

## LTC3555-1 and LTC3555-3 High Efficiency USB Power Manager + Triple Step Down DC/DC

### DESCRIPTION

Demonstration circuits 1376A-A and 1376A-B are High Efficiency USB Power Manager + Triple Step Down DC/DC featuring the LTC3555-1 and LTC3555-3 respectively. The LTC3555-1/LTC3555-3 are highly integrated power management and battery charger ICs for Li-Ion/polymer battery applications. It includes a high efficiency current limited switching PowerPath manager with automatic charge current reduction, a battery charger, an ideal diode and three general purpose synchronous step-down switching regulators. Designed specifically for USB applications, the LTC3555-1/LTC3555-3's switching power manager automatically limits input current to a maximum of either 100mA or 500mA for USB applications or 1A for AC-powered applications. Unlike linear PowerPath controllers, the LTC3555-1/LTC3555-3's switching input stage transmits

nearly all of the 2.5W available from the USB port to the system load with minimal power wasted as heat. This feature allows the LTC3555-1/LTC3555-3 to provide more power to the application and eases the constraint of thermal budgeting in small spaces. Two of the three general purpose switching regulators can provide up to 400mA and the third can deliver 1A. The entire product can be started from an external push button and subsequently controlled via I<sup>2</sup>C. The LTC3555-1/LTC3555-3 is available in the 28-pin (4mm × 5mm × 0.75mm) QFN surface mount package.

**Design files for this circuit board are available. Call the LTC factory.**

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### PERFORMANCE SUMMARY Specifications are at T<sub>A</sub> = 25°C

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V <sub>BUS</sub>	Input Supply Range		4.35		5.5	V
V <sub>OUT</sub>	V <sub>OUT</sub> Output Voltage	Mode and load dependant	3.4	Bat + 0.3	4.7	V
LDO3V3	LDO3V3 Output Voltage	Load and V <sub>OUT</sub> dependant		3.3		V
V <sub>FLOAT</sub>	BAT Regulated Output Voltage	LTC3555-1	4.179	4.2	4.221	V
		LTC3555-3	4.079	4.1	4.121	V
I <sub>BAT</sub>	Constant Current Mode Charge Current	R <sub>PROG</sub> = 2KΩ	460	511	532	mA
V <sub>OUT1</sub>	V <sub>OUT1</sub> Output Voltage			3.3		V
V <sub>OUT2</sub>	V <sub>OUT2</sub> Output Voltage	Servo Voltage = 0.8		3.0		V
V <sub>OUT3</sub>	V <sub>OUT3</sub> Output Voltage	Servo Voltage = 0.8		1.5		V

### QUICK START PROCEDURE

Demonstration circuits 1376A-A and 1376A-B are easy to set up to evaluate the performance of the LTC3555-1 and LTC3555-3. These circuits are best evaluated using a Li-Ion or Li-Polymer battery. When using a battery simulator for evaluation, oscillations must be verified with a real battery at the same conditions because it is

difficult to match the impedance of a real battery. Capacitor C15 in combination with R9, R10, and R11 were added to simulate the low impedance of a real battery. It will allow proper operation of the demo circuit with or without a battery, or a battery simulator consisting of a power supply in parallel with a 3.6 Ohm resistor.

Complete the Quick Start Procedure outlined in the Quick Start Guide for Demo Circuit 590 available from the Linear Technology Web Site, prior to proceeding.

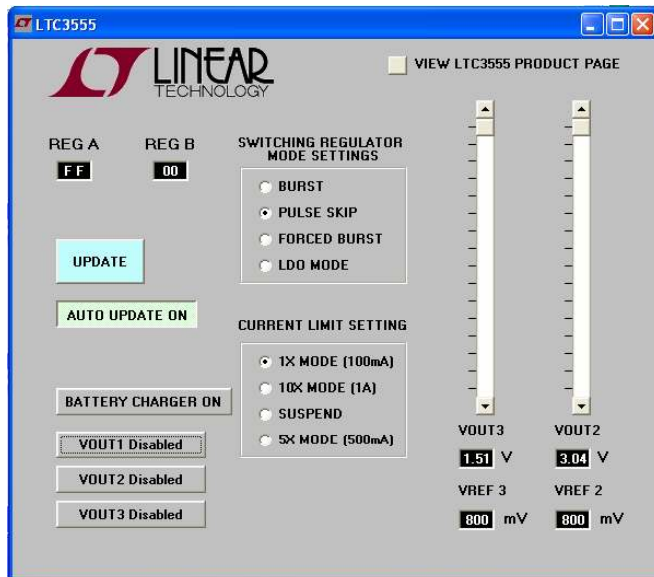
Refer to Figure 2 for proper measurement equipment setup and follow the procedure below:

**NOTE.** When measuring the input or output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the input or output voltage ripple by touching the probe tip directly across the VBUS or VOUT(x) and GND terminals. See Figure 3 for proper scope probe technique.

1. After following the software installation procedure in the DC590 Quick Start Guide, connect the DC1376A, the DC590 and the Host PC as shown in Figure 2.

**NOTE.** If using the DC590B board, a specific DVCC voltage level may be selected. This is done by setting the VCCIO jumper on the DC590 board to one of the following settings: 3.3V, 5V, removed for 2.7V or set to external if an external supply is desired to be used.

2. Run the QuikEval.exe software. The QuikEval software detects the DC1376A-A or the DC1376A-B demo board and the LTC3555 Graphical User Interface (GUI), shown in Figure 1, will pop-up.



**Figure 1. Graphical User Interface Demonstration Software for DC1376A-A and DC1376A-B.**

3. If using an external supply, connect a 0 to 6V, 1.5A supply with voltage adjusted to 0V between the VBUS and GND terminals. Connect a voltmeter across the VBUS and GND terminals. If using the USB input option, plug in the USB cable after all

loads and jumpers are set. Connect the positive terminal of a voltmeter to CLPROG and the negative terminal to GND to measure the average input current. The voltage on CLPROG will reach 1.188V when the average input current limit is reached. **Do not use the USB input and an external supply at the same time.**

4. Set JP1, (NTC) to “INT” to use the demo board resistor network. To use an external NTC resistor, connect the external NTC resistor between the J2-3 terminal and the GND terminal. Then set the NTC jumper to “EXT”.
5. Set JP2 and JP3 (ILIM0 and ILIM1 respectively) to “LO”. At Power-up, the average input current setting will be equal to the value set by the position of JP2 and JP3 until an I<sup>2</sup>C command is received and overwrites that default value.

**TABLE 1. Input Current Limit Settings**

ILIM1	ILIM0	CURRENT LIMIT
0	0	100mA (1X)
0	1	1A (10X)
1	0	0.5mA (SUSP)
1	1	500mA (5X)

6. Connect a 0 to 25mA adjustable load in series with an ammeter between the LDO3V3 and GND terminals. Connect a voltmeter between the LDO3V3 and GND terminals.
7. Connect a 0 to 2A adjustable load in series with an ammeter between the VOUT terminal and the GND terminal. Connect a voltmeter between the VOUT and GND terminals.
8. Connect a 0 to 400mA adjustable load in series with an ammeter between the VOUT1 and GND terminals. Connect a voltmeter between the VOUT1 and GND terminals.
9. Connect a 0 to 400mA adjustable load in series with an ammeter between the VOUT2 and GND terminals. Connect a voltmeter between the VOUT2 and GND terminals.

10. Connect a 0 to 1.0A adjustable load in series with an ammeter between the VOUT3 and GND terminals. Connect a voltmeter between the VOUT3 and GND terminals.
11. Connect a Li-Ion or Li-Polymer battery with the positive lead to the BAT terminal and the negative lead to a GND terminal. Connect the positive lead of a voltmeter to the BAT terminal and the negative lead to the GND terminal. Connect the positive terminal of a voltmeter to PROG and the negative terminal to GND to measure the current flowing into the battery. The voltage on PROG will read 1 Volt when the maximum charge current is reached. Observe VOUT and the LDO3V3 output.
12. If using the USB input, plug in the USB cable and observe the charge current and the various output voltages. If using an external power supply, slowly increase the supply and observe that the LTC3555-1/LTC3555-3 starts to use the VBUS input power as VBUS reaches 4.35V.
13. Set VBUS to 5V and set the CURRENT LIMIT SETTING to 10X MODE (1A) on the LTC3555 GUI.
14. Discharge the battery voltage to 2.5 volts. If Charger mode is on, observe it is charging in trickle charge mode and the charge current is 50mA. As the battery voltage increases above 2.85V observe that the charger goes into constant current mode. Observe charge current reduces when the VOUT load increases while VOUT is at or below 3.6V in order to keep VOUT from collapsing. When the input current limit is exceeded, power is then drawn from the battery to supply VOUT.
15. Remove the NTC jumper on JP1. Observe the CHRG LED slow blinking rate (1.5Hz at 50% Duty Cycle). Also observe the 35KHz pulse-width varying duty cycle between 6.25% and 93.75% on the  $\overline{\text{CHRG}}$  terminal with an oscilloscope. Reinstall the NTC jumper.
16. Increase the VOUT load and observe when the input current starts to limit. When input current limit is reached, additional load smoothly transitions to the battery through the ideal diode. Due to the high efficiency of the switching regulator, the sum of the charge and load current may be significantly above the input current, depending on the voltage on the BAT pin.
17. Repeat step 16 with different current limit modes.
18. Observe the battery current as the battery voltage increases above 4.1V for the LTC3555-1 or 4.0V for the LTC3555-3. The charge current starts to decrease as the battery voltage increases towards 4.2V for the LTC3555-1 or 4.1V for the LTC3555-3.

See the LTC3555/LTC3555-X data sheet for more information on how this part performs.

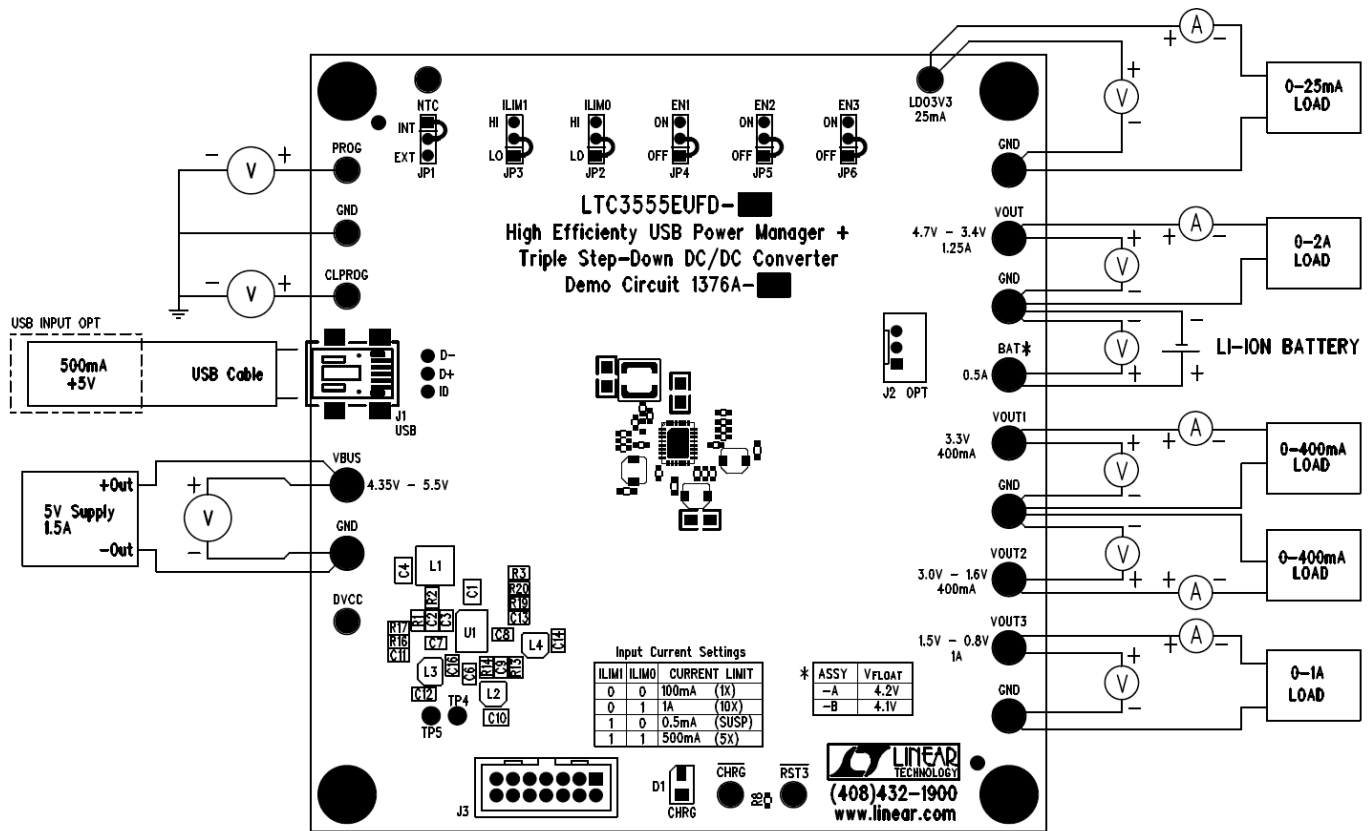


Figure 2. Proper Measurement Equipment Setup

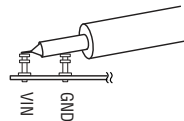


Figure 3. Measuring Input or Output Ripple

## APPLICATION INFORMATION

This demo circuit is designed to demonstrate the full capability of the device. Not all components are required in all applications. The critical circuit components are on the top of the board near the IC.

The input RC network of C5 and R26 is used to dampen input source inductances that commonly occur in laboratory setups with twisted leads and a bench power supply. When using a USB cable or adaptor cable this input damping network will likely not be required. Please note that the in-circuit capacitance of the specified 10uF, 0805 ceramic capacitor for C5 and C1 is approximately 5uF each at applied voltage.

The LTC3555-1/LTC3555-3 requires a minimum of 10uF on the VOUT pin in 10X mode for stability.

The RC network of C15 and R9, R10, and R11 is included to simulate a low impedance battery. It is especially helpful when testing the demo circuit with a battery simulator comprised of a power supply with a 3.6 Ohm power resistor across it. The leads connecting the power supply to the demo circuit should be a twisted pair to minimize lead inductance; although, even twisted pairs can introduce enough inductance into the circuit to cause instability in the battery charger section without the presence of the C15 RC network. The C15 RC network will also provide proper operation of the circuit without a battery present. Please refer to the datasheet for the suggested capacitor and resistance range.



# LTC3555-1 AND LTC3555-3

Linear Technology Corp.

LTC3555EUF-1

Parts List

Bill Of Material  
Demo Circuit: 1376A-A, Sch. Rev A

4/16/2008

Item	Qty	Reference - Des	Part Description	Manufacturer, Part #
<b>REQUIRED CIRCUIT COMPONENTS:</b>				
1	1	C1	CAP, CHIP, X5R, 10uF, 10V, 0805	MURATA, GRM21BR61A106KE19L
2	1	C2	CAP, CHIP, X7R, 0.1uF, 16V, 0402	MURATA, GRM155R71C104KA88D
3	3	C3, C7, C8	CAP, CHIP, X5R, 1.0uF, 6.3V, 0402	TDK, C1005X5R0J105M
4	2	C4, C10	CAP, CHIP, X5R, 22uF, 6.3V, 0805	TAIYO YUDEN, JMK212BJ226KG
5	1	C6	CAP, CHIP, X5R, 2.2UF, 6.3V, 0603	TDK, C1608X5R0J225M
6	3	C9, C11, C13	CAP, CHIP, COG, 10pF, 50V, 0402	MURATA, GRM1557U1H100JZ01D
7	2	C12, C14	CAP, CHIP, X5R, 10uF, 6.3V, 0603	TDK, C1608X5R0J106M
8	1	C16	CAP, CHIP, X7R, 0.1uF, 16V, 0402	MURATA, GRM155R71C104KA88
9	1	R1	RES, 0402 3.01K OHMS 1% 1/16W	VISHAY, CRCW04023K01FKED
10	1	R2	RES, 0402 8.25 OHMS 1% 1/16W	VISHAY, CRCW04028R25FNED
11	1	R3	RES, 0402 2.00K OHM 1% 1/16W	VISHAY, CRCW04022K00FKED
12	1	R13	RES, 0402 715K OHM 1% 1/16W	VISHAY, CRCW0402715KFKED
13	1	R14	RES, 0402 806K OHM 1% 1/16W	VISHAY, CRCW0402806KFKED
14	2	R16, R19	RES, 0402 1.02M OHMS 1% 1/16W	VISHAY, CRCW04021M02FKED
15	1	R17	RES, 0402 365K OHM 1% 1/16W	VISHAY, CRCW0402365KFKED
16	1	R20	RES, 0402 324K OHM 1% 1/16W	VISHAY, CRCW0402324KFKED
17	1	L1	INDUCTOR, 3.3uH, 0.08Ohms, 2.2A	COILCRAFT, LPS4018-332MLB
18	1	L2	INDUCTOR, 2.0uH, 0.067Ohms, 1.9A	TOKO, 1098AS-2R0M
19	2	L3,L4	INDUCTOR, 4.7uH, 0.130Ohms, 1.3A	TOKO, 1098AS-4R7M
20	1	U1	USB PWR MGR + TRIPLE STEP-DOWN DC/DC	LINEAR TECH, LTC3555EUF-1
<b>ADDITIONAL DEMO BOARD CIRCUIT COMPONENTS:</b>				
1	1	C5	CAP, CHIP, X5R, 10uF, 10V, 0805	MURATA, GRM21BR61A106KE19L
2	1	C15	CAP, CHIP, X5R, 100uF, ±20%, 6.3V, 1206	MURATA, GRM31CR60J107ME39L
3	1	C17	CAP, CHIP, X7R, 0.1uF, 16V, 0402	MURATA, GRM155R71C104KA88D
4	3	R4,R5,R8	RES, 0402 100K OHMS 1% 1/16W	VISHAY, CRCW0402100KFKED
5	3	R6,R7,R21	RES, 0402 0 OHMS 1/16W	VISHAY, CRCW04020000Z0ED
6	1	R27	RES, 0402 1K OHMS 1% 1/10W	VISHAY, CRCW04021K00FKED
7	3	R12,R15,R18	RES, 0402 20.0 OHM 1% 1/16W	VISHAY, CRCW040220R0FNED
8	4	R22,R23,R24,R25	RES, 0402 5.10K OHMS 1% 1/16W	VISHAY, CRCW04025K10FKED
9	4	R26,R9,R10,R11	RES, 0402 1 OHMS 5% 1/16W	VISHAY, CRCW04021R00JNED
10	1	D1	LED, GREEN	PANASONIC, LN1351C-(TR)
11	1	Q1	XSTR, MOSFET P- CHANNEL	VISHAY, Si2333DS-T1-E3
12	1	U2	SERIAL EEPROM	MICROCHIP, 24LC025-I/ST
<b>HARDWARE FOR DEMO BOARD ONLY:</b>				
1	1	J1	CONN, USB MINI-B	TYCO, 1734035-2
2	0	J2 (OPT)	CONN, DF3-3P-2DSA	HIROSE, DF3-3P-2DSA
3	1	J3	HEADER, 2X7PIN, 0.079CC	MOLEX, 87831-1420
4	11	E1,E2,E7,E8,E9,E10,E12,E15, E16,E18,E19	TURRET, 0.09 DIA	MILLMAX, 2501-2
5	8	E3,E4,E5,E6,E11,E13,E14,E17	TURRET, 0.061 DIA	MILLMAX, 2308-2
6	6	JP1,JP2,JP3,JP4,JP5,JP6	HEADER, 3 PINS 2mm	SAMTEC, TMM-103-02-L-S
7	6	JP1,JP2,JP3,JP4,JP5,JP6	SHUNT, 2mm	SAMTEC, 2SN-BK-G
8	4		STAND-OFF, NYLON 0.25" tall (SNAP ON)	KEystone, 8831 (SNAP ON)

# LTC3555-1 AND LTC3555-3

**Linear Technology Corp.**  
LTC3555EUF3

Parts List

**Bill Of Material**  
**Demo Circuit: 1376A-B, Sch. Rev A**  
3/17/2008

Item	Qty	Reference - Des	Part Description	Manufacturer, Part #
<b>REQUIRED CIRCUIT COMPONENTS:</b>				
1	1	C1	CAP, CHIP, X5R, 10uF, 10V, 0805	MUR, GRM21BR61A106KE19
2	1	C2	CAP, CHIP, X7R, 0.1uF, 16V, 0402	MUR, GRM155R71C104KA88
3	3	C3, C7, C8	CAP, CHIP, X5R, 1.0uF, 6.3V, 0402	TDK, C1005X5R0J105M
4	2	C4, C10	CAP, CHIP, X5R, 22uF, 6.3V, 0805	TAIYO YUDEN, JMK212BJ226KG
5	1	C6	CAP, CHIP, X5R, 2.2UF, 6.3V, 0603	TDK, C1608X5R0J225M
6	3	C9, C11, C13	CAP, CHIP, COG, 10pF, 50V, 0402	MUR, GRM1557U1H100JZ01D
7	2	C12, C14	CAP, CHIP, X5R, 10uF, 6.3V, 0603	TDK, C1608X5R0J106M
8	1	C16	CAP, CHIP, X7R, 0.1uF, 16V, 0402	MUR, GRM155R71C104KA88
9	1	R1	RES, 0402 3.01K OHMS 1% 1/16W	VISHAY, CRCW04023K01FKED
10	1	R2	RES, 0402 8.25 OHMS 1% 1/16W	VISHAY, CRCW04028R25FNED
11	1	R3	RES, 0402 2.00K OHM 1% 1/16W	VISHAY, CRCW04022K00FKED
12	1	R13	RES, 0402 715K OHM 1% 1/16W	VISHAY, CRCW0402715KFKED
13	1	R14	RES, 0402 806K OHM 1% 1/16W	VISHAY, CRCW0402806KFKED
14	2	R16, R19	RES, 0402 1.02M OHMS 1% 1/16W	VISHAY, CRCW04021M02FKED
15	1	R17	RES, 0402 365K OHM 1% 1/16W	VISHAY, CRCW0402365KFKED
16	1	R20	RES, 0402 324K OHM 1% 1/16W	VISHAY, CRCW0402324KFKED
17	1	L1	INDUCTOR, 3.3uH, 0.08Ohms, 2.2A	COILCRAFT, LPS4018-332MLB
18	1	L2	INDUCTOR, 2.0uH, 0.067Ohms, 1.9A	TOKO, 1098AS-2R0M
19	2	L3,L4	INDUCTOR, 4.7uH, 0.130Ohms, 1.3A	TOKO, 1098AS-4R7M
20	1	U1	USB PWR MGR + TRIPLE STEP-DOWN DC/DC	LINEAR TECH, LTC3555EUF3
<b>ADDITIONAL DEMO BOARD CIRCUIT COMPONENTS:</b>				
1	1	C5	CAP, CHIP, X5R, 10uF, 10V, 0805	MUR, GRM21BR61A106KE19
2	1	C15	CAP, CHIP, X5R, 100uF, ±20%, 6.3V, 1206	MURATA, GRM31CR60J107ME39
3	1	C17	CAP, CHIP, X7R, 0.1uF, 16V, 0402	MUR, GRM155R71C104KA88
4	3	R4,R5,R8	RES, 0402 100K OHMS 1%, 1/16W	VISHAY, CRCW0402100KFKED
5	3	R6,R7,R21	RES, 0402 0 OHMS 1/16W	VISHAY, CRCW04020000Z0ED
6	1	R27	RES, 0402 1K OHMS 1% 1/10W	VISHAY, CRCW04021K00FKED
7	3	R12,R15,R18	RES, 0402 20.0 OHM 1% 1/16W	VISHAY, CRCW040220R0FNED
8	4	R22,R23,R24,R25	RES, 0402 5.10K OHMS 1% 1/16W	VISHAY, CRCW04025K10FKED
9	4	R26,R9,R10,R11	RES, 0402 1 OHMS 5% 1/16W	VISHAY, CRCW04021R00JNED
10	1	D1	LED, GREEN	PANASONIC, LN1351C-(TR)
11	1	Q1	XSTR, MOSFET P- CHANNEL	VISHAY, Si2333DS-T1-E3
12	1	U2	SERIAL EEPROM	MICROCHIP, 24LC025-I/ST
<b>HARDWARE FOR DEMO BOARD ONLY:</b>				
1	1	J1	CONN, USB MINI-B	TYCO, 1734035-2
2	0	J2 (OPT)	CONN, DF3-3P-2DSA	HIROSE, DF3-3P-2DSA
3	1	J3	HEADER, 2X7PIN, 0.079CC	MOLEX, 87831-1420
4	11	E1,E2,E7,E8,E9,E10,E12,E15, E16,E18,E19	TURRET, 0.09 DIA	MILLMAX, 2501-2
5	8	E3,E4,E5,E6,E11,E13,E14,E17	TURRET, 0.061 DIA	MILLMAX, 2308-2
6	6	JP1,JP2,JP3,JP4,JP5,JP6	HEADER, 3 PINS 2mm	SAMTEC, TMM-103-02-L-S
7	6	JP1,JP2,JP3,JP4,JP5,JP6	SHUNT, 2mm	SAMTEC, 2SN-BK-G
8	4		STAND-OFF, NYLON 0.25" tall (SNAP ON)	KEYSTONE, 8831 (SNAP ON)