BL0910 Application Guide

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BL0910 is a multi-channel calibration-free energy metering chip with built-in clock developed by Shanghai Belling Co., Ltd. It can measure up to 10 phases of energy and is suitable for electric bicycle charging piles, PDUs, multi-circuit meters,

Scenarios that require multi-channel measurement, such as 4-20MA analog quantity acquisition.

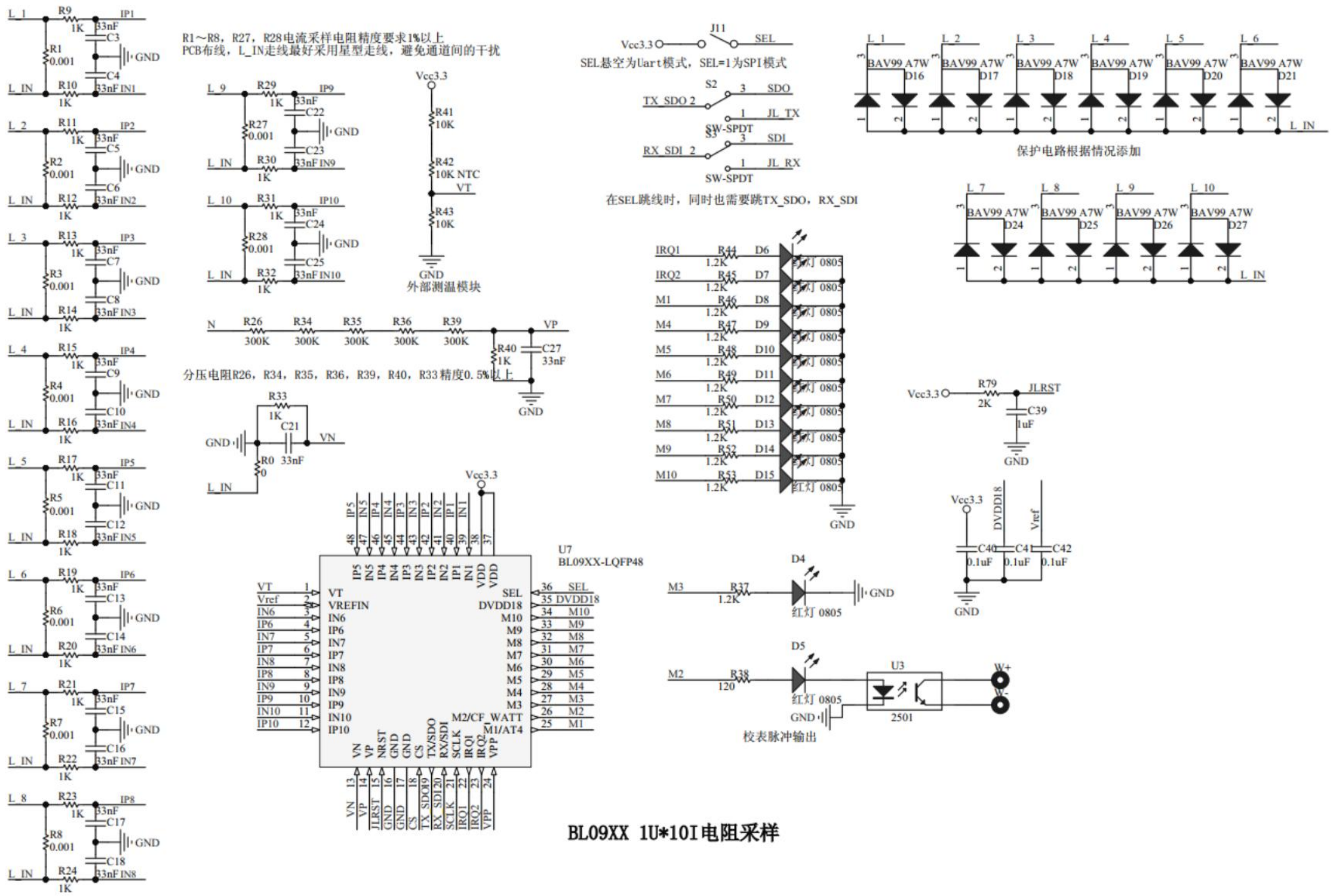
BL0910 integrates 11 high-precision Sigma-Delta ADCs and can measure 11 signals (current or voltage) simultaneously.

BL0910 can measure current, voltage RMS, active power, active electric energy and other parameters, and can output fast current RMS (for leakage monitoring, overcurrent protection and other fault detection), as well as temperature detection, waveform output and other functions, and output data through UART or high-speed SPI interface.

AC power measurement

Application circuit diagram:*1U10I* model)

Resistance sampling method



BL09XX 1U*10I电阻采样

Note: 1)

The default function of M1~M10 is overcurrent alarm output, and the M2 pin can be configured as a calibration pulse output (see the MODE3 register description for specific configuration);

2) For the speed of the SPI and UART interfaces and the description of the communication protocol, see "BL0910 datasheet Vx.x.pdf"; 3) BL0910 has been gain-corrected at the factory. If calibration is not required, the accuracy of the peripheral devices is guaranteed to be within 1%; 4) In Uart communication mode, the RX and TX pins need to be connected to external pull-up resistors;

Register Settings

When sampling with a 1 milliohm alloy resistor, the current channel uses a gain of 16 and the voltage channel uses a gain of 1;

0000=1 times; 0001=2 times; 0010=8 times; 0011=16 times;

(Note: The maximum differential voltage of the input channel is ±0.7V, which refers to a gain of 1. If a gain of 16 is used, the input

The maximum differential voltage of the input channel is ±43mV. It is necessary to ensure that the maximum measurement signal is within the measurement range allowed by the chip pin.

In the range, taking 16 times gain as an example, the maximum input signal of the current channel is 43mV peak (30mV rms), ignoring the sampling

Resistor heating, theoretically using a 1 milliohm resistor, the maximum current that can be measured is 30A)

Address	Name	External read/write	Internal read/write	Bit width	default value	description
60	GAIN1	R/W	R	24	0x000000	Channel PGA gain adjustment register, [3:0]->Channel 11 (voltage); [7:4]->Pass Channel 1; [8:11] -> Channel 2; . . .
61	GAIN2	R/W	R	20	0x00000	Channel PGA gain adjustment register, [3:0]->Channel 6; [7:4]->Channel 7ÿÿÿÿ

So GAIN1=0x333330; GAIN2=0x033333; Note: You need to write

0x5555 to the 0x9E (US_WRPROT) register before you can write gain-related settings!

About electrical parameter conversion

When defining the BL0910 product, we took into account that most user manufacturers are not professional measuring instrument manufacturers, do not have professional calibration equipment, and have relatively low requirements for the accuracy of electric energy measurement. They only provide reference information on electricity consumption and do not use it as a billing standard. Smart devices only need to read power, voltage, and current, and calculate the power consumption based on the active energy pulse count, so the BL0910 circuit guarantees that the chip's own gain deviation is less than 1% when

it leaves the factory. If the customer's peripheral device accuracy is higher than 1%, the accuracy of the entire machine can be within 2% without calibration;

Voltage RMS register value = 13162 ÿ ÿ _

Current RMS register value = 12875 ÿ ÿ _

Current fast effective value register value ÿ 12875 ÿ ÿ _ ÿ 0.55

Active power register value for each channel = 40.4125 ÿ ÿ _ ÿ ÿ _ ÿ (ÿ) / 2

Vv: voltage signal between **VP and VN** pins (unit: mV)

Vi: Voltage signal between **IPx and Inx** pins (unit: mV)

Vref: chip reference voltage **1.097V**

Gain_V, Gain_I: Gain multiples of voltage and current channels (1, 2, 8, 16)

The accumulated time of each CFx pulse and the active power register value (WATT) of each channel, CF frequency division register

Device (CFDIV = 0x10)

= 4194304 ÿ 0.032768 ÿ 16 / ÿ

Take the first parameter in the application circuit diagram as an example:

The current sampling resistor R1 is marked as RL, and the voltage channel is divided by resistors R26, R34, R35, R36, and R39.

Rf, R40 is marked as Rv; current channel gain 16 times

The current sampling resistor RL is 1 milliohm, and the voltage channel divides the AC voltage through the resistor Rf (300K*5) + Rv (1K)

The 220V voltage drops to mV level signal to VP pin; MCU obtains BL0910 register data through SPI/Uart interface;

Actual current value = Current effective value register value ÿVref / 12875ÿ16ÿRL Ampere->Current coefficient Ki=206000ÿ ÿ187784.87

Actual voltage value = Voltage RMS register value ÿVrefÿ (Rf+Rv) / 13162ÿ ÿ _ ÿ1000 Volt->voltage coefficient Kv=13162ÿ ÿ1000 / ÿ(+) ÿ7993.45

Actual active power value = Active power register value ÿ Vref2 ÿ (Rf + Rv) / 40.4125ÿRLÿGain_IÿRvÿGain_Vÿ1000 Watts-> Power factor Kp= 646.6ÿ ÿ ÿ1000 / 2ÿ(+) =

646.6ÿ1ÿ1ÿ1000 / 1.097ÿ1.097ÿ ÿ 300ÿ5+1 ÿ ÿ357.966

The CF_CNT register stores the number of energy pulses;

The amount of electricity corresponding to each energy pulse = 4194304ÿ0.032768ÿ16 / 3600000ÿ ÿ Every time

RL is in milliohms, Rf, Rv is in K ohms; Vref=1.097V; CFDIV=16;

Gain_I=16ÿGain_V=1ÿ

For example: the I_RMS register value is 762120, the V_RMS register value is 1556001, and the WATT register value is 283015.

CF_CNT register value is 1200; conversion according to the formula:

Actual current value = 762120ÿ1.097 / 206000ÿ1 =4.058 Ann

Actual voltage value = 1556001ÿ1.097ÿÿ300ÿ5+1ÿ / 13162ÿ1ÿ1000 Hidden = 194.66 Hidden

Actual active power = 283015ÿ1.097ÿ1.097ÿÿ300ÿ5+1ÿ / 40.4125ÿ1ÿ16ÿ1ÿ1ÿ1000 Watts = 790.62 Watts on, the accumulated energy of BL0910 = ÿ 1200 degrees 4194304ÿ0.032768ÿ16ÿ1.097ÿ1.097ÿÿ300ÿ5+1ÿ After power- 3600000ÿ40.4125ÿ1ÿ16ÿ1ÿ1ÿ1000ÿ16

Note: 1)

The active power WATT register is in the complement code mode. If it is negative power, complement code conversion is required;

About the active power anti-creep threshold setting

Usually, when PCB is being laid out, due to the wiring or external electromagnetic interference, when there is no load, due to the noise signal

The chip detects noise power, which may cause positive or negative power to appear in the active power register.

BL0910 has a patented power anti-creep function to ensure that the board-level noise power will not accumulate when there is no current input. The active anti-

creep threshold register (WA_CREEP) is a 12-bit unsigned number, with a default value of 0x04C. 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 register is zero. This can make the value output to the active power register be 0 even if there is a small noise signal under no-load conditions.

address	name	External Read/Write	Internal Read/	Default value of bit width		describe
0x88	VAR_CREEP/WA_CREEP	R/W	R	24	0x04C04C	Bit[11:0] is the active power anti-submarine register; Bit[23:12] is the reactive power anti-submersion register

WA_CREEP can be set according to the value of the power register WATT. Their corresponding relationship

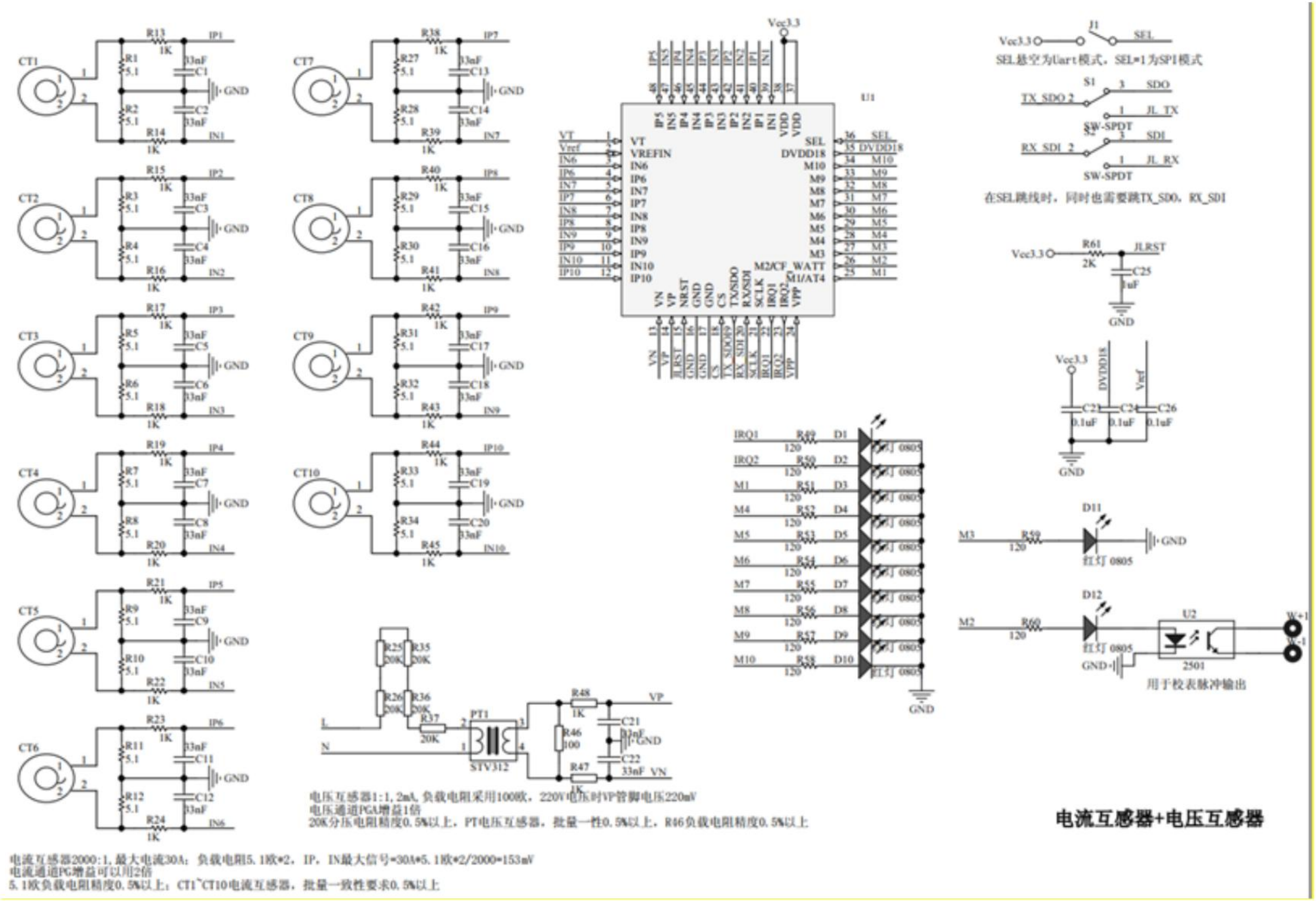
$$WA\_CREEP = WATT \frac{}{2}$$

The default value of WA_CREEP is 0x04C; the corresponding WATT active power register value = 76*2 = 152; If a 1 milliohm sampling

resistor is used, the voltage is divided by a resistor of 300K*5+1K; the corresponding actual power = 152/Kpÿ0.424 watts. In actual application, the setting of the active anti-creep

threshold register can be increased according to the application requirements, for example, no measurement is required below 2 watts. The threshold is set to the parameter corresponding to 2W.

Transformer sampling method


SEL悬空为Uart模式，SEL=1为SPI模式
在SEL跳线时，同时也需要跳TX_SDO，RX_SDI
用于校表脉冲输出
电压互感器1:1, 2mA, 负载电阻采用100欧，220V电压时VP管脚电压220mV
电压通道PGA增益1倍
20K分压电阻精度0.5%以上，PT电压互感器，批量一性0.5%以上，R46负载电阻精度0.5%以上
电流互感器+电压互感器
电流互感器2000:1, 最大电流30A; 负载电阻5.1欧*2, IP, IN最大信号=30A*5.1欧*2/2000=153mV
电流通道PG增益可以用2倍
5.1欧负载电阻精度0.5%以上；CT1~CT10电流互感器，批量一致性要求0.5%以上

Register Settings

Use current transformers and voltage transformers for signal sampling.

As shown in the typical application diagram, the current transformer ratio is 2000:1, the maximum current is 30A, and the load resistance is 5.1 ohms*2, then IP, IN

The maximum signal between pins = 30A*5.1 ohms*2/2000=153mV; the current channel can use a gain of 1;

The voltage transformer is 1:1, 2mA; the load resistance is 100 ohms, 220V is VP, and the voltage between the VN pins is 220mV. Considering the city

The voltage may fluctuate by ±20%, and the voltage channel uses a gain of 1.

0000=1 times; 0001=2 times; 0010=8 times; 0011=16 times;

(Note: The maximum differential voltage of the input channel is ±0.7V, which refers to a gain of 1. If a gain of 16 is used, the input channel

The maximum differential voltage is ±43.75mV)

Address	Name	external Read/Write	Inside Read/Write	Bit width	default value	description
60	GAIN1	R/W	R	24	0x000000	Channel PGA gain adjustment register, [3:0]->Channel 11 (voltage); [7:4]->Channel 1;[8:11]->Channel 2; . . .
61	GAIN2	R/W	R	20	0x00000	Channel PGA gain adjustment register, [3:0]->Channel 6; [7:4]->Channel 7; . . .

So GAIN1=0x000000; GAIN2=0x000000; just take the power-on default values.

Note: You need to write 0x5555 to the 0x9E (US_WRPROT) register before writing gain related settings!

About electrical parameter conversion

Assume that the transformation ratio of current transformer CT1 is Rt=2000 (2000:1), load resistors R1, R2 (5.1 ohms); voltage transformer (PT1)

1:1 current type voltage transformer; load resistance R46 = 100 ohms

Actual current value = Current effective value register value ÿVref / 12875ÿ _ ÿ(1+ 2)ÿ1000/   Ampere->Current coefficient Ki=~~12875ÿ _ ÿ(1+ 2)ÿ1000/~~

Actual voltage value = Voltage RMS register value ÿVrefÿ(R25+R26+R35+R36+R37) / 13162ÿ _ ÿ 46ÿ1000   Volts -> Voltage Coefficient

Kv= 13162ÿ _ ÿ 46ÿ1000 / ÿ(R25+R26+R35+R36+R37)

Actual active power value = Active power register value ÿ Vref2 ÿ (R25+R26+R35+R36+R37) / 40.4125ÿ((1+ 2)ÿ 1000)ÿ ÿR46ÿGain_Vÿ1000   Watts -> Power Factor

Kp= 40.4125ÿ((1+ 2)ÿ 1000)ÿ ÿ 46ÿ _ ÿ1000 / 2ÿ(R25+R26+R35+R36+R37)

The CF_CNT register stores the number of energy pulses;

The amount of electricity corresponding to each energy pulse = $\frac{4194304ÿ0.032768ÿ16}{3600000ÿ \quad ÿ}$ Every time

The unit of R1, R2, R46 is ohm, the unit of R25, R26, R35, R36, R37 is K ohm; Vref = 1.097 volts; CFDIV = 16;

For the setting of active power anti-creep threshold, refer to the description of resistance sampling method;

Grid frequency conversion

BL0910 Grid frequency measurement via voltage measurement channel signal

Address Name		external Read/Write	internal Read/Write	Bit Width	Default Value Description	
4E PERIOD	RW 20 0x000000 Line	voltage frequency	period register			

Grid frequency = $\frac{10000000}{\quad}$ Hz

DC energy measurement

Set the DC measurement mode

BL0910 supports DC signal measurement. If you want to measure DC power, you need to set the registers during power-on initialization. The setting steps are as follows:

as follows:

1) Write 0x5555 to the USR_WRPROT register to allow operation of user registers.

MODE1 Register

0x96	MODE1	Working Mode Register	
No.	name	default value	description
[10:0]	WAVE_SEL	11{1'b0}	Active waveform selection: 0-select high pass, full wave, 1-select low pass 2, DC; (V, I10, I9, ... I1)
[21:11]	WAVEF_SEL	11{1'b0}	Active waveform selection: 0-select low pass 1, fundamental wave, 1-select low pass 2, DC; (V, I10, I9, ... I1)
[22]	L_F_SEL	1'b0	Leakage selects high pass, the default is 0 Select no high pass, 1 Choose Qualcomm
[23]	WAVE_REG_SHE	1'b0	Current WAVE waveform register output selection, default 0 selects positive The waveform of the constant current channel is 1, and the waveform output of the leakage channel is selected

Select DC for active waveform, and set MODE1[10:0] to 1;

2) MODE1 register is written to 0x0007FF;

MODE2 Register

0x97	MODE2	Working Mode Register	
No.	name	default value	description

[21:0] WAVE_RMS_SEL 11{2'b00}			Effective value waveform selection, 00-high pass, 10-DC, 01-select fundamental wave, 11-select Select sinc output; (V, I10, I9, ... I1)
[22] RMS_UPDATE_SEL		1'b0	Slow effective value register update speed selection, 0b1 is 1.05s, 0b0 is 525ms, 525ms is selected by default;
[23]	AC_FREQ_SEL	1'b0	AC frequency selection, 0b1 is 60Hz, 0b0 is 50Hz, default Select 50Hz

The effective value waveform selects DC,

3) Write 0x2AAAAA to the MODE2 register;

At this time, the chip switches to DC measurement mode.

DC bias correction

Since BL0910 does not have high voltage isolation inside, it can only be measured on the low side of DC ground. If the DC bias needs to be corrected,

It is performed when there is no signal in the channel (zero signal input).

1) Read the corresponding effective value register value RMS[N];

2) Calculate the corresponding CHOS register value based on the effective value register value

CHOS[N]=RMS[N]/2ÿ

Note that since the effective value register is an unsigned number, it is not possible to determine whether the offset value is positive or negative. There are two ways to determine the sign:

kind:

A. If the RMS[N] read out after adjustment by CHOS[N] becomes larger, then the offset value is positive; the CHOS register to be written

value = 65535-RMS[N]/2;

B. You can also read the waveform register value and determine the actual sign of the effective value register based on its sign. If the sign is positive,

CHOS[N]= 65535-RMS[N]/2; if the sign is negative, CHOS[N]= RMS[N]/2;

(Note: The effective value correction range of the CHOS register is -65534~65534. Values beyond the compensation range cannot be corrected.)

Address Name		external Read/Write	internal Read/Write	Bit width def	ault value description	
AB	FOOT[1]	R/W	R	16	0x0000	Corresponding channel offset adjustment register, complement
AC	FOOT[2]	R/W	R	16	0x0000	Corresponding channel offset adjustment register, complement
HAT COS[3]		R/W	R	16	0x0000	Corresponding channel offset adjustment register, complement
BUT	FOOT [4]	R/W	R	16	0x0000	Corresponding channel offset adjustment register, complement
OF	FOOT[5]	R/W	R	16	0x0000	Corresponding channel offset adjustment register, complement
B0	FOOT [6]	R/W	R	16	0x0000	Corresponding channel offset adjustment register, complement
B1	FOOT [7]	R/W	R	16	0x0000	Corresponding channel offset adjustment register, complement
B2	FOOT [8]	R/W	R	16	0x0000	Corresponding channel offset adjustment register, complement
B3	FOOT [9]	R/W	R	16	0x0000	Corresponding channel offset adjustment register, complement
B4	FOOT [10]	R/W	R	16	0x0000	Corresponding channel offset adjustment register, complement

B5	FOOT [11]	R/W	R	16	0x0000	Corresponding channel offset adjustment register, complement

PCB Design Considerations

When wiring the PCB, please note:

1) The resistor and capacitor of current sampling should be as close to the BL0910 pin as possible to prevent the lead from being too long and other signal lines on the PCB board.

interference;

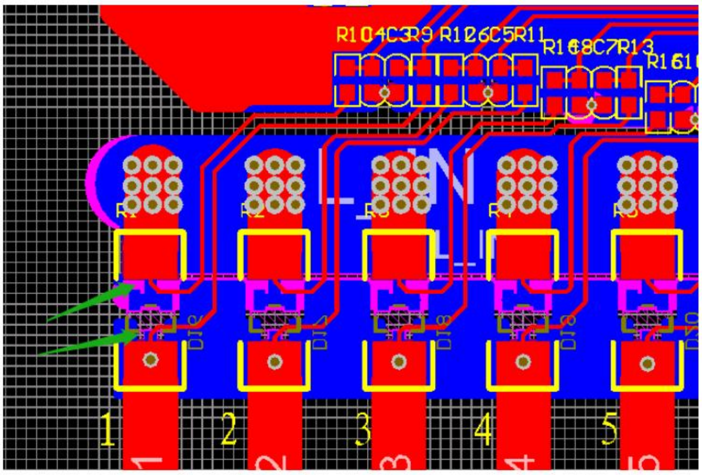
2) To reduce interference to the current sampling signal, the ground wire of the sampling resistor is separated from the power ground (refer to R1 in the following layout).

The current channel is differential sampling, the signal lines of IP and IN are parallel and close, and the lines on the PCB board are as close as possible.

The external circuit parameters of current sampling IP and IN should be balanced as much as possible.

3) When using the resistor sampling method, if a chip sampling resistor is used, the current sampling line will be connected from the inside of the resistor pad;

Channel filter circuit 1K, 33nF during AC sampling;



When measuring DC, the channel filter circuit needs to be modified. The following figure is the schematic diagram and PCB layout of a channel for design reference.

(Channel filter resistor changed from 1K to 100 ohms (1% 25ppm))

4) In the resistor sampling mode, since the load current flows through the sampling resistor, it is necessary to pay attention to the maximum possible load current.

To tens of amperes, the traces connecting the sampling resistor on the PCB board should be as thick as possible (high current star traces or copper busbars);

5) Avoid using single-ended sampling wiring method.

6ÿ The 3.3V decoupling capacitor C40 of BL0910 power supply should be as close to the chip VDD pin as possible; DVDD1.8V, Vref is externally connected

The decoupling capacitors C41 and C42 should be as close to the chip pins as possible;

7) Unused measurement channels can be turned off via the ADC enable control register ADC_PD (0x93).

Attached calibration method:

If the sampling element has poor accuracy or needs to be accurate to within 1%, calibration can be performed using the standard signal comparison method;

Taking current as an example, add the standard load current, the corresponding current effective value register value is I_RMS0.

The above formula can calculate the corresponding current register standard value I_RMS1;

Then the deviation Err = 0ÿ _ 1 / _ 1

There are two ways to calibrate

1) Write the calibration parameters to the corresponding channel gain register (CHGN[X]);

If Err is negative, then [ ] = 2 16 ÿ / 1+

If Err is positive, then [ ] = 2 16 + 2 16 ÿ / 1+

2) Adjust the resistance parameters in the formula to correct the conversion coefficient;

RL Correction = (1-Err)*RL

If the small signal bias needs to be compensated, apply the small signal current under the premise of standard load current correction.

Write value correction to the corresponding small signal bias register.

Reference: BL0910_Datasheet_Vx.x.pdf

DC two-point calibration: Y=KX+B;

Add two sets of signals separately, for example

1) 48V, 10A; read the voltage register value V_RMS1 and the current register value I_RMS1 at this time; calculate the corresponding

The voltage register value standard value V_RSM1_S, the current register standard value I_RMS1_S;

2) 10V, 0.5A; read the voltage register value V_RMS2 and the current register value I_RMS2 at this time; calculate the corresponding

The voltage register value standard value V_RSM2_S, the current register standard value I_RMS2_S;

3) Take voltage as an example:

(_Bias compensation formula: = 2_ ÿ _ 1ÿ _ 1_ ÿ _ 2) / (_ 1ÿ _ 2)

If B>=0, then write B/2 to the CHOS[X] register;

If B<0, then write 2^16+B/2 to the CHOS[X] register

Gain compensation formula: = _ 1_ ÿ / _ 1

If (1-K)>=0, then write 2^16+2^16*(K-1)/(2-K) into the CHGN[X] register;

If (1-K) < 0; then write 2^16*(K-1)/(2-K) to the CHGN[X] register;

Current is calibrated in a similar manner.

Note: When calibrating, please first confirm that the CHGN[X] and CHOS[X] register values are 0x000000;