

AFE4110 Thermometer Demonstration Board

This user's guide provides a general description of the AFE4110 thermometer demonstration board (demo-pen). Use this document with the AFE4110 data sheet to get a broader understanding of the functions and applications of this device.

Contents

1	Hardware Description	1
2	Getting Started	3
	2.1 Inserting Battery and Reading the LCD Display	3
	2.2 Board Jumper Configuration	4
3	Electrical Characteristics	4
4	Schematics and Layout	4
	4.1 Schematics	4
	4.2 Layouts	5
5	Bill of Materials	6

List of Figures

1	AFE4110 Thermometer Demonstration Board Front (Bottom Layer) and Back (Top Layer)	2
2	Firmware Flowchart	3
3	Inserting Battery Into Holder	4
4	Measured Temperature Accuracy vs Temperature	4
5	Top Layer Copper	5
6	Bottom Layer Copper	5
7	Silk Screen Top	5
8	Silk Screen Bottom	5

List of Tables

1	Description of Main Board Components	2
2	Bill of Materials	6

1 Hardware Description

Figure 1 shows the front and back sides of the thermometer. The board demonstrates an accurate, low-cost, single-chip temperature measurement solution based on the AFE4110. This device is a general-purpose, low-cost, 1.5-V microcontroller optimized for this application with features like an internal 1.85-V/3.3-V charge-pump for LCD/GPIO interface, buzzer driver, low-power sleep mode, etc. See the AFE4110 data sheet ([SLLSE48](#)) for further details.

The measurement is done using an external thermistor with a negative temperature coefficient (NTC) characteristic (resistance decreases with increasing temperature). The thermistor response has been calibrated using two temperature points (at 31°C and 43°C), for an overall typical accuracy of $\pm 0.1^\circ\text{C}$ over that range, when measured in a calibration bath. *The system has not been designed to measure human body temperature and must not be used for health diagnosis purposes.*

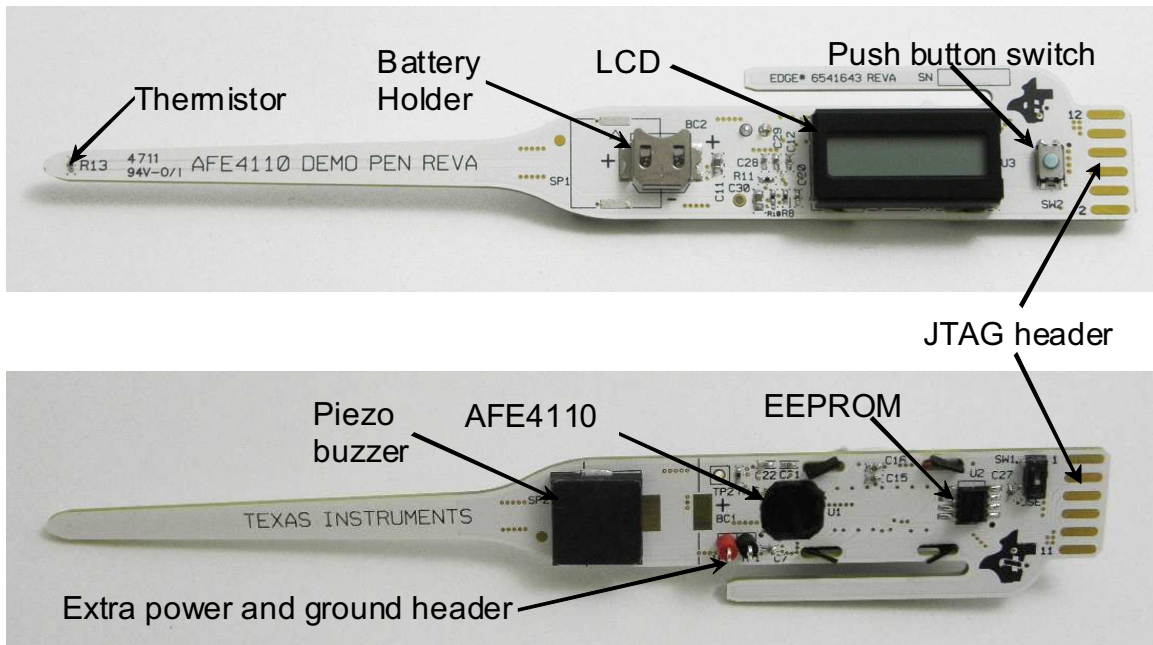


Figure 1. AFE4110 Thermometer Demonstration Board Front (Bottom Layer) and Back (Top Layer)

As the AFE4110 lacks any nonvolatile memory to store code or data (unless is burnt permanently into its ROM), the board actually uses the AFE4110 RAM-based (15 KB) emulation version and loads, at boot time, the thermometer application code (~3 KB long) from an external 128k-bit SPI EEPROM. Notice that in the final application, the EEPROM is not needed if the code is burnt into the ROM version of the AFE4110. Furthermore, the device displays the temperature, in Celsius, with 0.1°C resolution, using a 5-digit LCD display. The solution also includes a piezo-based buzzer, along with a JTAG interface for programming or debugging (Table 1 presents a list of key components).

Finally, the kit comes with a 1.5-V button-cell battery (SR60 standard) with a typical capacity of 20 mAh, under standard operating conditions.

Table 1. Description of Main Board Components

Component	Description
Thermistor	Murata NCP15WB473J03RC. NTC thermistor, 47 kΩ ± 5% and a B-constant tolerance of ± 1%. This implementation demonstrates a cost-effective solution by complementing the use of a relaxed tolerance thermistor with a 2-point calibration.
EEPROM	128k-bit SPI EEPROM. When a battery is inserted into the holder, the code is loaded from the EEPROM into the AFE4110 internal RAM, and the AFE4110 proceeds to measure the resistance of the thermistor. Notice that in the final application, the EEPROM is not needed if the code is burnt into the ROM version of the AFE4110.
Piezo-Buzzer	The buzzer is used to indicate the end of the temperature display. Following this, the AFE4110 goes into LPM5 (sleep) mode.
Power-Supply/Ground Header	Onboard connectors for 1.5-V external power supply and ground. Can be used instead of battery.
LCD	The AFE4110 has an internal charge pump to provide constant 3.3-V supply operation to the LCD, for constant contrast even when battery voltage drops.
Push-Button Switch	This switch is used to bring the AFE4110 out of the LPM5 mode. See Section 2 for the sequence of events.
JTAG Header	Provided for programming/debugging purposes.
Battery Holder	1.5-V button cell holder.

2 Getting Started

After inserting the battery in the battery holder, the temperature is displayed in the LCD. Several readings are displayed during the next 45 seconds. After the final temperature readout, the device beeps and goes into LPM5 (sleep) mode. After that, the user needs to press and hold the push-button switch for approximately 4 seconds to activate the sequence once again.

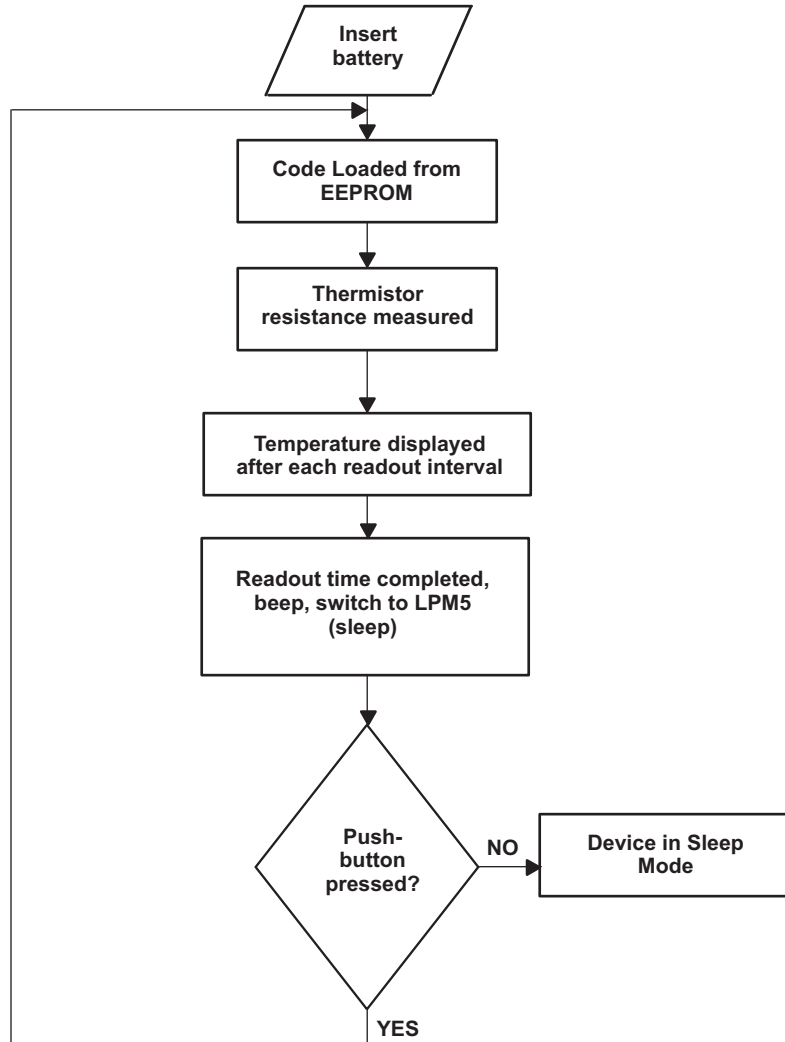


Figure 2. Firmware Flowchart

2.1 Inserting Battery and Reading the LCD Display

The battery must be inserted into the battery holder as shown in [Figure 3](#), with the positive side of the battery on top. Once this is done, the LCD displays the Firmware Version and the Hardware version, followed by the temperature display.

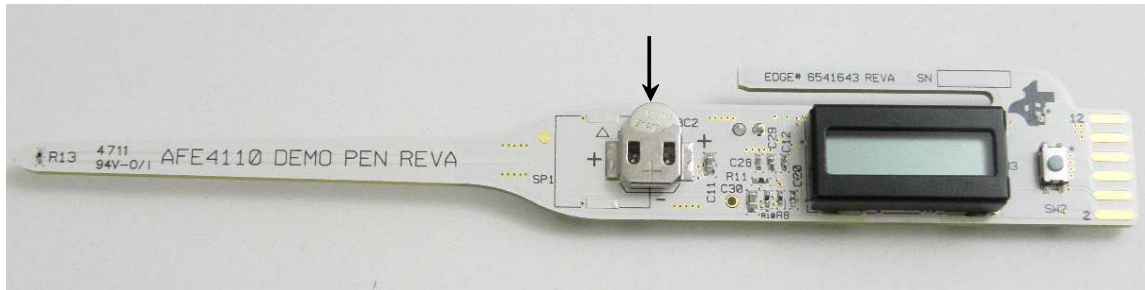


Figure 3. Inserting Battery Into Holder

2.2 Board Jumper Configuration

Power to the VDDIO pin of the AFE4110 and to the JTAG interface can be supplied from either the charge pump CP18CAP ($1.8 \times V_{BAT}$) or from the JTAG_VCCO. This is controlled by the SW1 switch on the demonstration board. By default, the switch SW1 is in the USE position (See [Section 4.1](#) for schematics and [Figure 7](#) and [Figure 8](#) for the top and bottom silk screen views, respectively). In this configuration, the AFE4110 VDDIO is powered from CP18CAP (1.8-V charge pump). For programming/debugging purposes, the AFE4110 VDDIO must be powered from the JTAG_VCCO by sliding the switch SW1 to pin #1 position.

3 Electrical Characteristics

[Figure 4](#) displays the typical resulting accuracy of the demo-pen after 2-point calibration at 31°C and 43°C.

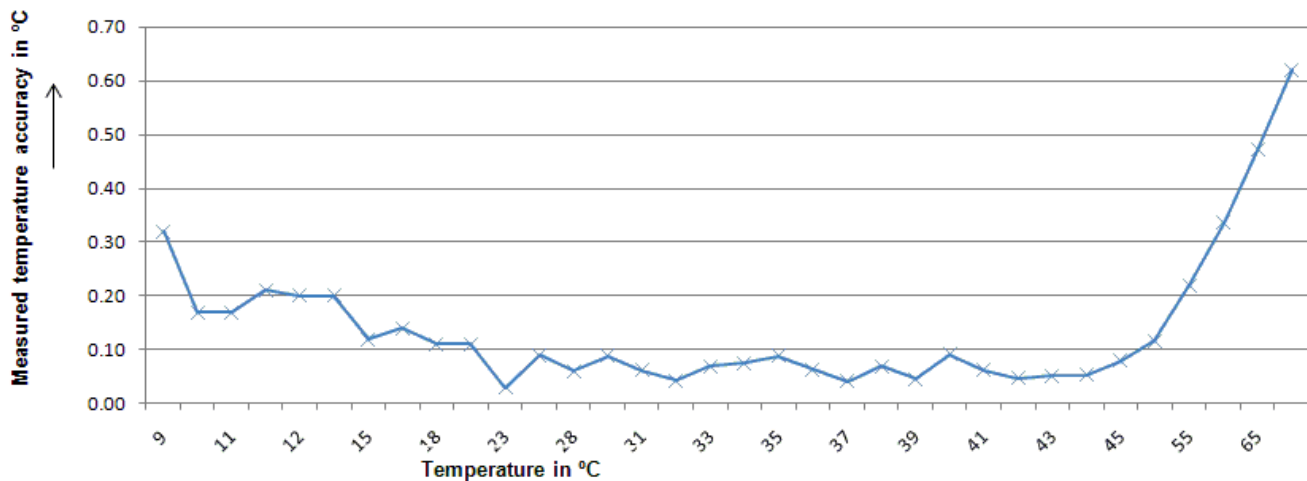


Figure 4. Measured Temperature Accuracy vs Temperature

4 Schematics and Layout

4.1 Schematics

The schematics are located at the end of this document.

4.2 Layouts

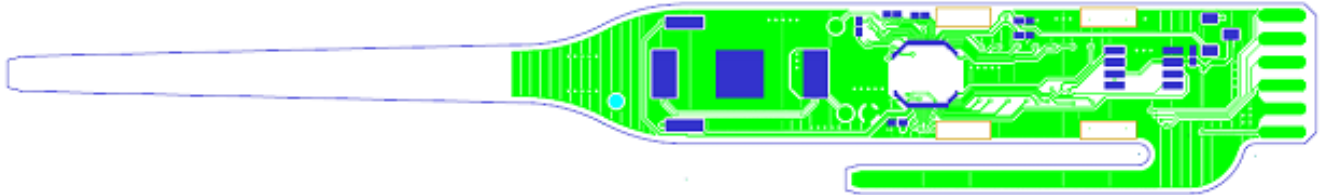


Figure 5. Top Layer Copper

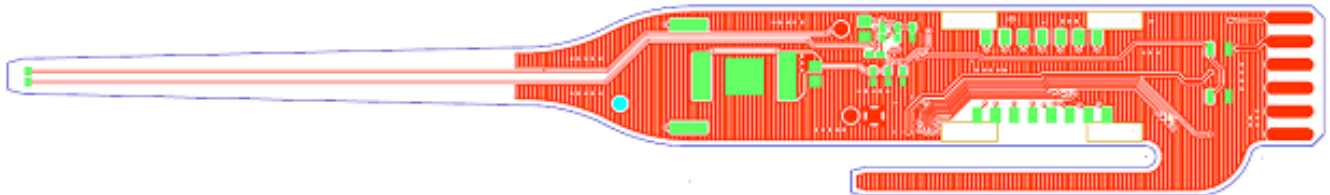


Figure 6. Bottom Layer Copper

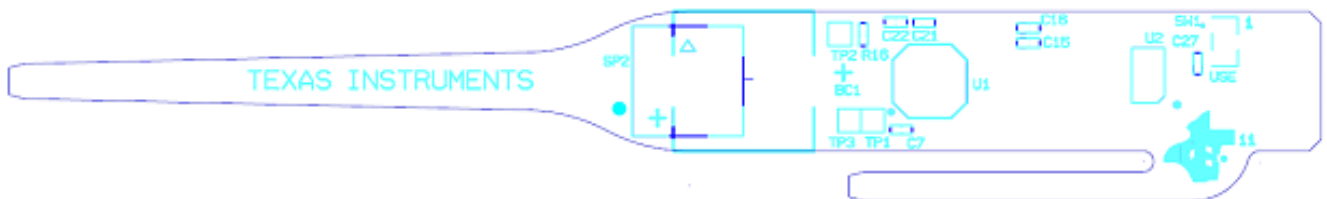


Figure 7. Silk Screen Top

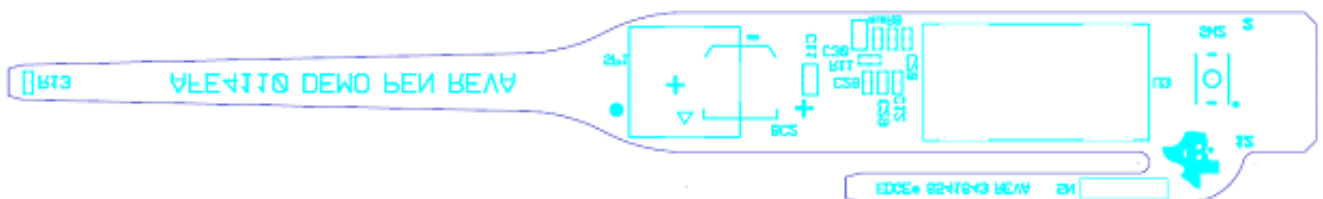


Figure 8. Silk Screen Bottom

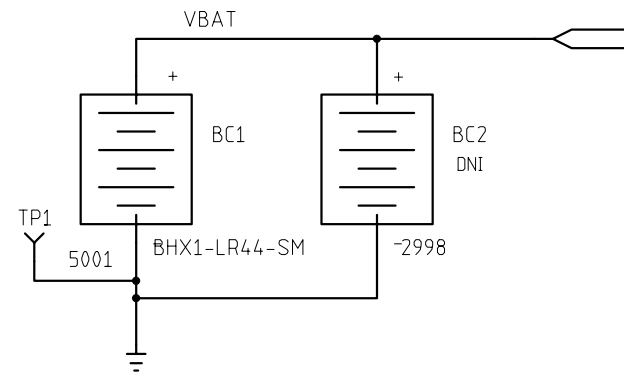
5 Bill of Materials

Table 2. Bill of Materials

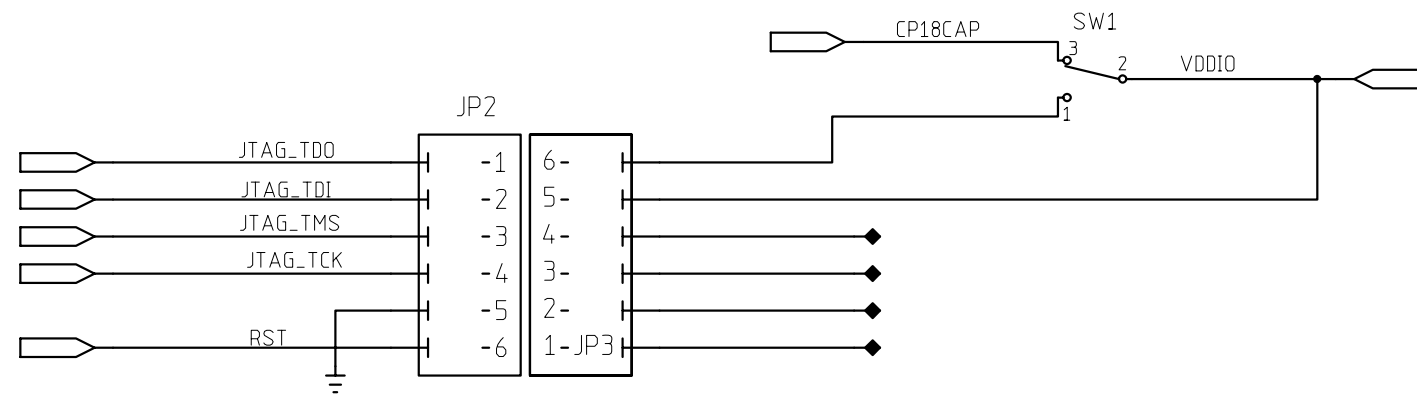
QTY	MFG	MFG PART NO.	REF DES	DESCRIPTION
1	KEystone	2998	BC2	BATT HOLDER,THU,3P
1	MEMORY PROTECT DEVICES	BHX1-LR44-SM	BC1 (DNI)	BATT HOLDER,THU,3P
2	MURATA	PKLCS1212E4001-R1	SP1 (DNI), SP2	BUZZER,SMT
5	AVX	0402YC104KAT2A	C7, C12, C20, C27, C29	CAP,SMT,0402
1	TDK	C1005C0G1E102J	C28	CAP,SMT,0402
2	SAMSUNG	CL05A475MQ5NRNC	C15, C16	CAP,SMT,0402
2	PANASONIC	ECJ-0EB1H102K	C21, C22	CAP,SMT,0402
2	PANASONIC	ECJ-1VB0J106M	C11, C30	CAP,SMT,0603
2		HEADER,SMT,6P,.1CTRS	JP2, JP3	CUSTOMER INSTALLED
1	SOFTBAUGH	SBLCDA8	U3	DISPLAY,SMT,15P
1	COPAL ELECTRONICS	CAS-120TA	SW1	SWITCH, SLID, 3P
1	ST MICRO	M95128-RMN6TP	U2	IC,SMT,SOIC-8N
1	TI	AFE4110	U1	MODULE
1	SUSUMU	RG1005P-303-B-T5	R10	RES,SMT,0402
1	MURATA	NCP15WB473J03RC	R13	THERMISTOR,SMT,0402
1	PANASONIC	ERJ-2RKF1004X	R11	RES,SMT,0402
1	SUSUMU	RG1005P-6492-B-T5	R8	RES,SMT,0402
1	SUSUMU	RG1005N102B	R16	RES,SMT,0402
1	PANASONIC	EVQ-P2H02B	SW2	SWITCH,SMT,2P
3	KEystone ELECTRONICS	5001	TP1, TP2 (DNI), TP3	TESTPOINT,THU,1P

SYM	REVISIONS
A	ECR 2119959, 11/01/11, MPK

JTAG and POWER

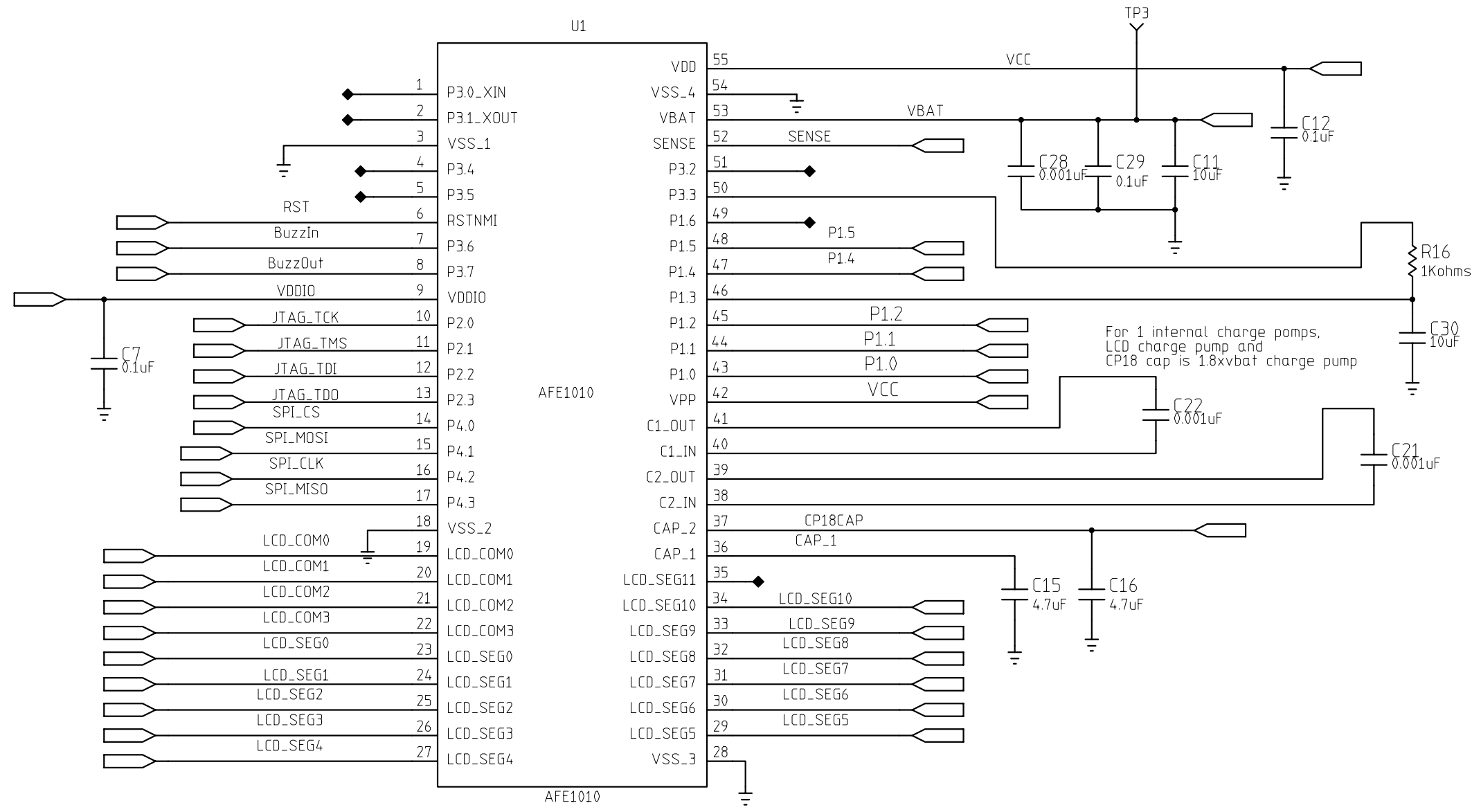


Supply the DUT and JTAG IF
with CP18 or JTAG_VCCO
1.8V x VBAT

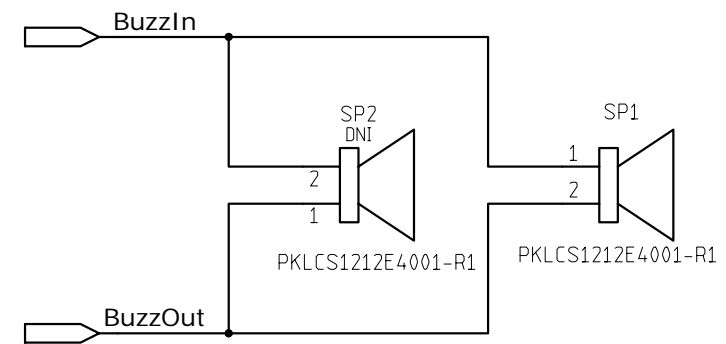
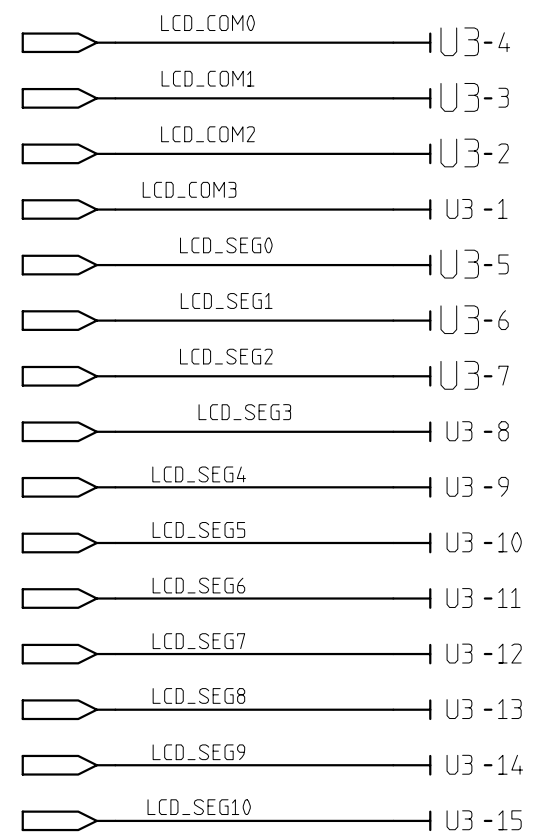


DRAFTSMAN: CHUCK SMYTH	DATE 11/01/11	TEXAS INSTRUMENTS SEMICONDUCTOR OPERATIONS	CODE IDENTITY NUMBER 01295
DESIGNER: CHUCK SMYTH	DATE 11/01/11		TITLE: SCHEMATIC, AFE4110_DEMO_PEN
CHECKER: CHUCK SMYTH	DATE 11/01/11		
ENGINEER: CHUCK SMYTH	DATE 11/01/11		
APPROVED: CHUCK SMYTH	DATE 11/01/11		
RELEASED: MIKE KORSON	DATE 011/01/11	SCALE N	SIZE B
		6541643	REV A
			SHEET 01/06

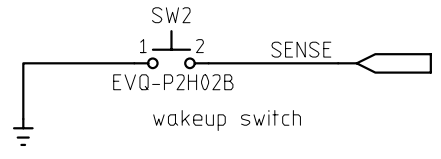
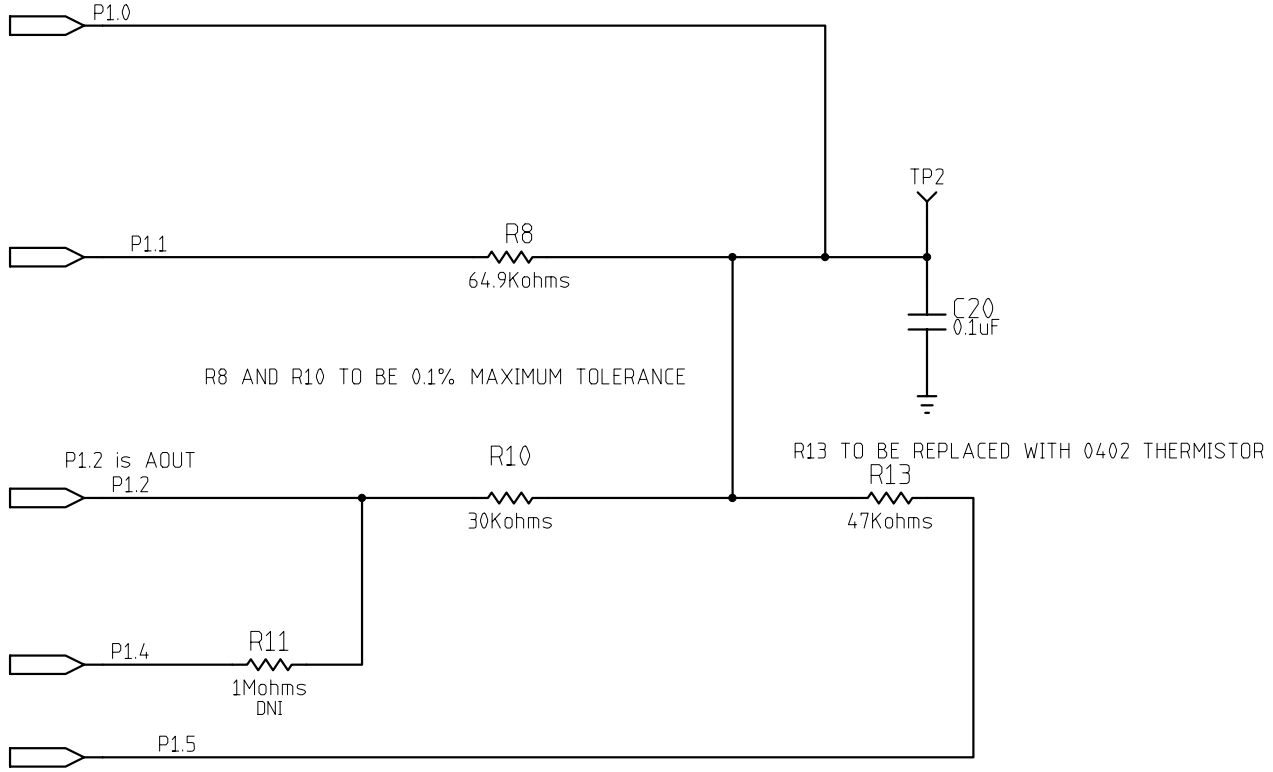
DUT



LCD and SPEAKER

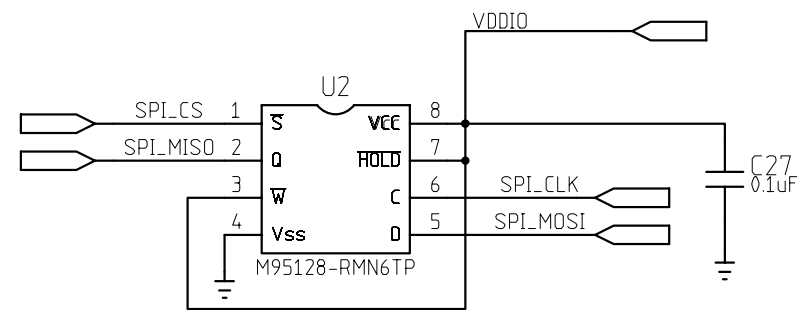


PORT1 RC NETWORKS



EEPROM and BOOTLOADER

Need to verify the blue wire
to see the PORT pin is right or not



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