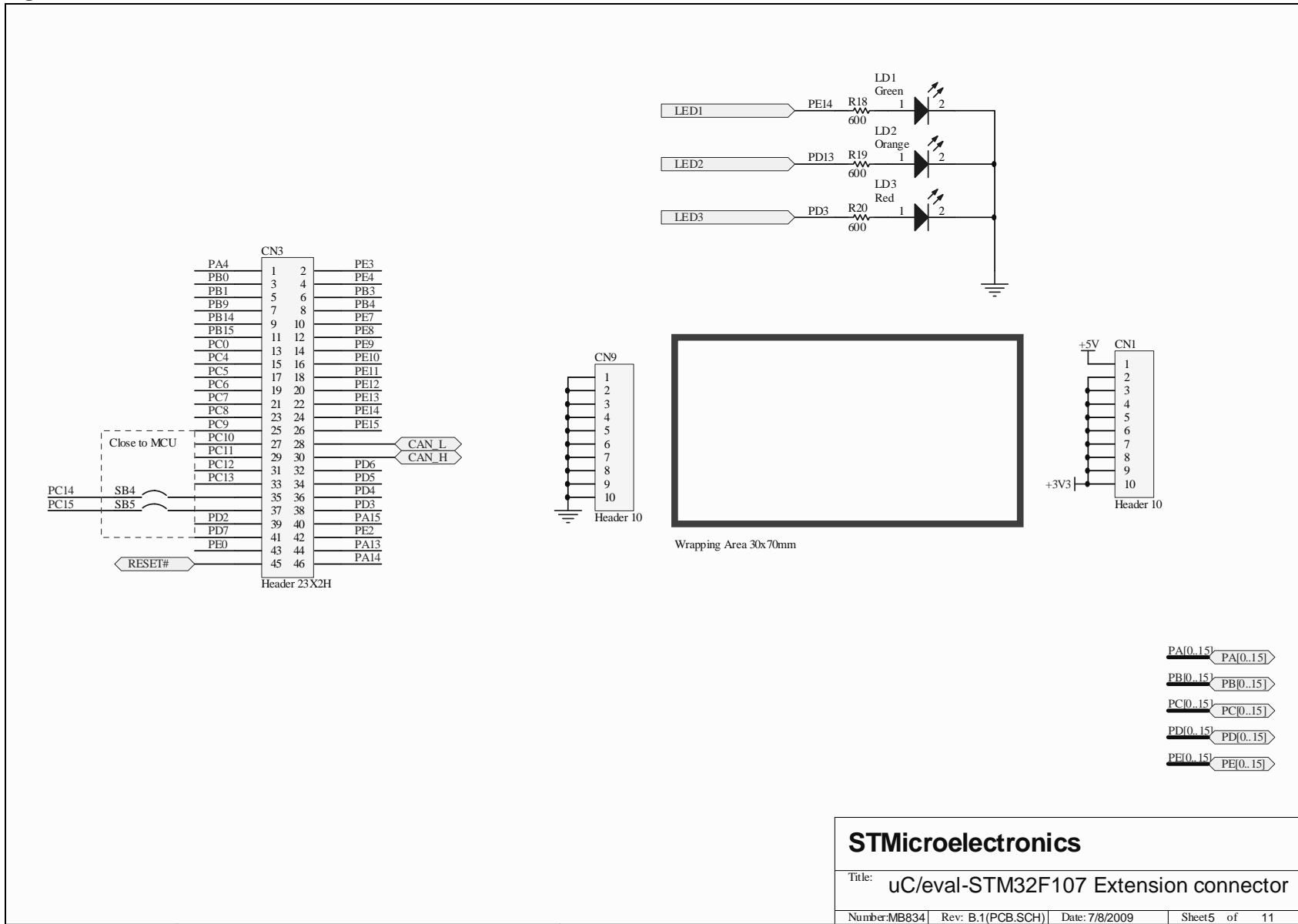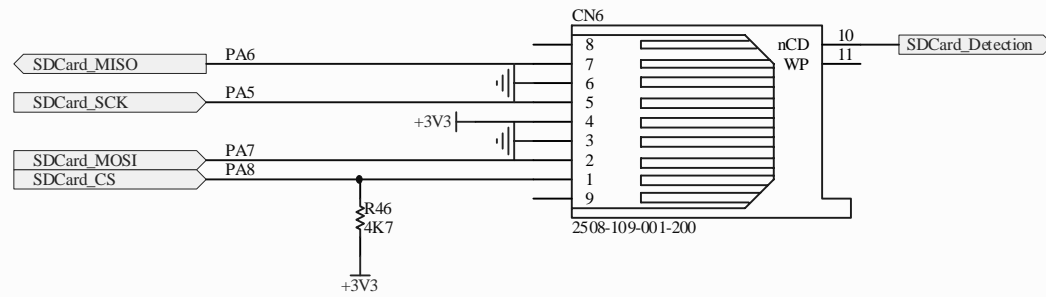Number:MB834   Rev: B.2(PCB.SCH)   Date: 10/9/2009

Figure 8. Ethernet

Figure 9.   Extension connector
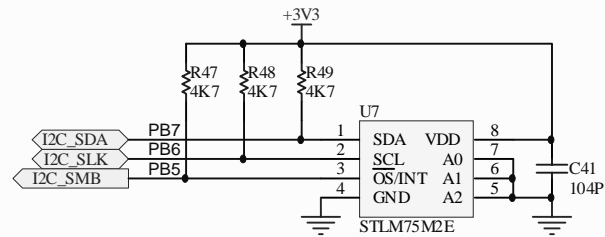
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Title: uC/eval-STM32F107 Extension connector

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Figure 10. SD card

CN6

SDCard_MISO PA6
SDCard_SCK PA5
SDCard_MOSI PA7
SDCard_CS PA8

8
7
6
5
4
3
2
1
9

+3V3

nCD
WP

10
11

SDCard_Detection

2508-109-001-200

R46
4K7

+3V3

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Title: uC/eval-STM32F107 SD card

Number:MB834   Rev: B.1(PCB.SCH)   Date: 7/8/2009

Figure 11. Temperature sensor

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Title: uC/eval-STM32F107 TemperatureSensor

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Figure 12. RS-232
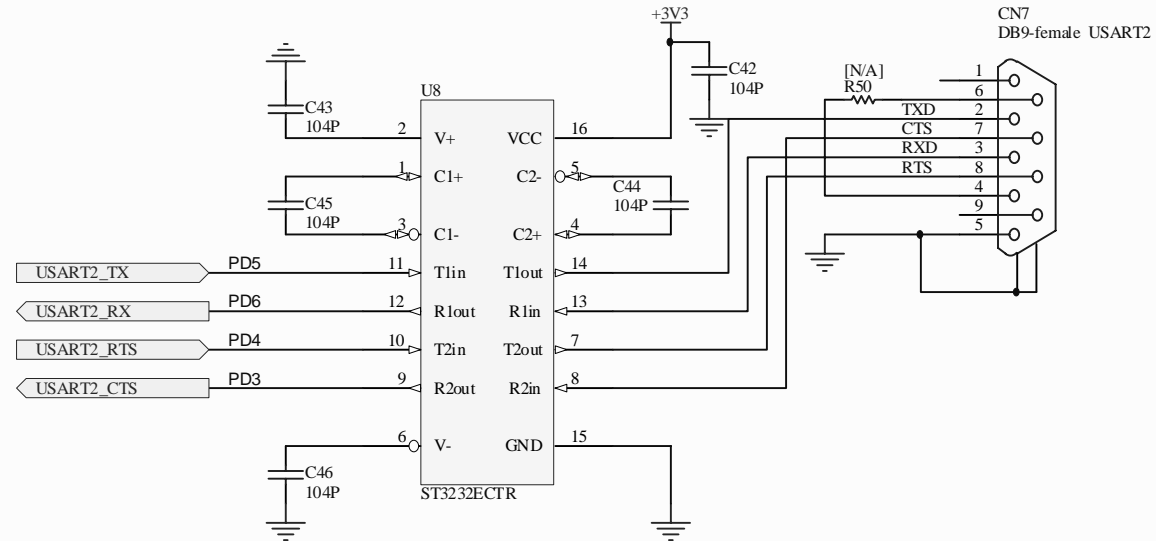
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Title: uC/eval-STM32F107 RS232

Number:MB834 | Rev: B.1(PCB.SCH) | Date: 7/8/2009

Figure 13.   USB-OTG-FS
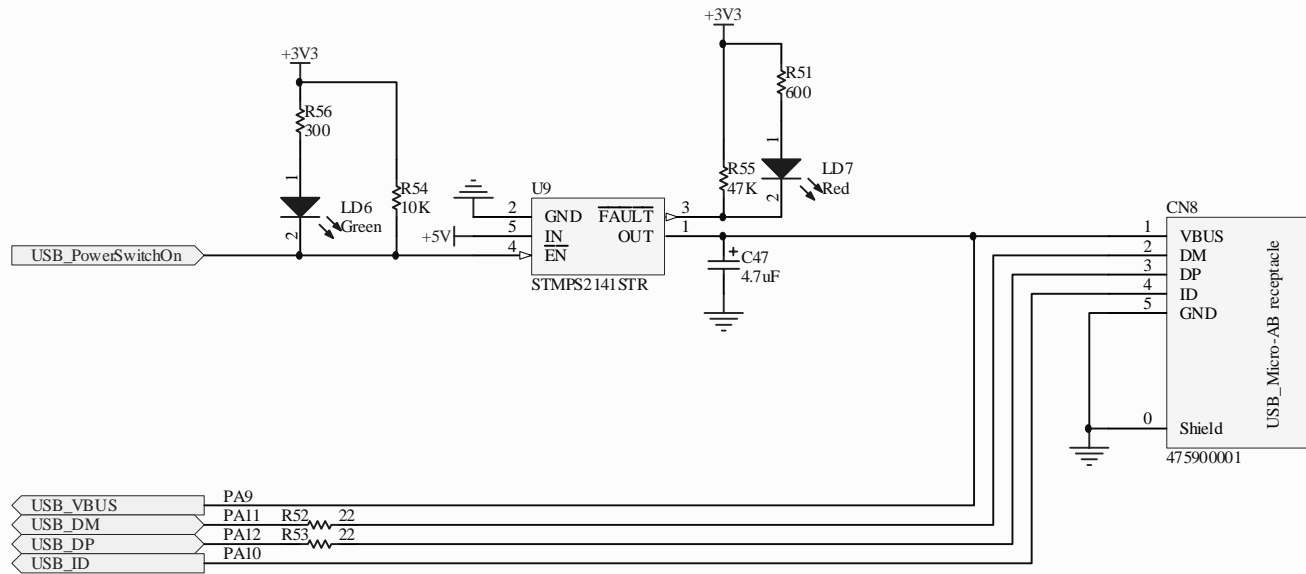
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Title: uC/eval-STM32F107 USB_OTG_FS

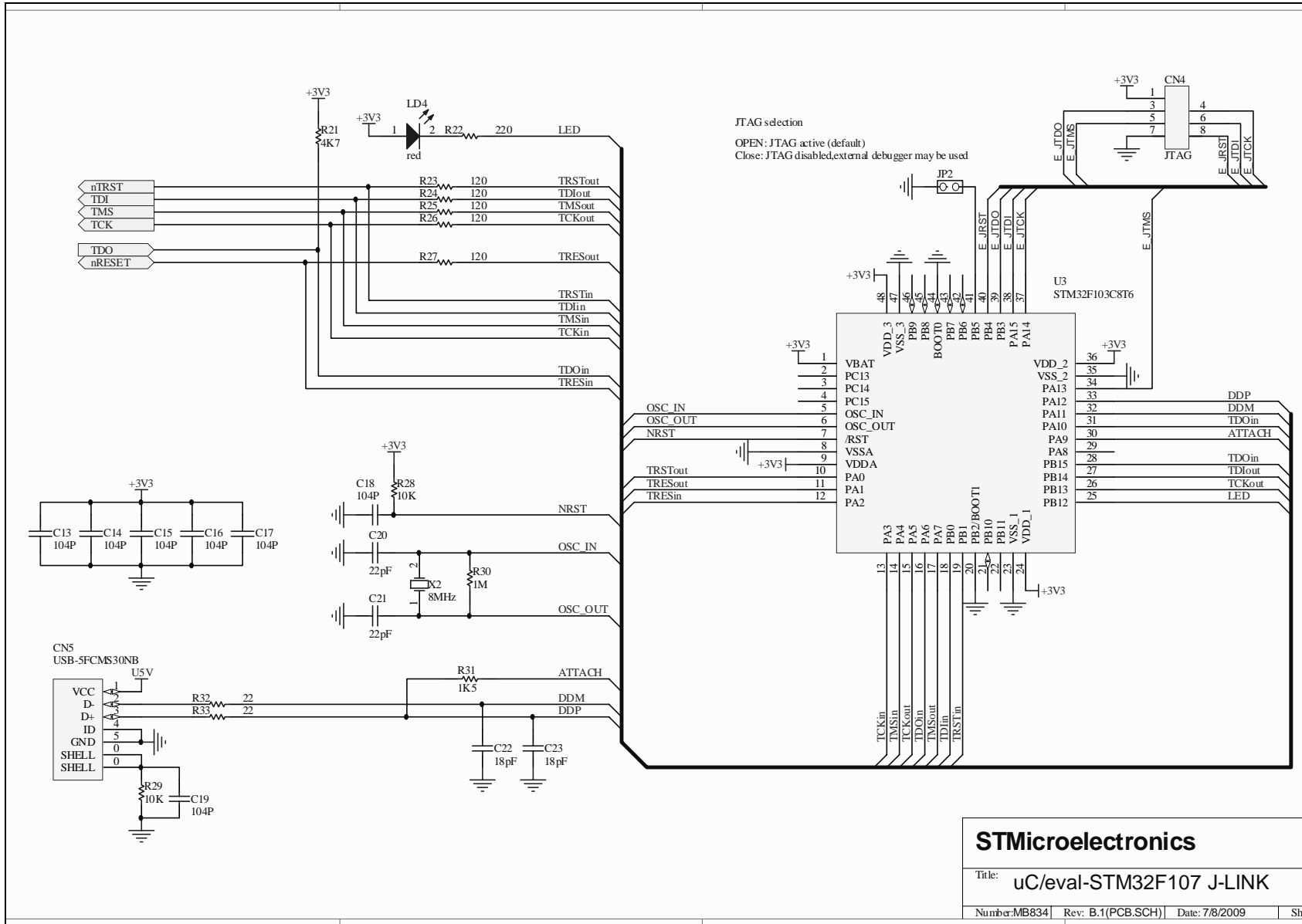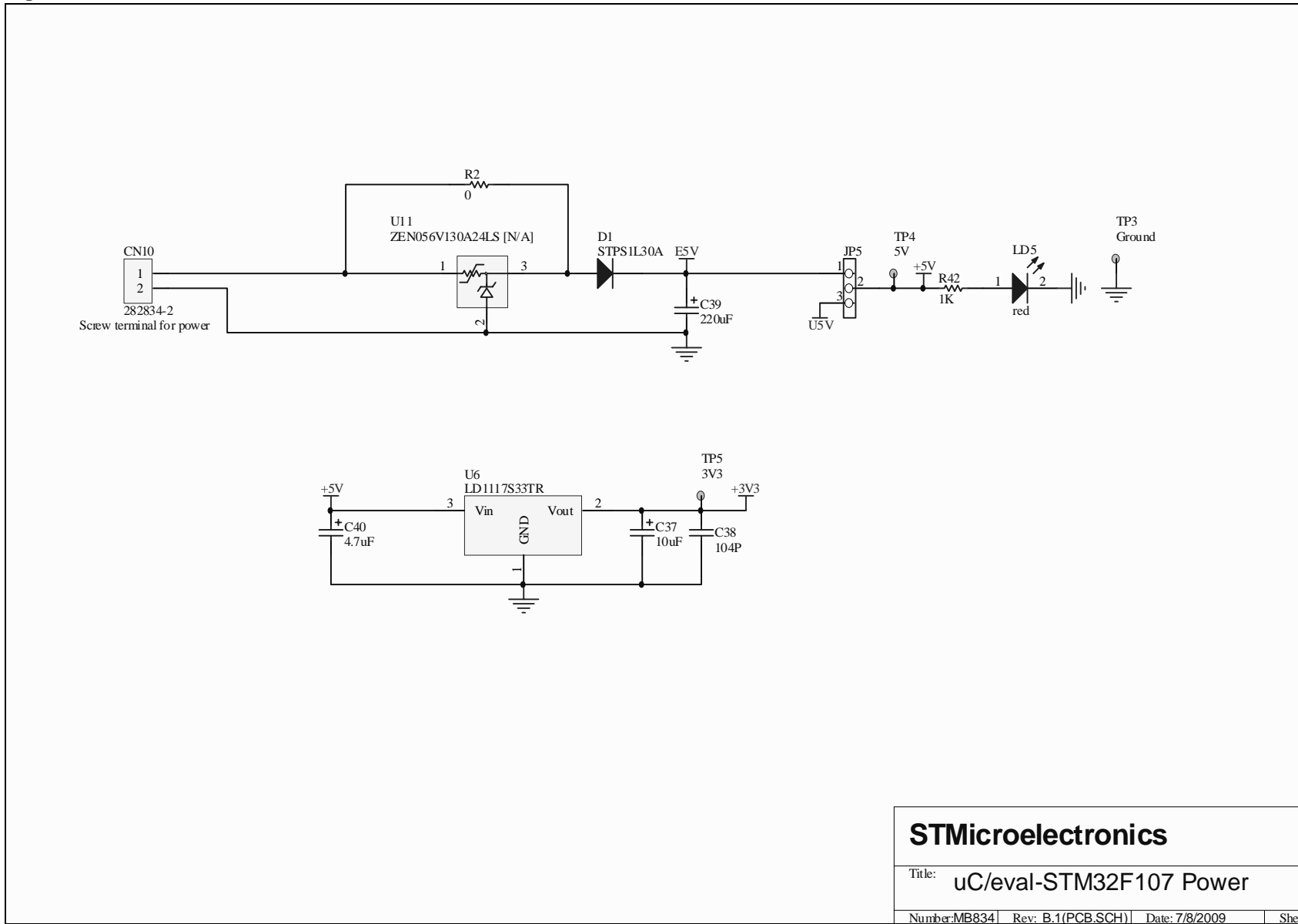Number:MB834 | Rev: B.1(PCB.SCH) | Date: 7/8/2009 | Sheet 9 of

Figure 14. J-Link

Figure 15. Power

R2
0

U11
ZEN056V130A24LS [N/A]

D1
STPS1L30A

E5V

TP4
5V

LD5

TP3
Ground

CN10
1
2
282834-2
Screw terminal for power

JP5
1
2
3
U5V

+5V

R42
1K

1

red

2

C39
220uF

U6
LD1117S33TR

TP5
3V3

+5V
Vin   Vout
GND

+3V3

C40
4.7uF

C37
10uF

C38
104P

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Title: uC/eval-STM32F107 Power

Number:MB834 | Rev: B.1(PCB.SCH) | Date: 7/8/2009 | She

5 Revision history

Table 10. Document revision history

Date	Revision	Changes
14-Sept-2009	1	Initial release.
22-Oct-2009	2	*Table 5* default settings changed. *Section 1.2* added, *Section 1.3* changed.

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