# Shanghai Siproin Microelectronics Co.,Ltd.

## Built-in Clock, Calibration Free, Single Phase Energy Meter IC with Integrated Oscillator

## SSP1840 Datasheet


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# Catalog

# 1. General Description

SSP1840 is a built-in clock and calibration-free energy metering IC, suitable for single-phase multifunctional electricity meter, smart socket, smart home appliances, electric bicycle charging pile and other applications with better cost performance.

SSP1840 integrates 2 high-precision sigma-delta ADC to measure current and voltage simultaneously. Reference voltage, power management and other analog circuit modules, and processing active power, current and voltage RMS electrical parameters digital signal processing circuit.


SSP1840 can measure electric parameters such as current and voltage RMS, active power, active energy, fast current RMS (for leakage detection/over-current protection), and temperature detection, waveform output and so on. SSP1840 output data through the UART/SPI interface. It is available for the smart socket, smart appliances, single-phase multi-function power meter, electric bicycle charging pile and information requirement of data acquisition in electricity applications.

SSP1840 has a patented anti-creep design, which can be combined with reasonable external hardware design to ensure that the noise energy cannot be calculated in the energy pulse when there is no load.

# 2. Features

- 2 high-precision sigma-delta ADC for current and voltage measuring
- The range of current（10mA~35A）@1mohm
- The range of Active energy（1w~7700w）@1mohm@220V
- Measure RMS Voltage and Current, fast current RMS, Active Power, Active Energy
- The gain error is less than 1%, calibration-free when peripheral components meet certain conditions.
- The current channel support electric leakage/over-current monitoring function, the threshold and response time can be configured
- Voltage zero-Crossing logic output
- Built-in waveform register for load type analysis, Waveform data can be output for load type analysis
- Built-in temperature sensor, Meet the requirements of the product itself, such as over-temperature monitoring, high current node preset temperature alarm, room temperature measurement
- SPI（≤900KHz）/UART（4800bps）
- On-chip power supply monitoring, IC reset when VDD is lower than 2.7V(typical).
- On-chip voltage reference of 1.218V
- On-chip 4MHz oscillator circuit
- Power supply 3.3V, low power consumption 10mW (typical)
- Package：TSSOP14

## 3. Order specification

| Part No | Package | Manner of Packing | Devices per bag/reel |
|---|---|---|---|
| SSP1840 | TSSOP14 | Reel | 3000PCS |

## 4. Block Diagram

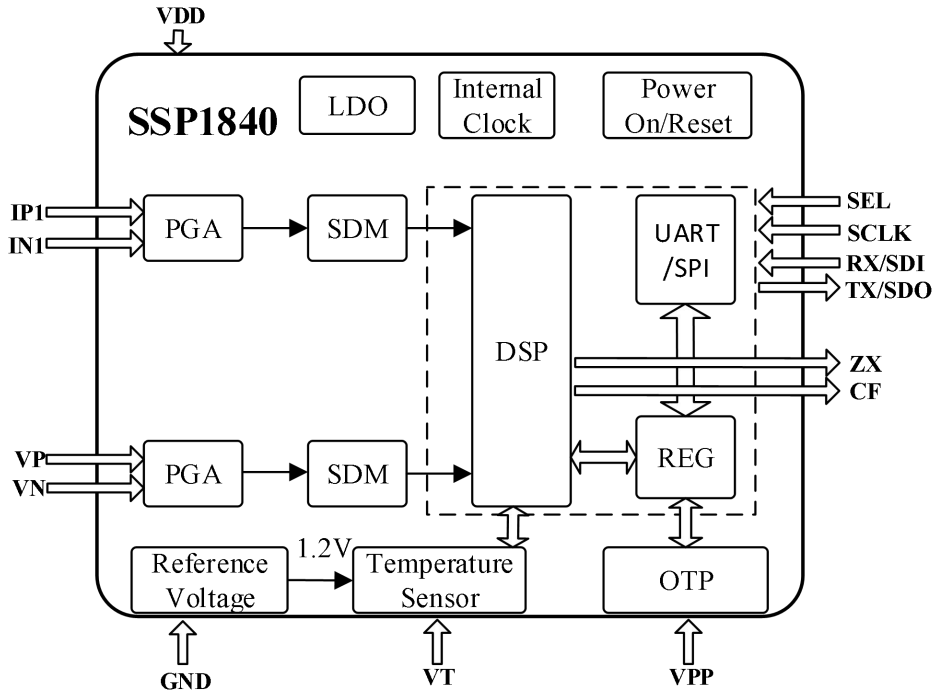



**Figure 1 Internal block diagram**

## 5. Pin Assignment

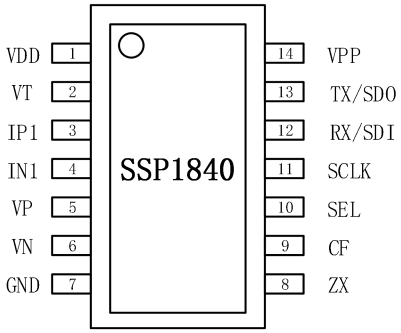



**Figure 2 TSSOP14**

| Pin No. | Pin Name | Description |
|---|---|---|
| 1 | VDD | Power Supply (+3.3V). |
| 2 | VT | External temperature sensor(NTC) signal input. |
| 3,4 | IP1,IN1 | Analog input of current channel, maximum differential voltage has a maximum input range of ±50mV(35mV RMS). |
| 5,6 | VP,VN | Analog input for voltage channel, this differential input has a maximum input range of ±100mV(70mV RMS). |

| | | |
|---|---|---|
| 7 | GND | GND |
| 8 | ZX | Voltage channel zero-crossing output pin |
| 9 | CF | Energy pulse output, multiplex function refer to MODE register description |
| 10 | SEL | Interface select pin (0: UART 1: SPI), pull-down resistance inside, disconnect is low-level (UART), connected to VDD is high-level (SPI) |
| 11 | SCLK | SPI clock input. If using UART interface, this pin doesn't need be connected. |
| 12 | RX/SDI | Data input for SPI interface/Receive line for UART interface |
| 13 | TX/SDO | Data output for SPI interface/Transmit line for UART interface, this pin require external pull-up resistor. |
| 14 | VPP | Reserved, not connected. |

## 6. Absolute Maximum Ratings

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Power Voltage VDD | VDD | -0.3～+4 | V |
| Analog Input Voltage to GND | IP1,VP | -4～+4 | V |
| Digital Input Voltage to GND | UART_SEL,RX/SDI | -0.3～VDD+0.3 | V |
| Digital Output Voltage to GND | CF,TX/SDO | -0.3～VDD+0.3 | V |
| Operating Temperature Range | T | -40～+85 | ℃ |
| Storage Temperature Range | Tstg | -40～+85 | ℃ |

Note: Unless specified otherwise, Tamb= 25℃

## 7. Electrical Characteristics

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Power Supply | VDD | | 3.0 | | 3.6 | V |
| Power Dissipation | Iop | VDD=3.3V | | 3 | | mA |
| Measuring range | | 4000:1 Input dynamic range | | | | |
| Active energy measurement accuracy (large signal) | | 35A~100mA Input@ 1mohm sampling resistor | | 0.2 | | % |
| Active energy measurement accuracy (small signal) | | 100mA~50mA Input@ 1mohm sampling resistor | | 0.4 | | % |
| Active energy measurement accuracy (tiny signal) | | 50mA~10mA Input@ 1mohm sampling resistor | | 0.6 | | % |
| RMS measurement accuracy(large signal) | | 35A~100mA Input@ 1mohm sampling resistor | | 0.2 | | % |
| RMS measurement accuracy(small signal) | | 100mA~50mA Input@ 1mohm sampling resistor | | 2 | | % |
| RMS measurement accuracy(tiny signal) | | 50mA~10mA Input@ 1mohm sampling resistor | | 6 | | % |
| Fast RMS response time | 50Hz | Can be set to cycle/half cycle | 10 | | 40 | mS |
| | 60Hz | | 8.3 | | 33 | mS |

| | | | | | | |
|---|---|---|---|---|---|---|
| Zero-crossing signal output delay | | | | 571 | | uS |
| Measurement error caused by phase angle between channels (capacitance) | PF08err | Phase advance 37 °（PF=0.8） | | | 0.5 | % |
| Measurement error caused by phase angle between channels (sensibility) | PF05err | Phase delay 60 °（PF=0.5） | | | 0.5 | % |
| AC power suppression (output frequency amplitude variation) | ACPSRR | IP/N=100mV | | | 0.1 | % |
| DC power suppression (output frequency amplitude variation) | DCPSRR | VP/N=100mV | | | 0.1 | % |
| Analog input level (current) | | Differential current input (peak) | | | 50 | mV |
| Analog input level (voltage) | | Differential voltage input (peak) | | | 200 | mV |
| Analog input impedance | | | | 370 | | kΩ |
| SEL pull-down resistor | | SEL（pull-down） | | 56.9 | | kΩ |
| Analog input bandwidth | | （-3dB） | | 3.5 | | kHz |
| Internal voltage reference | Vref | | | 1.218 | | V |
| Logic input high-level | | VDD=3.3V±5% | 2.6 | | | V |
| Logic input low-level | | VDD=3.3V±5% | | | 0.8 | V |
| Logic output high-level | | VDD=3.3V±5%<br>IOH=5mA | VDD<br>-0.5 | | | V |
| Logic output low-level | | VDD=3.3V±5%<br>IOL=5mA | | | 0.5 | V |

Note：Unless specified otherwise, Tamb= 25℃

All voltage values take GND terminal potential as reference point.

Test conditions VDD=3.3V, Built-in crystal oscillator, electric energy is measured by CF output.

# 8. Internal Register Description

## 8.1 Register list

| Address | Symbol | External R/W | Internal R/W | Bits | Default | Description |
|---|---|---|---|---|---|---|
| Electrical parameter register (read only) | | | | | | |
| 0x00 | IA_FAST_RMS | R | W | 24 | 0x000000 | Fast current RMS, unsigned |
| 0x01 | IA_WAVE | R | W | 20 | 0x00000 | Current waveform register, signed |
| 0x03 | V_WAVE | R | W | 20 | 0x00000 | Voltage waveform register, signed |
| 0x04 | IA_RMS | R | W | 24 | 0x000000 | Current RMS register, unsigned |
| 0x06 | V_RMS | R | W | 24 | 0x000000 | Voltage RMS register, unsigned |
| 0x08 | A_WATT | R | W | 24 | 0x000000 | Active power register, signed |
| 0x0A | CFA_CNT | R | W | 24 | 0x000000 | Active energy pulse count, unsigned |
| 0x0C | A_CORNER | R | W | 16 | 0x0000 | Current voltage waveform phase angle register |
| 0x0E | TPS1 | R | W | 10 | 0x000 | Internal temperature register, unsigned |
| 0x0F | TPS2 | R | W | 10 | 0x000 | External temperature register, unsigned |
| User operated register (read and write) | | | | | | |
| 0x10 | IA_FAST_RMS_CTRL | R/W | R | 16 | 0xFFFF | Fast current RMS control register |
| 0x11 | IA_CHOS | R/W | R | 8 | 0x00 | Current DC offset correction |
| 0x13 | IA_RMSOS | R/W | R | 8 | 0x00 | Current RMS offset adjust register |
| 0x15 | A_WATTOS | R/W | R | 8 | 0x00 | Active power offset adjust register |
| 0x17 | WA_CREEP | R/W | R | 8 | 0x0B | Active power no-load threshold register |
| 0x18 | MODE | R/W | R | 16 | 0x0000 | User mode selection register |
| 0x19 | SOFT_RESET | R/W | R | 24 | 0x000000 | When 0x5A5A5A is written, the user area register is reset to default |
| 0x1A | USR_WRPROT | R/W | R | 8 | 0x00 | Write protection register. After writing 0x55, the user operation register can be written. Write other values, user operated register area is not writable |
| 0x1B | TPS_CTRL | R/W | R | 16 | 0x07FF | Temperature mode control register |
| 0x1C | TPS2_A | R/W | R | 8 | 0x0000 | External temperature sensor gain coefficient adjust register |
| 0x1D | TPS2_B | R/W | R | 8 | 0x0000 | External temperature sensor offset coefficient adjust register |

## 8.2 Special Register Description

### 8.2.1 User mode selection register（Note: X indicates either 0 or 1）

| 0x18 | MODE | User mode selection register | | |
|---|---|---|---|---|
| No. | name | default value | description | |
| [1:0] | IA_F_SEL | 0b00 | Current waveform selection | 0X：High pass, AC |

| | | | | |
|---|---|---|---|---|
| | | | through filter | measurement |
| | | | | 10：Low pass, DC measurement |
| | | | | 11：Full wave, AC/DC measurement |
| 2~3 | reserved | 0b00 | reserved | |
| [5:4] | V_F_SEL | 0b00 | Voltage waveform selection through filter | 0X：High pass, AC measurement |
| | | | | 10：Low pass, DC measurement |
| | | | | 11：Full wave, AC/DC measurement |
| 6 | L_F_SEL | 0b0 | Fast effective value selection through filter | 0：High pass filter front output |
| | | | | 1：High pass filter behind output |
| 7 | reserved | 0b00 | reserved | |
| 8 | RMS_UPDATE_SEL | 0b0 | RMS register update rate | 0：400ms |
| | | | | 1：800ms |
| 9 | AC_FREQ_SEL | 0b0 | AC frequency select | 0：50Hz |
| | | | | 1：60Hz |
| 10 | Reserved | 0b0 | reserved | |
| 11 | Reserved | 0b0 | reserved | |
| 12 | CF_UNABLE | 0b0 | CF output function selection | 0：reserved |
| | | | | 1：Over-current alarm function enable by TPS_CTRL[14] configured |
| 13~15 | Reserved | 3b000 | reserved | |

### 8.2.2 Temperature mode control register

| 0x1B | TPS_CTRL | Temperature mode control register | | |
|---|---|---|---|---|
| **No.** | **name** | **default value** | **description** | |
| 0x1B | TPS_CTRL | 0x07FF | [15] Temperature switch, default 0b0,Open the temperature measurement | 0：on |
| | | | | 1：off |
| | | | [14] Alarm switch, default 0b0, | 0：Temperature alarm on |
| | | | | 1：Over-current and leakage alarm on |
| | | | [13:12]] Temperature measurement selection, default 0b00<br>Automatic temperature measurement | 00：Automatic temperature measurement |
| | | | | 01：the same as 00 |
| | | | | 10：Internal temperature measurement |
| | | | | 11：External temperature measurement |

| | | | | |
|---|---|---|---|---|
| | | | [11:10]Temperature measurement interval default 0b01 100ms | 00：50ms |
| | | | | 01：100ms |
| | | | | 10：200ms |
| | | | | 11：400ms |
| | | | [ 9:0] External temperature measurement alarm threshold setting, default 0x3FF,not alarm | Alarm when TPS2 register value is greater than or equal to it. |

# 9. Theory of Operation

SSP1840 is composed of analog signal processing module and digital signal processing module. The analog module includes two-channel PGA, two-channel sigma-delta ADC, internal clock, power on/reset monitor, temperature sensor and other related analog modules. The digital module is digital signal processing module (DSP).

## 9.1 Current and voltage transient waveform measurement

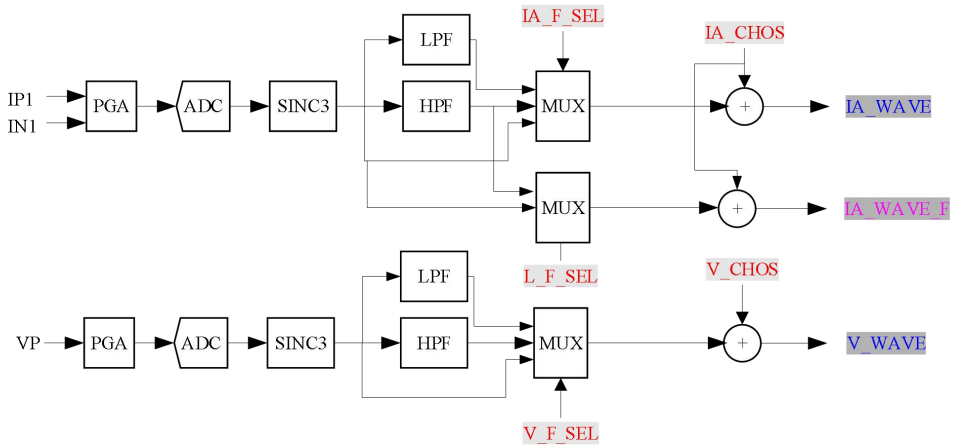



**Figure 4**

As shown in the figure above, the current and voltage pass through the analog module amplifier (PGA) and the high-precision analog-to-digital conversion (ADC) respectively to get two channels of 1bit PDM to the digital module. The digital module passes through the SINC3 filter (SINC3), optional high-pass filter (HPF) or low-pass filter (LPF) and channel offset correction modules. Obtain the required current waveform data and voltage waveform data (IA_WAVE, V_WAVE).

HPF and LPF are optional for the two channels. HPF is an AC measurement mode, LPF is a DC measurement mode, and full-wave measurement mode is a full-wave measurement mode if neither of them is passed. Set through user MODE register MODE[5:0].

The current and voltage waveform data are updated at a rate of 7.8k. Each sampled data is 20bit signed value, which are saved in waveform registers (I_WAVE, V_WAVE). The waveform value can be read continuously when the SPI rate is greater than 375Kbps.

| Address | Symbol | External | Internal | Bits | Default | Description |
|---|---|---|---|---|---|---|
| | | R/W | R/W | | | |
| 0x01 | IA_WAVE | R | W | 20 | 0x00000 | Current waveform register |
| 0x03 | V_WAVE | R | W | 20 | 0x00000 | Voltage waveform register |

## 9.2 Channel offset correction

The SSP1840 contains an 8-bit calibration register (IA_CHOS) with a default value of 00H. They eliminate the deviation caused by the analog-to-digital conversion of the current channel and the voltage channel respectively by the data in the form of the complement of 2. The deviation here may be due to the offset generated by the input and the ANALOG-to-digital conversion circuit itself. The offset correction allows the waveform offset to be 0 without load.

| Address | Symbol | External | Internal | Bits | Default | Description |
|---|---|---|---|---|---|---|
| | | R/W | R/W | | | |
| 0x11 | IA_CHOS | R/W | R | 8 | 0x00 | Current channel DC offset correction |

These registers are used for DC measurement mode, IA/V_LPF_SEL=1。

Correction formula：$CHOS = \frac{WAVE-WAVE0}{2^4}$

WAVE is the corrected waveform value, WAVE0 is the uncorrected waveform value;

Corresponding RMS value：$RMS = RMS0 + \frac{3125*CHOS}{4}$

RMS is the corrected valid value, RMS0 is the uncorrected valid value.

## 9.3 Active Power

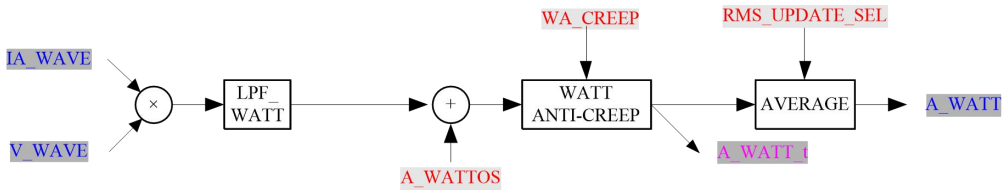



**Figure 5**

| Address | Symbol | External | Internal | Bits | Default | Description |
|---|---|---|---|---|---|---|
| | | R/W | R/W | | | |
| 0x08 | A_WATT | R | W | 24 | 0x000000 | Active power register |

Formula for calculating active power: $A\_WATT = \frac{4046*I(A)*V(V)*COS(\varphi)}{Vref^2}$

I(A) and V(V) are the voltage RMS of analog input PIN(IP&IN, VP&GND), Φ is the phase angle between I(A) and V(V) (AC signal), Vref is the on-chip reference voltage, the typical value is 1.218V.

This register indicates whether the active power is positive or negative. Bit[23] is the symbol Bit. Bit[23]=0 means the current power is positive and Bit[23]=1 means the current power is negative, in

complement form.

## 9.4 Active power offset correction

SSP1840 has one 8-bit active power offset adjust register (A_WATTOS), default value is 00H. It eliminate the offset of active power in the measurement of electric energy with the data in the form of complement of 2. Bit[7] is the symbol Bit. The offset may come from board level noise or crosstalk. Offset adjustment can make the values in the active power register close to 0 with no load.

| Address | Symbol | External | Internal | Bits | Default | Description |
|---|---|---|---|---|---|---|
| | | R/W | R/W | | | |
| 0x15 | A_WATTOS | R/W | R | 8 | 0x00 | Active power offset adjust register |

$$WATTOS = \frac{WATT - WATT0}{8 \times 3.05172}$$

WATT is the active power after adjustment, and WATT0 is the active power before adjustment.

## 9.5 Active power anti-creep

SSP1840 has the patented power anti-creep function, which ensures that the power of board level noise will not accumulate when there is no load.

This active power no-load threshold register(WA_CREEP) is 8bit unsigned data, default value is 0BH. The corresponding relationship between this value and the active power register value is shown in the following formula. When the absolute value of the input active power signal is less than this value, the output active power is set to 0. This can make the value of the active power register is 0 and the energy does not accumulate in the case of no load, even if there is a tiny noise signal.

| Address | Symbol | External | Internal | Bits | Default | Description |
|---|---|---|---|---|---|---|
| | | R/W | R/W | | | |
| 0x17 | WA_CREEP | R/W | R | 8 | 0x0B | Active power no-load threshold register |

Set WA_CREEP based on the value of the power register A_WATT, their corresponding relationship as below:

$$WA\_CREEP = \frac{WATT}{3.0517578125 * 8}$$

When the channel is in the anti-creep state, the RMS current register of this channel is also set to 0.

## 9.6 Energy Measurement

SSP1840 provides energy pulse measurement. The active instantaneous power is integrated by time to get active energy and output calibration pulse CF in proportion. CFA_CNT register saves the count of output energy pulse.

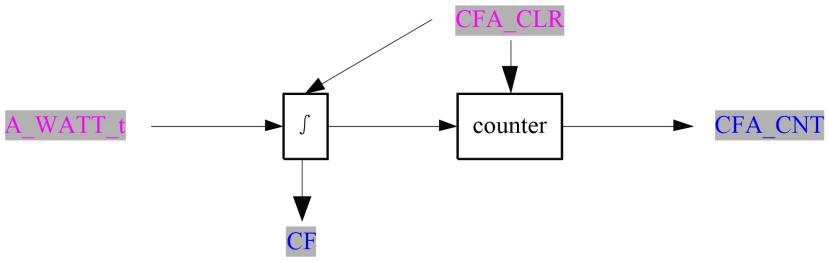



**Figure 6**

| Address | Symbol | External | Internal | Bits | Default | Description |
|---|---|---|---|---|---|---|
| | | R/W | R/W | | | |
| 0x0A | CFA_CNT | R | W | 24 | 0x000000 | Active energy pulse count, unsigned |

The count of active energy pulses corresponds to the consumption of electricity. The count of pulses can be counted directly from the CF pin through I/O interruption. When the period of CF is less than 180ms, the pulse is 50% duty cycle. When it is greater than or equal to 180ms, the fixed pulse width of high-level is 90ms.

Note: CFA_CNT is pulse algebraic sum accumulation. It means that pulse plus at positive energy and minus at negative energy.

The cumulative time of each CF pulse: $t_{CF}=\frac{1638.4*256}{WATT}$

WATT is the corresponding active power register value (A_WATT)

## 9.7 Current and Voltage RMS

The RMS of these channels is shown in the figure below. After the square circuit ($X^2$), the low-pass filter (LPF_RMS) and the ROOT circuit (ROOT), the instantaneous value RMS_t of RMS is calculated, and then the average value of the two channels (A_RMS, V_RMS) is calculated.

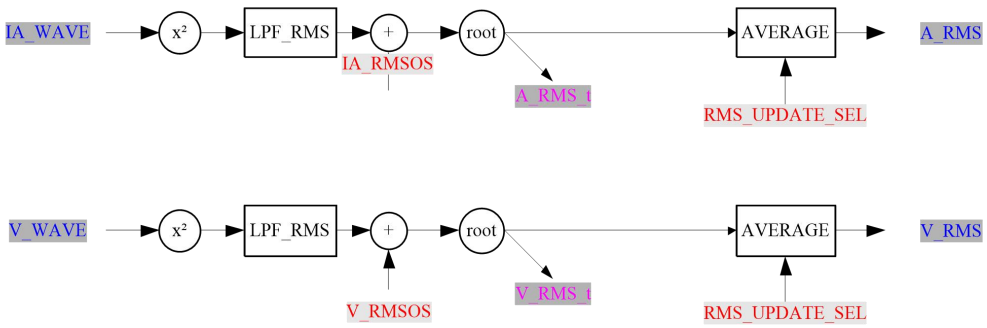



**Figure 7**

| Address | Symbol | External | Internal | Bits | Default | Description |
|---|---|---|---|---|---|---|
| | | R/W | R/W | | | |
| 0x04 | IA_RMS | R | W | 24 | 0x000000 | Current RMS register, unsigned |
| 0x06 | V_RMS | R | W | 24 | 0x000000 | Voltage RMS register, unsigned |

| 0x18 | MODE | User mode selection register | | |
|---|---|---|---|---|
| No. | name | default value | description | |
| 8 | RMS_UPDATE_SEL | 0b0 | RMS register update rate | 0：400ms |
| | | | | 1：800ms |

Set MODE[8].RMS_UPDAT_SEL, the average refresh time of RMS can be selected as 400ms or 800ms, and the default value is 400ms. When a current channel is in anti-creep state, the RMS of the current channel is 0.

The current RMS conversion formula: IA_RMS = $\frac{324004*I(A)}{Vref}$

The voltage RMS conversion formula: V_RMS = $\frac{79931*V(V)}{Vref}$

Vref is the reference voltage, the typical value is 1.218V.

I(A) is the input signal between IP1 and IN1 pins (mV), and V(V) is the input signal of VP pins (mV).

## 9.8 RMS offset calibration of current and voltage

SSP1840 has one 8-bit RMS offset register (IA_RMSOS), whose default value is 00H. It is used to calibrate the deviation in RMS with the complement form of 2. Bit[7] is the sign Bit,This deviation may come from the input noise.Because there is a square operation in calculating the RMS, this may introduce DC offset caused by noise.The deviation calibration can make the value in the RMS register close to 0 without load.

| Address | Symbol | External | Internal | Bits | Default | Description |
|---|---|---|---|---|---|---|
| | | R/W | R/W | | | |
| 0x13 | IA_RMSOS | R/W | R | 8 | 0x00 | Current RMS offset adjust register |

Calibration formula: RMSOS = $\frac{RMS^2-RMS0^2}{9.3132\times2^{15}}$

RMS0 is the RMS current value before correcting and RMS is the RMS current value after correcting。

## 9.9 Leakage/Over-current Detection

SSP1840 has a fast RMS register, which can detect half cycle or cycle RMS. This function can be used for leakage or over-current detection. The source of waveform L_WAVE is shown below.

HPF can be passed or not passed， HPF is not passed by default， can get the absolute value of IA_WAVE_F accumulate by half-cycle or one cycle time, which is selected by FAST_RMS_CTRL[15]. Cycle accumulation is selected by default, The maximum response time is 40ms (50Hz) or 33mS (60Hz)， Note that the runout of IA_FAST_RMS register is relatively large when half cycle wave accumulation

occurs. Distinguish between 50Hz and 60Hz half-cycle time (AC_FREQ_SEL).

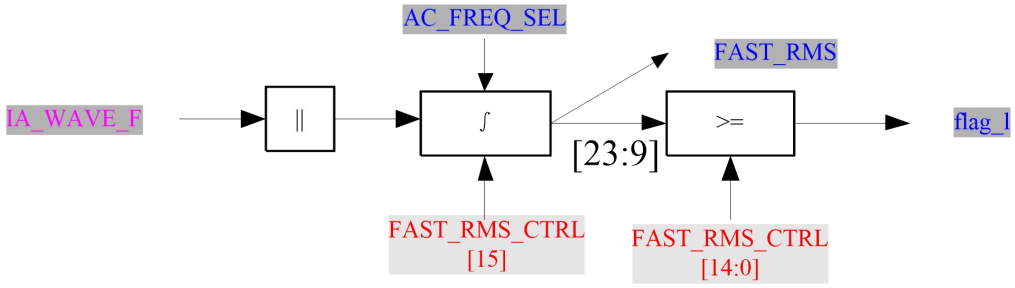



**Figure 8**

| Address | Symbol | External | Internal | Bits | Default | Description |
|---|---|---|---|---|---|---|
| | | R/W | R/W | | | |
| 0x10 | IA_FAST_RMS_CTRL | R/W | R | 16 | 0xFFFF | Fast current RMS control register |

Set the refresh time to half-cycle or cycle by IA_FAST_RMS_CTRL, and set the fast RMS threshold (Leakage or over-current threshold).

| 0x10 | MODE | Fast RMS register | | |
|---|---|---|---|---|
| No. | name | default value | description | |
| 0x10 | IA_FAST_RMS_CTRL | 0xFFFF | [15]Fast RMS refresh time | 0：half-cycle |
| | | | | 1：cycle |
| | | | [14:0]Fast RMS threshold | |

Set AC frequency by MODE[9].

| 0x18 | MODE | User mode selection register | | |
|---|---|---|---|---|
| No. | name | default value | description | |
| 9 | AC_FREQ_SEL | 0b0 | AC frequency selection | 0：50Hz |
| | | | | 1：60Hz |

Refresh the 24-bit unsigned RMS register according to one cycle or half cycle, Bit[23:9] of the FAST_RMS register compare with the leakage/over-current threshold FAST_RMS_CTRL [14:0], if the value is greater than or equal to the set threshold, then leakage/over-current alarm output pin will be high level.

| Address | Symbol | External | Internal | Bits | Default | Description |
|---|---|---|---|---|---|---|
| | | R/W | R/W | | | |
| 0x00 | IA_FAST_RMS | R | W | 24 | 0x000000 | Fast current RMS，unsigned |

Leakage/over-current alarm output indicator pin is CF, set MODE[12]=1 and TPS_CTRL[14]=1 before use it.

| 0x18 | MODE | User mode selection register | | |
|---|---|---|---|---|
| No. | name | default value | description | |
| 12 | CF_UNABLE | 0b0 | CF output function selection | 0：energy pulse, enable by MODE[11] configured |

| | | | | |
|---|---|---|---|---|
| | | | | 1：Temperature measurement/Leakage alarm, enable by TPS[14] configured |

| 0x1B | TPS_CTRL | Temperature mode control register | | |
|---|---|---|---|---|
| **No.** | **name** | **default value** | **description** | |
| 14 | ALERT_CTRL | 0b0 | Alarm selection | 0：Temperature alarm on |
| | | | | 1：Leakage/over-current alarm on |

Since the fast effective values are updated by cycle or half-cycle, the interrupt response time is up to 2 cycles or 2 half-cycles.

## 9.10 Phase Angle Calculation

SSP1840 has phase angle measurement function. The reactive quadrant can be indicated by the angle of current and voltage respectively by calculating the positive zero-crossing time difference between current and voltage. It is updated to the register CORNER_A when the current is positive zero crossing.The register is a 16-bit unsigned number.

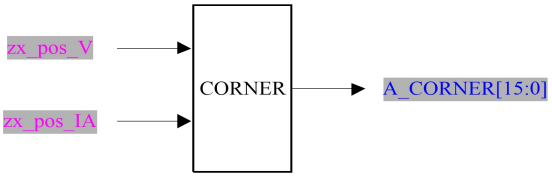



**Figure 9**

| Address | Symbol | External | Internal | Bits | Default | Description |
|---|---|---|---|---|---|---|
| | | R/W | R/W | | | |
| 0x0C | A_CORNER | R | W | 16 | 0x0000 | Current voltage waveform phase angle register |

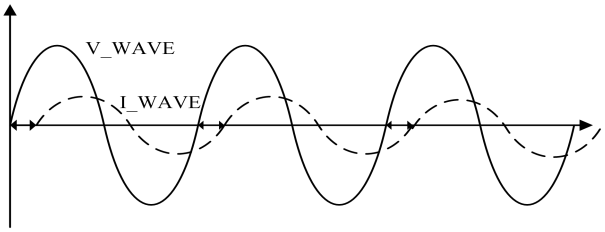



**Figure 10**

Phase Angle conversion formula: $2*pi*A\_CORNER*\frac{f_c}{f_0}$ The unit is radian

Among them, $f_c$ is the frequency of the AC signal source, the default value is 50Hz. $f_0$ is the sampling frequency, the typical value is 1MHz.

## 9.11 Zero Crossing Detection

SSP1840 has the voltage zero-crossing detection function, and the zero-crossing signal is directly output by pin ZX. When ZX=0, it indicates the positive half cycle of the waveform, and when ZX=1, it indicates the negative half cycle of the waveform. The delay between the zero-crossing signal and the actual input signal is about 570us.

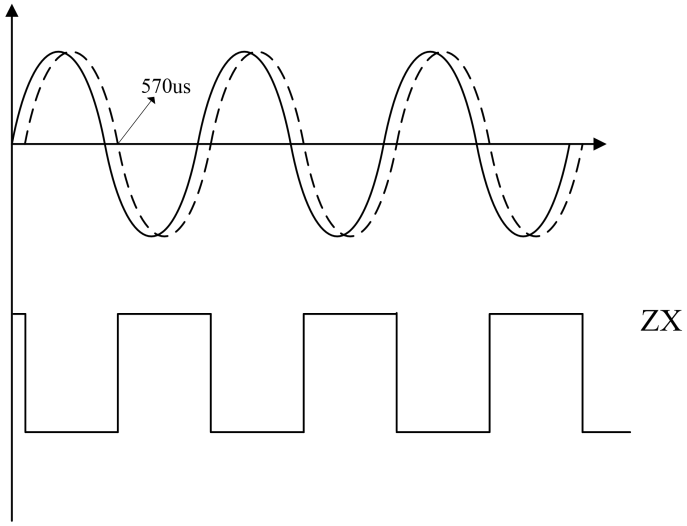



**Figure 11**

## 9.12 Temperature Measurement

SSP1840 supports internal temperature measurement and external temperature measurement.

External temperature measurement, optional output alarm indicator,Turn on the alarm function,CF pin selection output alarm signal,the CF pin will output high-level if the TPS2 is greater than or equal to the alarm threshold, Temperature indicator alarm.when the temperature value is lower than the alarm value or the alarm function is turned off,Exit alarm indicator.

| **0x1B** | **TPS_CTRL** | **Temperature mode control register** | | |
|---|---|---|---|---|
| **No.** | **name** | **default value** | **description** | |
| 0x1B | TPS_CTRL | 0x07FF | [15] Temperature measurement switch，default 0b0,Open the temperature measurement | 0：on |
| | | | | 1：off |
| | | | [14] Alarm selection ， default 0b0, | 0：Temperature alarm on |
| | | | | 1：Leakage/over-current alarm on |
| | | | [13:12]Temperature measurement selection，default 0b00 Automatic temperature measurement | 00：Automatic temperature measurement |
| | | | | 01：the same as 00 |
| | | | | 10：internal temperature measurement |
| | | | | 11：external temperature measurement |
| | | | [11:10]Temperature measurement | 00：50ms |

| | | | | |
|---|---|---|---|---|
| | | | interval selection ， default 0b01 100ms | 01：100ms |
| | | | | 10：200ms |
| | | | | 11：400ms |
| | | | [ 9:0]External temperature alarm threshold，default 0x3FF | |

First set MODE[12]=1, and then set TPS_CTRL[14]=0, then CF pin is turned on to output external temperature alarm indicator.

| 0x18 | MODE | User mode selection register | | |
|---|---|---|---|---|
| No. | name | default value | description | |
| 12 | CF_UNABLE | 0b0 | CF output function selection | 0：energy pulse, enable by MODE[11] configured |
| | | | | 1：Temperature measurement alarm, enable by TPS[14] configured |

The external and internal temperature values are saved in the TPS2 and TPS1 registers respectively.

| Address | Symbol | External | Internal | Bits | Default | Description |
|---|---|---|---|---|---|---|
| | | R/W | R/W | | | |
| 0x0E | TPS1 | R | W | 10 | 0x0000 | Internal temperature register, unsigned |
| 0x0F | TPS2 | R | W | 10 | 0x0000 | External temperature register, unsigned |

Internal temperature measurement formula: Tx=(170/448)(TB/2-32)-45

TB is the value in TPS1

The external temperature is measured by SAR ADC.The maximum input signal of the VT pin is 0.55*VDD（V），The TPS2 register value is the corresponding AD sampling value,full scale is 1024.

| Address | Symbol | External | Internal | Bits | Default | Description |
|---|---|---|---|---|---|---|
| | | R/W | R/W | | | |
| 0x1C | TPS2_A | R/W | R | 8 | 0x00 | External temperature sensor gain coefficient correction A register |
| 0x1D | TPS2_B | R/W | R | 8 | 0x00 | External temperature sensor offset coefficient correction B register |

# 10. Communication Interface

Register data are sent as 3 bytes (24bit). The data is fixed 3 bytes, if valid data bytes are less than 3 bytes, invalid bits are filled with 0.

## 10.1 SPI

- Select by pin UART_SELL, multiplex with UART
- Slave mode
- Half-duplex communication, the communication rate can be configured, the maximum communication rate is 900khz
- 8-bit data transmission, MSB first, LSB last
- Clock polarity / phase (CPOL = 0, CPHA = 1)

### 10.1.1 Operation Mode

The master device works in Mode1：CPOL=0，CPHA=1，In idle state, SCLK is at low-level. Data is transmitted on the first edge, which is the transition from low level to high level of SCLK, so data is received on the falling edge and data is sent on the rising edge.

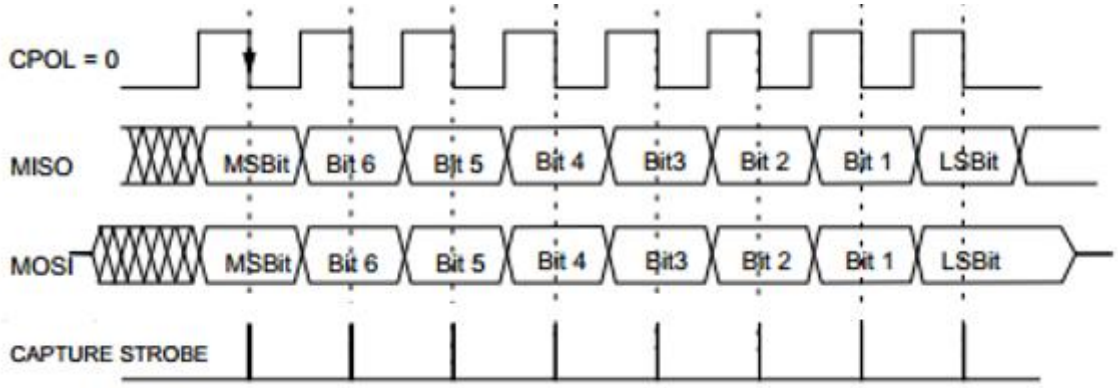



**Figure 12**

### 10.1.2 Frame Structure

In SPI communication mode, MCU send 8-bit identification byte (0x58) or (0xA8). (0x58) is the read operation identification byte and (0xA8) is the write operation identification byte. Then send the address byte of the register will be accessed (refer to SSP1840 register list). The below figure shows the data transfer sequence for read and write operations respectively. After one frame of data is transmitted, SSP1840 re-enters the communication mode. The number of SCLK pulses required for each reading and writing operation is 48 bits.

There are two types of frame structures, which are explained as follows:

1） Write operation frame

| | | | | | | |
|---|---|---|---|---|---|---|
| **Write operation frame** | 0xA8 | ADDR[7:0] | DATA_H[7:0] | DATA_M[7:0] | DATA_L[7:0] | CHECKSUM[7:0] |

The checksum byte is（（0xA8 + ADDR + DATA_H + DATA_M+ DATA_L）& 0xFF）and then bitwise inverted.

2） Read operation frame

| | | |
|---|---|---|
| **MCU send read command frame** | 0x58 | ADDR[7:0] |

| | | | | |
|---|---|---|---|---|
| **return data frame** | DATA_H[7:0] | DATA_M[7:0] | DATA_L[7:0] | CHECKSUM[7:0] |

The checksum byte is（（0x58 + ADDR + DATA_H + DATA_M+ DATA_L）& 0xFF）and then bitwise inverted.

### 10.1.3 Write Operation Timing

The serial write timing is performed as follows. The frame identification byte {0xA8} indicates that the data communication operation is data writing. The MCU need make the data ready before the lower edge of SCLK, and shift the data at the lower edge of this clock. All remaining bits of the data are also shifted left on the lower edge of this SCLK (Figure 13）。

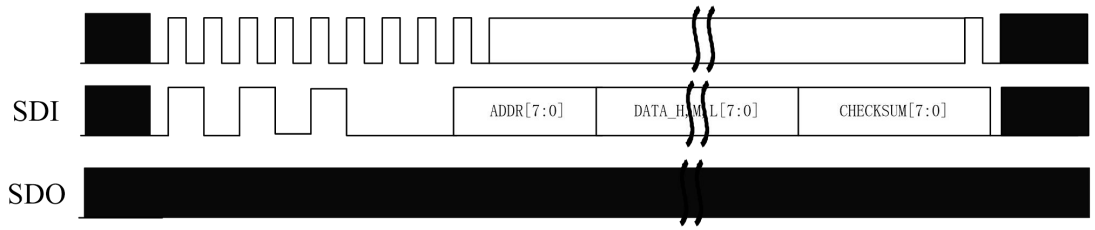



**Figure 13**

### 10.1.4 Read Operation Timing

During the data read operation, SSP1840 shifts the corresponding data to the DOUT pin on the rising edge of SCLK. DOUT keeps unchanged during SCLK =1.MCU can sample DOUT value before the next falling edge. MCU must send a read command frame first before read operation.

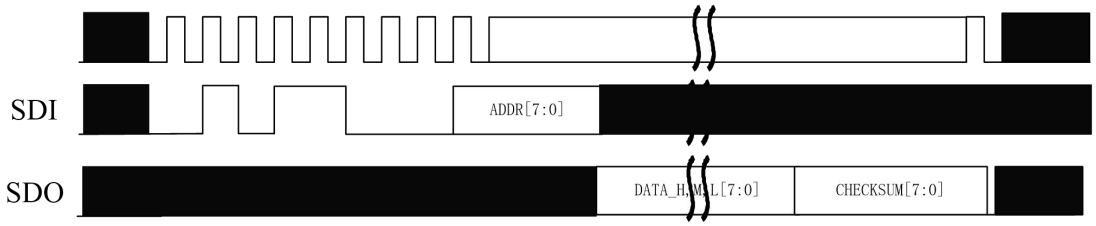



**Figure 14**

When SSP1840 is in communication mode, the frame identification byte {0x58} indicates that the data communication operation is data reading. After receiving the register address, SSP1840 starts to shift out the data in the register on the rising edge of SCLK (Figure 14). All remaining bits of the register data are shifted out on subsequent rising SCLK edges.Therefore，On the falling edge of SCLK, an external device can sample the output data of the SPI. Once the read operation is completed, SPI re-enters the communication mode. SDO enters a high-impedance state on the falling edge of the last SCLK signal.

### 10.1.5 Fault-tolerant mechanism of SPI interface

SPI supports soft reset function, reset SPI interface individually by sending 6bytes of 0xFF.

## 10.2 UART Communication methods

### 10.2.1 Summarize

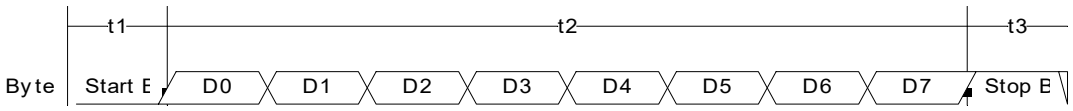
SSP1840 supports UART communication. The UART interface only requires two low speed optocouplers to achieve isolated communication.

Baud rate: 4800bps Check bits: None Data bits: 8 Stop bits: 1.5 Slave mode, half-duplex communication

### 10.2.2 Description

UART port Settings: Communication baud rate is 4800bps, no parity, stop bit 1.5 .

### 10.2.3 Byte Formation



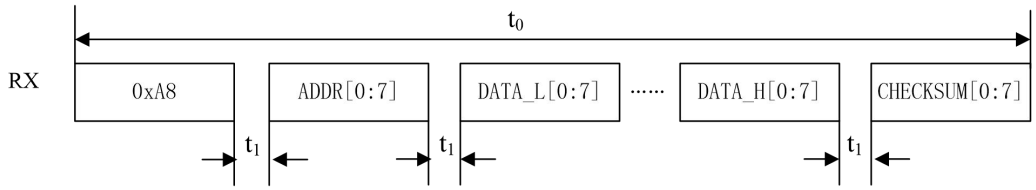

Start bit low duration: t1=208us;

Valid data bit duration: t2=208*8=1664us

Stop bit high duration: t3=208us+104us

### 10.2.4 Write Timing

The data write sequence of the host UART is shown in the figure below. The host sends command bytes (0xA8) first, then write address bytes (ADDR), then sends data bytes in sequence, and finally checksum bytes.

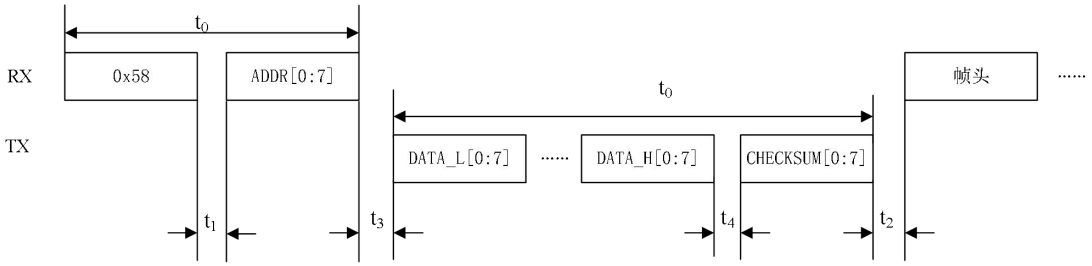



(0xA8)is the frame identification byte for the write operation. ADDR is the internal target register in SSP1840 corresponding to the write operation.

The checksum byte is（（0xA8+ADDR+Data_L+Data_M+Data_H）& 0xFF）and then bitwise inverted.

### 10.2.5 Read Timing

The timing of reading data is shown below. MCU first sends the command byte (0x58) and the address of the target register (ADDR), and then SSP1840 sends data bytes in sequence. Finally sends the checksum byte.




(0x58) is the frame identification byte for the read operation. ADDR is the internal target register in SSP1840 corresponding to the read operation.

The checksum byte is（（0x58+ADDR+Data_L+Data_M+Data_H）& 0xFF）and then bitwise inverted.

Timing Description ：

| | Description | Min | Type | Max | Unit |
|---|---|---|---|---|---|
| t1 | Interval between MCU sending bytes | 0 | | 20 | mS |
| t2 | Frame interval | 0.5 | | | uS |
| t3 | Interval between the end of MCU sending register address and SSP1840 sending byte during read operation | | 72 | | uS |
| t4 | Interval between SSP1840 sending bytes | | 116 | | uS |

### 10.2.6 Packet sending mode

After received the command "(0x58) + 0xAA", SSP1840 will return a full electrical parameter data packet. The returned data packet has a total of 35 bytes, and 4800bps takes 77ms.The specific format is：Frame head（1byte head）→Current A fast effective value（3byte IA_FAST_RMS）→Current A effective value（3byte IA_RMS）→reserved（3byte）→Effective voltage（3byte V_RMS）→reserved（3byte）→Channel A power value（3byte A_WATT）→reserved（3byte）→Channel A pulse meter value（3byte CFA_CNT）→reserved（3byte）→Internal thermometer value（2byte TPS1 + 1byte 0）→External thermometer value（2byte TPS2 + 1byte 0）→Checksum value（1byte CHECKSUM）.

Full electrical parameter data packet format:

| Name | No. | Value | Name | No. | Value |
|---|---|---|---|---|---|
| Frame head | 0 | Head（0x55） | reserved | 19 | reserved |
| IA_FAST_RMS | 1 | IA_FAST_RMS_l | | 20 | reserved |
| | 2 | IA_FAST_RMS_m | | 21 | reserved |
| | 3 | IA_FAST_RMS_h | CFA_CNT | 22 | CFA_CNT_l |
| IA_RMS | 4 | IA_RMS_l | | 23 | CFA_CNT_m |
| | 5 | IA_RMS_m | | 24 | CFA_CNT_h |
| | 6 | IA_RMS_h | reserved | 25 | reserved |
| reserved | 7 | reserved | | 26 | reserved |
| | 8 | reserved | | 27 | reserved |
| | 9 | reserved | TPS1 | 28 | TPS1_l |
| V_RMS | 10 | V_RMS_l | | 29 | TPS1_m |
| | 11 | V_RMS_m | | 30 | 0x00 |
| | 12 | V_RMS_h | TPS2 | 31 | TPS2_l |
| reserved | 13 | reserved | | 32 | TPS2_m |
| | 14 | reserved | | 33 | 0x00 |
| | 15 | reserved | checksum | 34 | checksum |
| A_WATT | 16 | A_WATT_l | | | |
| | 17 | A_WATT_m | | | |
| | 18 | A_WATT_h | | | |

checksum=（（0x58 + 0x55 + data1_l + data1_m + data1_h +……）& 0xff）and then bitwise inverted.

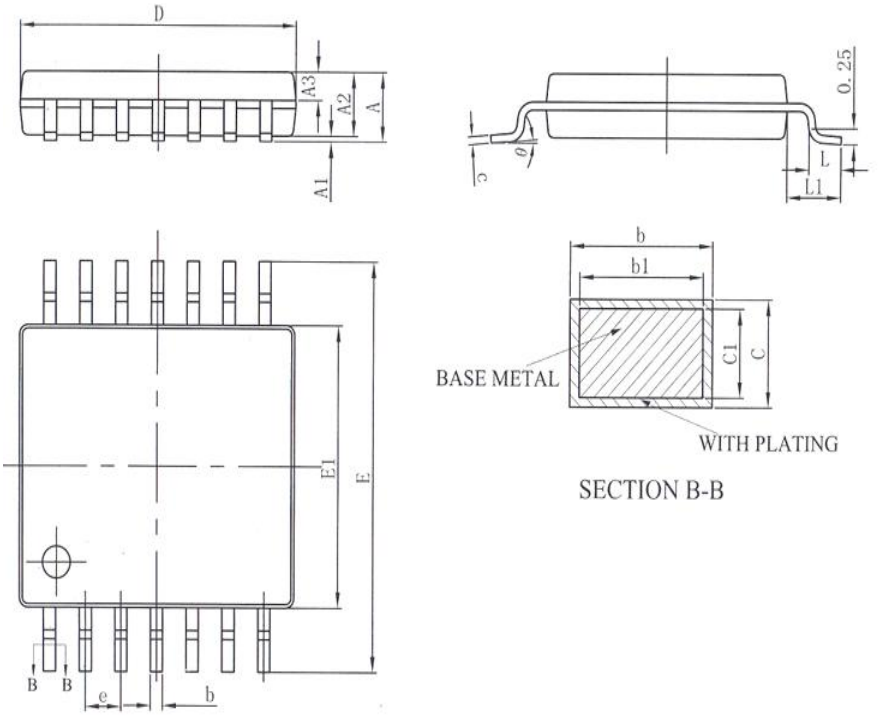
### 10.2.7 Protection mechanism of UART interface

UART communication has a timeout protection mechanism. If the interval between bytes exceeds 18.5ms, the UART interface will automatically reset.

If the frame identification byte is incorrect or the checksum byte is incorrect, the frame data will be discarded.

UART module reset: The RX pin is pulled high after the low-level exceeds 6.65mS, and the UART module will be reset.

## 11. Package Information（TSSOP14）




| SYMBOL | MILLIMETER | | |
|---|---|---|---|
| | MIN | NOM | MAX |
| A | — | — | 1.20 |
| A1 | 0.05 | — | 0.15 |
| A2 | 0.90 | 1.00 | 1.05 |
| A3 | 0.39 | 0.44 | 0.49 |
| b | 0.20 | — | 0.28 |
| b1 | 0.19 | 0.22 | 0.25 |
| c | 0.13 | — | 0.17 |
| c1 | 0.12 | 0.13 | 0.14 |
| D | 4.90 | 5.00 | 5.10 |
| E1 | 4.30 | 4.40 | 4.50 |
| E | 6.20 | 6.40 | 6.60 |
| e | 0.65BSC | | |
| L | 0.45 | 0.60 | 0.75 |
| L1 | 1.00BSC | | |
| θ | 0 | — | 8° |

## 12. Special Instructions

The company reserves the right of final interpretation of this specification.

## Version Change Description

Version：V1.03 Author：Lifeng Liu Time：2021.9.09

Modify the record：

1. Re-typesetting the manual and checking some data

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