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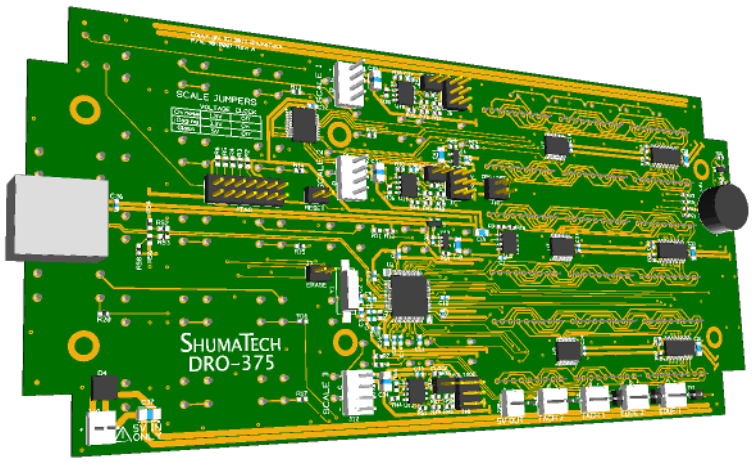
DRO-375 Hardware Manual

Revision 1



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Revision History

Revision	Date	Author	Comment
1	1/18/12	S. Shumate	Initial draft based on revision A hardware

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Introduction

The DRO-375 combines the advanced technology of the DRO-550 running OpenDRO software with a maximally cost-effective design. The board is designed to fit the DRO-550 form factor and thus can leverage the existing overlay and machined enclosure. The DRO-375 offers nearly the same capabilities as the DRO-550 but with support for fewer scales and less expandability. The hardware capabilities of the DRO-375 include:

- 50MHz 32-bit ARM7 processor that runs the open-source OpenDRO software
- Supports three Chinese (bin24, bcd7, bin6 formats), iGaging, and/or quadrature digital scales
- Six digit 7-segment LED display with auto-precision
- Five mode indicator LEDs
- Twenty-three key keypad matrix
- USB interface for programming and control
- Dual edge finder inputs

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- Dual tachometer inputs
- JTAG debugging interface
- Integrated piezo buzzer for near-zero warning and key-chirp
- Constant-current LED drivers for lower heat and flicker-free display

The notable features that the DRO-375 does not have that the DRO-550 does are:

- Support for the LCD-200 display
- SD card interface
- Expansion headers for analog and digital inputs
- RS-232 UART ports

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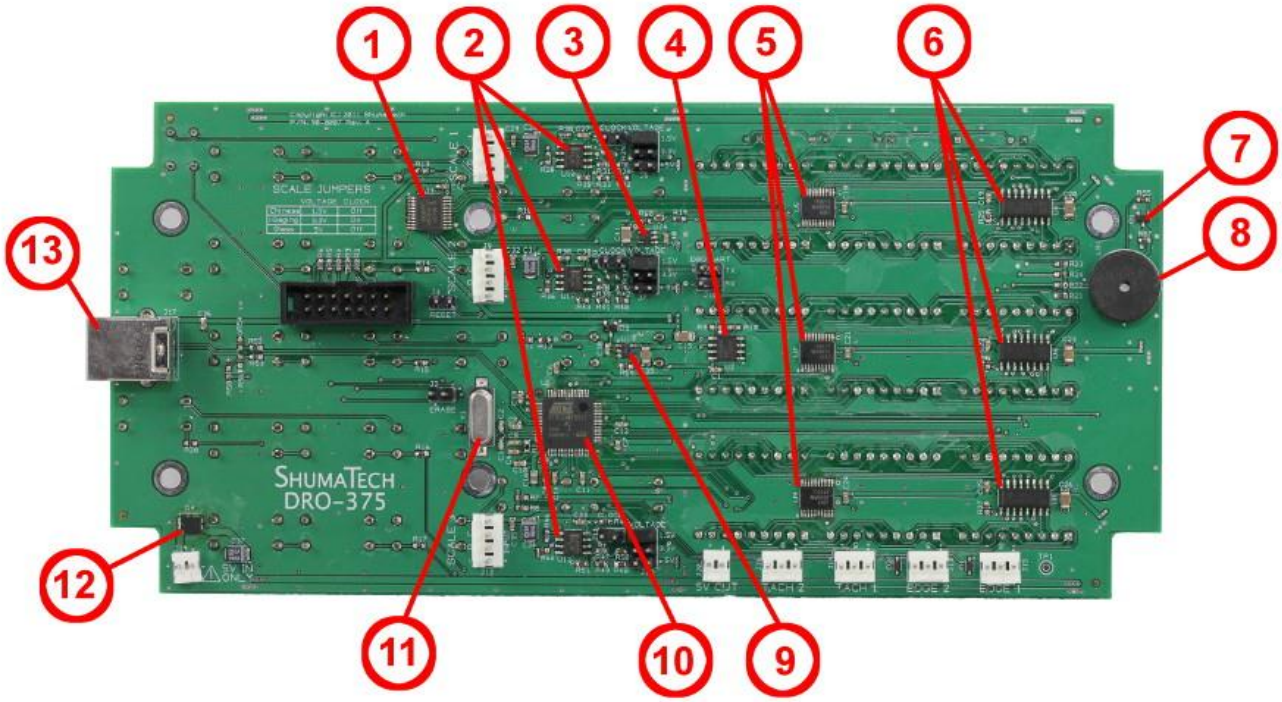
Components



Top Side

1. SN74HC4351 – Analog multiplexer used to send signals with the correct voltage level back to the scales.
2. LM393 (x 3) – Dual comparators that translate the scale signal voltages to logic levels appropriate for the ARM7 processor.
3. TPS76915 – 1.5V 100mA voltage regulator. The scale voltage for Chinese scales that is selected by the Scale Voltage Select Jumpers (see below).
4. AT24C64 – 8KB I2C EEPROM. This is the non-volatile data storage for all OpenDRO configuration and settings.
5. TLC59213 (x 3) – 8-bit Darlington source drivers with integrated latches. There is one device per display row and it is responsible for driving the correct column in the LED display matrix.
6. TLC5916 (x 3) – 8-bit constant current LED sink driver. There is one device per display row and it drives the individual LEDs in the 7-segment display. Constant current means that it provides a consistent current and reduces power dissipation, heat and flicker.
7. NPN Transistor – Provides amplification for the Piezo transducer.
8. Piezo Transducer – A generic buzzer used by the OpenDRO for near-zero warning, audible key chirp, and other functions.
9. TPS76933 – 3.3V 100mA voltage regulator. This provides the I/O voltage for the ARM7 processor.
10. AT91SAM7S256 – A 50MHz ARM7 processor with 256KB of flash for code storage and 64KB of SRAM for data storage. This is the heart of the DRO-375 and is where the OpenDRO software runs.

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11. 18.432MHz Crystal – The main timing reference for the ARM7. The ARM7 derives the main processor clock and the USB clock from this crystal.
12. ZEN056V – 5V 2.3A resettable fuse. This protects the board from high current and voltage conditions such as when the wrong power supply is connected.
13. USB Type B Connector – A full speed USB device interface for programming and control.

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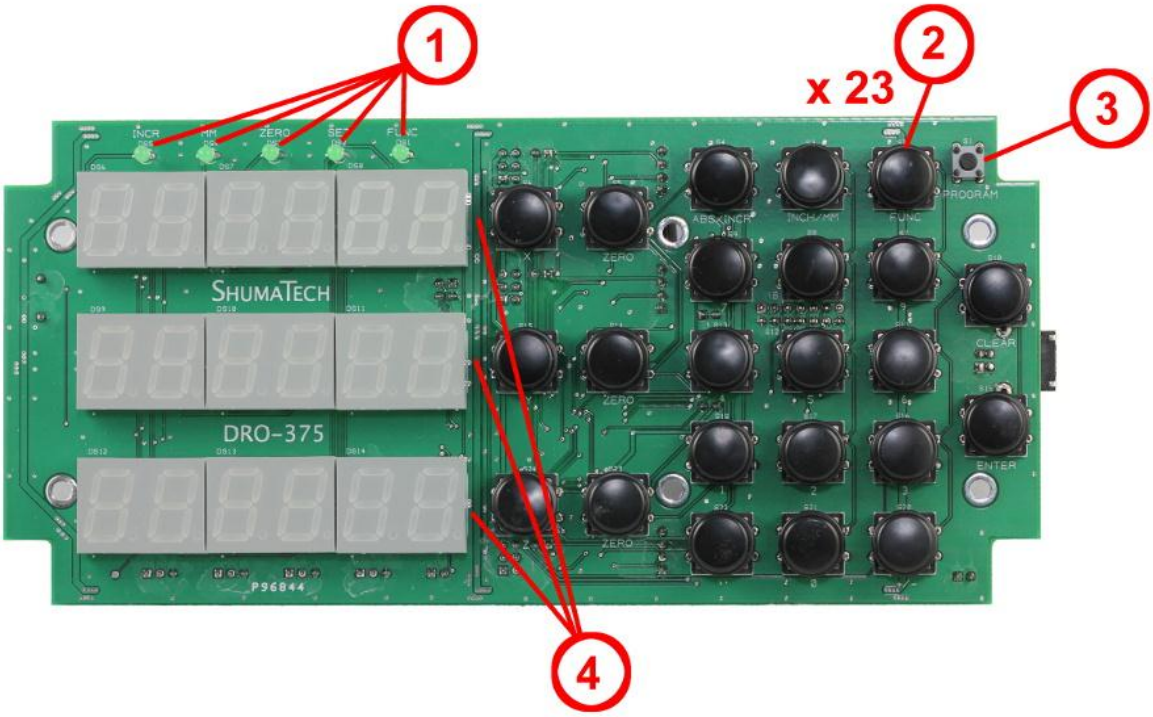

Bottom Side

1. 3mm LED Indicators (x 5) – These LEDs provide the five indicators for OpenDRO: INCR, MM, ZERO, SET, and FUNC. The LEDs are through-hole devices that make it easy to use different color LEDs.
2. 12mm Tact Switches (x 23) – These form the keypad for input.
3. 6mm Tact Switch (PROGRAM) – Holding this switch down for 15 seconds when connecting power to the DRO-375 places the ARM7 in program mode which is used by the BOSSA program to load the OpenDRO software into the ARM7.
4. Dual 7 Segment LEDs (6 Digits x 3 Rows) – Provides the display of readings for up to three axes and also serves as the informational display when there is no LCD display connected.

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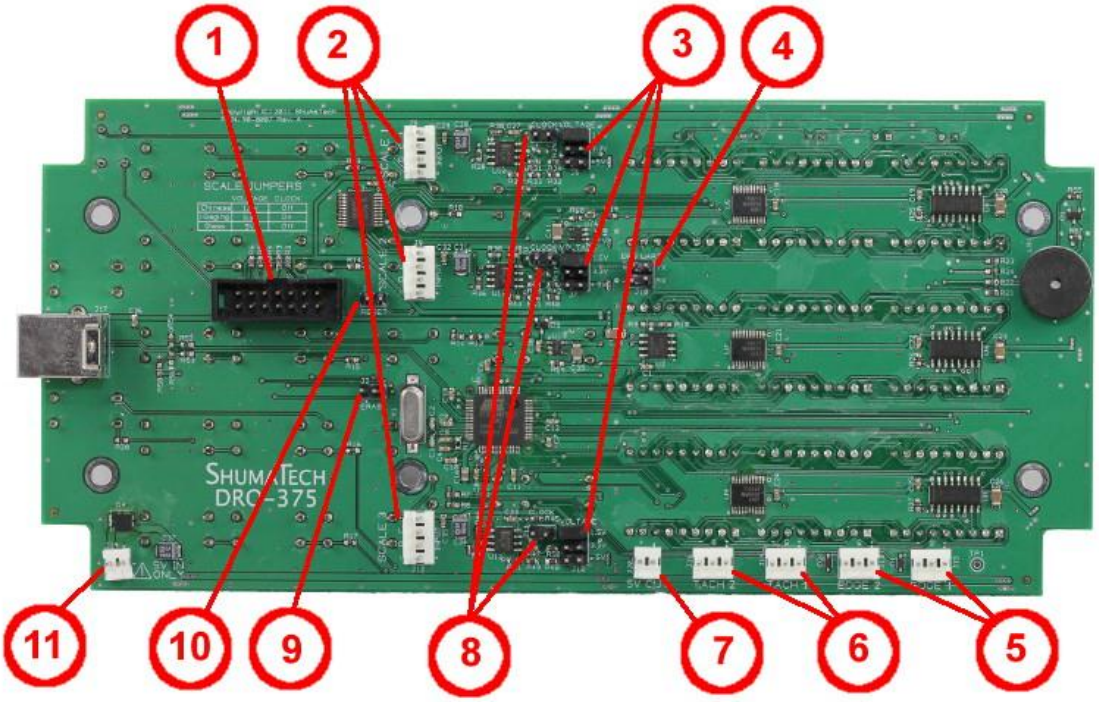

Headers

1. JTAG – This header is used to access the JTAG port for debug and boundary scan applications. This is typically used with an external JTAG pod for software development. This header conforms to the standard 14 pin JTAG pin-out.

Pin	Signal	Description	ARM7
1	3V3	3.3V power	
2	GND	Ground	
3	nTRST	Not used – pull-up to 3V3	
4	GND	Ground	
5	TDI	JTAG test data input	Pin 33
6	GND	Ground	
7	TMS	JTAG test mode	Pin 51
8	GND	Ground	
9	TCK	JTAG test clock	Pin 53
10	GND	Ground	
11	TDO	JTAG test data out	Pin 49
12	N/C	Not connected	
13	3V3	3.3V power	
14	GND	Ground	

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2. Scale Inputs (x 3) – These 3 headers connect to the digital scales. The voltage used by each scale interface is determined by its corresponding scale power jumper described below. The OpenDRO software supports Chinese scales (24bit, bcd7, and bin6 protocols) iGaging scales (21bit protocol), and standard quadrature signals.

Pin	Signal	Description
1	GND	Ground
2	Data (A)	Chinese scale data signal or quadrature phase A
3	Clock (B)	Chinese scale clock signal or quadrature phase B
4	Power	1.5V, 3.3V or 5V scale power determined by the scale power jumper Total 1.5V power < 100mA, 3.3V < 100mA and total 5V power < 1A

Scale	Input	ARM7
1	Data (A)	PA26 pin 26
1	Clock (B)	PA29 pin 41
2	Data (A)	PA27 pin 37
2	Clock (B)	PA30 pin 42
3	Data (A)	PA28 pin 38
3	Clock (B)	PA31 pin 52

3. Scale Power (x 3) – Each scale power header selects the voltage supplied to the scale input horizontally across from it. A standard shorting jumper is either placed across the 1.5V selection for Chinese scales or across the 5V selection for quadrature scales.

Pin	Signal	Description
1	5V	5V power
2	Power	Power output when 5V is selected
3	3V3	3.3V power
4	Power	Power output when 5V is selected
5	1V5	1.5V power
6	Power	Power output when 1.5V is selected

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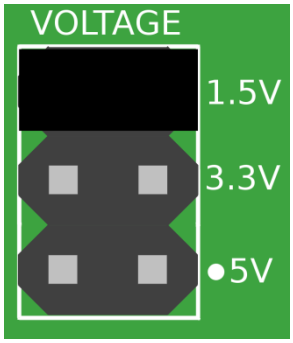
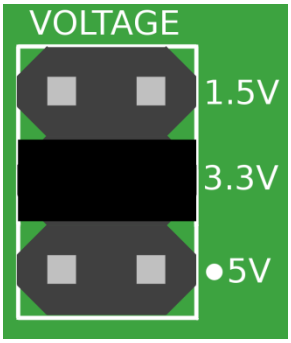
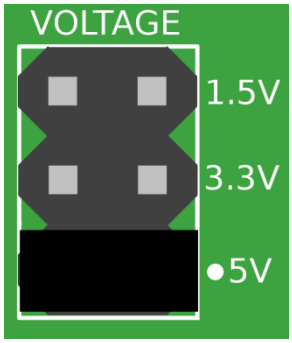


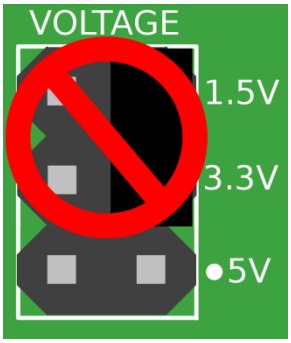
Chinese Scale Power (1.5V)



iGaging Power (3.3V)



Quadrature Power (5V)



NEVER jumper vertically!

4. DBG UART – A debug header for the logic level UART signals from the ARM7 serial debug interface. This header can be used with an external RS-232 transceiver.

Pin	Signal	Description	AMR7
1	3V3	Total 3.3V power < 100mA	
2	TX	DBG UART transmit	PA10 pin 29
3	GND	Ground	
4	RX	DBG UART receive	PA9 pin 30

5. EDGE (x 2) – The edge finder inputs provide a connection to an electronic edge finder that is used to zero the DRO when a surface is contacted. The OpenDRO software responds to a negative going pulse.

Pin	Signal	Description	ARM7
1	5V	5V power	
2	EDGE	Edge finder signal (negative going pulse)	EDGE 1: AD4 pin 3 EDGE 2: AD4 pin 4
3	GND	Ground	

6. TACH (x 2) – The tachometer inputs are connected to external sensors that provide feedback to measure the spindle speed of machine equipment. The OpenDRO software measures between negative going pulses.

Pin	Signal	Description	ARM7
1	5V	5V power	
2	TACH	Tachometer signal (negative going pulse)	TACH1: PA0 pin 48 TACH2: PA15 pin 20
3	GND	Ground	

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7. 5V OUT – 5V power output header. Total 5V power must be less than 1A.

Pin	Signal	Description
1	GND	Ground
2	5V	5V power

8. CLOCK (x 3) – Shorting this jumper outputs a clock for use with iGaging (a.k.a 21 bit) scales. You must install this jumper when using iGaging scales and remove it for all other scale types.

Position	Description
On	Outputs a clock for iGaging scales
Off	No clock output for Chinese and quadrature scales.

9. ERASE – Shorting this jumper erases the flash in the ARM7.

Pin	Signal	Description
1	3V3	3.3V power
2	ERASE	Erase signal (ARM7 pin 55)

10. RESET – Shorting this jumper asserts the reset signal to the ARM7.

Pin	Signal	Description
1	NRST	Negative polarity reset signal (ARM7 pin 39)
2	GND	Ground

11. 5V IN – The main power input to the DRO-375. Connect this **ONLY** to a 5V DC regulated power supply with at least 1.5A output current. See the section later for more information in selecting the proper current rating for the power supply. This provides the 5V power on the board from which all other voltages are derived. This input is protected by a resettable fuse so connecting an incorrect power supply or wrong polarity will not damage the board and it will reset itself after a few minutes rest.

Pin	Signal	Description
1	GND	Ground
2	5V	See later section for proper current rating

Electrical

Most of the digital signals on the DRO-375 headers are connected directly to the ARM7 processor. The ARM7 generates 3.3V outputs and can take up to 5V inputs (“5V tolerant”). When connecting 5V devices to the DRO-375, special care must be considered. Most 5V

CMOS devices have a worst-case input high voltage of 0.7 * Vcc or 3.5V. The 3.3V output generated by the ARM7 may not be high enough to reliably drive these devices. Instead, one can use CMOS devices with TTL inputs that guarantee an input high voltage of around 2V. Alternatively, individual outputs can be placed in open drain mode by the software and a pull-up resistor to 5V added to supply the high level voltage.

The ARM7 digital outputs are capable of outputting up to 8mA of current and care should be exercised to assure that level is not exceeded.

Power

The DRO-375 requires an external 5V DC regulated power supply. The power input is protected with a resettable fuse so connecting a power supply with the wrong voltage or polarity will not damage the board. If this occurs, disconnect the power and wait a few minutes for the fuse to reset itself.

The external power supply directly feeds everything on the board. Proper selection of the external power supply is necessary if one wants to use the full capabilities of the DRO-375. Absolute worst cast power consumption on the DRO-375 is around 1.3A of which over 90% is used by the LED display. A minimum 1.5A power supply is recommended for the DRO-375. The resettable fuse is guaranteed not to trigger at 2.3A and below. This allows up to 1A of 5V power for use by external circuits and equipment. This is more than sufficient to power a set of three glass scales. If you want to use the full 5V 1A external output capability, then use at least a 2.5A 5V power supply.

CAUTION: Only use a 5V DC regulated power adapter rated of at least 1.5A.

The 3.3V and 1.5V power supplies each can supply up to 100mA. The 3.3V power supply is mainly for powering the ARM7 digital I/O pins and should be used sparingly for other purposes. iGaging scales use 3.3V power but consume very little power and it is safe to use them on all three scale inputs. The 1.5V power supply is for powering the Chinese scales and should not be used for other purposes in order to keep the scale power as noise free as possible.

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ARM7 PIO Map

Port A

Port	Pin	Net	PIO	Dir	PU	OD	Int	Notes
PA0	48	TACH0	B					
PA1	47	SCALE_CLK_OUT	A					For iGaging scales
PA2	44	KEYPAD_COL0	P	O				
PA3	43	SDA	A			Y		External 4.7 K pull-up
PA4	36	SCL	A			Y		External 4.7 K pull-up
PA5	35	USB_DETECT	P	I				
PA6	34	DISPLAY_COL_CLK	P	O				
PA7	32	BUZZER	B					
PA8	31	DISPLAY_ROW_OE	P	O				
PA9	30	RS232_RX	A					
PA10	29	RS232_TX	A					
PA11	28	DISPLAY_ROW_LE	A					
PA12	27	SACLE_OUT_LATCH	P	O				74HC4351 latch enable
PA13	22	DISPLAY_ROW_SI	A					
PA14	21	DISPLAY_ROW_CLK	A					
PA15	20	TACH1	B					
PA16	19	DISPLAY_COL0	P	I/O				Also KEYPAD_ROW0, 74HC4351 S0
PA17	9	DISPLAY_COL1	P	I/O				Also KEYPAD_ROW1, 74HC4351 S1
PA18	10	DISPLAY_COL2	P	I/O				Also KEYPAD_ROW2, 74HC4351 S2
PA19	13	DISPLAY_COL3	P	I/O				Also KEYPAD_ROW3
PA20	16	DISPLAY_COL4	P	I/O				Also KEYPAD_ROW4
PA21	11	DISPLAY_COL5	P	I/O				Also KEYPAD_ROW5
PA22	14	DISPLAY_COL6	P	I/O				Also KEYPAD_ROW6
PA23	15	DISPLAY_COL7	P	I/O				Also KEYPAD_ROW7
PA24	23	KEYPAD_COL1	P	O				
PA25	25	KEYPAD_COL2	P	O				
PA26	26	SCALE_A_IN0	P	I			Y	
PA27	37	SCALE_A_IN1	P	I			Y	
PA28	38	SCALE_A_IN2	P	I			Y	
PA29	41	SCALE_B_IN0	P	I			Y	
PA30	42	SCALE_B_IN1	P	I			Y	
PA31	52	SCALE_B_IN2	P	I			Y	

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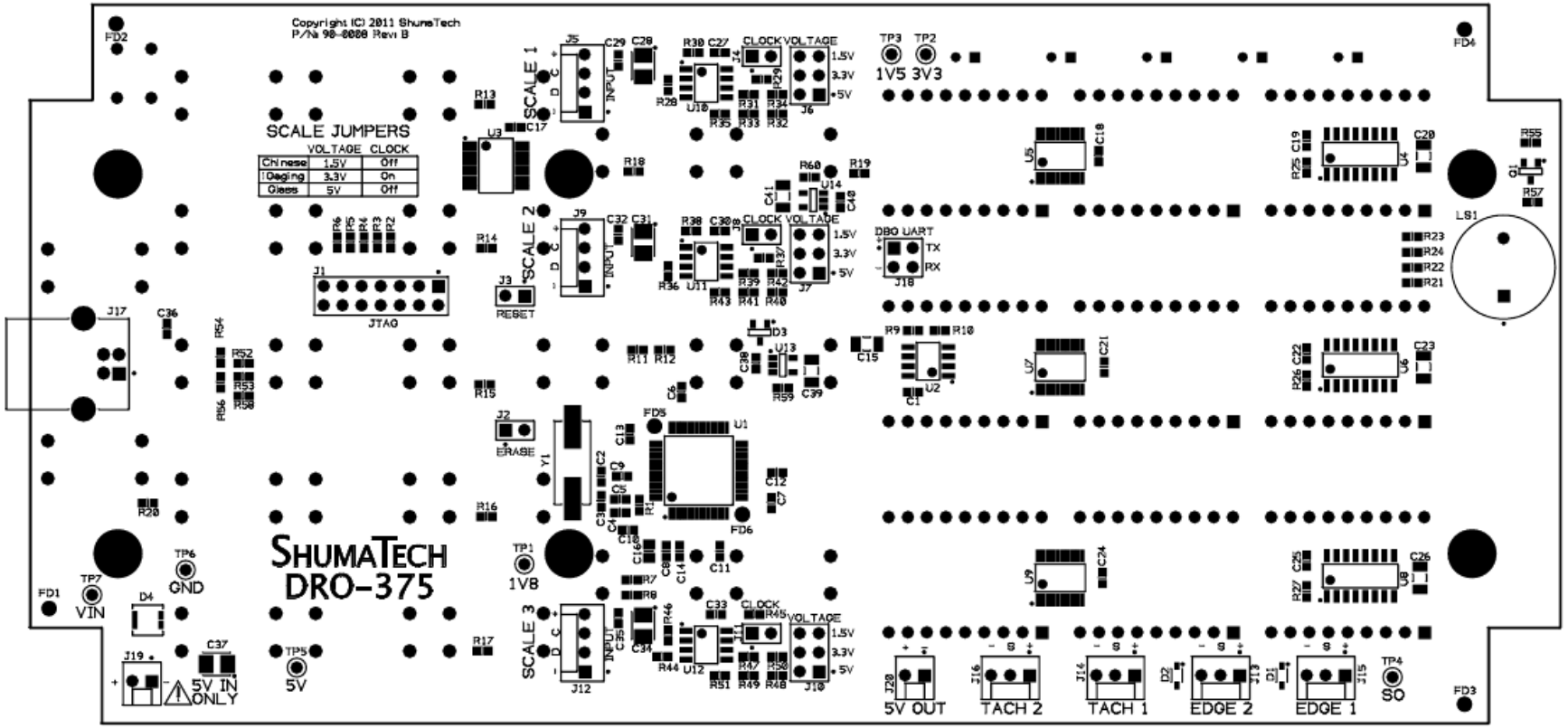
PCB

Top-Side



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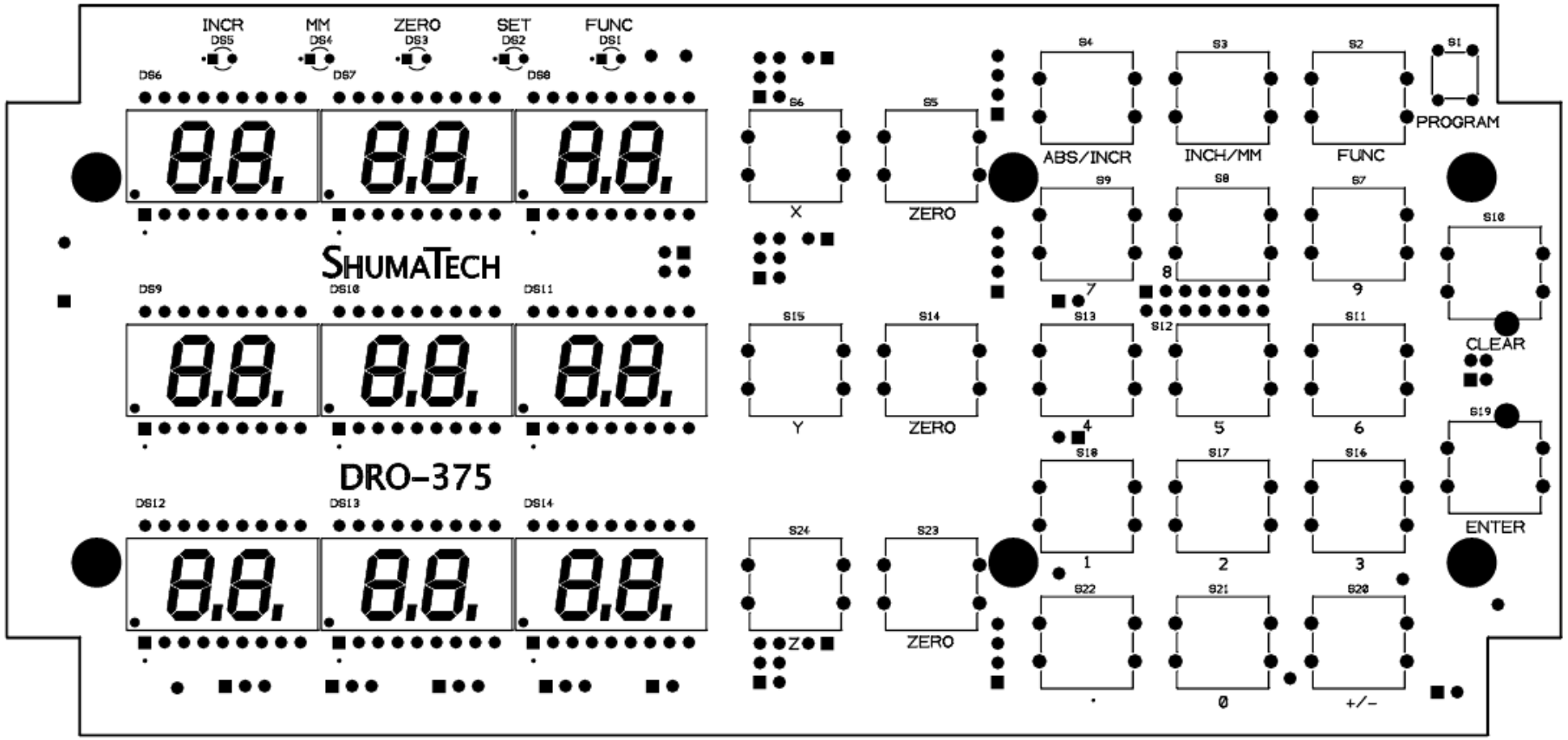
Bottom-Side



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Bill of Materials

Surface-Mount Parts

Item	Qty	Ref Des	Distributor	Dist Part #	Description
1	25	C1,C6,C7,C8,C9,C10,C11,C12,C13,C17,C18,C19,C21,C22,C24,C25,C27,C29,C30,C32,C33,C35,C36,C38,C40	DigiKey	490-1519-1-ND	CAP,CER,0.1UF,10%,X7R,50V,0603
2	2	C2,C3	DigiKey	490-1403-1-ND	CAP,CER,10PF,5%,C0G,50V,0603
3	1	C4	DigiKey	490-1511-1-ND	CAP,CER,10NF,10%,X7R,50V,0603
4	2	C5,C14	DigiKey	490-1494-1-ND	CAP,CER,1NF,10%,X7R,50V,0603
5	6	C15,C20,C23,C26,C39,C41	DigiKey	445-1391-1-ND	CAP,CER,10UF,10%,Y5V,16V,1206
6	1	C16	DigiKey	490-1696-1-ND	CAP,CER,2.2UF,10%,X7R,10V,0805
7	4	C28,C31,C34,C37	DigiKey	718-1313-1-ND	CAP,TANT,100UF,10%,6.3V,3528
8	2	D1,D2	DigiKey	1N4448WSFSCT-ND	DIODE,SMALL SIGNAL,100V,4NS,SOD-323
9	1	D3	DigiKey	BAT54CFSCT-ND	DIODE,SCHOTTKY,DUAL,CC,30V,200mA,SOT-23
10	1	D4	DigiKey	ZEN056V230A16LSCT-ND	POLYZEN 5.6V PPTC/ZENER SMD
11	5	DS1,DS2,DS3,DS4,DS5	DigiKey	160-1708-ND	LED RED DIFFUSED 3MM
12	9	DS6,DS7,DS8,DS9,DS10,DS11,DS12,DS13,DS14	DigiKey	516-1206-5-ND	LED DISPLAY 7SEG RED 2 DIGIT CA 18DIP
13	1	J1	DigiKey	WM8125-ND	HEADER 2X7 14 POS TIN 0.100 SPC 0.230" LN"
14	5	J2,J3,J4,J8,J11	DigiKey	WM8072-ND	HEADER 2 POS TIN 0.100 SPC 0.230" LN"
15	3	J5,J9,J12	DigiKey	A1922-ND	HEADER 4 POS TIN STR MTA-100 W/ FRIC LCK
16	3	J6,J7,J10	DigiKey	WM8121-ND	HEADER 2X3 6 POS TIN 0.100 SPC 0.230" LN"
17	4	J13,J14,J15,J16	DigiKey	A19470-ND	HEADER 3 POS TIN STR MTA-100 W/ FRIC LCK
18	1	J17	DigiKey	609-3657-ND	CONN,USB,TYPE B,RA
19	1	J18	DigiKey	WM8120-ND	HEADER 2X2 4 POS TIN 0.100 SPC 0.230" LN"
20	2	J19,J20	DigiKey	A1921-ND	HEADER 2 POS TIN STR MTA-100 W/ FRIC LCK

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21	1	LS1	DigiKey	668-1101-ND	PIEZO BUZZER 4KHZ 5V 14MM PC MNT
22	1	Q1	DigiKey	MMBT3904FSCT-ND	TRANSISTOR, GP, NPN, 200mA, SOT-23
23	2	R1,R57	DigiKey	RHM1.87KHTR-ND	RESISTOR, R0603, 1.87K, 1/10W, 0.01
24	11	R2,R3,R4,R5,R6,R30,R31,R38,R39,R46,R47	DigiKey	RHM100KGCT-ND	RESISTOR, R0603, 100K, 1/10W, 0.05
25	22	R7,R8,R11,R28,R29,R32,R33,R34,R35,R36,R37,R40,R41,R42,R43,R44,R45,R48,R49,R50,R51,R55	DigiKey	RHM10.0KHCT-ND	RESISTOR, R0603, 10K, 1/10W, 0.01
26	15	R9,R10,R12,R13,R14,R15,R16,R17,R18,R19,R20,R21,R22,R23,R24	DigiKey	RHM4.7KGCT-ND	RESISTOR, R0603, 4.7K, 1/10W, 0.05
27	3	R25,R26,R27	DigiKey	RHM300GCT-ND	RESISTOR, R0603, 300, 1/10W, 0.05
28	2	R52,R53	DigiKey	RHM27GCT-ND	RESISTOR, R0603, 27, 1/10W, 0.05
29	2	R54,R56	DigiKey	RHM330KGCT-ND	RESISTOR, R0603, 330K, 1/10W, 0.05
30	1	R58	DigiKey	RHM1.5KGCT-ND	RESISTOR, R0603, 1.5K, 1/10W, 0.05
31	2	R59,R60	DigiKey	RHM1.0GCT-ND	RESISTOR, R0603, 1, 1/10W, 0.05
32	1	S1	Mouser	101-0261-EV	SWITCH 6MM TACT 5MM 130GF
33	23	S2,S3,S4,S5,S6,S7,S8,S9,S10,S11,S12,S13,S14,S15,S16,S17,S18,S19,S20,S21,S22,S23,S24	Mouser	101-0621-EV	SWITCH 12MM TACT CAP 160GF
34	1	U1	DigiKey	AT91SAM7S256C-AU-ND	IC,ARM7,MCU,32-BIT,256K,3.3V,64 PIN,LQFP
35	1	U2	DigiKey	CAT24C64WI-GT3CT-ND	IC,SERIAL EEPROM,64K,LP,LV,8 PIN,SOIC
36	1	U3	DigiKey	568-2702-5-ND	IC,ANALOG MUX/DEMUX,LATCH ,SSOP20
37	3	U4,U6,U8	DigiKey	296-22710-1-ND	IC,LED SINK DRIVER,16 PIN,SOIC
38	3	U5,U7,U9	DigiKey	296-24262-1-ND	IC,LED SOURCE DRIVER,20 PIN,TSSOP
39	3	U10,U11,U12	DigiKey	LM393DGOS-ND	IC,COMP,DUAL,LV OFFSET,8 PIN,SOIC
40	1	U13	DigiKey	296-11039-1-ND	IC,VREG,LDO,FXD,POS,3.3V,100MA,SOT23-5
41	1	U14	DigiKey	296-11032-1-ND	IC,VREG,LDO,FXD,POS,1.5V,100MA,SOT23-5
42	1	Y1	DigiKey	535-9072-1-ND	CRYSTAL,18.432MHZ,18PF,FUND,HC-49/US

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Schematics

The DRO-375 schematics are included in the following pages.

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ARM7 Processor..... Sheet 2
LED Display Block Diagram..... Sheet 3
LED Display Row 1 ..... Sheet 4
LED Display Row 2 ..... Sheet 5
LED Display Row 3 ..... Sheet 6
Scale Interface Block Diagram..... Sheet 7
Scale 1 Interface..... Sheet 8
Scale 2 Interface..... Sheet 9
Scale 3 Interface.....Sheet 10
Keypad Matrix.....Sheet 11
I/O Interfaces (Edge/Tach, Piezo, USB).....Sheet 12
Power Supplies.....Sheet 13

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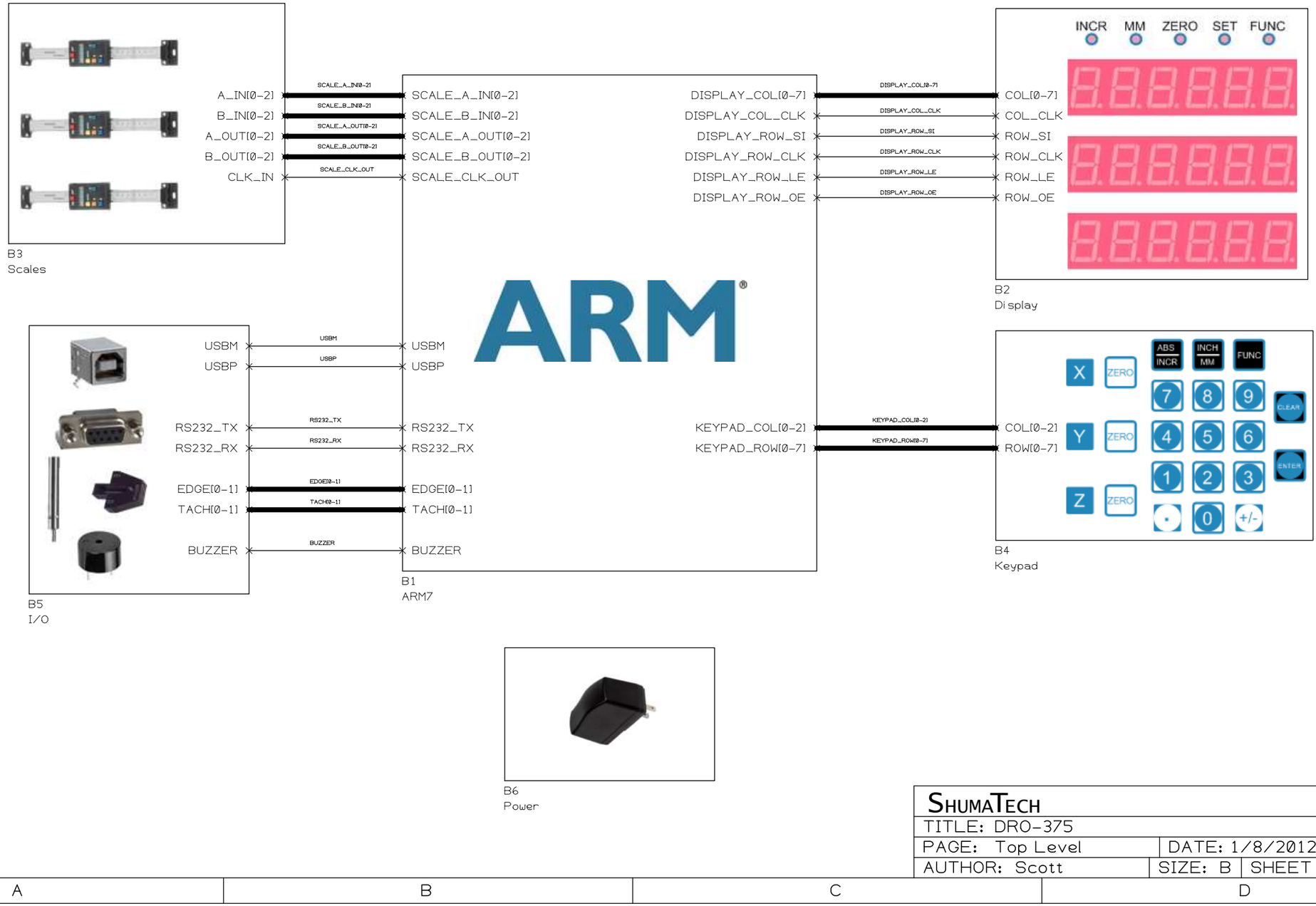

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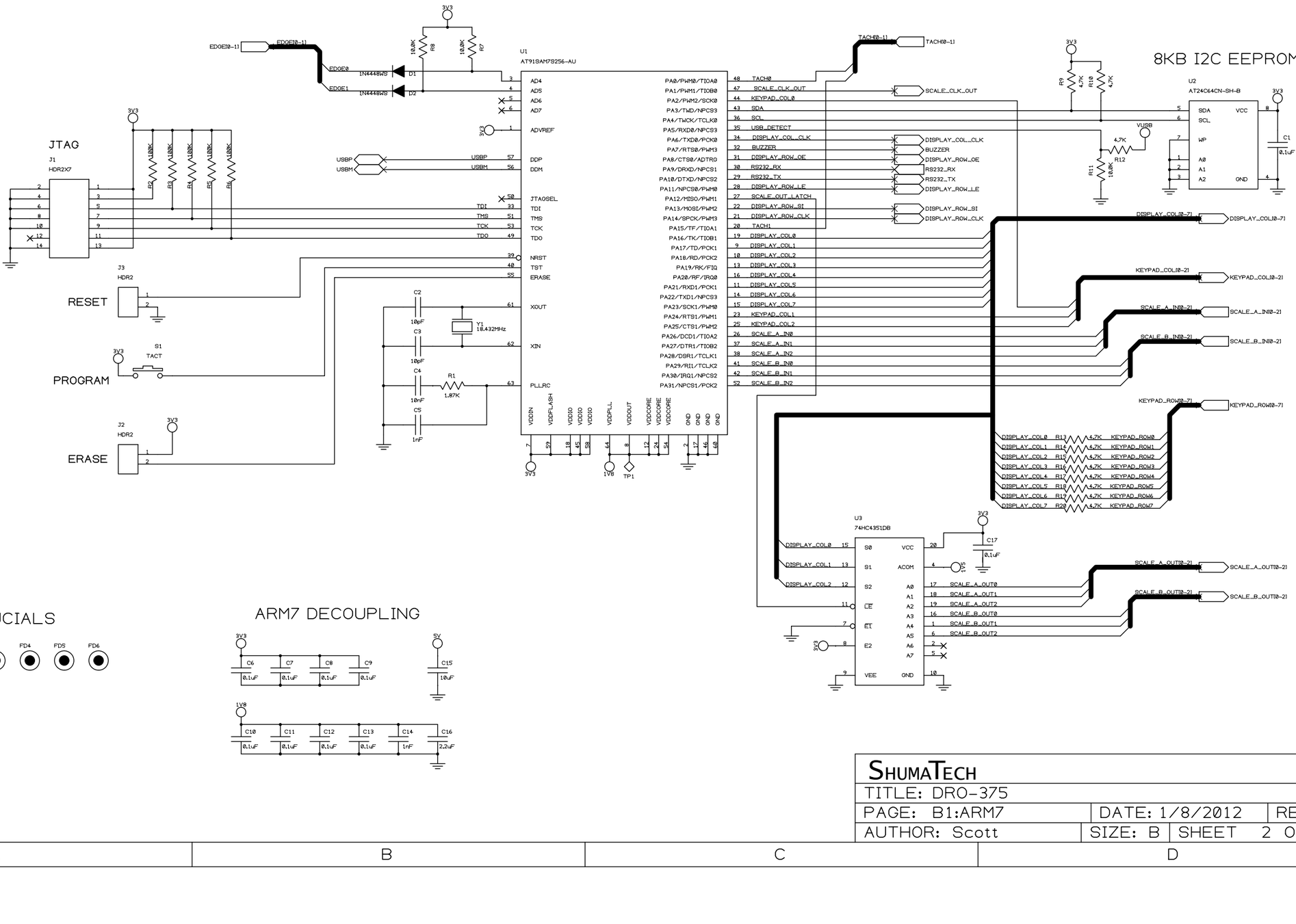

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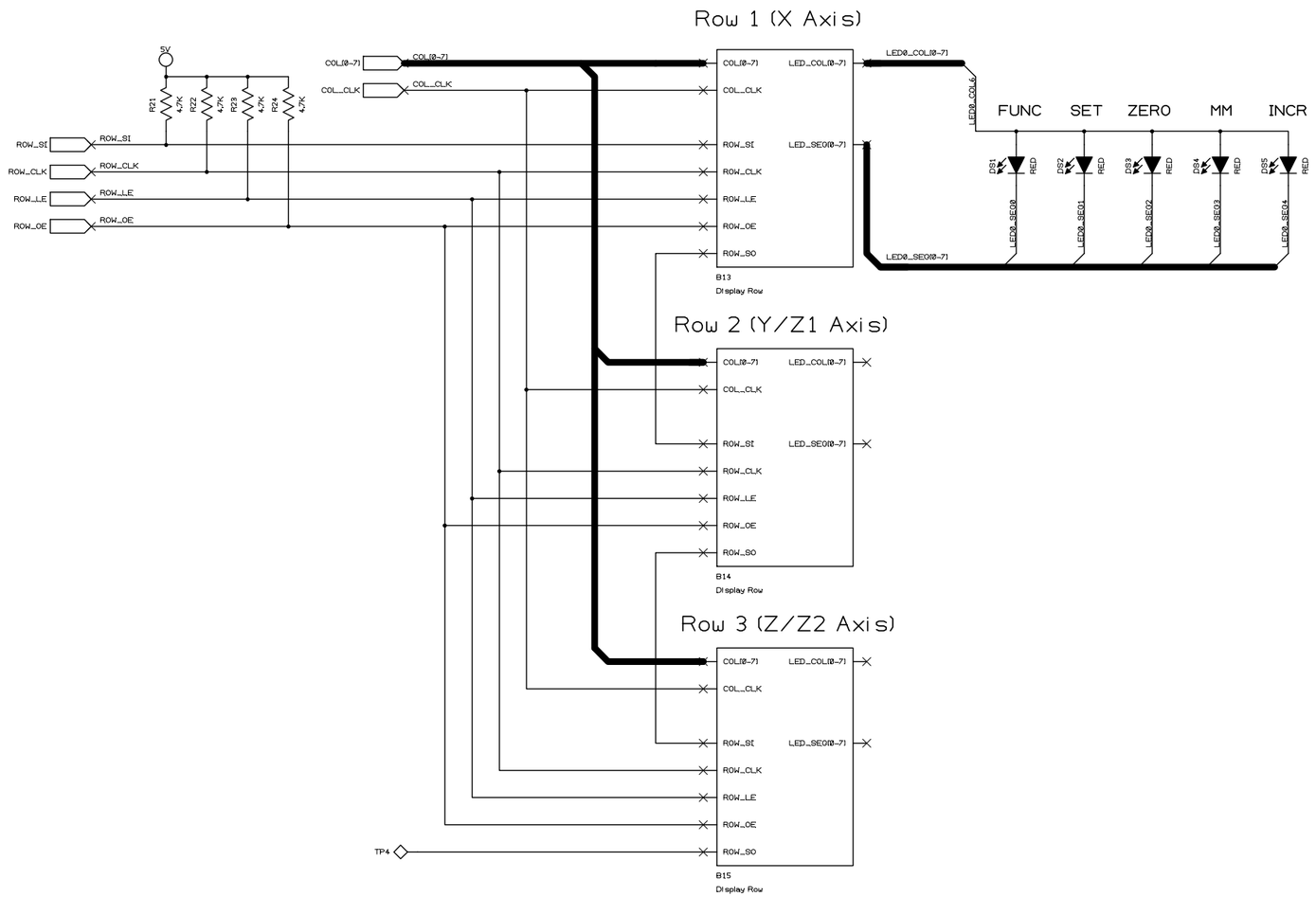

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AUTHOR: Scott	SIZE: B SHEET 3 OF 13

SHUMATECH		
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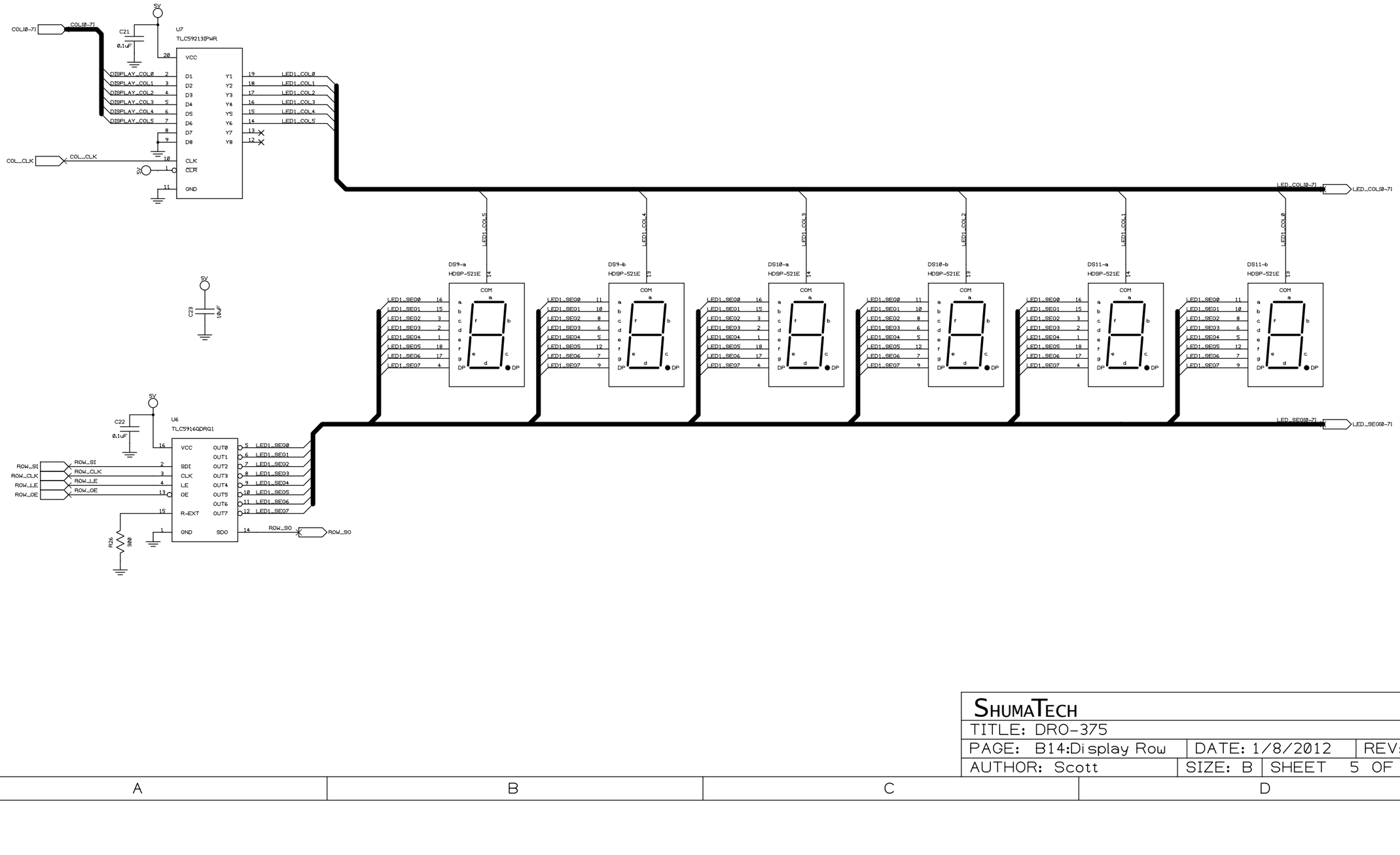
PAGE: B13:Display Row	DATE: 1/8/2012	REV: B
AUTHOR: Scott	SIZE: B	SHEET 4 OF 13



SHUMATECH		
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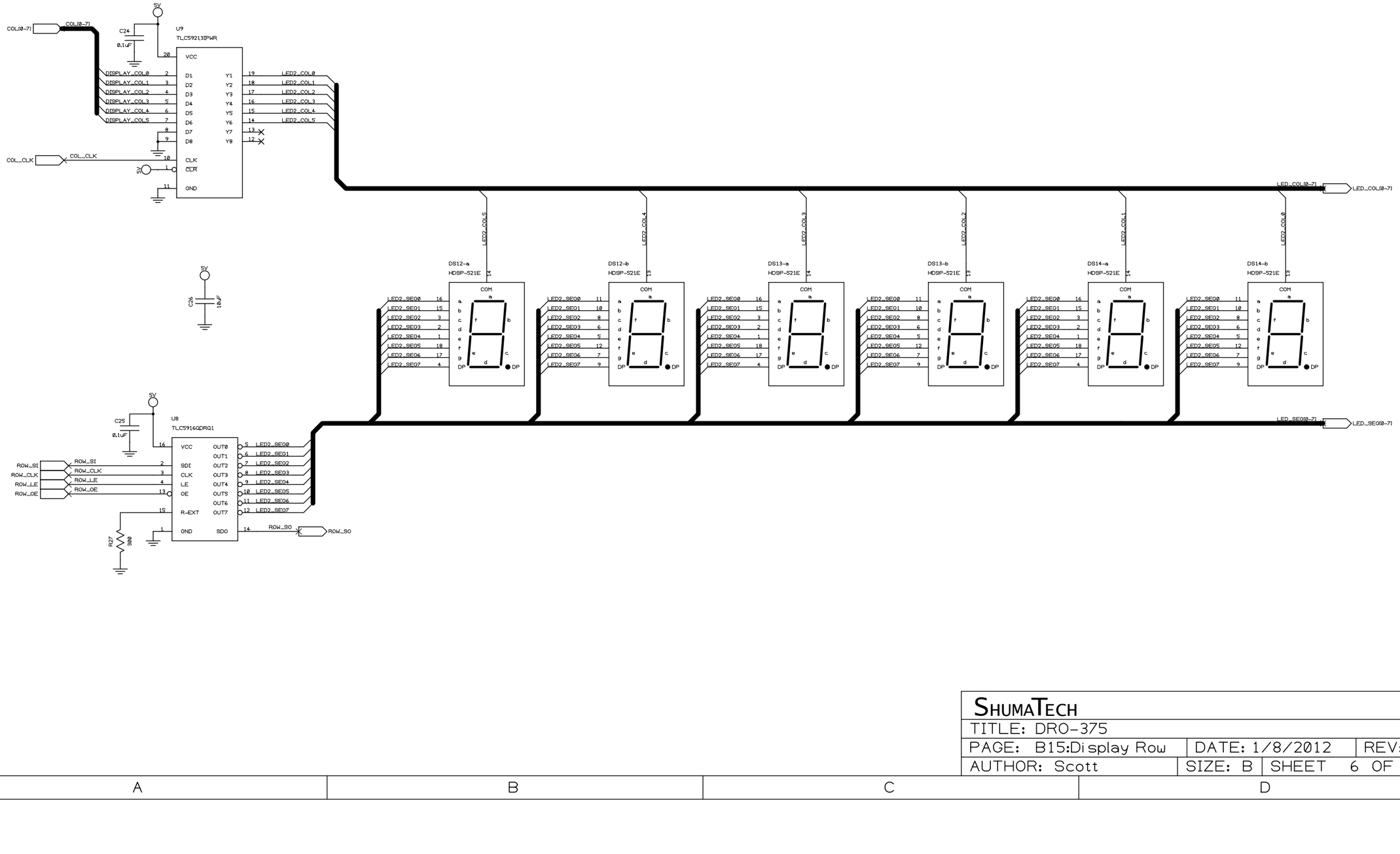
PAGE: B14:Display Row	DATE: 1/8/2012	REV: B
AUTHOR: Scott	SIZE: B	SHEET 5 OF 13



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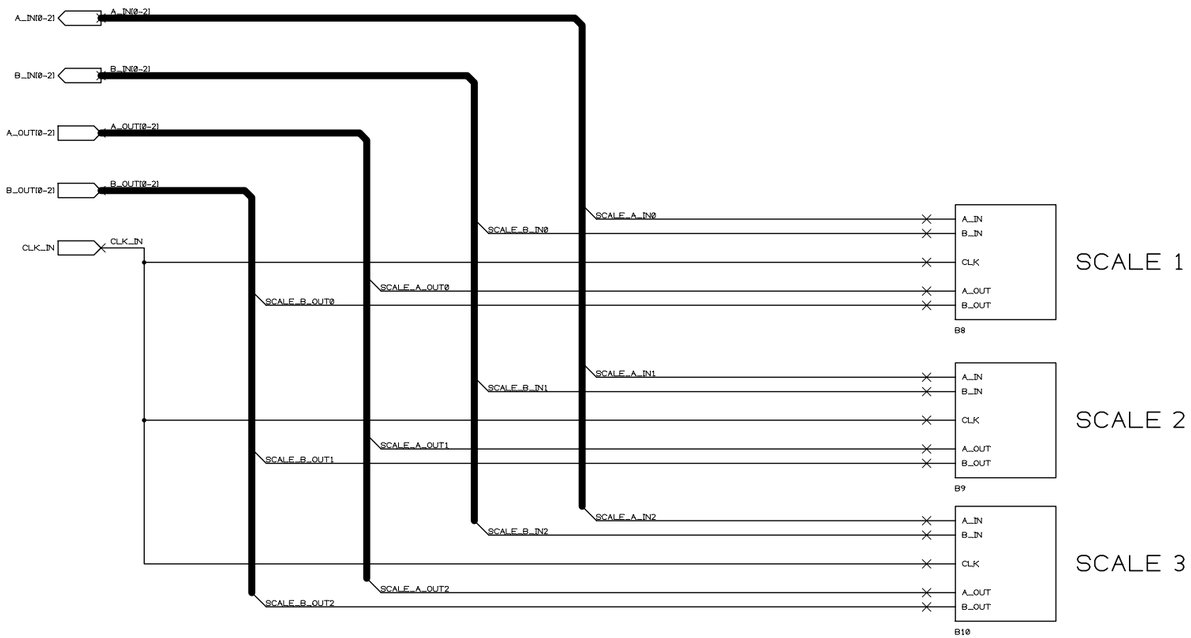
PAGE: B15:Display Row	DATE: 1/8/2012	REV: B
AUTHOR: Scott	SIZE: B	SHEET 6 OF 13



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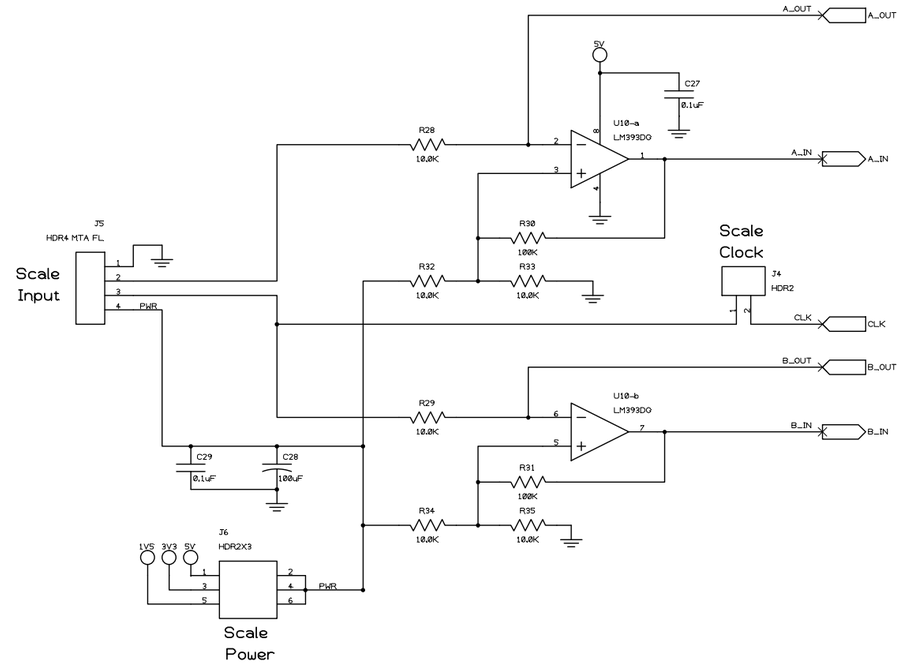
PAGE:	DATE:	REV:
AUTHOR:	SIZE: B SHEET	OF



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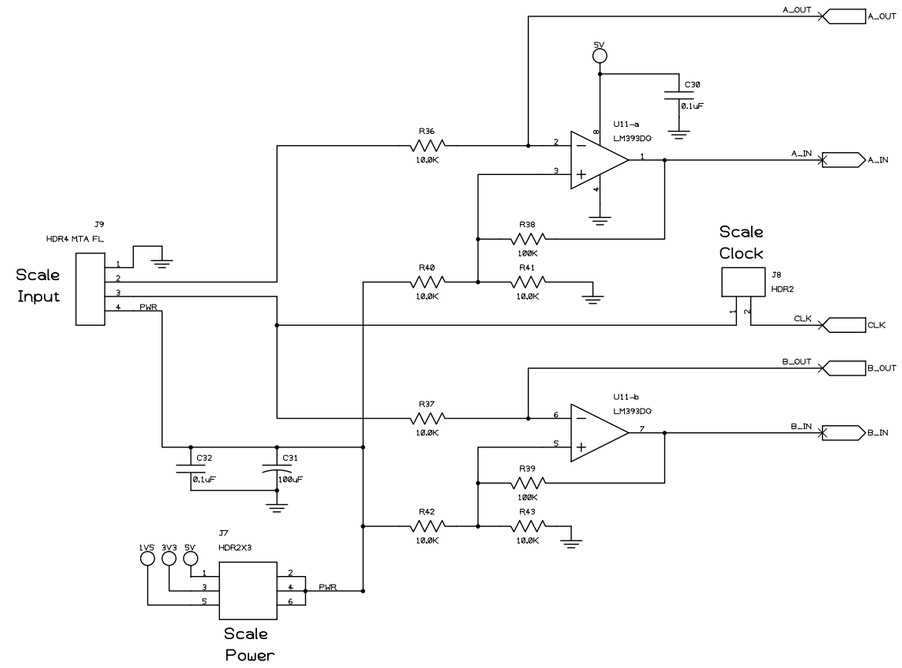
TITLE: DRO-375		
PAGE: B8:Scale	DATE: 1/8/2012	REV: B
AUTHOR: Scott	SIZE: B | SHEET 8 OF 13	



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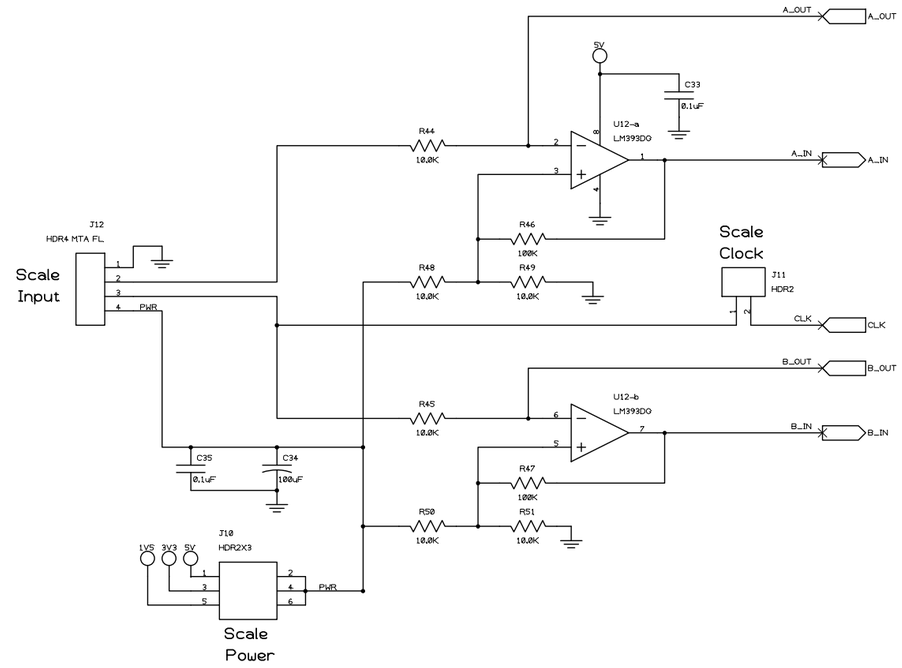
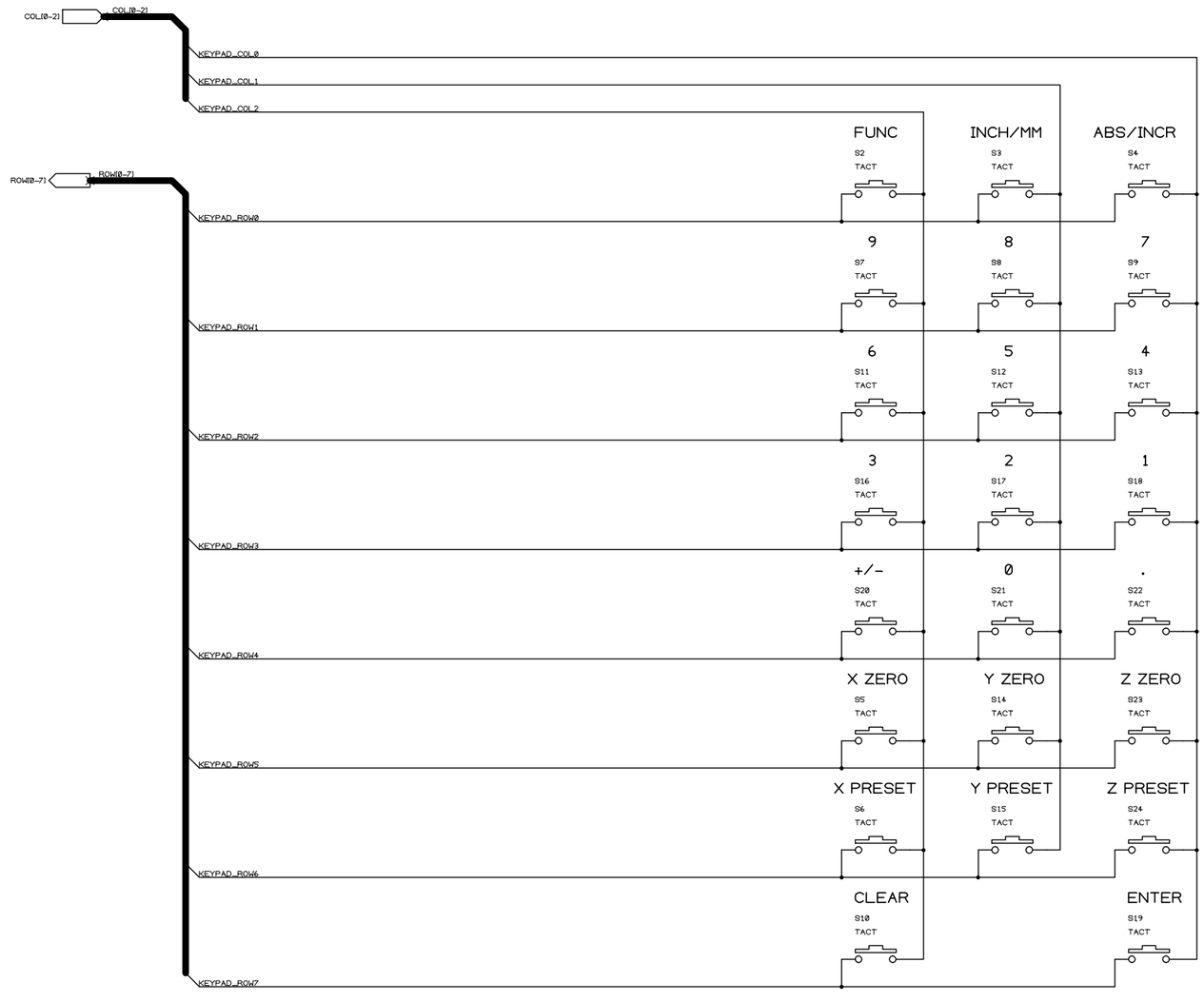
PAGE: B9:Scale	DATE: 1/8/2012	REV: B
AUTHOR: Scott	SIZE: B SHEET 9 OF 13	



SHUMATECH	
TITLE: DRO-375	
PAGE: B10:Scale	DATE: 1/8/2012 REV: B
AUTHOR: Scott	SIZE: B SHEET 10 OF 13



SHUMATECH		
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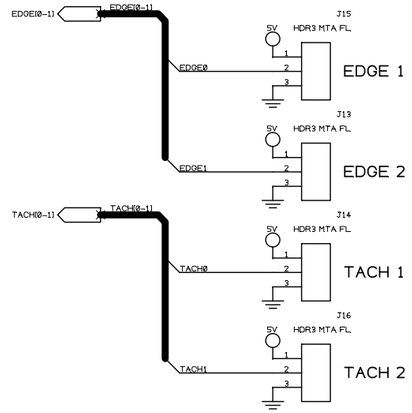
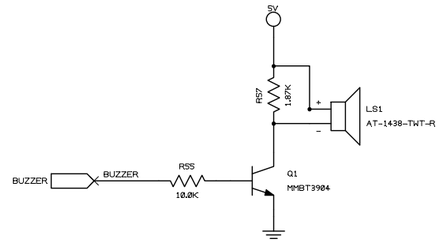
PAGE: B4:Keypad	DATE: 1/8/2012	REV: B
AUTHOR: Scott	SIZE: B	SHEET 11 OF 13

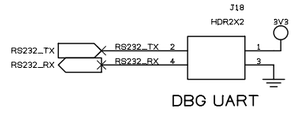
Edge Finder & Tachometer Inputs



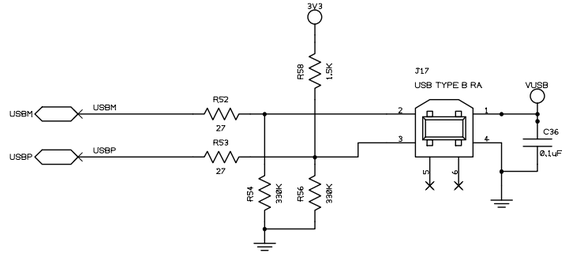
Piezo Transducer



Debug UART Port

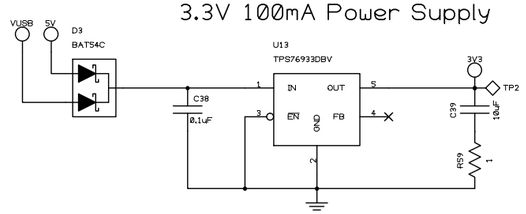


USB Type B Port

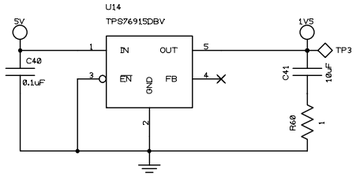


SHUMATECH		
TITLE: DRO-375		
PAGE: B5:I/O	DATE: 1/8/2012	REV: B
AUTHOR: Scott	SIZE: B | SHEET 12 OF 13	

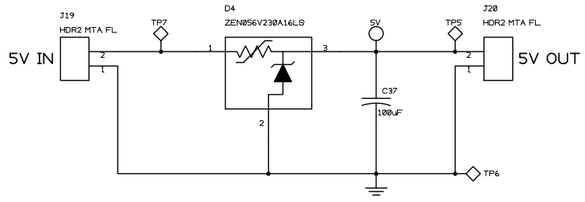
3.3V 100mA Power Supply



1.5V 100mA Power Supply



5V Power Entry



SHUMATECH			
TITLE: DRO-375			
PAGE: B6:Power	DATE: 1/8/2012	REV: B	
AUTHOR: Scott	SIZE: B	SHEET 13 OF 13	