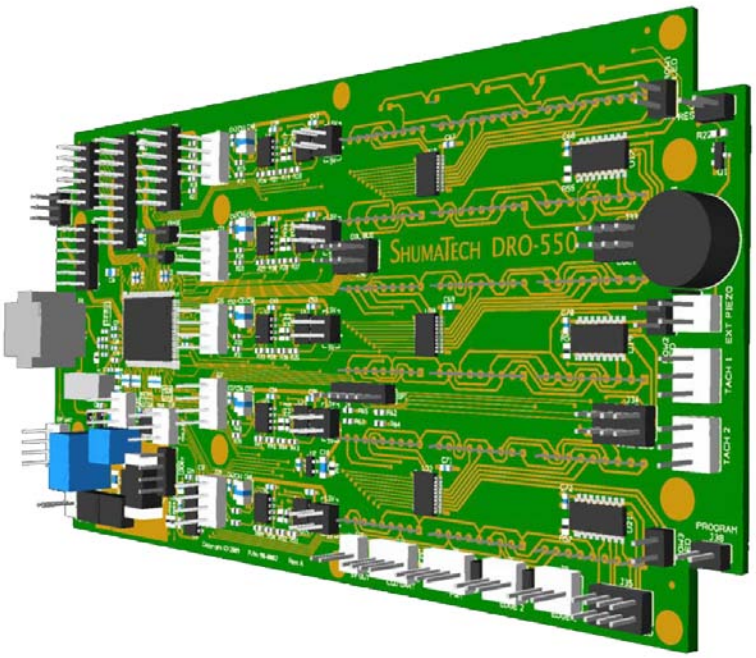
SHUMATECH

DRO-550 Hardware Manual

Revision 2



Revision History

Revision	Date	Author	Comment
1	01/02/10	S. Shumate	Initial draft based on revision A prototype hardware
2	01/25/10	S. Shumate	Minor changes to ARM7 PIO Map Updated EXP2 and COL BUS headers for PCB Rev B Removed ERASE description and updated PROGRAM Used photos of the prototype for the call-out images

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Introduction

The DRO-550 is a new DRO that combines the advanced capabilities of the DPU-550 running OpenDRO software with the cost-effectiveness of the DRO-350 into a single board. The board is designed to fit the DRO-350 form factor and thus can leverage the existing overlay and machined enclosure. The DRO-550 offers nearly the same capabilities as the combination of the DRO-350 and DPU-550 with the addition of greatly expanded flexibility for future enhancement. The hardware capabilities that the DRO-550 has in common with the DRO-350 + DPU-550 are:

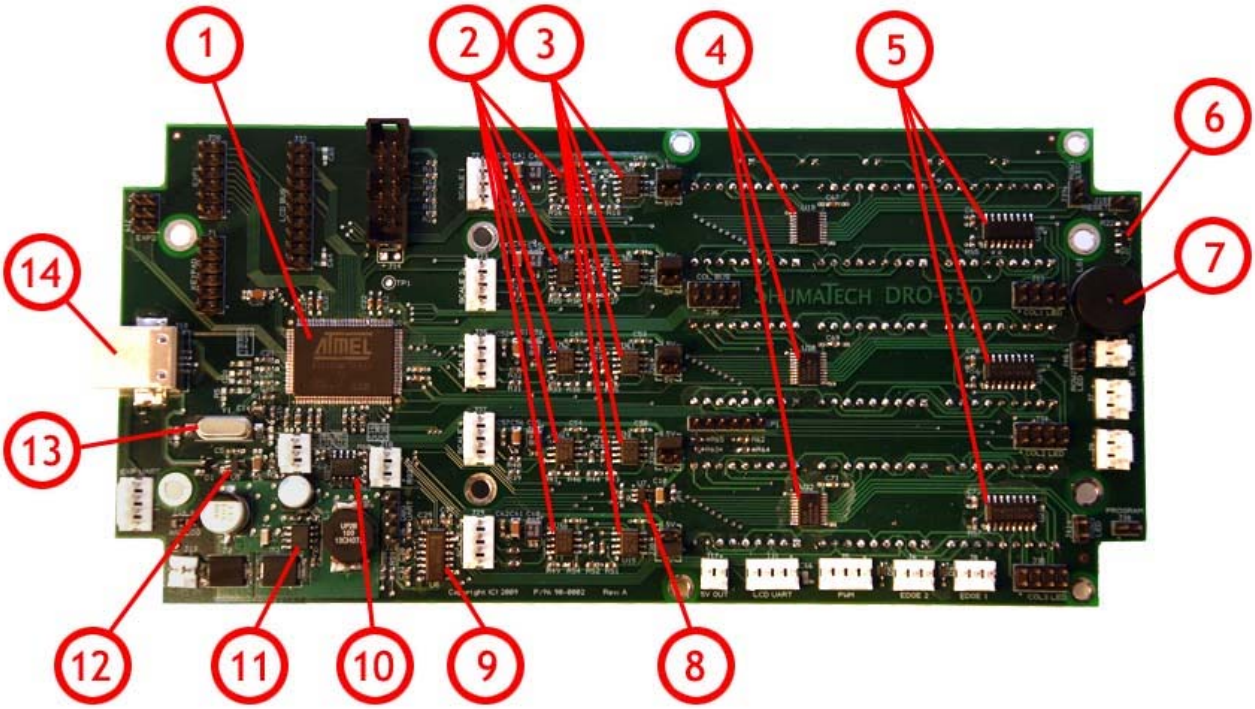
- 50MHz 32-bit ARM7 processor that runs the open-source OpenDRO software
- Supports up to five Chinese (bin24, bcd7, bin6 formats) and quadrature digital scales
- Six digit 7-segment LED display with auto-precision
- Five mode indicator LEDs
- Twenty-three key keypad matrix
- USB and true RS-232 interface for programming and control
- Dual edge finder inputs
- Dual tachometer inputs
- High current 5V power supply
- JTAG debugging interface

The notable enhancements to the DRO-550 over the DRO-350 + DPU-550 are:

- Newer surface mount technology using more available components
- Four-layer PCB with solid ground plane to eliminate Chinese scale jitter
- Integrated piezo buzzer for near-zero warning and key-chirp
- Constant-current LED drivers for lower heat and flicker-free display
- Expansion headers for generic digital I/O applications
- Pulse-width modulated outputs for stepper motor control
- 8-bit data and address bus header for control of graphical or text LCD displays
- Two analog inputs (0-3.3V)
- Two extra UART interfaces for intelligent LCD and microcontroller support
- Headers for adding additional LEDs
- Debug headers for I2C, SPI, and the LED display
- Mounting holes for attaching an enhanced LED or graphical LCD display

Components

Top Side

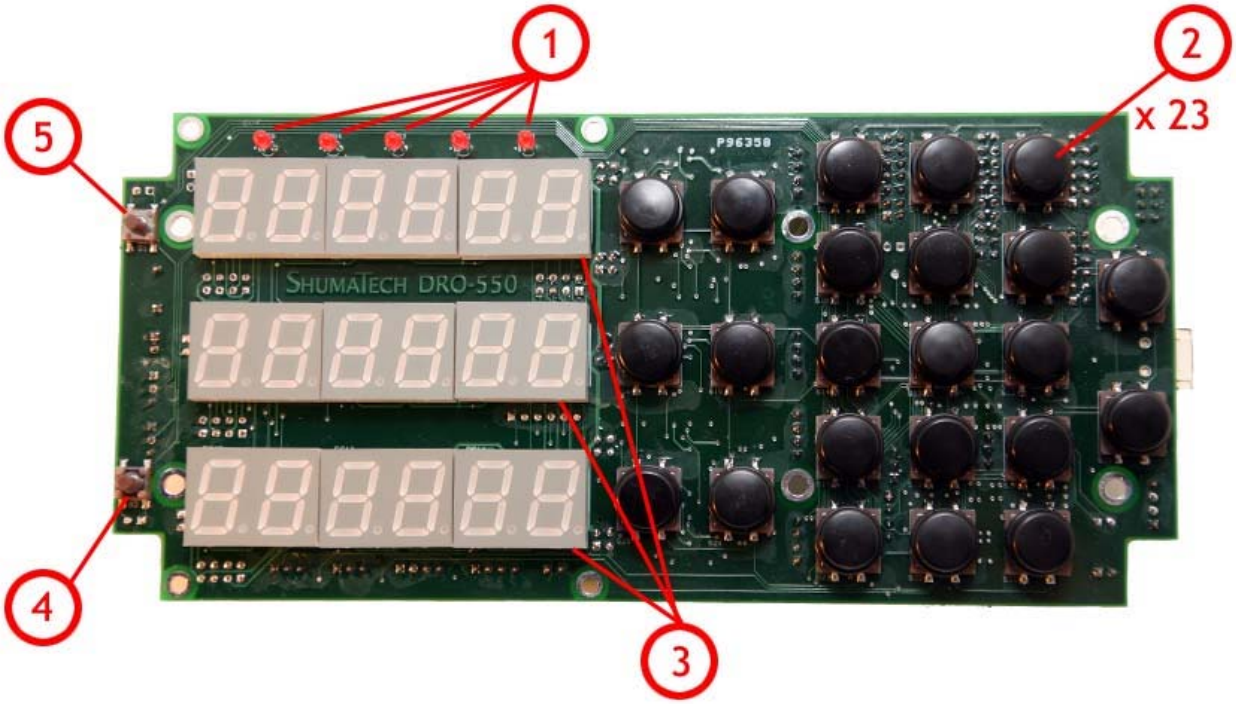


1. AT91SAM7SE256 – A 50MHz ARM7 processor with 256KB of flash for code storage and 32KB of SRAM for data storage. This is the heart of the DRO-550 and is where the OpenDRO software runs.
2. LM393 (x 5) – Dual comparators that translate the scale signal voltages to logic levels appropriate for the ARM7 processor.
3. SN74CBT3306 (x 5) – Dual analog switches that are used to send signals with the correct voltage level back to the scales.
4. 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.
5. 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.
6. NPN Transistor – Provides amplification for the Piezo transducer.
7. Piezo Transducer – A generic buzzer used by the OpenDRO for near-zero warning, audible key chirp, and other functions.
8. TPS76915 – 1.5V 100mA voltage regulator. The scale voltage for Chinese scales that is selected by the Scale Voltage Select Jumpers (see below).
9. MAX3232 – RS-232 transceiver that converts logic level UART signals to RS-232

voltage levels that are appropriate for connection to a PC or other external equipment.

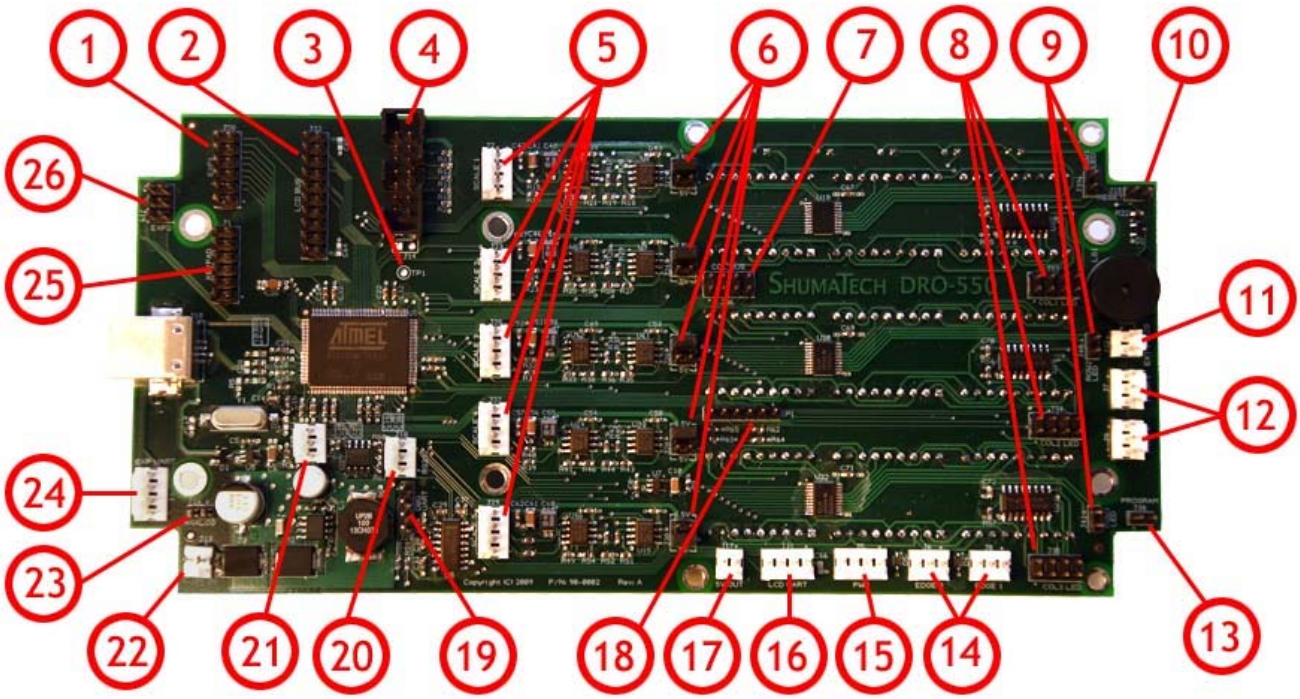
10. AT24C256 – 32KB I2C EEPROM. This is the non-volatile data storage for all OpenDRO configuration and settings.
11. TPS5431 – 5V 3A DC/DC converter. The primary power supply for the DRO-550 from which all other voltages are derived.
12. TPS76933 – 3.3V 100mA voltage regulator. This provides the I/O voltage for the ARM7 processor.
13. 18.432MHz Crystal – The main timing reference for the ARM7. The ARM7 derives the main processor clock and the USB clock from this crystal.
14. USB Type B Connector – A full speed USB device interface for programming and control.

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. 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.
4. 6mm Tact Switch (PROGRAM) – Holding this switch down for 15 seconds when connecting power to the DRO-550 places the ARM7 in program mode which is used by the SAM-BA program to load the OpenDRO software into the ARM7.
5. 6mm Tact Switch (RESET) – Pressing this switch resets the ARM7 processor.

Headers



1. EXP1 – Expansion Header 1 provides spare signals from the ARM7's port C. These signals may be used for future GPIO applications.

Pin	Signal	Description	ARM7
1	5V	5V power	
2	5V	5V power	
3	EXP1-1	Expansion 1 signal 1	PC8 pin 98
4	EXP1-2	Expansion 1 signal 2	PC9 pin 93
5	EXP1-3	Expansion 1 signal 3	PC10 pin 92
6	EXP1-4	Expansion 1 signal 4	PC11 pin 91
7	EXP1-5	Expansion 1 signal 5	PC12 pin 90
8	EXP1-6	Expansion 1 signal 6	PC13 pin 89
9	EXP1-7	Expansion 1 signal 7	PC14 pin 88
10	EXP1-8	Expansion 1 signal 8	PC15 pin 87
11	EXP1-9	Expansion 1 signal 9	PC19 pin 83
12	GND	Ground	

2. LCD BUS – The LCD Bus is connected to the ARM7 external bus interface which can provide automatic generation for accessing an external memory-like device. The primary purpose seen for this on the DRO-550 is with LCD character and graphic

modules that have a HD44780 or other similar interface.

Pin	Signal	Description	ARM7
1	5V	5V power	
2	GND	Ground	
3	LCD_DATA4	LCD data bus bit 4	PC4 pin 102
4	LCD_DATA3	LCD data bus bit 3	PC3 pin 103
5	LCD_DATA5	LCD data bus bit 5	PC5 pin 101
6	LCD_DATA2	LCD data bus bit 2	PC2 pin 104
7	LCD_DATA6	LCD data bus bit 6	PC6 pin 100
8	LCD_DATA1	LCD data bus bit 1	PC1 pin 105
9	LCD_DATA7	LCD data bus bit 7	PC7 pin 99
10	LCD_DATA0	LCD data bus bit 0	PC0 pin 106
11	LCD_ADDR0	LCD address bus bit 0	PC16 pin 86
12	LCD_ADDR1	LCD address bus bit 1	PC17 pin 85
13	LCD_ADDR2	LCD address bus bit 2	PC18 pin 84
14	LCD_NCS1	LCD chip select 1	PC20 pin 82
15	LCD_NWE	LCD write enable	PC21 pin 81
16	LCD_NRD	LCD read	PC22 pin 80
17	LCD_NCS0	LCD chip select 0	PC23 pin 79
18	N/C	No connection	
19	5V	5V power	
20	GND	Ground	

3. JTAGSEL – This pin is connected to the ARM7 JTAGSEL signal which places the ARM7 in boundary scan mode when asserted high. This is used only for manufacturing test purposes.

4. 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 65
6	GND	Ground	

7	TMS	JTAG test mode	Pin 77
8	GND	Ground	
9	TCK	JTAG test clock	Pin 76
10	GND	Ground	
11	TDO	JTAG test data out	Pin 66
12	N/C	Not connected	
13	3V3	3.3V power	
14	GND	Ground	

5. Scale Inputs (x 5) – These 5 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 both Chinese scales (bin24, bcd7, and bin6 protocols) 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	Either 1.5V or 5V scale power determined by the scale power jumper Total 1.5V power < 100mA and total 5V power < 3A

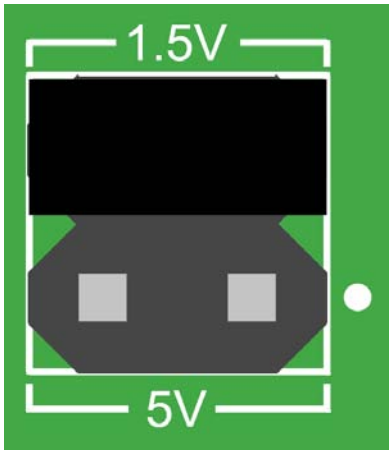
Scale	Input	ARM7
1	Data (A)	PA16 pin 13
1	Clock (B)	PA27 pin 111
2	Data (A)	PA17 pin 12
2	Clock (B)	PA28 pin 110
3	Data (A)	PA18 pin 11
3	Clock (B)	PA29 pin 109
4	Data (A)	PA19 pin 10
4	Clock (B)	PA30 pin 108
5	Data (A)	PA20 pin 9
5	Clock (B)	PA31 pin 107

Scale	Output	ARM7
1	Data (A)	PB22 pin 42
1	Clock (B)	PB27 pin 37
2	Data (A)	PB23 pin 41
2	Clock (B)	PB28 pin 36
3	Data (A)	PB24 pin 40

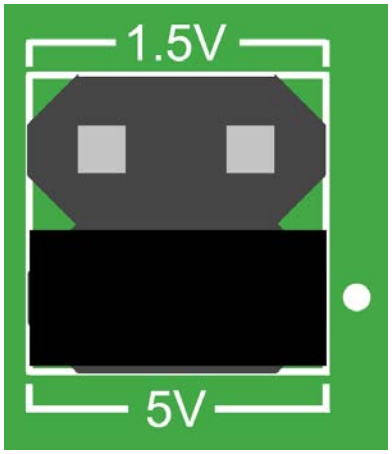
3	Clock (B)	PB29 pin 35
4	Data (A)	PB25 pin 39
4	Clock (B)	PB30 pin 34
5	Data (A)	PB26 pin 38
5	Clock (B)	PB31 pin 33

6. Scale Power (x 5) – 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	1.5V	1.5V power
4	Power	Power output when 1.5V is selected



Chinese Scale Power (1.5V)



Quadrature Power (5V)

NEVER jumper vertically!

7. COL BUS – The column bus header is for debugging the signals that control the three Darlington source drivers. If a 7-segment LED display is not used, then these signals may be used for other uses.

Pin	Signal	Description	ARM7
1	COL0	Display column 0	PB1 pin 68
2	COL1	Display column 1	PB2 pin 67
3	COL2	Display column 2	PB3 pin 64
4	COL3	Display column 3	PB4 pin 63
5	COL4	Display column 4	PB5 pin 62

6	COL5	Display column 5	PB6 pin 61
7	COL6	Display indicator LED's	PB7 pin 60
8	COL7	Unused	PB8 pin 59
9	COL_CLK	Display column clock	PB16 pin 51
10	GND	Ground	

8. ROW LED – The outputs of the constant-current LED drivers. Since the 7-segment display only uses 6 of the 8 columns on the Darlington source driver, up to 43 additional LED outputs (48 minus the 5 indicator LEDS) can be added to the DRO-550 for additional display digits or indicators. Since the 7-segment display is multiplexed, these must be used in combination with the COL LED drivers described below. The row LED outputs are constant-current at 60mA.

Pin	Signal	Description
1	SEG0	LED segment 0 (60mA constant)
2	SEG1	LED segment 1 (60mA constant)
3	SEG2	LED segment 2 (60mA constant)
4	SEG3	LED segment 3 (60mA constant)
5	SEG4	LED segment 4 (60mA constant)
6	SEG5	LED segment 5 (60mA constant)
7	SEG6	LED segment 6 (60mA constant)
8	SEG7	LED segment 7 (60mA constant)

9. COL LED – The two extra columns on the Darlington source drivers are provided on these headers. As described above, these are used in combination with the ROW LED headers to provide additional LED outputs. Maximum current provided by each output should be limited to 500mA.

Pin	Signal	Description
1	COL6	Display column 6 (500mA max)
2	COL7	Display column 7 (500mA max)

10. RESET – Shorting this jumper asserts the reset signal to the ARM7. This jumper may be used in lieu of the reset tact switch to install a panel-mount switch elsewhere on the DRO-550.

Pin	Signal	Description
1	NRST	Negative polarity reset signal (ARM7 pin 73)
2	GND	Ground

11. EXT PIEZO – This output may be used to drive an external piezo transducer instead of the integrated piezo transducer. It can also be used to drive a generic power driver for other uses with the appropriate software modifications. The maximum current rating of this output is 200mA.

Pin	Signal	Description	ARM7
1	5V	Limit to 200mA through BUZZER	
2	BUZZER	Buzzer output switched to ground with maximum current of 200mA	PB15 pin 52

12. 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: PB0 pin 69 TACH2: PB15 pin 52
3	GND	Ground	

13. PROGRAM - Shorting this jumper for 1 second when power is applied to the DRO-550 erases the flash and places the ARM7 in program mode. This jumper may be used in lieu of the program tact switch to install a panel-mount switch elsewhere on the DRO-550.

Pin	Signal	Description
1	TST	Hold high for 15 seconds on power up for program mode
2	5V	5V power

14. 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 6 EDGE 2: AD4 pin 5
3	GND	Ground	

15. PWM – Pulse-width modulation (PWM) outputs. This header provides three signals from the ARM7 processor's PWM logic. These can be used to connect to external stepper motors or power feeds. Note that these are logic level signals and will need external drivers to interface with stepper motors or other high current devices. These signals can also be used as generic digital inputs or outputs.

Pin	Signal	Description	ARM7
1	PWM1	PWM signal 1 (16 mA max)	PA0 pin 32
2	PWM2	PWM signal 2 (16 mA max)	PA1 pin 31
3	PWM3	PWM signal 3 (16 mA max)	PA2 pin 30
4	GND	Ground	

16. LCD UART – A logic-level UART interface for connecting to “intelligent” LCD panels or other such devices. Logic level UART signals should not be directly connected to RS-232 level signals.

Pin	Signal	Description	ARM7
1	5V	5V power	
2	RX	UART receive	PA5 ARM7 pin 27
3	TX	UART transmit	PA6 ARM7 pin 26
4	GND	Ground	

17. 5V OUT – 5V power output header. Total 5V power must be less than 3A.

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

18. SPI – The SPI bus controls the constant-current LED drivers for the 7-segment display. The signals on this header are used primarily for debugging. With software enhancements, other SPI devices can be connected to this interface though care must be exercised to not disrupt the timing of the 7-segment display which would cause display flicker.

Pin	Signal	Description	ARM7
1	ROW_LE	Display row latch enable	PA11 pin 18
2	ROW_SO	Display row serial output	PA12 pin 17
3	ROW_SI	Display row serial input	PA13 pin 16
4	ROW_CLK	Display row clock	PA14 pin 15
5	ROW_OE	Display row output enable	PA15 pin 14
6	GND	Ground	

19. DBG UART – A debug header for the logic level UART signals from the ARM7 serial debug interface. This header can be used with a RS-232 level translation cable if the RS-232 circuit is not installed on the board.

Pin	Signal	Description	AMR7

1	3V3	Total 3.3V power < 100mA	
2	RX	DBG UART receive	PA9 pin 20
3	TX	DBG UART transmit	PA10 pin 19
4	GND	Ground	

20. RS232 – RS-232 level outputs for the ARM7 serial debug interface. These outputs can be directly connected to a PC or other RS-232 port. These signals should not be directly connected to logic level signals.

Pin	Signal	Description
1	TX	RS-232 level DBG UART transmit
2	RX	RS-232 level DBG UART receive
3	GND	Ground

21. I2C – I2C interface used by the EEPROM. Since I2C is a multi-device bus, other I2C devices can be connected via this interface.

Pin	Signal	Description	ARM7
1	SCL	I2C clock	PA4 pin 28
2	SDA	I2C data	PA3 pin 29
3	GND	Ground	

22. 9-20V IN – The main power input to the DRO-550. Connect this to a 9-20V DC power supply with sufficient current for the intended application. See the section later for more information in selecting the proper current rating for the power supply. This directly feeds the 5V power supply from which all other voltages are derived. It is protected by a Schottky diode so connecting an incorrect polarity power supply will not damage the board.

Pin	Signal	Description
1	GND	Ground
2	9-20V	See later section for proper current rating

23. ANALOG – Two generic analog inputs to the ARM7. The ARM7 can measure the voltage on these pins with a 10-bit SAR analog-to-digital converter. The voltages on these signals MUST remain in the range of 0V to 3.3V or damage to the ARM7 can result.

Pin	Signal	Description	ARM7
1	ANALOG1	Must remain within 0-3.3V	AD6 pin 4
2	ANALOG2	Must remain within 0-3.3V	AD7 pin 3

24. EXP UART – Logic-level expansion UART interface for connection to other intelligent devices. Logic level UART signals should not be directly connected to RS-232 level signals.

Pin	Signal	Description	ARM7
1	5V	5V power	
2	RX	EXP UART receive	PA21 ARM7 pin 117
3	TX	EXP UART transmit	PA22 ARM7 pin 116
4	GND	Ground	

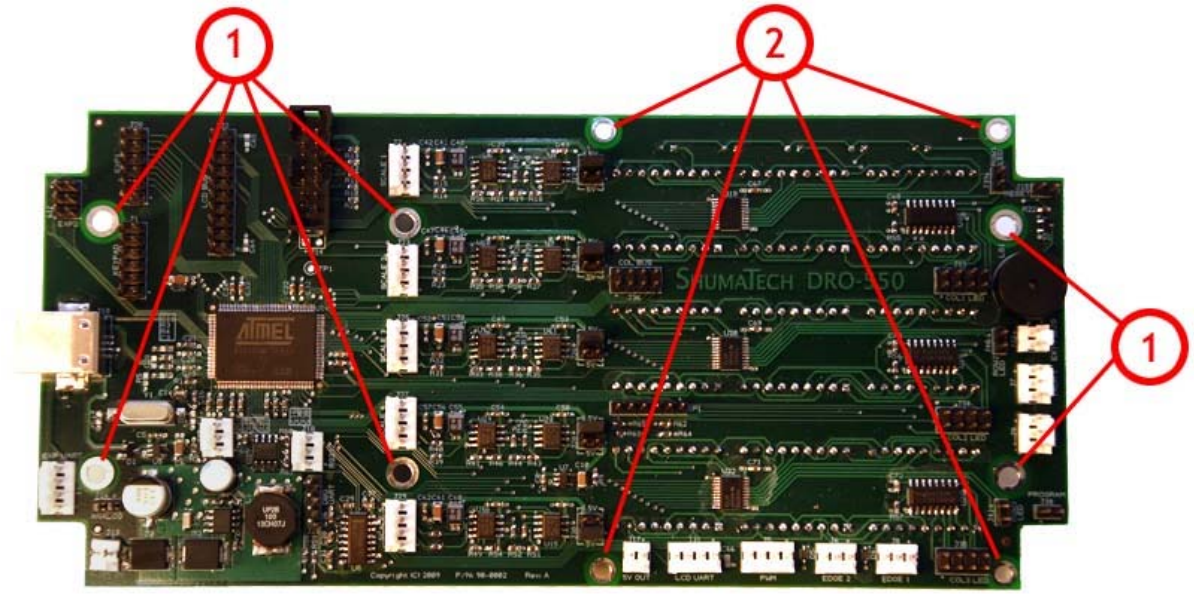
25. KEYPAD – This header connects to the row and column signals that comprise the keypad matrix. The header is mainly for debugging but can be used to connect to a separate membrane keypad.

Pin	Signal	Description	ARM7
1	5V	5V power	
2	GND	Ground	
3	COL0	Keypad column 0	PB17 pin 50
4	ROW0	Keypad row 0	PB9 pin 58
5	COL1	Keypad column 1	PB18 pin 49
6	ROW1	Keypad row 1	PB10 pin 57
7	COL2	Keypad column 2	PB19 pin 48
8	ROW2	Keypad row 2	PB11 pin 56
9	COL3	Keypad column 3	PB20 pin 44
10	ROW3	Keypad row 3	PB12 pin 55
11	COL4	Keypad column 4	PB21 pin 68
12	ROW4	Keypad row 4	PB13 pin 43

26. EXP2 - Expansion Header 2 provides spare signals from the ARM7's port A. These signals may be used for future GPIO applications.

Pin	Signal	Description	ARM7
1	5V	5V power	
2	5V	5V power	
3	EXP2-1	Expansion 2 signal 1	PA23 pin 115
4	EXP2-2	Expansion 2 signal 2	PA24 pin 114
5	EXP2-3	Expansion 2 signal 3	PA25 pin 113
6	EXP2-4	Expansion 2 signal 4	PA26 pin 112
7	EXP2-5	Expansion 2 signal 5	PA7 pin 25
8	GND	Ground	

Mechanical



1. Enclosure Mounts (x 6) – Six 150mil holes (6-32 screws) for mounting six hex standoffs that secure the DRO-550 board to the back enclosure cover.
2. Auxiliary Display Mounts (x 4) – Four 125 mil holes (4-40 screws) for the attachment of an alternate display such as a PCB with eight 7-segment LED digits or a graphical LCD panel.

Electrical

Most of the digital signals on the DRO-550 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-550, 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. The PWM outputs are special high-current pins on the ARM7 and can output twice as much current at 16mA.

Power

The DRO-550 needs an external power supply in the range of 9V to 20V DC. The power input is protected so connecting the power supply with the wrong polarity will not damage the

board. The external power supply feeds a 5V 3A DC/DC converter circuit that powers everything else on the board. Proper selection of the external power supply is necessary if one wants to use the full capabilities of the DRO-550.

Absolute worst cast power consumption on the DRO-550 is around 1.5A of which over 90% is used by the LED display. This leaves up to another 1.5A of 5V power available for use by external circuits and equipment. This is more than sufficient to power a full set of five glass scales. To select the proper current for the external power supply, one must determine the desired amount of current for the 5V supply and use the rated voltage of the external supply in the following equation:

*Power Supply Current = 5V * (DRO-550 Currrent) / 0.9 / (Power Supply Voltage)*

For example, assume one wants to use a 9V power supply and use the minimum capabilities of the 5V power supply at 1.5A. Plug in these values into the equation above:

*Power Supply Current = 5 * 1.5 / 0.9 / 9*

Power Supply Current = 0.93A

This means that a 9V 1A power supply is sufficient for a minimal configuration. The following table shows some typical power supply results.

DRO-550 5V Current	Power Supply Voltage	Power Supply Current
1.5A	9V	0.93A
1.5A	12V	0.69A
2A	9V	1.23A
2A	12V	0.93A
3A	9V	1.85A
3A	12V	1.39A

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. The 1.5V power supply is for powering the Chinese scales and should not be used for other uses in order to keep the scale power as noise free as possible.

ARM7 PIO Map

Port A

Port	Pin	Net	PIO	Dir	PU	OD	Int	Notes
PA0	32	PWM1	A					
PA1	31	PWM2	A					
PA2	30	PWM3	A					
PA3	29	SDA	A			Y		External 4.7 K pull-up
PA4	28	SCL	A			Y		External 4.7 K pull-up
PA5	27	LCD_RX	A					
PA6	26	LCD_TX	A					
PA7	25	EXP2-5						Function TBD
PA8	24	USB_DETECT	P	I				
PA9	20	RS232_RX	A					
PA10	19	RS232_TX	A					
PA11	18	DISPLAY_ROW_LE	A					
PA12	17	DISPLAY_ROW_SO	A					
PA13	16	DISPLAY_ROW_SI	A					
PA14	15	DISPLAY_ROW_CLK	A					
PA15	14	DISPLAY_ROW_OE	P	O				
PA16	13	SCALE_A_IN0	P	I			Y	
PA17	12	SCALE_A_IN1	P	I			Y	
PA18	11	SCALE_A_IN2	P	I			Y	
PA19	10	SCALE_A_IN3	P	I			Y	
PA20	9	SCALE_A_IN4	P	I			Y	
PA21	117	UART_RX	A					
PA22	116	UART_TX	A					
PA23	115	EXP2-1						Function TBD
PA24	114	EXP2-2						Function TBD
PA25	113	EXP2-3						Function TBD
PA26	112	EXP2-4						Function TBD
PA27	111	SCALE_B_IN0	P	I			Y	
PA28	110	SCALE_B_IN1	P	I			Y	
PA29	109	SCALE_B_IN2	P	I			Y	
PA30	108	SCALE_B_IN3	P	I			Y	
PA31	107	SCALE_B_IN4	P	I			Y	

Port B

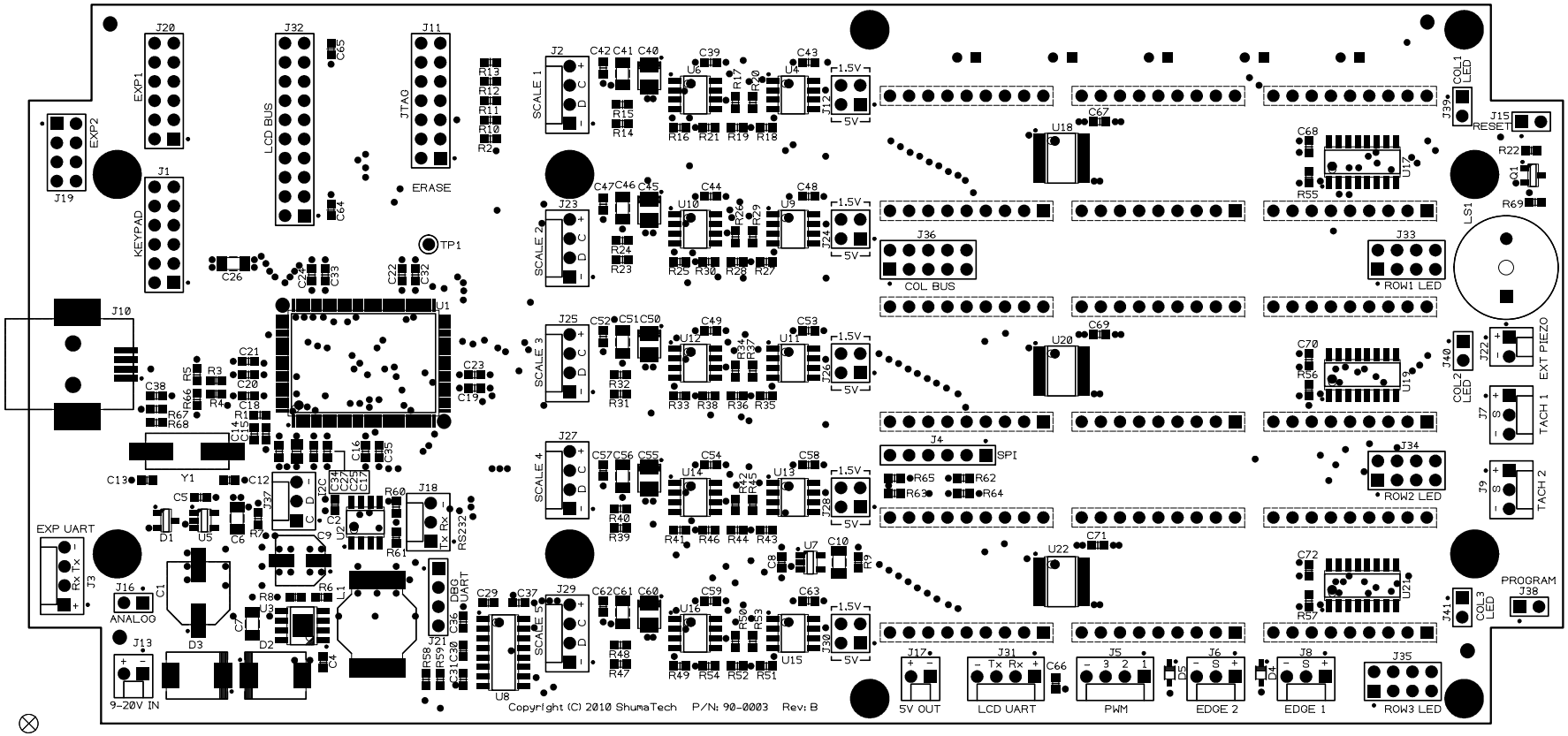
Port	Pin	Net	PIO	Dir	PU	OD	Int	Notes
PB0	69	TACH0	A					
PB1	68	DISPLAY_COL0	P	O				
PB2	67	DISPLAY_COL1	P	O				
PB3	64	DISPLAY_COL2	P	O				
PB4	63	DISPLAY_COL3	P	O				
PB5	62	DISPLAY_COL4	P	O				
PB6	61	DISPLAY_COL5	P	O				
PB7	60	DISPLAY_COL6	P	O				
PB8	59	DISPLAY_COL7	P	O				
PB9	58	KEYPAD_ROW0	P	I				
PB10	57	KEYPAD_ROW1	P	I				
PB11	56	KEYPAD_ROW2	P	I				
PB12	55	KEYPAD_ROW3	P	I				
PB13	54	KEYPAD_ROW4	P	I				
PB14	53	BUZZER	A					PWM at 3.8kHz
PB15	52	TACH1	A					
PB16	51	DISPLAY_COL_CLK	P	O				
PB17	50	KEYPAD_COL0	P	O	Y	Y		
PB18	49	KEYPAD_COL1	P	O	Y	Y		
PB19	48	KEYPAD_COL2	P	O	Y	Y		
PB20	44	KEYPAD_COL3	P	O	Y	Y		
PB21	43	KEYPAD_COL4	P	O	Y	Y		
PB22	42	SCALE_A_OUT0	P	O				
PB23	41	SCALE_A_OUT1	P	O				
PB24	40	SCALE_A_OUT2	P	O				
PB25	39	SCALE_A_OUT3	P	O				
PB26	38	SCALE_A_OUT4	P	O				
PB27	37	SCALE_B_OUT0	P	O				
PB28	36	SCALE_B_OUT1	P	O				
PB29	35	SCALE_B_OUT2	P	O				
PB30	34	SCALE_B_OUT3	P	O				
PB31	33	SCALE_B_OUT4	P	O				

Port C

Port	Pin	Net	PIO	Dir	PU	OD	Int	Notes
PC0	106	LCD_DATA0	A					
PC1	105	LCD_DATA1	A					
PC2	104	LCD_DATA2	A					
PC3	103	LCD_DATA3	A					
PC4	102	LCD_DATA4	A					
PC5	101	LCD_DATA5	A					
PC6	100	LCD_DATA6	A					
PC7	99	LCD_DATA7	A					
PC8	98	EXP1-1						Funtion TBD
PC9	93	EXP1-2						Funtion TBD
PC10	92	EXP1-3						Funtion TBD
PC11	91	EXP1-4						Funtion TBD
PC12	90	EXP1-5						Funtion TBD
PC13	89	EXP1-6						Funtion TBD
PC14	88	EXP1-7						Funtion TBD
PC15	87	EXP1-8						Funtion TBD
PC16	86	LCD_ADDR0	A					
PC17	85	LCD_ADDR1	A					
PC18	84	LCD_ADDR2	A					
PC19	83	EXP1-9						Funtion TBD
PC20	82	LCD_NCS1	A					
PC21	81	LCD_NWE	A					
PC22	80	LCD_NRD	A					
PC23	79	LCD_NCS0	A					

PCB

Top-Side


J20
EXP1
J32
LCD BUS
J11
JTAG
ERASE
J2
SCALE 1
J23
SCALE 2
J25
SCALE 3
J27
SCALE 4
J29
SCALE 5
1.5V
5V
J19
EXP2
J1
KEYPAD
TP1
J10
U1
Y1
EXP UART
J3
ANALOG
J16
9-20V IN
J13
U8
DBG UART
RS232
J36
COL BUS
J4
SPI
J33
ROW1 LED
J34
ROW2 LED
J35
ROW3 LED
J17
5V OUT
J31
LCD UART
J5
PWM
J6
EDGE 2
J8
EDGE 1
COL1 LED
COL2 LED
COL3 LED
J15
RESET
LS1
J22
EXT PIEZO
J7
TACH 1
J9
TACH 2
J38
PROGRAM
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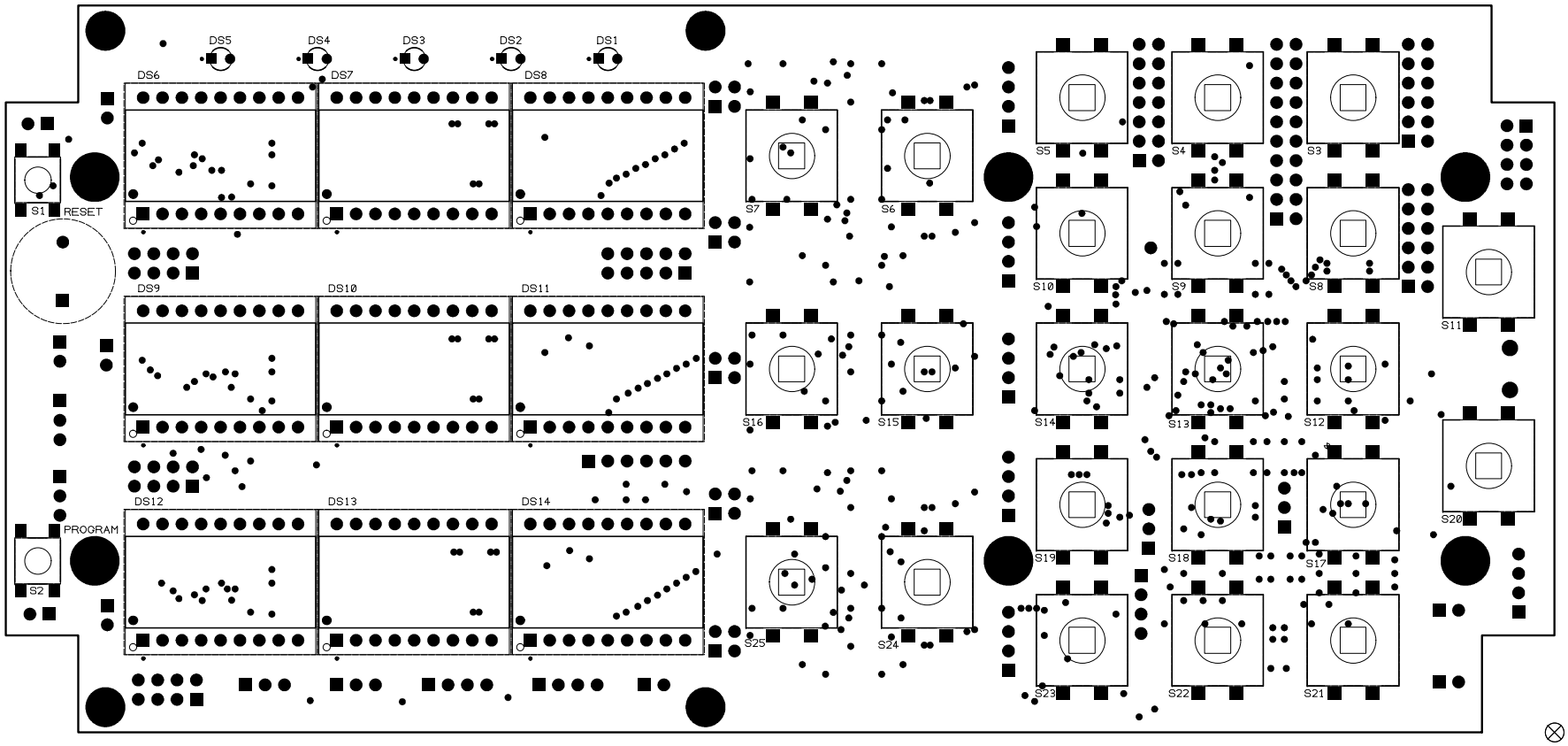
Bottom-Side



Bill of Materials

Surface-Mount Parts

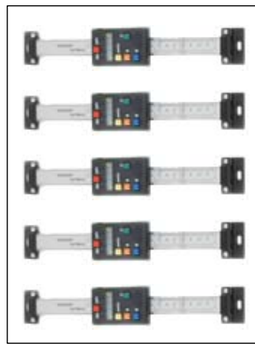
Item	Qty	Ref Des	Distributor	Dist Part #	Description
1	1	C1	DigiKey	PCE4204CT-ND	CAP,ELECT,330UF,20%,25V,HA,CASE-F
2	46	C2,C5,C8,C16,C17,C18,C19,C20,C21,C22,C23,C24,C29,C30,C31,C32,C33,C34,C35,C36,C37,C38,C39,C42,C43,C44,C47,C48,C49,C52,C53,C54,C57,C58,C59,C62,C63,C64,C65,C66,C67,C68,C69,C70,C71,C72	DigiKey	490-1519-1-ND	CAP,CER,0.1UF,10%,X7R,50V,0603
3	2	C4,C14	DigiKey	490-1511-1-ND	CAP,CER,10NF,10%,X7R,50V,0603
4	9	C6,C7,C10,C26,C41,C46,C51,C56,C61	DigiKey	445-1391-1-ND	CAP,CER,10UF,10%,Y5V,16V,1206
5	1	C9	DigiKey	565-3190-1-ND	CAP,POLY,330UF,20%,6.3V,CASE-D8
6	2	C12,C13	DigiKey	490-1403-1-ND	CAP,CER,10PF,5%,X7R,50V,0603
7	2	C15,C25	DigiKey	490-1494-1-ND	CAP,CER,1NF,10%,X7R,50V,0603
8	1	C27	DigiKey	490-1696-1-ND	CAP,CER,2.2UF,10%,X7R,10V,0805
9	5	C40,C45,C50,C55,C60	DigiKey	718-1313-1-ND	CAP,TANT,100UF,10%,6.3V,3528
10	1	D1	DigiKey	BAT54CFSCT-ND	DIODE,SCHOTTKY,DUAL,CC,30V,200mA,SOT-23
11	2	D2,D3	DigiKey	B320-FDICT-ND	DIODE,SCHOTTKY,RECT,20V,3A,SMC
12	2	D4,D5	DigiKey	1N4448WSFSCT-ND	DIODE,SMALL SIGNAL,100V,4NS,SOD-323
13	5	DS1,DS2,DS3,DS4,DS5	DigiKey	160-1708-ND	LED RED DIFFUSED 3MM
14	9	DS6,DS7,DS8,DS9,DS10,DS11,DS12,DS13,DS14	DigiKey	516-1206-5-ND	LED DISPLAY 7SEG RED 2 DIGIT CA 18DIP
15	2	J1,J20	DigiKey	WM8124-ND	HEADER 2X6 12 POS TIN 0.100 SPC 0.230" LN"
16	8	J2,J3,J5,J23,J25,J27,J29,J31	DigiKey	A1922-ND	HEADER 4 POS TIN STR MTA-100 W/ FRIC LCK
17	1	J4	DigiKey	WM8076-ND	HEADER 6 POS TIN 0.100 SPC 0.230" LN"
18	6	J6,J7,J8,J9,J18,J37	DigiKey	A19470-ND	HEADER 3 POS TIN STR MTA-100 W/ FRIC LCK
19	1	J10	Mouser	154-UBR44-E	CONN,USB,TYPE B,SMT
20	1	J11	DigiKey	WM8125-ND	HEADER 2X7 14 POS TIN 0.100 SPC 0.230" LN"

21	5	J12,J24,J26,J28,J30	DigiKey	WM8120-ND	HEADER 2X2 4 POS TIN 0.100 SPC 0.230" LN"
22	3	J13,J17,J22	DigiKey	A1921-ND	HEADER 2 POS TIN STR MTA-100 W/ FRIC LCK
23	6	J15,J16,J38,J39,J40,J41	DigiKey	WM8072-ND	HEADER 2 POS TIN 0.100 SPC 0.230" LN"
24	4	J19,J33,J34,J35	DigiKey	WM8122-ND	HEADER 2X4 8 POS TIN 0.100 SPC 0.230" LN"
25	1	J21	DigiKey	WM8074-ND	HEADER 4 POS TIN 0.100 SPC 0.230" LN"
26	1	J32	DigiKey	WM8128-ND	HEADER 2X10 20 POS TIN 0.100 SPC 0.230" LN"
27	1	J36	DigiKey	WM8123-ND	HEADER 2X5 10 POS TIN 0.100 SPC 0.230" LN"
28	1	L1	DigiKey	513-1185-1-ND	IND,PWR,UP2B,10UH,4.3A,SMD
29	1	LS1	DigiKey	668-1101-ND	PIEZO BUZZER 4KHZ 5V 14MM PC MNT
30	1	Q1	DigiKey	MMBT3904FSCT-ND	TRANSISTOR, GP, NPN, 200mA, SOT-23
31	2	R1,R69	DigiKey	RHM1.69KHCT-ND	RESISTOR, R0603, 1.69K, 1/10W, 0.01
32	15	R2,R10,R11,R12,R13,R16,R17,R25,R26,R33,R34,R41,R42,R49,R50	DigiKey	RHM100KGCT-ND	RESISTOR, R0603, 100K, 1/10W, 0.05
33	2	R3,R4	DigiKey	RHM27GCT-ND	RESISTOR, R0603, 27, 1/10W, 0.05
34	2	R5,R66	DigiKey	RHM330KGCT-ND	RESISTOR, R0603, 330K, 1/10W, 0.05
35	1	R6	DigiKey	RHM10.0KHCT-ND	RESISTOR, R0603, 10K, 1/10W, 0.01
36	2	R7,R9	DigiKey	RHM1.0GCT-ND	RESISTOR, R0603, 1, 1/10W, 0.05
37	1	R8	DigiKey	RHM3.16KHCT-ND	RESISTOR, R0603, 3.16K, 1/10W, 0.01
38	34	R14,R15,R18,R19,R20,R21,R22,R23,R24,R27,R28,R29,R30,R31,R32,R35,R36,R37,R38,R39,R40,R43,R44,R45,R46,R47,R48,R51,R52,R53,R54,R58,R59,R67	DigiKey	RHM10KGCT-ND	RESISTOR, R0603, 10K, 1/10W, 0.05
39	3	R55,R56,R57	DigiKey	RHM300GCT-ND	RESISTOR, R0603, 300, 1/10W, 0.05
40	7	R60,R61,R62,R63,R64,R65,R68	DigiKey	RHM4.7KGCT-ND	RESISTOR, R0603, 4.7K, 1/10W, 0.05
41	2	S1,S2	Mouser	101-0264-EV	SWITCH 6MM TACT 5.0MM 160GF SMT
42	23	S3,S4,S5,S6,S7,S8,S9,S10,S11,S12,S13,S14,S15,S16,S17,S18,S19,S20,S21,S22,S23,S24,S25	Mouser	101-0624-EV	SWITCH 12MM TACT CAP 160GF
43	1	U1	DigiKey	AT91SAM7SE256-AU-ND	IC,ARM7,MCU,32-BIT,256K,3.3V,128 PIN,LQFP
44	1	U2	DigiKey	AT24C256BN-SH-B-ND	IC,SERIAL EEPROM,256K,LP,LV,8 PIN,SOIC
45	1	U3	DigiKey	296-19662-5-ND	IC,PWM CONV,STEP DOWN,3A,9 PIN,SOIC
46	5	U4,U9,U11,U13,U15	DigiKey	296-1540-1-ND	IC,DUAL FET BUS SWITCH,8 PIN,SOIC

47	1	U5	DigiKey	296-11039-1-ND	IC,VREG,LDO,FXD,POS,3.3V,100MA,SOT23-5
48	5	U6,U10,U12,U14,U16	DigiKey	LM393DGOS-ND	IC,COMP,DUAL,LV OFFSET,8 PIN,SOIC
49	1	U7	DigiKey	296-11032-1-ND	IC,VREG,LDO,FXD,POS,1.5V,100MA,SOT23-5
50	1	U8	DigiKey	296-19851-1-ND	IC,DRVR/RCR,MULTCH,RS232,16 PIN,SOIC
51	3	U17,U19,U21	DigiKey	296-6610-1-ND	IC,LED SINK DRIVER,16 PIN,SOIC
52	3	U18,U20,U22	DigiKey	296-24262-1-ND	IC,LED SOURCE DRIVER,20 PIN,TSSOP
53	1	Y1	DigiKey	535-9072-1-ND	CRYSTAL,18.432MHZ,18PF,FUND,HC-49/US

Schematics

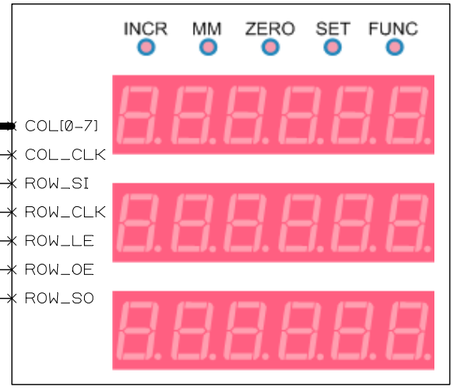
The DRO-550 schematics are included in the following pages.



B3
Scales

A_IN[0-4] — SCALE_A_IN[0-4] — SCALE_A_IN[0-4]
B_IN[0-4] — SCALE_B_IN[0-4] — SCALE_B_IN[0-4]
A_OUT[0-4] — SCALE_A_OUT[0-4] — SCALE_A_OUT[0-4]
B_OUT[0-4] — SCALE_B_OUT[0-4] — SCALE_B_OUT[0-4]

DISPLAY_COL[0-7] — DISPLAY_COL[0-7] — COL[0-7]
DISPLAY_COL_CLK — DISPLAY_COL_CLK — COL_CLK
DISPLAY_ROW_SI — DISPLAY_ROW_SI — ROW_SI
DISPLAY_ROW_CLK — DISPLAY_ROW_CLK — ROW_CLK
DISPLAY_ROW_LE — DISPLAY_ROW_LE — ROW_LE
DISPLAY_ROW_OE — DISPLAY_ROW_OE — ROW_OE
DISPLAY_ROW_SO — DISPLAY_ROW_SO — ROW_SO



B2
Display

USBM — USBM — USBM
USBP — USBP — USBP

RS232_TX — RS232_TX — RS232_TX
RS232_RX — RS232_RX — RS232_RX

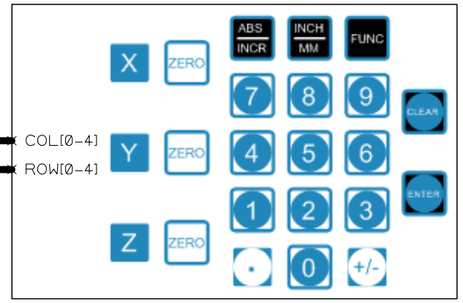
EDGE[0-1] — EDGE[0-1] — EDGE[0-1]
TACH[0-1] — TACH[0-1] — TACH[0-1]

BUZZER — BUZZER — BUZZER

B6
I/O

ARM

KEYPAD_COL[0-4] — KEYPAD_COL[0-4] — COL[0-4]
KEYPAD_ROW[0-4] — KEYPAD_ROW[0-4] — ROW[0-4]



B5
Keypad

LCD_DATA[0-7] — LCD_DATA[0-7] — DATA[0-7]
LCD_ADDR[0-2] — LCD_ADDR[0-2] — ADDR[0-2]
LCD_CTRL — LCD_CTRL — CTRL
LCD_TX — LCD_TX — TX
LCD_RX — LCD_RX — RX

B4
LCD

B1
ARM7

B7
Power

SHUMATECH		
TITLE: DRO-550		
PAGE: Top Level	DATE: 1/22/2010	REV: B
AUTHOR: Scott	SIZE: B	SHEET 1 OF 16

EXP1
J20
HDR2X6
5V
5V
EXP1-1
EXP1-2
EXP1-3
EXP1-4
EXP1-5
EXP1-6
EXP1-7
EXP1-8
EXP1-9
TACH[0-1]
DISPLAY_COL[0-7]
KEYPAD_ROW[0-4]
BUZZER
DISPLAY_COL_CLK
KEYPAD_COL[0-4]
SCALE_A_OUT[0-4]
SCALE_B_OUT[0-4]
LCD_DATA[0-7]
LCD_ADDR[0-2]
LCD_CTRL
U1
AT91SAM7SE256-AU
PB0/TIOA0/A0_NBS0
PB1/TIOB0/A1_NBS2
PB2/SCK0/A2
PB3/NPCS3/A3
PB4/TCLK0/A4
PB5/NPCS3/A5
PB6/PCK0/A6
PB7/PWM3/A7
PB8/ADTRG/A8
PB9/NPCS1/A9
PB10/NPCS2/A10
PB11/PWM0/A11
PB12/PWM1/A12
PB13/PWM2/A13
PB14/PWM3/A14
PB15/TIOA1/A15
PB16/TIOB1/A16_BA0
PB17/PCK1/A17_BA1
PB18/PCK2/D16
PB19/FIQ/D17
PB20/IRQ0/D18
PB21/PCK1/D19
PB22/NPCS3/D20
PB23/PWM0/D21
PB24/PWM1/D22
PB25/PWM2/D23
PB26/TIOA2/D24
PB27/TIOB2/D25
PB28/TCLK1/D26
PB29/TCLK2/D27
PB30/NPCS2/D28
PB31/PCK2/D29
PA0/NBS0_A0/PWM0
PA1/NBS2_A1/PWM1
PA2/PWM2
PA3/TWD
PA4/TWCK
PA5/RXD0
PA6/TXD0
PA7/RTS0
PA8/CTS0
PA9/DRXD
PA10/DTXD
PA11/NPCS0
PA12/MISO
PA13/MOSI
PA14/SPCK
PA15/TF
BA0_A16/TK
AD0/BA1_A17/TD
AD1/NBCS3_CFIOW/RD
AD2/NCS4_CFCS0/RK
AD3/NCS2_CFCS2/RF
NCS6_CFCE2/RXD1
NCS5_CFCE1/TXD1
NWR1_NBS1_CFIOR/SCK1
SDA10/RTS1
SDCKE/CTS1
SDCS_NCS1/DCD1
SDWE/DTR1
CAS/DSR1
RAS/RI1
D30/IRQ1/PA30
D31/NPCS1/PA31
SDCK
AD4
AD5
AD6
AD7
ADVREF
NRST
TST
ERASE
USBM
USBP
DM
DP
TDI
TMS
TCK
TDO
JTAGSEL
TP1
XOUT
XIN/PGMCK
PLLRC
VDDIN
VDDPLLA5H
VDDIO
VDDPLL
VDDOUT
VDDCORE
GND
SPI
J4
HDR6
DISPLAY_ROW_LE
DISPLAY_ROW_SO
DISPLAY_ROW_SI
DISPLAY_ROW_CLK
DISPLAY_ROW_OE
I2C
J37
HDR3 MTA FL
SCL
SDA
J5
HDR4 MTA FL
PWM
PWM1
PWM2
PWM3
3V3
R60
4.7K
R61
4.7K
32KB I2C EEPROM
U2
AT24C256BN-SH-B
SDA
SCL
WP
A0
A1
A2
VCC
GND
C2
0.1uF
LCD_RX
LCD_TX
RS232_RX
RS232_TX
DISPLAY_ROW_LE
DISPLAY_ROW_SO
DISPLAY_ROW_SI
DISPLAY_ROW_CLK
DISPLAY_ROW_OE
USB_DETECT
VUSB
4.7K
R67
10K
R68
SCALE_A_IN[0-4]
SCALE_B_IN[0-4]
J3
HDR4 MTA FL
EXP
UART
UART_RX
UART_TX
EXP2-1
EXP2-2
EXP2-3
EXP2-4
JTAG
J11
HDR2X7
R9
100K
R10
100K
R11
100K
R12
100K
R13
100K
EDGE[0-1]
R58
10K
R59
10K
D4
1N4448WS
D5
1N4448WS
J16
HDR2
ANALOG
ANALOG1
ANALOG2
EXP2
J19
HDR2X4
J15
HDR2
RESET
NRST
S1
TACT
J38
HDR2
PROGRAM
ERASE
S2
TACT
C12
10pF
C13
10pF
C14
10nF
C15
1nF
R1
1.69K
Y1
18.432MHz
Decoupling
C16
C17
C18
C19
C20
C32
C33
C26
0.1uF
10uF
C21
C22
C23
C24
C34
C35
C25
C27
1nF
2.2uF
1V8
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PAGE: B1:ARM7
DATE: 1/22/2010
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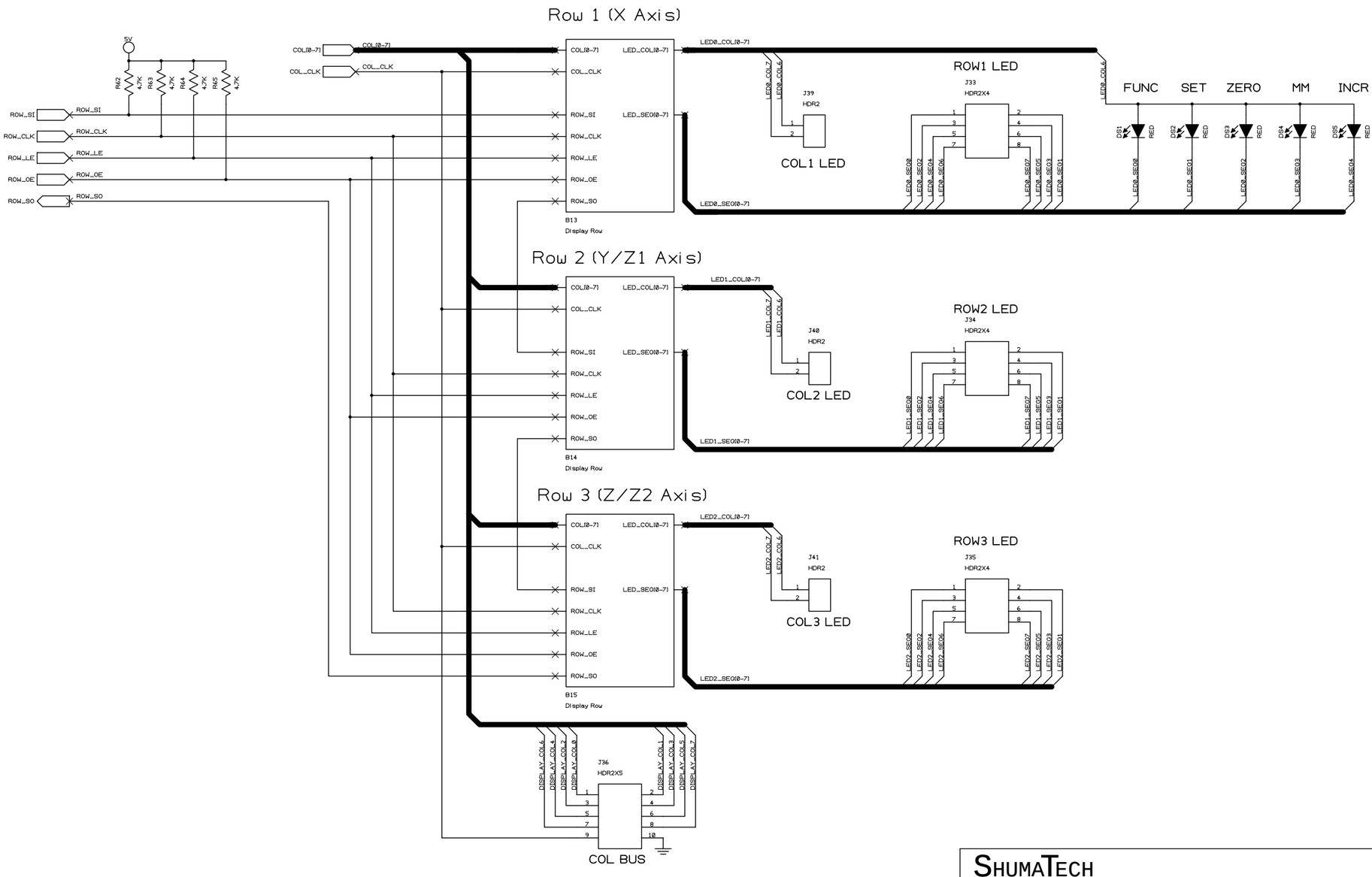
SHEET 2 OF 16



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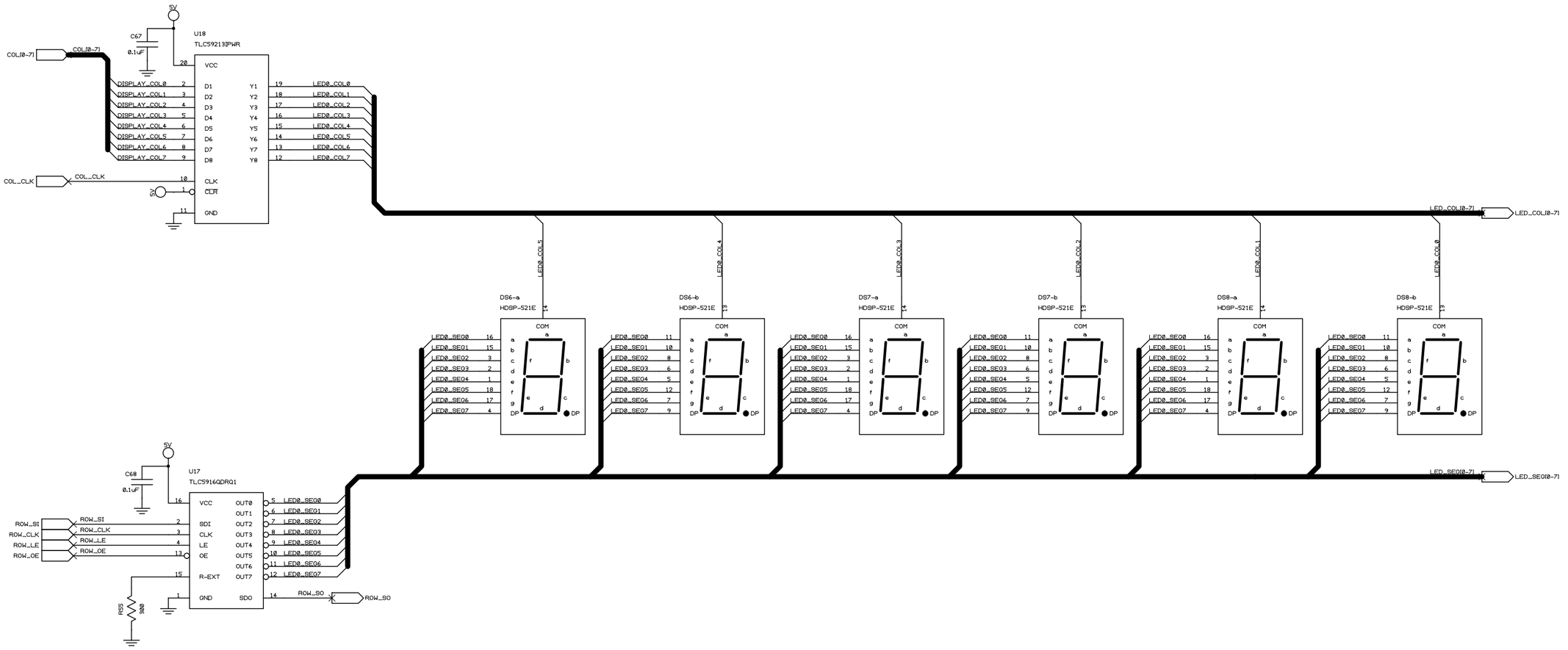
AUTHOR: Scott	SIZE: B	SHEET 3 OF 16



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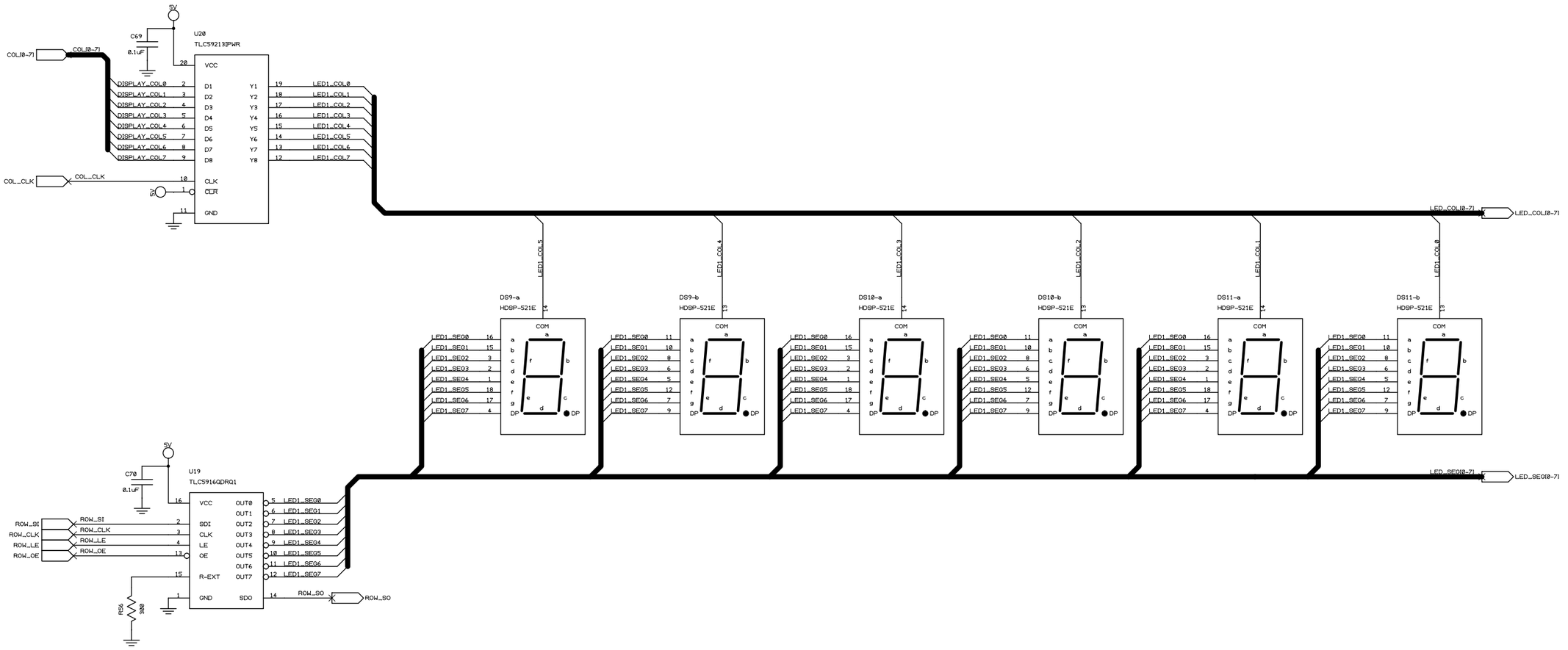
PAGE: B13:Display Row	DATE: 1/22/2010	REV: B
AUTHOR: Scott	SIZE: B	SHEET 4 OF 16



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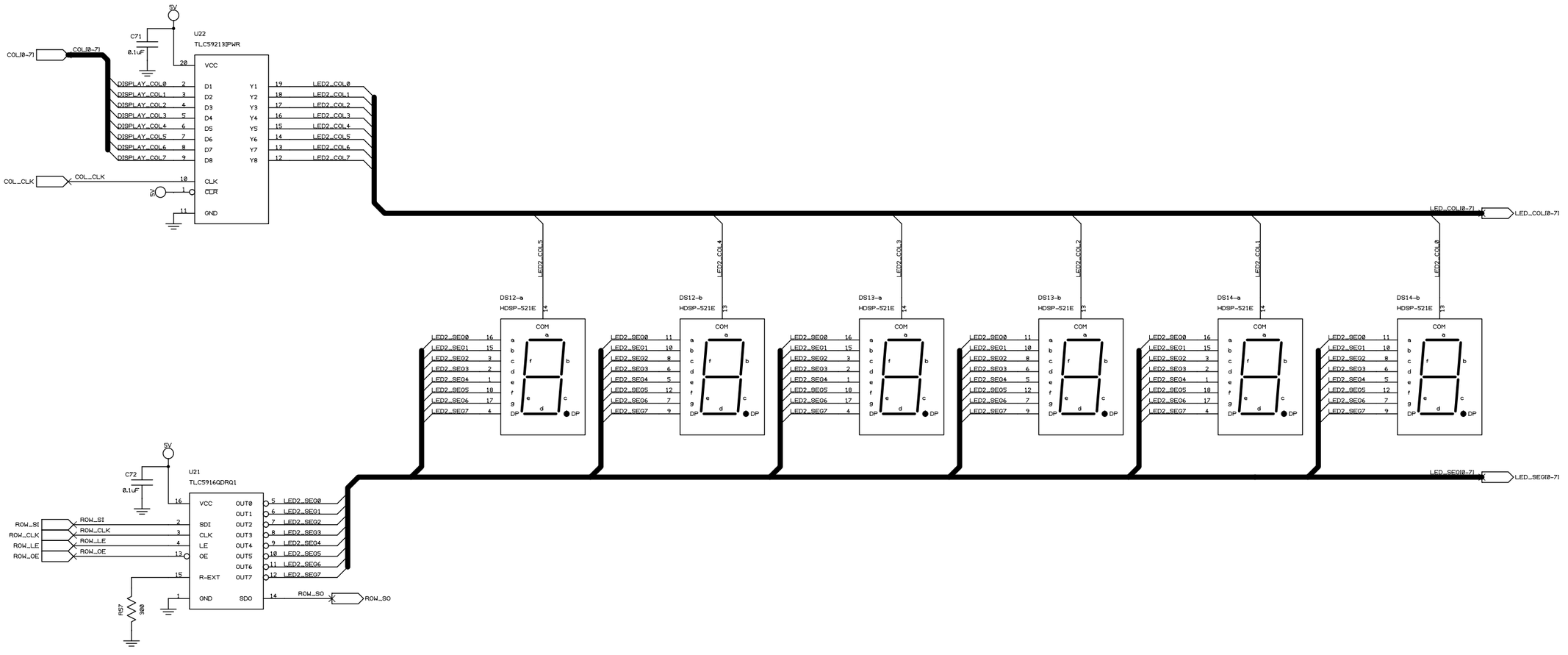
PAGE: B14:Display Row	DATE: 1/22/2010 REV: B
AUTHOR: Scott	SIZE: B SHEET 5 OF 16



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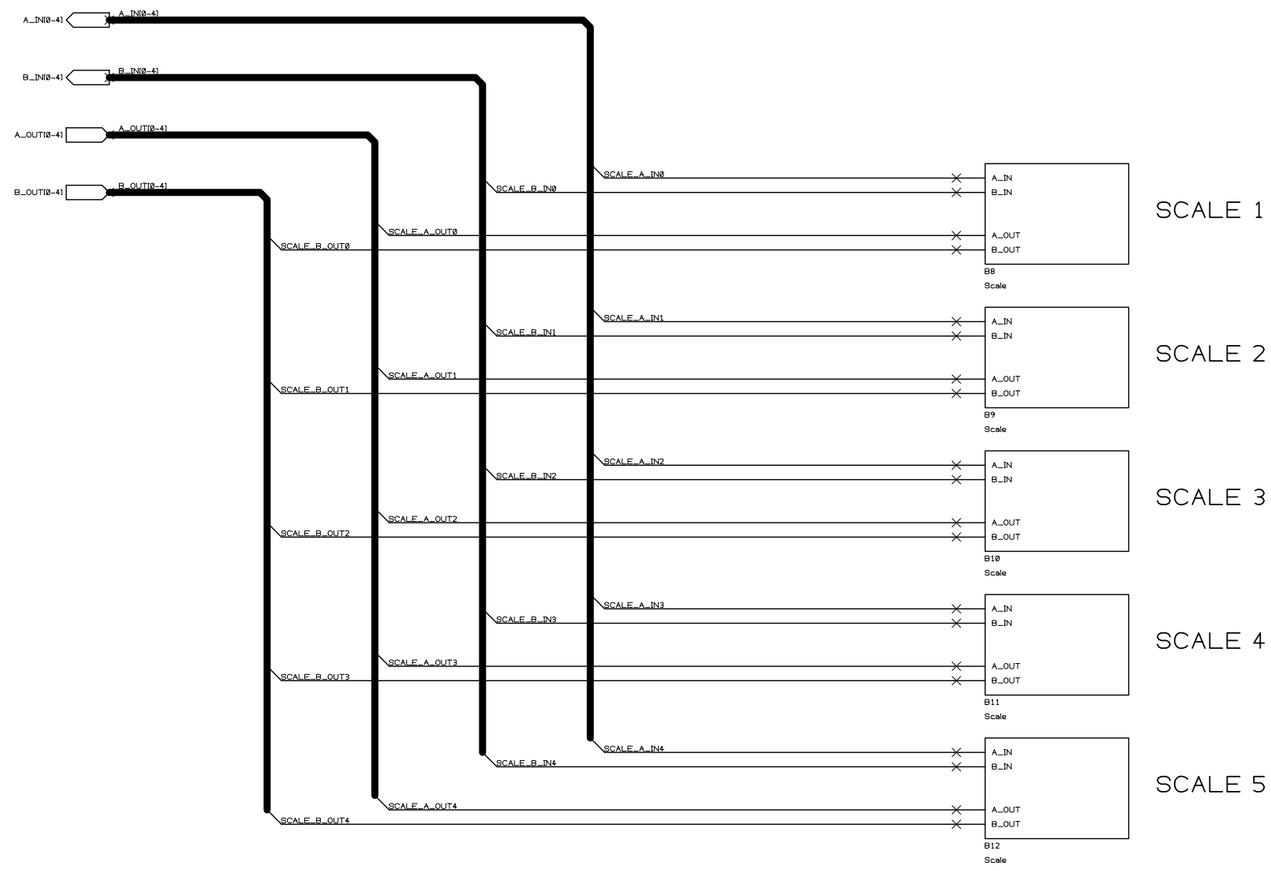
AUTHOR: Scott	SIZE: B	SHEET 6 OF 16



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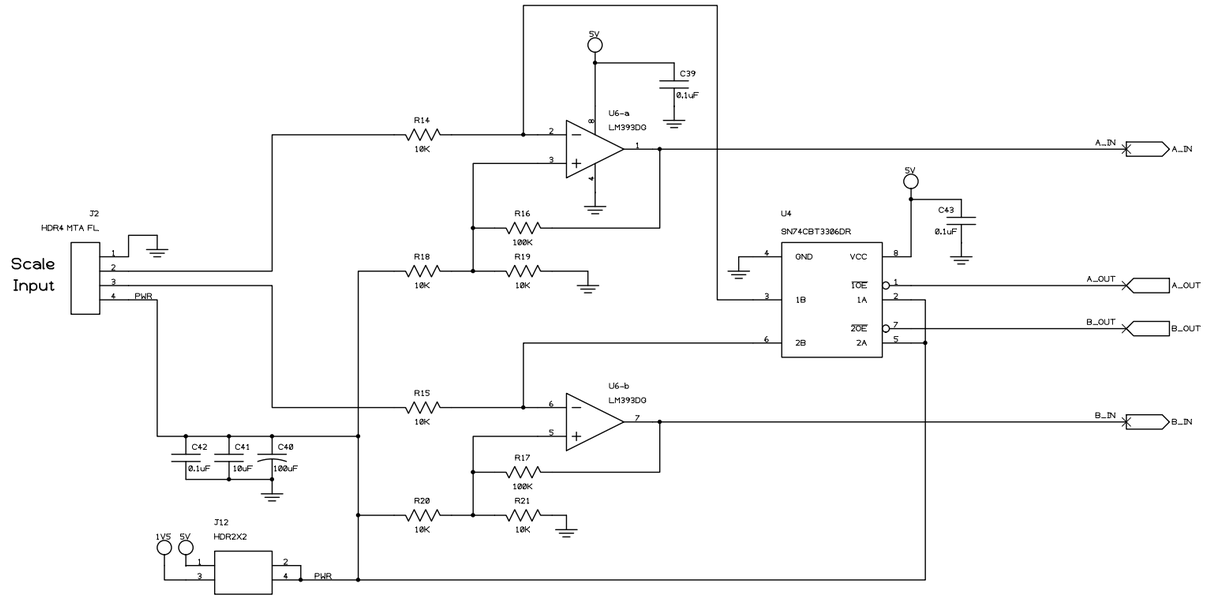
PAGE: B3:Scales	DATE: 1/22/2010 | REV: B
AUTHOR: Scott	SIZE: B | SHEET 7 OF 16



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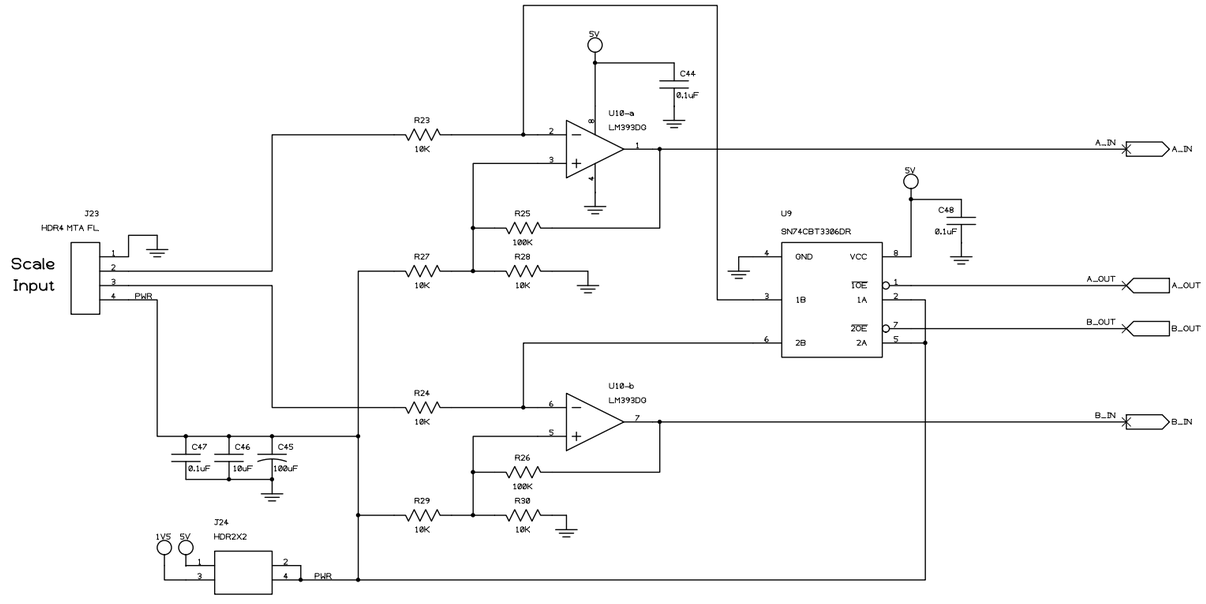
AUTHOR: Scott	SIZE: B | SHEET 8 OF 16



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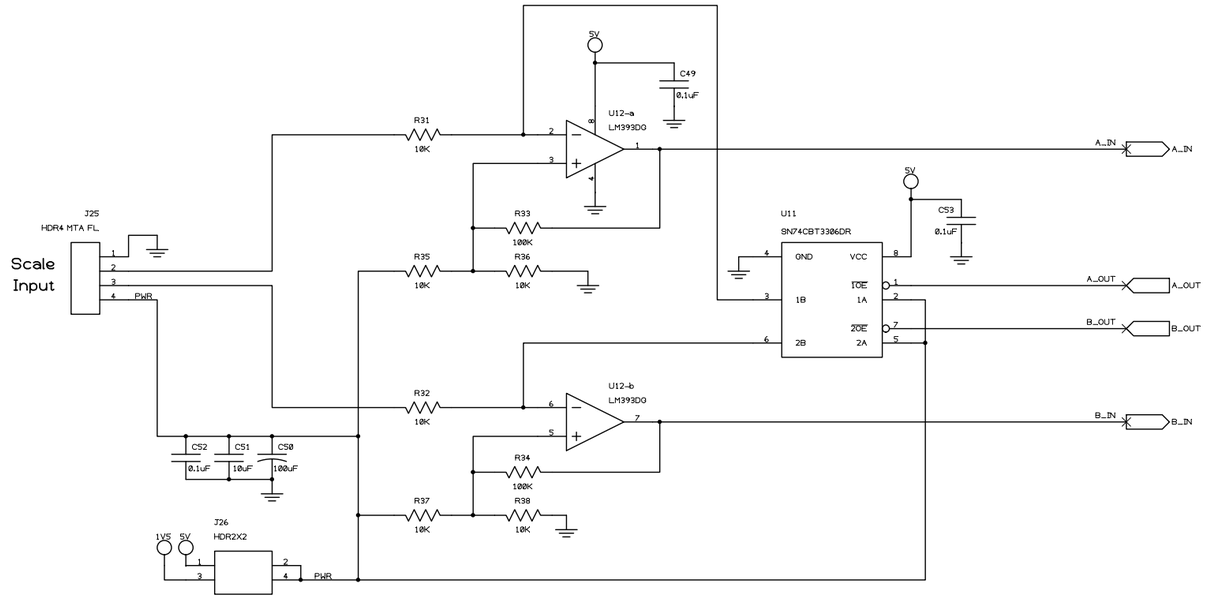
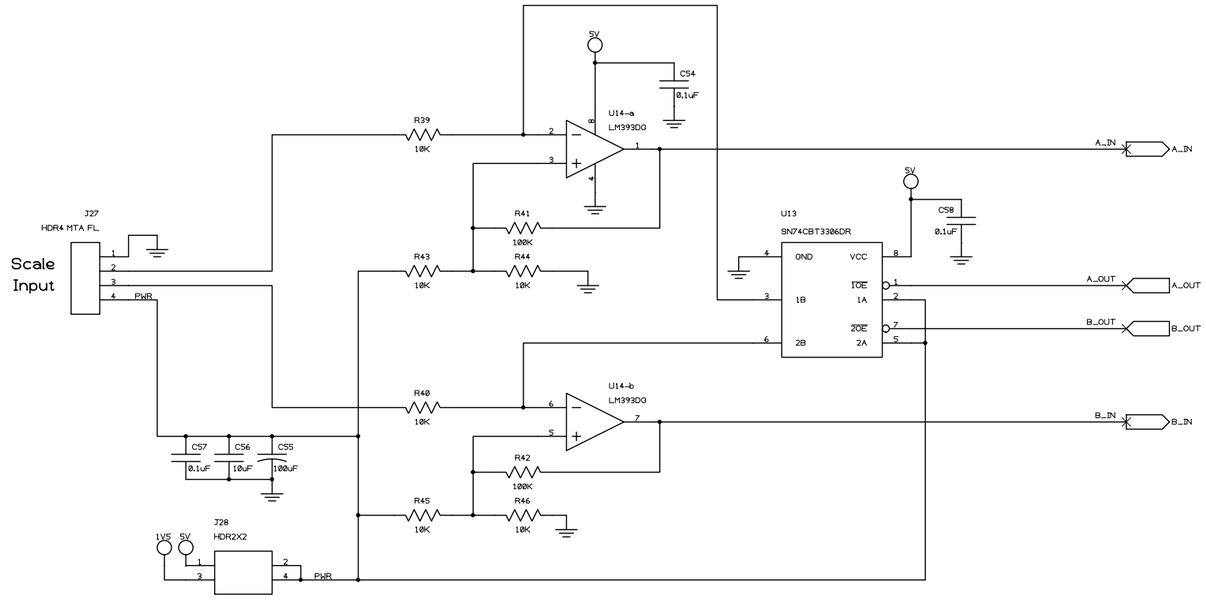
PAGE: B9:Scale	DATE: 1/22/2010	REV: B
AUTHOR: Scott	SIZE: B | SHEET 9 OF 16	



SHUMATECH	
TITLE: DRO-550	
PAGE: B10:Scale	DATE: 1/22/2010 | REV: B
AUTHOR: Scott	SIZE: B | SHEET 10 OF 16



SHUMATECH	
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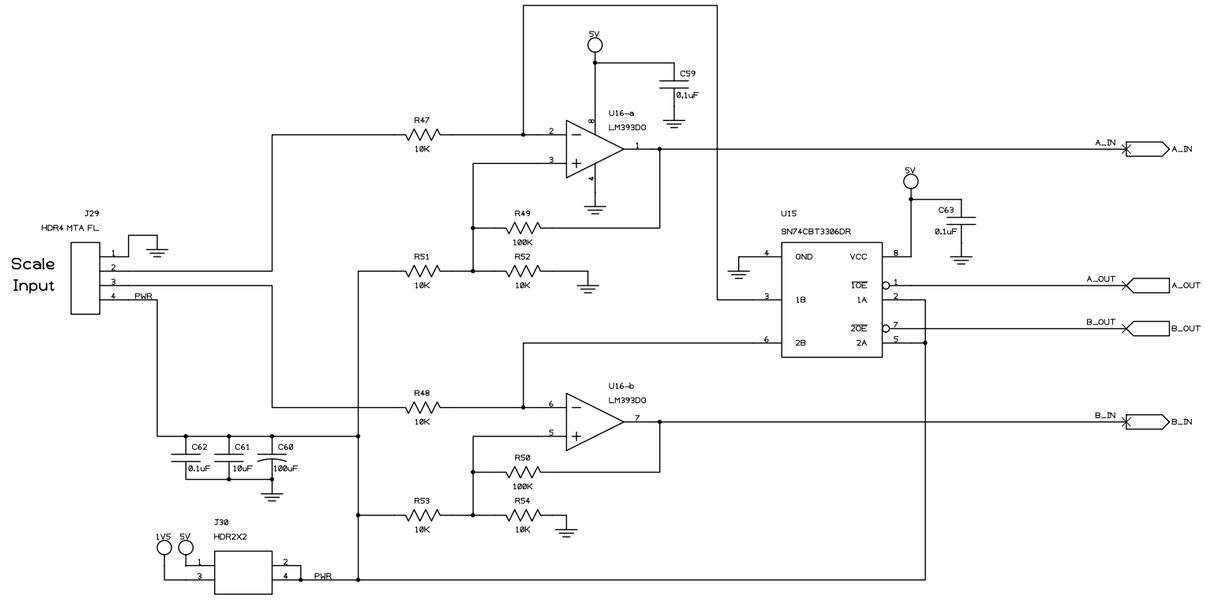
PAGE: B11:Scale	DATE: 1/22/2010 | REV: B
AUTHOR: Scott	SIZE: B | SHEET 11 OF 16



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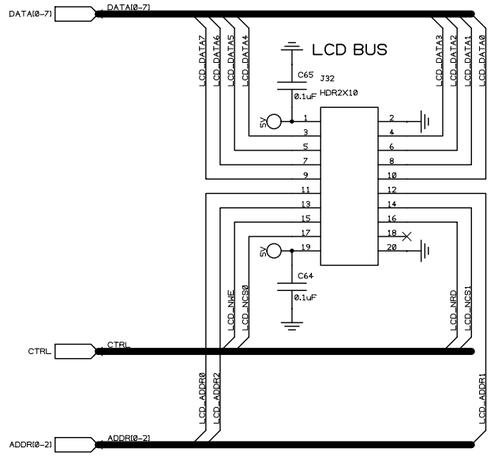
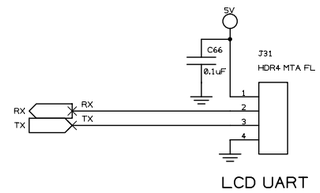
PAGE: B12:Scale	DATE: 1/22/2010 REV: B
AUTHOR: Scott	SIZE: B SHEET 12 OF 16





SHUMATECH		
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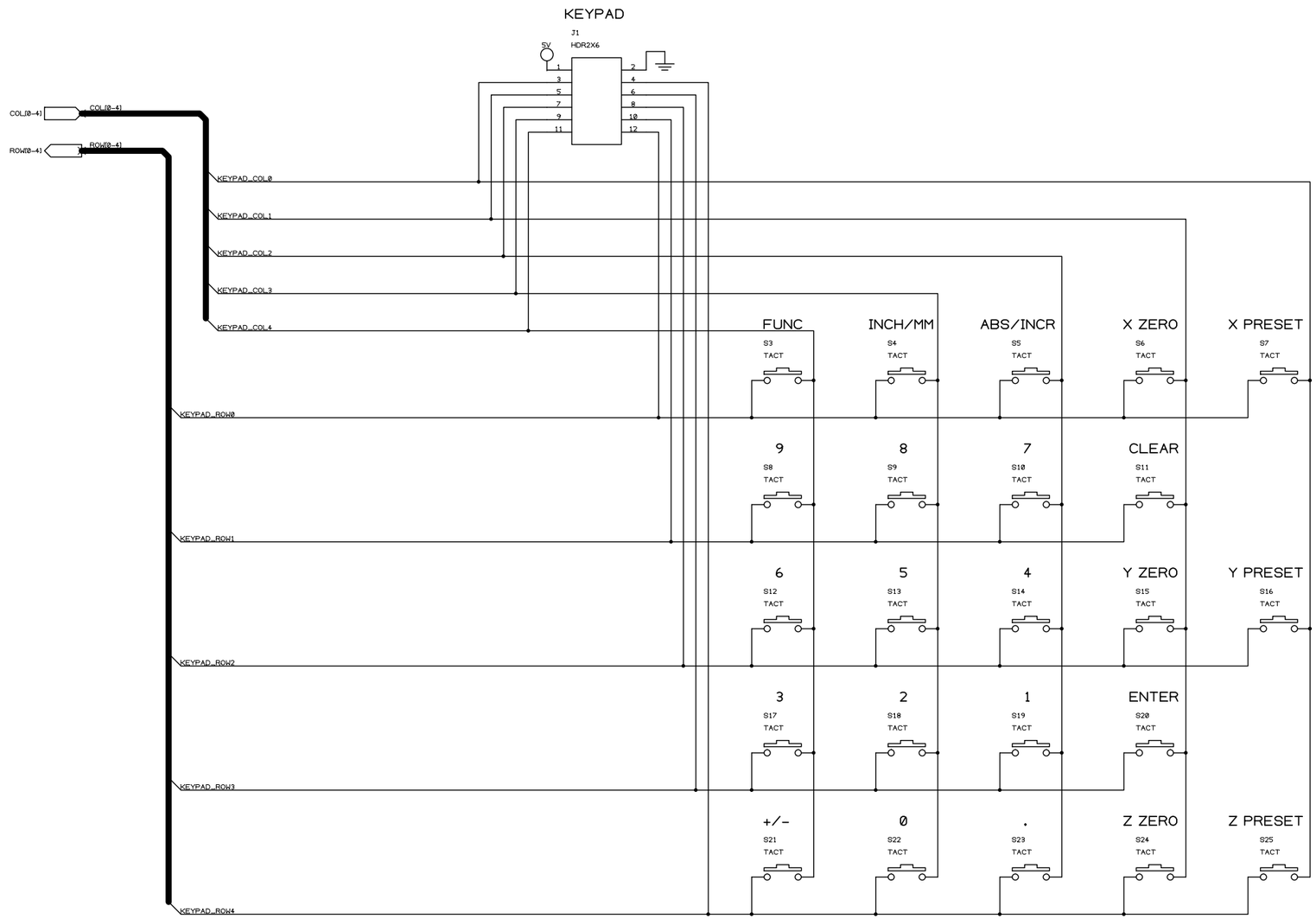
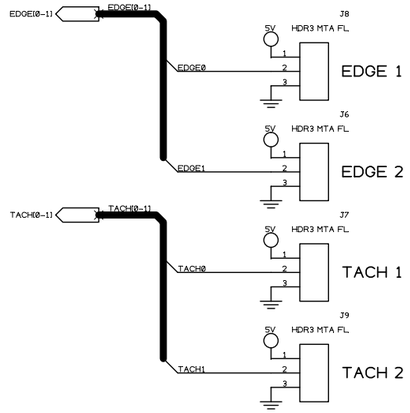
PAGE: B4:LCD	DATE: 1/22/2010	REV: B
AUTHOR: Scott	SIZE: B	SHEET 13 OF 16

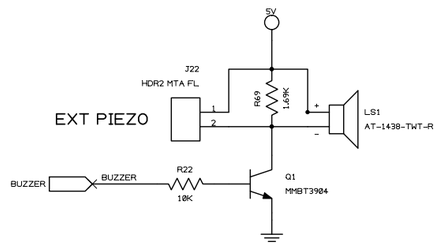


SHUMATECH			
TITLE: DRO-550			
PAGE: B5:Keypad	DATE: 1/22/2010	REV: B	
AUTHOR: Scott	SIZE: B	SHEET 14 OF 16	

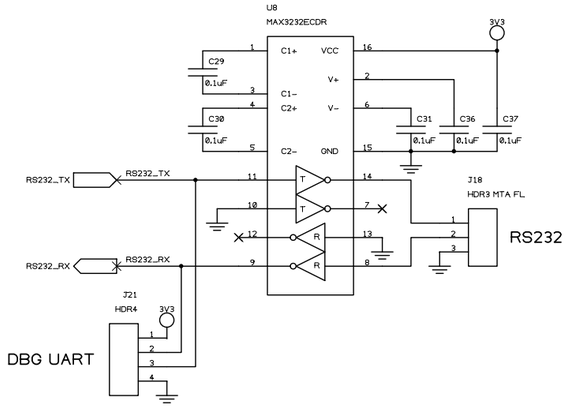
Edge Finder & Tachometer Inputs



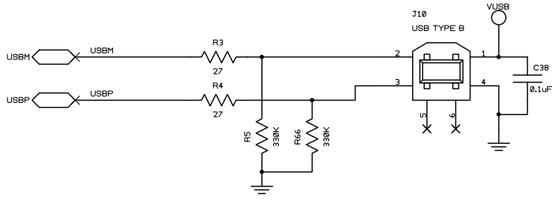
Piezo Transducer



RS-232 Transceiver



USB Type B Port



SHUMATECH			
TITLE: DRO-550			
PAGE: B6:I/O	DATE: 1/22/2010	REV: B	
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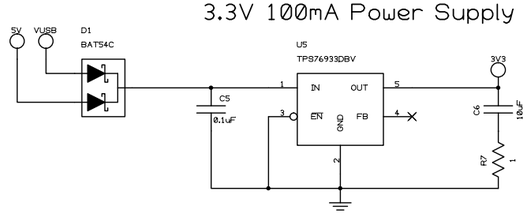
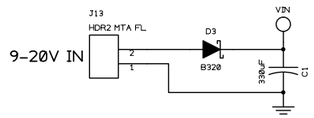
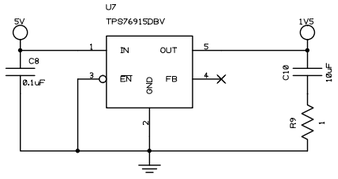
3.3V 100mA Power Supply



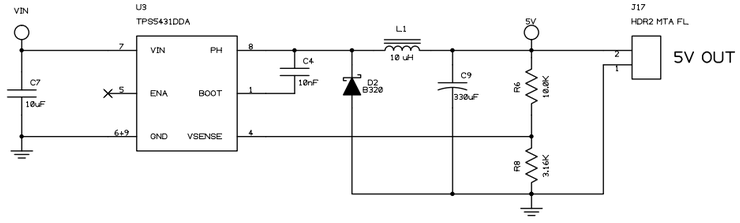
9-20V Power Entry



1.5V 100mA Power Supply



5V 3A Power Supply



SHUMATECH			
TITLE: DRO-550			
PAGE: B7:Power	DATE: 1/22/2010	REV: B	
AUTHOR: Scott	SIZE: B	SHEET 16 OF 16	