TIDM-ENERGY-WATCHDOG Single-Phase Electricity Sub-Meter for Smart Buildings

1 Features

- Fully Functional Smart Plug Tool Allows Quick and Efficient Development
- Measurements Performed and Displayed
  - Incoming AC Voltage, Current, and Frequency
  - Active Power, Reactive Power, Apparent Power, and Power Factor
  - Energy Consumption in kWh
- Uses MSP430AFE253IPWR
- Interface to Communication Modules
  - RS232
  - ZigBee
  - Sub-1GHz 802.15.4 or Proprietary
  - Wireless M-Bus
- Simple Push Buttons for Adjusting LCD Display and Time Settings
- Schematics and Software Are Included

2 General Description

TI's Energy Watchdog is a tool that enables system designers to quickly develop their own smart plug or sub-meter designs. It is a fully functional smart plug that is accompanied by hardware, software, and reference schematics.

3 Main Components

The appliance whose power consumption is to be measured is plugged into the female receptacle on the Energy Watchdog. The electrical cord with the male plug connects to the wall outlet. The LCD displays time, date, and electricity parameters. There are four keys from the left to right labeled as 1, 2, 3, and 4. At power up, the time is displayed on the LCD, and the LCD backlight is off. The Energy Watchdog starts in Mode 0 (see Table 1 for details).

Figure 1. MSP430 Energy Watchdog Tool

The Energy Watchdog has three modes of operation: Mode 0, Mode1, and Mode 2. Table 1 shows the details of each mode.

Table 1. Mode of Operation

Mode 0 - Default Mode After Power Up				
Key Pressed	1	2	3	4
Action	Toggle between time and date display	Go to electricity parameters display	Go to adjust date and time menu	Toggle backlight on and off
Mode After Key Press	0	2	1	0
Mode 1 - Time and Date Adjust Mode				
Key Pressed	1	2	3	4
Action	Adjust digits	Go to next digits	Go to next group (time→date) or cancel adjust	Time or date adjust confirmation
Mode After Key Press	1	1	1	0
Mode 2 - Electricity Parameters Display Mode				
Key Pressed	1	2	3	4
Action	Switch among electricity parameters(1)	Display time or date	None	Toggle backlight on and off
Mode After Key Press	2	0	2	0

(1) Electricity parameters are displayed in this order:

1. Voltage (V)
2. Current (A)
3. Frequency (Hz)
4. Active Power (W)
5. Reactive Power (Var)
6. Apparent Power (VA)
7. Power Factor (cos(p))
8. Energy Consumption (kWh)

CAUTION

Do not exceed maximum ratings as shown on the label that is on the bottom of the MSP430 Energy Watchdog Tool.

4 Using the Energy Watchdog as a Development Tool

4.1 Functions

- **Measurement:** The Energy Watchdog measures the values of voltage, current, frequency, active power, reactive power, apparent power, power factor, and energy consumption (in kWh). The Energy Watchdog can measure up to 9999 kWh, after which the data is cleared to zero.
- **LCD Display:** Displays the voltage, current, frequency, active power, reactive power, apparent power, power factor, and energy consumption (in kWh). It also displays the date and time.
- **Real-Time Clock (RTC):** The RTC function can be optionally populated by users. The battery (P/N: LSG14250) on LSG1 location of the PCB can be soldered to supply power to the RTC.
- **Functional Commands:** Users can read electrical parameters using functional commands through the RF1, RF2, and UART interfaces.

4.2 Electrical Parameters

- **EMC:**
  - Contacted ESD Test: 10 kV
  - EFT/B Test (EFT): 4 kV
- **Accuracy class:** Class1

NOTE: The Energy Watchdog is designed to achieve Class 1 accuracy. However, as the Energy Watchdog is not calibrated in production, Class 1 accuracy cannot be ensured out of the box.

- **Incoming frequency:** 50 Hz to 60 Hz
- **Incoming voltage:** 110 V to 240 V
- **Incoming current:** 10 A Maximum

CAUTION

Operation at 10 A for extended periods of time is not recommended.

- **Power Consumption:** ≤1 W

Table 2. Electrical Parameters

Parameter			Value
Signal input	Wire connection		Single phase direct connection
	Voltage	Reference voltage	220 V or 110 V
		Operation range	0.7 Un to 1.2 Un
	Current	Basic current	5 A
		Maximum current	10 A
	Frequency		40 Hz to 60 Hz
Power			AC or DC 80 V to 270 V <1 VA
Indicator LED Blinking Characteristics			Blink once for every 1/1600 kWh of energy consumed Pulse duration: 80 ms ± 20%
Communication			UART interface (physical layer is isolated) Communication rate: 2400 bps (RS232) Data check mode: N81
Measurement class			Frequency: ± 0.1 Hz Active power: Class 1
Display mode			LCD
Environment			Operation temperature range: -10°C to 55°C Storage temperature range: -20°C to 75°C

5 MSP430 Energy Watchdog Components

Figure 2. MSP430 Energy Watchdog Tool (Top View)

5.1 Main Components on Top Side of MSP430 Energy Watchdog

For a description of the main components of the Energy Watchdog, refer to Section 3.

5.2 AAA Battery Box

Put two (2) AAA batteries in the battery box on the bottom of the Energy Watchdog (refer to Figure 3) to supply power to externally connected RF modules. These batteries are required only if external RF modules are connected to the Energy Watchdog.

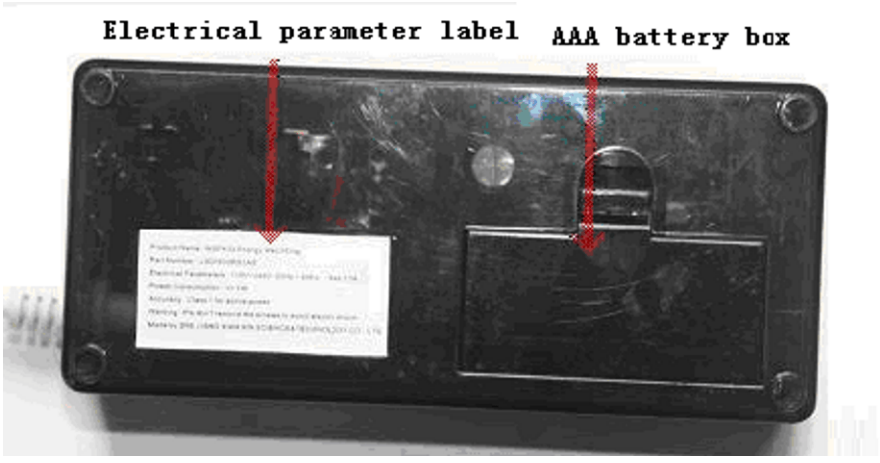

Figure 3. MSP430 Energy Watchdog Tool (Bottom View)

5.3 Interface Ports

Figure 4 shows the interface ports on the Energy Watchdog Tool.

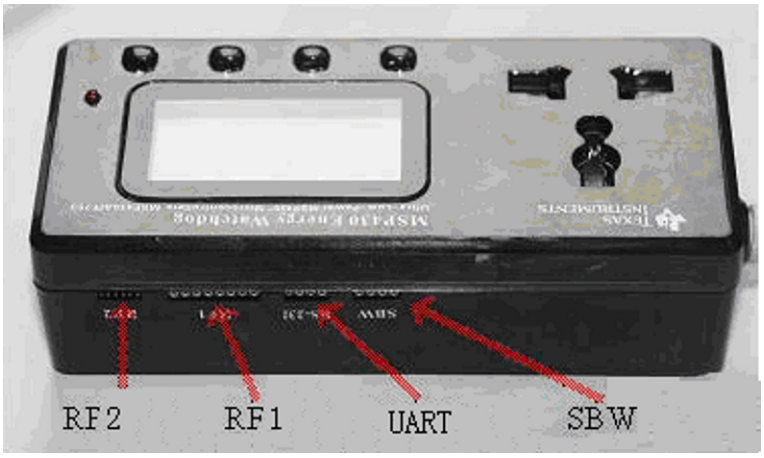

Figure 4. Interface Ports on the MSP430 Energy Watchdog Tool

- **SBW:** This interface can be used to connect tools to program and debug the MSP430AFE253 that is inside the Energy Watchdog.

> **CAUTION**
>
> The SBW interface is not isolated internally. External isolation must be added before connecting an emulation or debug tool to this interface. Failure to follow these instructions could damage the PC.

- **UART:** The UART interface can be used to access registers on the MSP430AFE253. This can be used to calibrate the Energy Watchdog or to communicate data to a remote location using RF.
- **RF1:** The RF1 interface can be connected to TI's RF modules with a 6-pin 1.27-mm pitch B-TO-B connector. RF modules are powered by the two AAA batteries inserted in the battery box.
- **RF2:** The RF2 interface can be connected to TI's RF modules with an 8-pin 2.0-mm pitch B-TO-B connector. RF modules are powered by the two AAA batteries inserted in the battery box.

NOTE: The UART communication between the MSP430 Energy Watchdog and the RF modules is at 2400 bps. All three interfaces (UART, RF1, and RF2) are isolated.

Figure 5 shows the pins used by the interface connections.

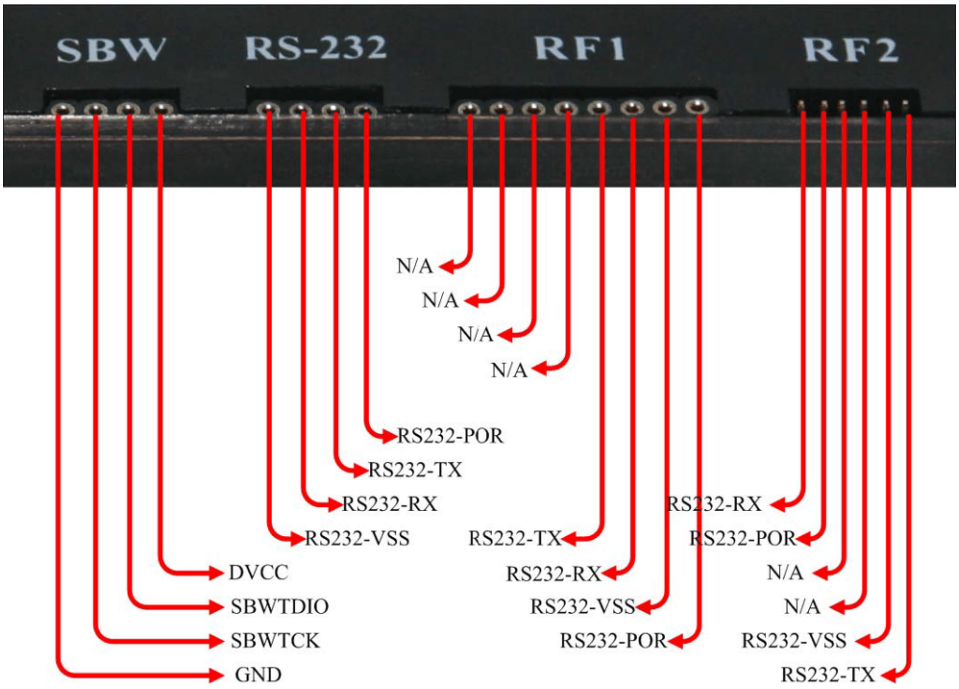

Figure 5. Detailed Pin Listing of the Energy Watchdog Interface Ports

6 UART Communication Commands

Table 3 shows the commands that can be used for the RF1, RF2, and UART interfaces.

Table 3. Communication Commands

Read calibration registers	
HOST_CMD_GET_METER_I1RMS_OFFSET	0x40
HOST_CMD_GET_METER_I1RMS_GAIN	0x42
HOST_CMD_GET_METER_P1_GAIN	0x44
HOST_CMD_GET_METER_P1_PHASE	0x46
HOST_CMD_GET_METER_P1_OFFSET	0x48
HOST_CMD_GET_METER_Q1_OFFSET	0x4A
HOST_CMD_GET_METER_VRMS_GAIN	0x4C
//V5	
HOST_CMD_GET_READINGS_VDC	0x4D
HOST_CMD_GET_READINGS_I1DC	0x4E
Read meter registers	
HOST_CMD_GET_READINGS_P1	0x60
HOST_CMD_GET_READINGS_Q1	0x62
HOST_CMD_GET_READINGS_S1	0x64
HOST_CMD_GET_READINGS_VRMS	0x66
HOST_CMD_GET_READINGS_FREG	0x67
HOST_CMD_GET_READINGS_I1RMS	0x68
HOST_CMD_GET_READINGS_PF1	0x6A
HOST_CMD_GET_READINGS_ACTENERGY1	0x6C
HOST_CMD_GET_READINGS_REACTENERGY1	0x6D
//V5	
HOST_CMD_GET_READINGS_NEGTIVE_ACTENERGY1	0x6E
HOST_CMD_GET_READINGS_NEGTIVE_REACTENERGY1	0x6F
HOST_CMD_GET_READINGS_VWFS	0x70
HOST_CMD_GET_READINGS_I1WFS	0x71
Read configuration registers	
HOST_CMD_GET_METER_SYSCONF	0x74
HOST_CMD_GET_METER_CSGCONF	0x75
HOST_CMD_GET_METER_POWER_CONST	0x76
HOST_CMD_GET_METER_START_CURRENT	0x77
HOST_CMD_GET_READINGS_IE	0x78
HOST_CMD_GET_READINGS_IFG	0x79
HOST_CMD_GET_READINGS_STATUS	0x7A
HOST_CMD_GET_READINGS_CHECKSUM1	0x7B
HOST_CMD_GET_READINGS_WREN	0x7C
HOST_CMD_GET_READINGS_METER_STATUS	0x7D
HOST_CMD_GET_READINGS_RXBUF	0x7E
HOST_CMD_GET_READINGS_TXBUF	0x7F
Write calibration registers	
HOST_CMD_SET_METER_I1RMS_OFFSET	0x80
HOST_CMD_SET_METER_I1RMS_GAIN	0x82
HOST_CMD_SET_METER_P1_GAIN	0x84
HOST_CMD_SET_METER_P1_PHASE	0x86
HOST_CMD_SET_METER_P1_OFFSET	0x88

Table 3. Communication Commands (continued)

HOST_CMD_SET_METER_Q1_OFFSET	0x8A
HOST_CMD_SET_METER_VRMS_GAIN	0x8C
//V5	
HOST_CMD_SET_READINGS_VDC	0x8D
HOST_CMD_SET_READINGS_I1DC	0x8E
Write configuration register	
HOST_CMD_SET_METER_SYSCONF	0xB4
HOST_CMD_SET_METER_CSGCONF	0xB5
HOST_CMD_SET_METER_POWER_CONST	0xB6
HOST_CMD_SET_METER_START_CURRENT	0xB7
HOST_CMD_SET_IE	0xB8
HOST_CMD_SET_WREN	0xBC
HOST_CMD_SET_SRST	0xBD

7 Schematics

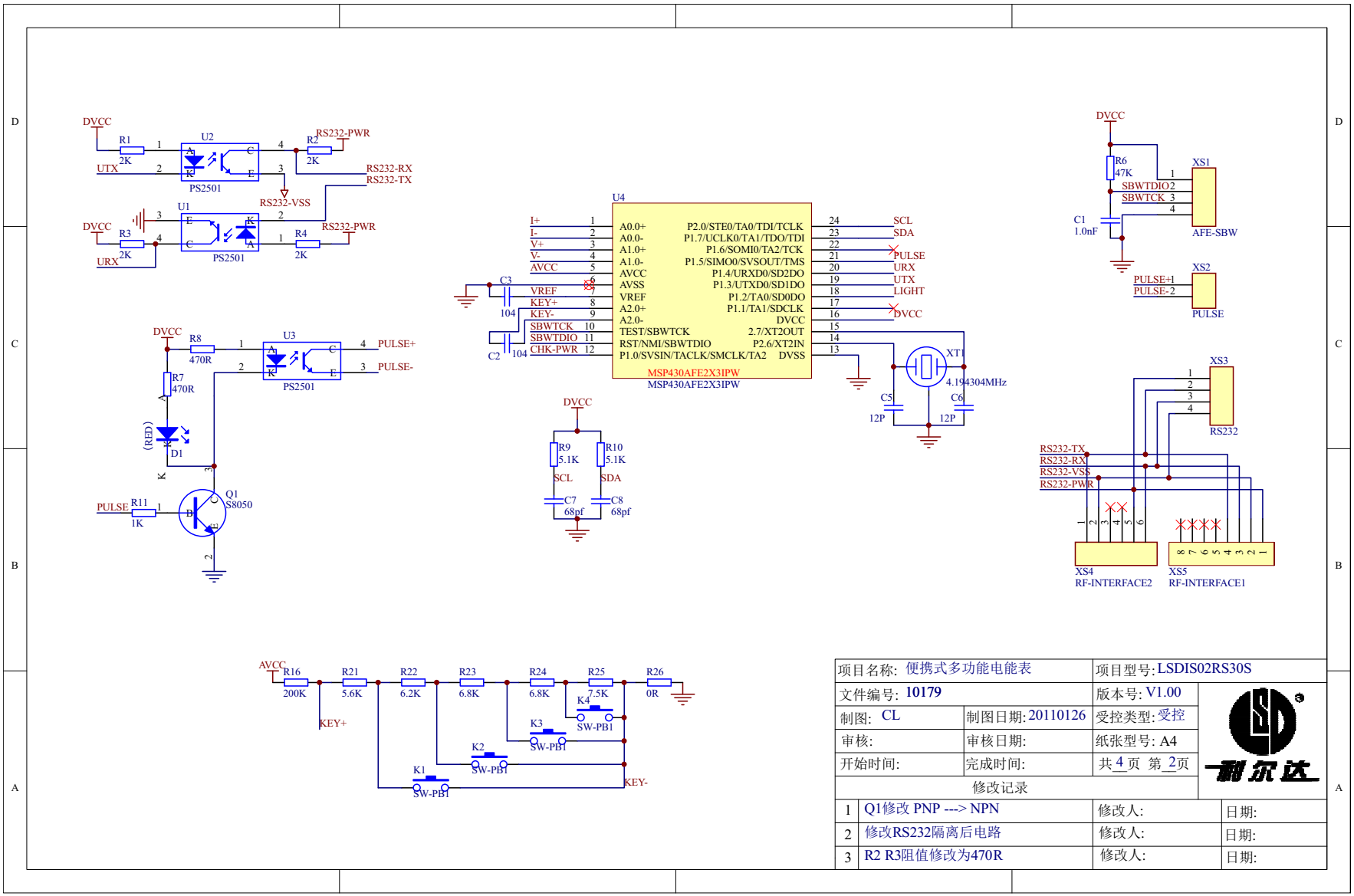

Figure 6. Schematics, 1 of 3

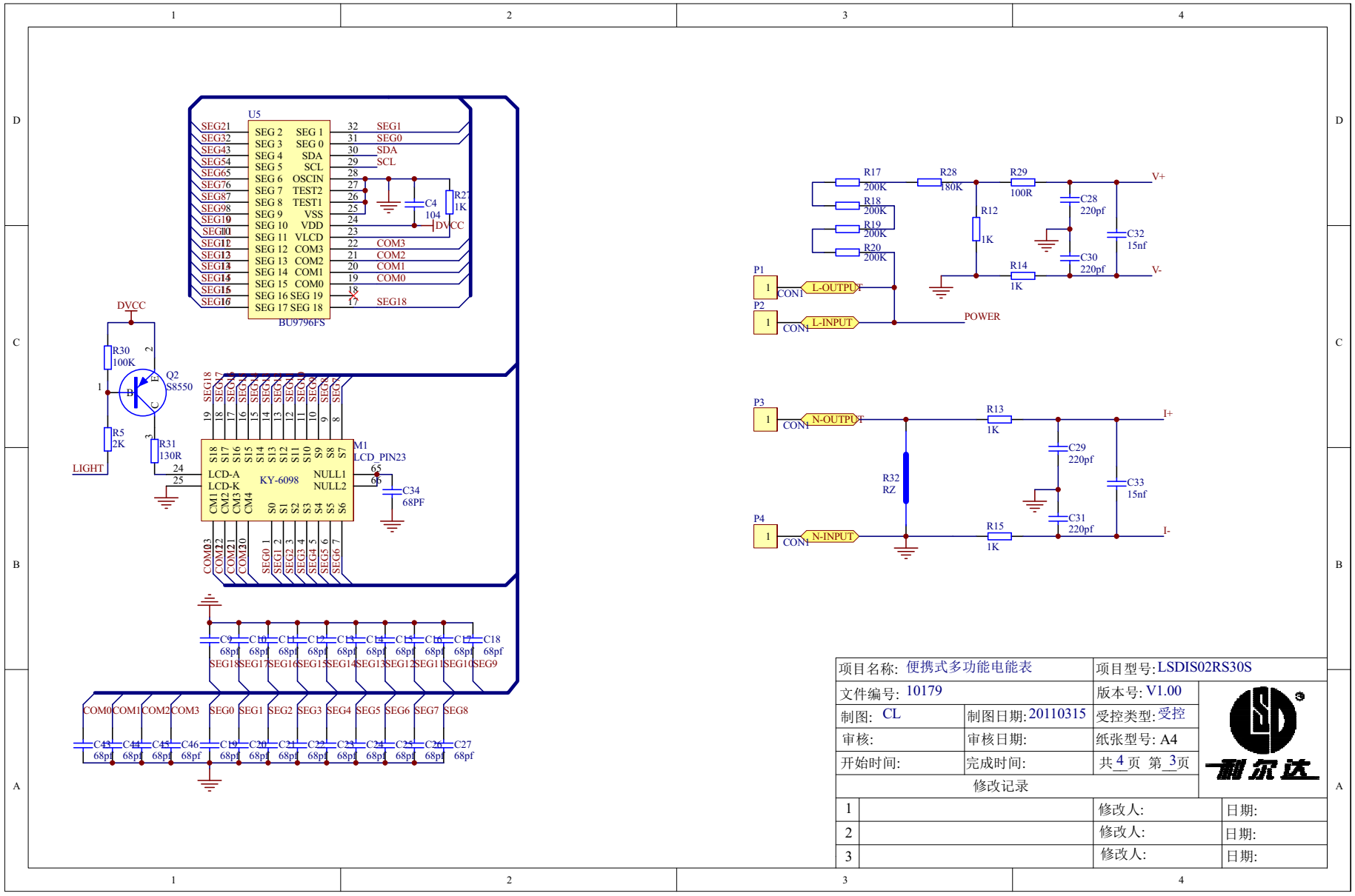

Figure 7. Schematics, 2 of 3

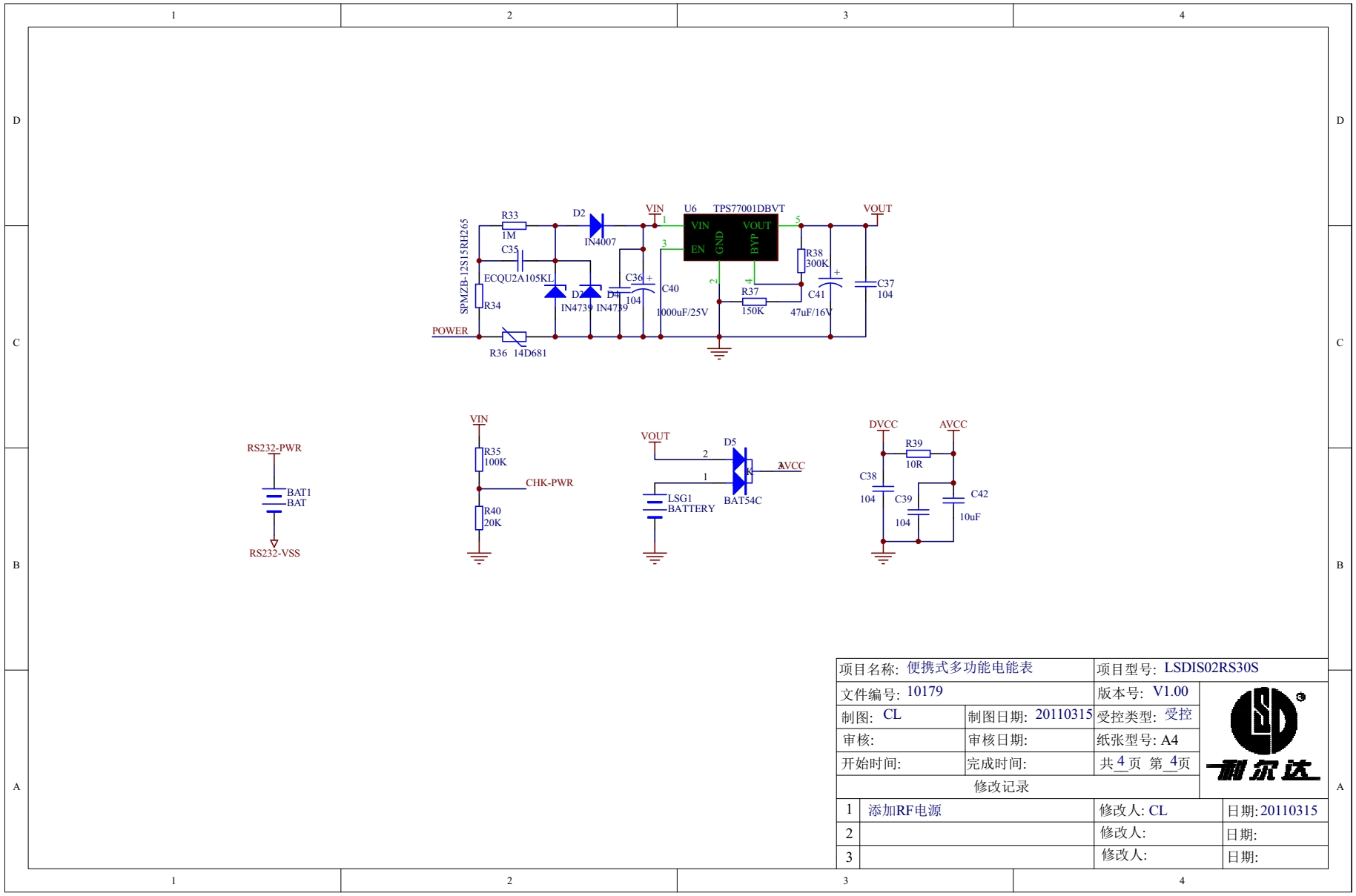

Figure 8. Schematics, 3 of 3

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