LTC4091
36V Battery Charger and Power Backup Manager

DESCRIPTION

Demonstration circuit 2558A is a high voltage switching buck regulator, Li-Ion cell charger and power backup manager. It is based on the LTC4091 and provides the following functions: 2A buck regulator with 7.5V-36V (60V absolute max) input range and with output voltage tracking cell voltage, full-featured cell charger with selectable 4.1V or 4.2V maximum charge voltage, and a power path manager for the cell. Output voltage is strictly limited to 4.45V. Temperature protection is optional with an external NTC temperature sensor.

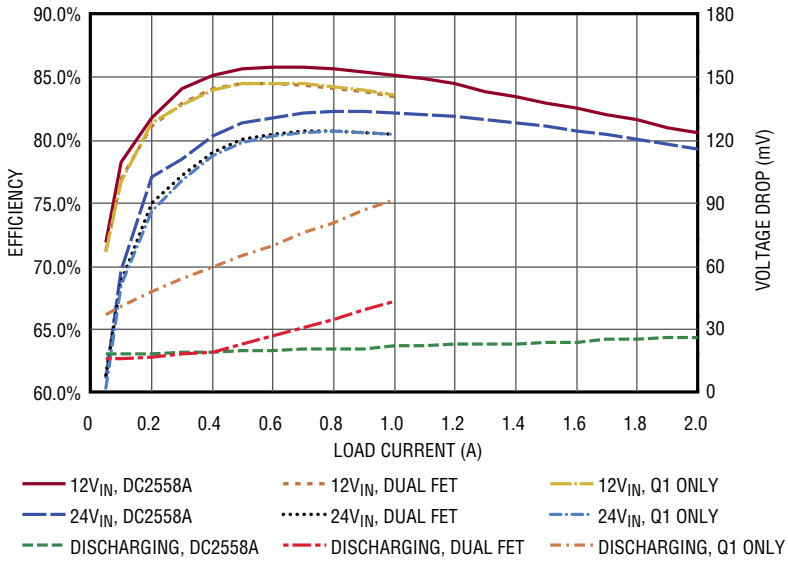
Design files for this circuit board are available at http://www.linear.com/demo/DC2558A

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{VIN}	Input Supply Range - V_{IN}	(Withstands up to 60V Without Damage)	7.5		36	V
V_{UVLO}	V_{IN} Undervoltage Lockout Threshold		7.0		7.4	V
V_{OVLO}	V_{IN} Overvoltage Lockout Threshold		36	38	40	V
V_{OUT}	Output Voltage with V_{IN}	Assumes HVOUT to OUT Connection (Q1)	3.45	V_{BAT}+0.1	4.45	V
Cell Charger						
I_{CHG}	Constant-Current Mode Charging Current	V_{VIN} = 12V, V_{BAT} = 3.6V , R14 = 75kΩ	650	700	750	mA
V_{CHG}	V_{BAT} Regulated Output Voltage	I_{BAT} = 2mA; JP4 in 4.1V position I_{BAT} = 2mA; JP4 in 4.2V position	4.048 4.148	4.100 4.200	4.152 4.252	V V
I_{TRKL}	Trickle Charge Current	V_{BAT} = 2V	35	50	75	mA
ΔV_{RECHRG}	Recharge Threshold	Threshold Voltage Relative to V_{CHG}	–65	–100	–150	mV

Efficiency with Alternate FET Selection



Key to Efficiency Plots

DC2558A

Q1,Q2 – Vishay SiS447DN

L1 – Coilcraft XAL4030-682MEC

Dual FET

Q1+Q2 – Rohm TT8J11T

L1 – Delta CMLB051H-6R8MS

Q1 Only

Q1 – Toshiba SSM3J328R

Q2 – Not Installed

L1 – Delta CMLB051H-6R8MS

Note: Vertical axis on the right applies to the dashed curves.

FUNCTIONAL OVERVIEW

The DC2558A demonstration board showcases the LTC4091 cell charger and power backup manager integrated circuit. The LTC4091 includes a buck converter that both provides an intermediate output voltage as well a constant-current, constant-voltage charging circuit for a lithium-ion cell. The LTC4091 features a hard voltage-output limit of 4.45V making it suitable for powering, for example, MMIC LNA (monolithic microwave integrated circuit low-noise amplifier) devices with absolute-maximum power supply voltages of 4.5V.

The intermediate voltage output (J3) follows the cell voltage plus approximately 130mV of headroom to minimize power dissipation when charging the lithium-ion cell. However, regardless of cell voltage, the buck converter will regulate its output voltage to at least 3.45V, and no more than 4.45V .

The V_{IN} input is capable of withstanding input voltages up to 60V; the buck converter is guaranteed to operate up to 36V. The cell-charging current can be programmed with a single resistor. The buck regulator operates at 800kHz and can deliver a total of 2A of current split between the intermediate output voltage and charging current.

Current to the output is supplied by the lithium-ion cell when input power is removed. An on-chip 75mΩ ideal diode ensures seamless switchover without interruption of load current. Gate drive for an optional external PMOS FET to further reduce ideal-diode voltage drop is also provided.

EQUIPMENT

6 DVMs

1 DC Supply 0V-50V 3A for the V_{IN} Input Test

1 DC Supply 0V-5V 3A

1 Power Resistor 2Ω, 10W

1 Adjustable Load 0A-2A

QUICK START PROCEDURE

Refer to Figure 1 for proper measurement equipment setup, and follow the procedure below:

1. With power off, connect the input power supplies, meters and output load as shown in Figure 1. For the V_{IN} input use a 0V-50V, 3A adjustable power supply. To emulate the cell, use a 0V-5V adjustable power supply that can deliver at least 3A in parallel with a 2Ω, 10W power resistor. Attach a 0A-2A adjustable load to the system output (OUT).
2. Check that the jumpers are in their default positions as shown in the schematic.

Validation of Trickle-Charge Current

3. Set the cell emulator voltage to zero. Set the system load at zero. Connect the adjustable 0V-50V power supply to the demo board V_{IN} input; turn it on and slowly increase the V_{IN} voltage. When V_{IN} passes through ~7.2V-7.4V, current is drawn from V_{IN}. The red LED D2 will light up to indicate that the buck regulator is active. The charger should activate, and green LED D4 will turn on to indicate cell charging.
4. Set the V_{IN} input voltage at 12V. Increase the voltage at BAT to 2.0V. The cell will now be in trickle-charge mode, and the charge current should be in the range 70mA-80mA.

Validation of Operation at Full Constant-Current Charge

5. Slowly increase the cell emulator voltage, and note that when the cell voltage rises through 2.8V-3.0V the cell charge current will jump to ~700mA.
6. Increase the cell voltage to 3.6V. The voltage at OUT will be 3.7V-3.9V. The cell will be charging at 665mA-735mA. Increase the system load (at OUT) to 1.3A and check that the cell charge current does not drop significantly. (The buck regulator is delivering 1.3A + 0.7A = 2A current).

Validation of Input Overvoltage Behavior

7. Increase the voltage at V_{IN} slowly and note that as the voltage exceeds ~36V-38V, the input current will drop to zero, and the red LED (D2) and the green LED (D4) will turn off, indicating that the buck regulator has shut down due to overvoltage, and charging has terminated. Set the input voltage (V_{IN}) to 40V. Confirm that the load connected to OUT is now powered from the cell. Decrease the V_{IN} voltage through 36V-38V, and observe that the buck regulator and charger will resume normal operation.

Validation of Operation at OUT Voltage = V_{BAT}

8. Increase the cell emulator voltage (at BAT) slowly, and note that the green LED turns off and the charge current falls to zero as the voltage at BAT rises above ~4.15V-4.25V. Confirm the voltage at OUT does not exceed 4.45V.

QUICK START PROCEDURE

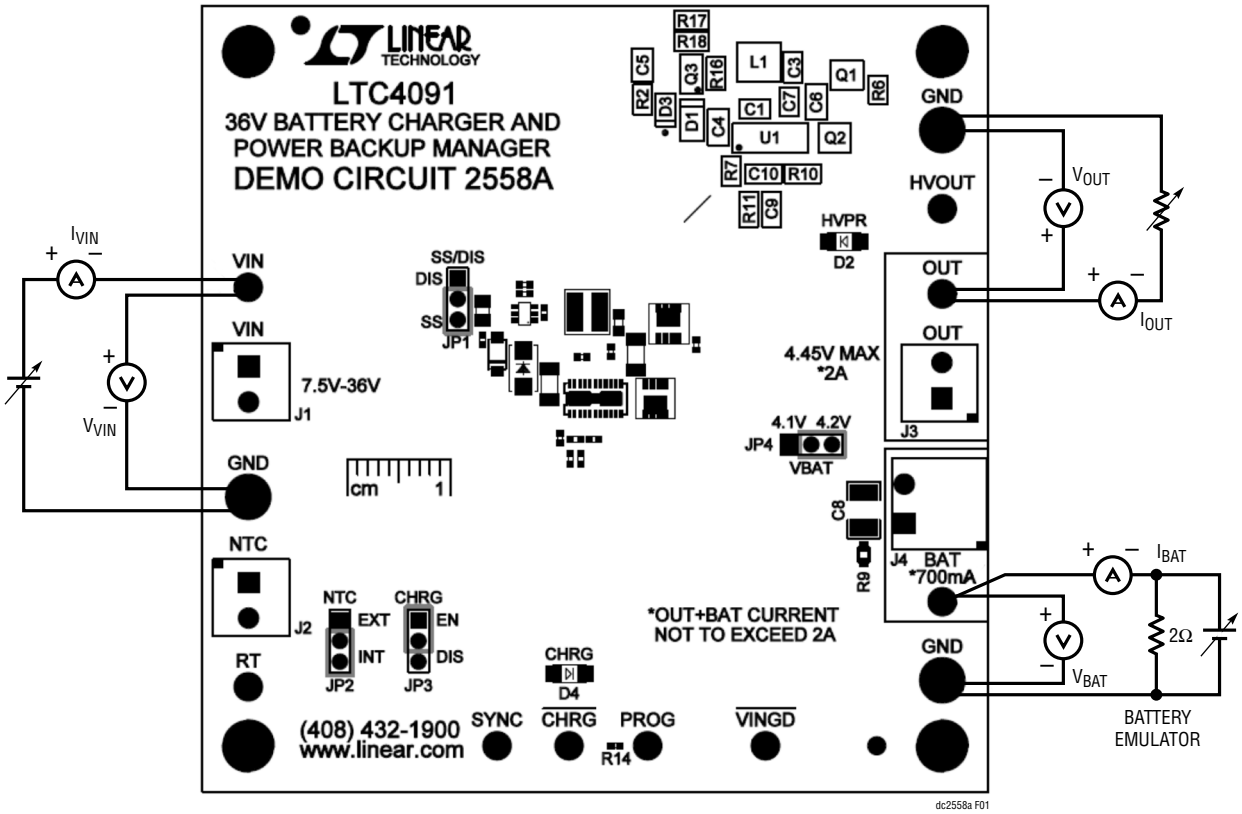


Figure 1. Proper Test Equipment Setup

APPLICATION NOTES

The jumpers on the DC2558A can be used as follows:

JUMPER	POSITION	FUNCTION
JP1	SS/DIS	SS: Enables the LTC4091 with soft-start circuit DIS: Disables LTC4091
JP2	NTC	INT: Uses an on-board 10kΩ resistor in lieu of NTC EXT: Uses an external NTC connected through J2
JP3	CHRG	EN: Enables cell-charging function DIS: Disables cell-charging function
JP4	V_{BAT}	4.1V: Sets maximum cell-charging voltage to 4.1V 4.2V: Sets maximum cell-charging voltage to 4.2V

CIRCUIT NOTES

The LTC4091 includes enable/disable functionality through the RUN/SS pin. For the demanding automotive cold-crank application, an additional undervoltage-lockout feature is included. See the circuit surrounding D3 and Q3 in the schematic.

R1 and C2 comprise a snubber which has been included on the input to reduce voltage surges that might be induced onto the DC2558A when it is hot-plugged to a power source.

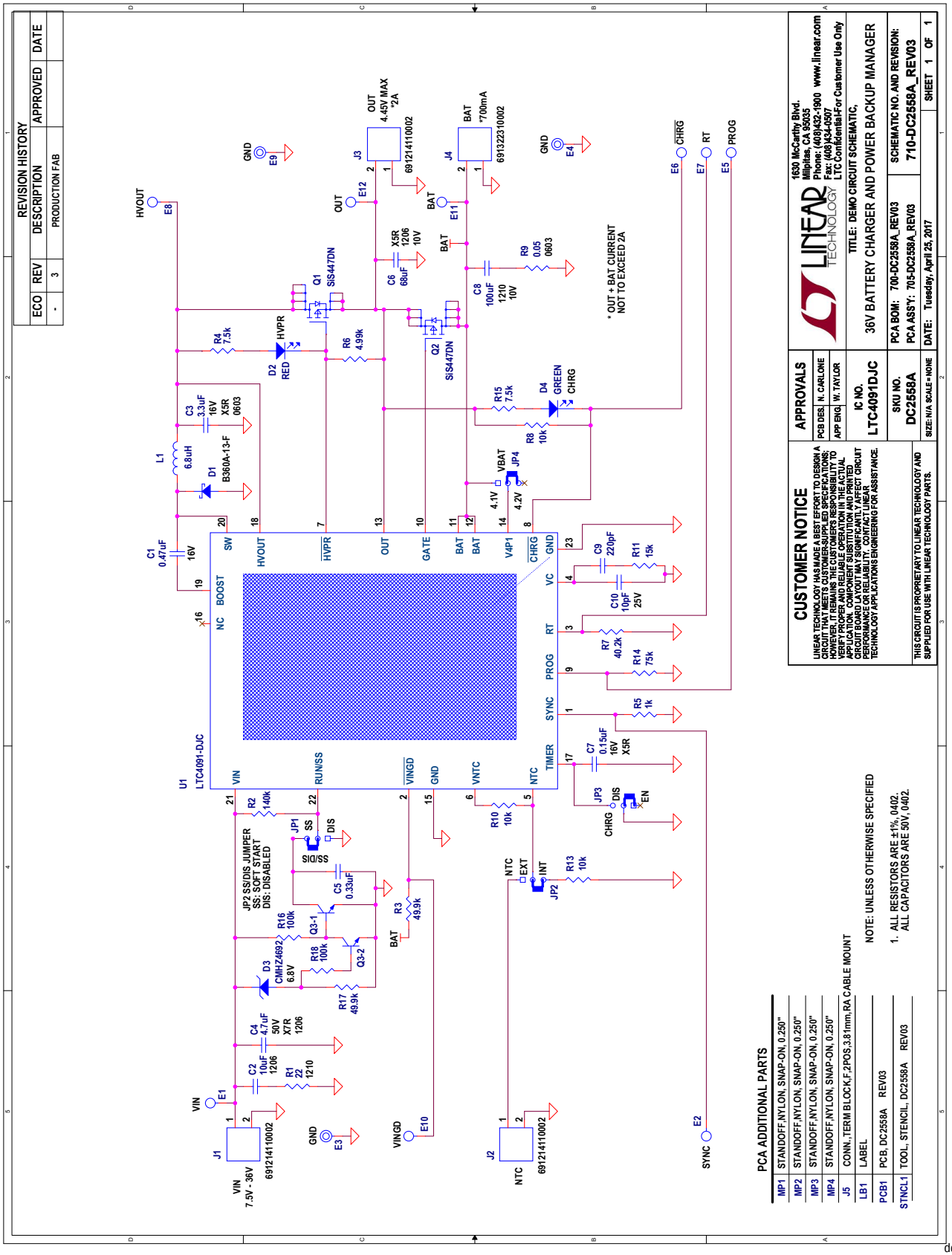
Q1 is chosen so the voltage drop across it does not interfere with the operation of the charging circuit. The Bat-Track™ functionality of the LTC4091 regulates the voltage at the HVOUT pin to ~130mV above the voltage at OUT. Additionally, the voltage difference between the OUT pin and BAT pin (V_{CEN} in Electrical Characteristics table) must be ~80mV for the charger to enable. This leaves ~50mV of margin for voltage drop across Q1. The DC2558A uses a relatively low-$R_{DS(ON)}$ (9mΩ max.) PMOS FET for Q1 which allows 2A total current (load current plus cell-charging current) to pass through the device with plenty of voltage-drop margin. An application with a lower total-current requirement will work with a smaller PMOS device provided the voltage drop across the device is less than ~50mV with maximum load plus charging current.

Functionality of the DC2558A can be deleteriously affected by contamination in the vicinity of the GATE pin of the LTC4091. If a soldering iron is used on the board, be sure the board is properly cleaned.

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	C1	CAP., 0.47µF, X5R, 16V, ±10%, 0402	TAIYO YUDEN EMK105ABJ474KV-F
2	1	C10	CAP., 10pF, NP0, 25V, ±10%, 0402	AVX 04023A100KAT2A
3	1	C3	CAP., 3.3µF, X5R, 16V, ±10%, 0603	TDK C1608X5R1C335K080AC
4	1	C4	CAP., 4.7µF, X7R, 50V, ±10%, 1206	AVX 12065C475KAT2A
5	1	C5	CAP., 330nF, X7R, 50V, ±10%, 0805	Murata Electronics GCM219R71H334KA55
6	1	C6	CAP., 68µF, X5R, 10V, ±20%, 1206	TDK C3216X5R1A686M160AC
7	1	C7	CAP, 150nF, X5R, 16V, ±20%, 0402	TDK C1005X5R1C154M050BB
8	1	C8	CAP., 100µF, X5R, 10V, ±20%, 1210	MURATA GRM32ER61A107ME20L
9	1	C9	CAP., 220pF, C0G, 50V, ±5%, 0402	AVX 04025A221JAT2A
10	1	D1	DIODE, SCHOTTKY RECTIFIER, 60V	DIODES INC. B360A-13-F
11	1	D3	DIODE, ZENER, 6.8V, 500mW, SOD-123	CENTRAL SEMICONDUCTOR CORP. CMHZ4692
12	1	L1	IND., 6.8µH, PWR, ±20%, 3.9A, 74.1mΩ	COILCRAFT XAL4030-682MEC
13	1	Q1	XSTR., MOSFET P-CHAN, 20V, 17A	VISHAY SIS447DN-T1-GE3
14	1	Q3	TRANSISTOR, DUAL NPN, SOT-363	DIODES INC MMDT5551-7-F
15	1	R11	RES., 15kΩ, ±1%, 1/16W, 0402	NIC NRC04F1502TRF
16	1	R14	RES SMD, ±75kΩ, 1%, 1/16W, 0402	VISHAY DALE CRCW040275K0FKED
17	2	R16, R18	RES., 100kΩ, ±1%, 1/16W, 0402	VISHAY CRCW0402100KFKED
18	1	R17	RES., 49.9kΩ, ±1%, 1/16W, 0402	NIC NRC04F4992TRF
19	1	R2	RES., 140kΩ, ±1%, 1/16W, 0402	VISHAY CRCW0402140KFKED
20	1	R6	RES., AEC-Q200, 4.99kΩ, ±1%, 1/10W, 0402	PANASONIC ERJ2RKF4991X
21	1	R7	RES., 40.2kΩ, ±1%, 1/16W, 0402	NIC NRC04F4022TRF
22	1	R9	RES., 0.05Ω, ±1%, 1/4W, 0603	SUSUMU RL0816S-R050-F
23	1	U1	IC, 36V BAT.CHARGER & BACKUP, 22-Pin DFN	LINEAR TECHNOLOGY LTC4091EDJC#PBF
Additional Demo Board Circuit Components				
1	1	C2	CAP., 10µF, X5R, 50V, ±10%, 1206	MURATA GRM31CR61H106KA12L
2	1	D2	LED, RED, WATERCLEAR, 1206	WURTH ELEKTRONIK 150120RS75000
3	1	D4	LED, GREEN, WATERCLEAR, 1206	WURTH ELEKTRONIK 150120GS75000
4	1	Q2	XSTR., MOSFET P-CHAN, 20V, 17A	VISHAY SIS447DN-T1-GE3
5	1	R1	RES., 22Ω, ±1%, 1/2W, 1210	VISHAY CRCW121022R0FKEA
6	1	R3	RES., 49.9kΩ, ±1%, 1/16W, 0402	NIC NRC04F4992TRF
7	2	R4, R15	RES., 7.5kΩ, ±1%, 1/16W, 0402	VISHAY CRCW04027K50FKED
8	1	R5	RES., 1kΩ, ±1%, 1/16W, 0402	VISHAY CRCW04021K00FKED
9	3	R8, R10, R13	RES., 10kΩ, ±1%, 1/16W, 0402	VISHAY CRCW040210K0FKED
Hardware: For Demo Board Only				
1	9	E1, E2, E5-E8, E10-E12	TEST POINT, TURRET, 0.064", MTG. HOLE	MILL-MAX 2308-2-00-80-00-00-07-0
2	3	E3, E4, E9	TEST POINT, TURRET, 0.094", MTG. HOLE	MILL-MAX 2501-2-00-80-00-00-07-0
3	3	J1-J3	CONN., TERMINAL BLOCK, 1x2, 3.5mm, THT	WURTH ELEKTRONIK 691214110002
4	1	J4	CONN., SHROUDED HEADER, 1x2, 3.81mm,THT	WURTH 691322310002
5	1	J5	TERM BLOCK PLUG 2POS STR 3.81MM	Wurth Electronics Inc 691361300002
6	4	JP1-JP4	CONN., HDR, MALE, 1x3, 2mm,THT, STR	Wurth ELEKTRONIK 62000311121
7	4	MP1-MP4	STANDOFF, NYLON, SNAP-ON, 0.250"	KEYSTONE 8831
8	4	XJP1-XJP4	CONN., SHUNT, FEMALE, 2 POS, 2mm	Wurth ELEKTRONIK 60800213421

SCHEMATIC DIAGRAM



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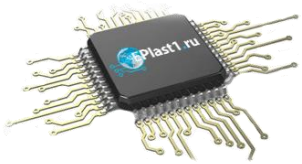

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