BL6552 Application Guide

Table of contents

1. Introduction

BL6552 is a high-precision three-phase multi-function energy metering chip, suitable for three-phase three-wire and three-phase four-wire multi-function energy meter applications. It integrates seven high-precision Sigma-Delta ADCs, reference voltage circuits and other analog circuit modules, and Digital signal processing circuit for processing power, effective value, energy and other electrical parameters. Capable of measuring active power and energy, reactive power and energy, apparent power and energy, effective value of current of each phase, power factor, effective value of voltage and other parameters of each phase and combined phase of three phases; with loss of voltage and overvoltage monitoring function ; Current and voltage peak detection; zero-crossing detection and other power quality management, which can give real-time waveforms; can fully meet the needs of three-phase multi-function electric energy meters.

BL6552 integrates an SPI/UART interface to facilitate the transfer of measurement parameters and calibration parameters with an external MCU; it supports full digital domain input gain adjustment, phase calibration (±0.574° adjustable), gain adjustment of each channel, active power/ Reactive/apparent power calibration, effective value calibration, etc.; can directly output active energy CF1, reactive energy CF2 signals in pulse form, and directly connect to standard meters for active and reactive power error correction; internal data flow calculation method processing Various signals have good reliability in the case of external interference. The internal voltage monitoring circuit can ensure normal operation during power-up and power-off.

Figure 1 shows the block diagram of the BL6552 system.

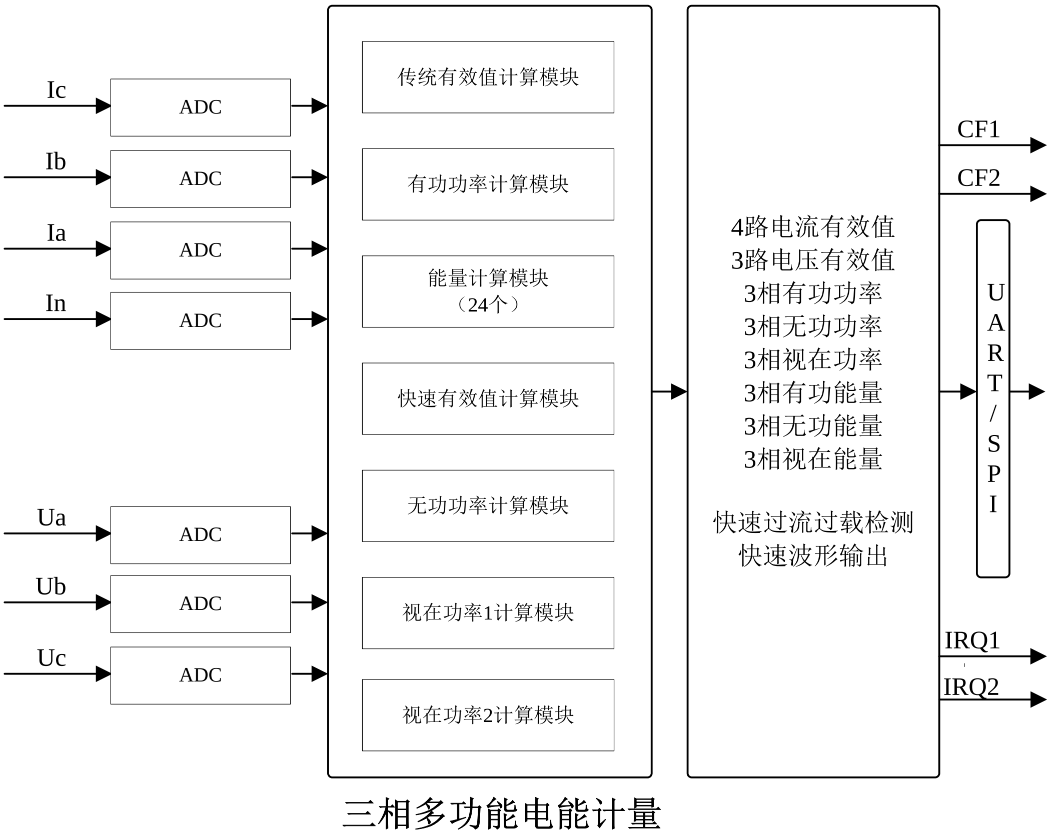


Figure 1. BL6552 system block diagram

2. Hardware design

2.1 Power circuit

Figure 2 is a design diagram of a three-phase power supply:

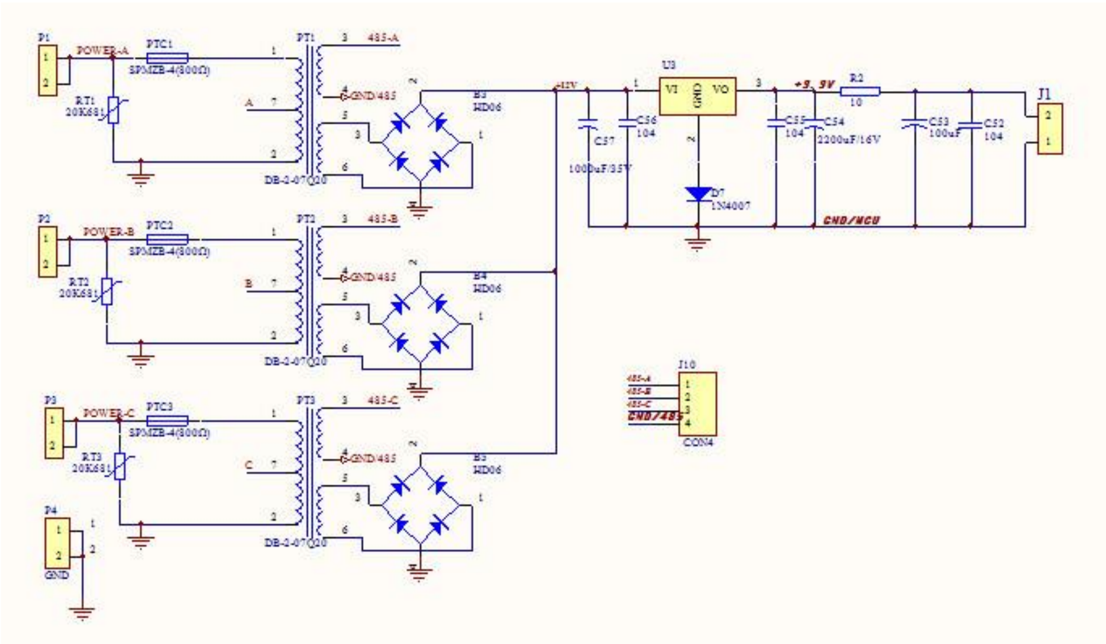


Figure 2. Three-phase power supply diagram

The design of the power circuit is particularly important to the performance of the meter. In order to improve the anti-interference and reliability of the system, it is divided into two independent power supplies, so that RS485 communication and MCU and other power supplies are isolated from each other to achieve the purpose of not affecting each other. Pay attention to the selection of transformer parameters.

Three transformers are used to ensure that the meter can still work normally in the case of a phase failure (and one-phase power supply). In order to ensure good electromagnetic compatibility, please pay attention to the following points：

1、The power supply voltage VCC and AVCC should be within 10% of 3.3V.

2、GND and AGND are the reference points for digital and analog power supplies. Digital ground and analog ground should be connected together in a large area on the PCB. Do not distinguish between analog ground and digital ground, and do not connect inductors, resistors and other devices between the two grounds. Do not spread the large area before the rectifier components.

3、Decoupling resistor R2 and capacitors C53, C52 are close to the analog part of the IC to ensure a better filtering effect.

4、The 3 transformers should be placed as far away as possible from the metering part to reduce their impact on metering.

2.2 Metering circuit

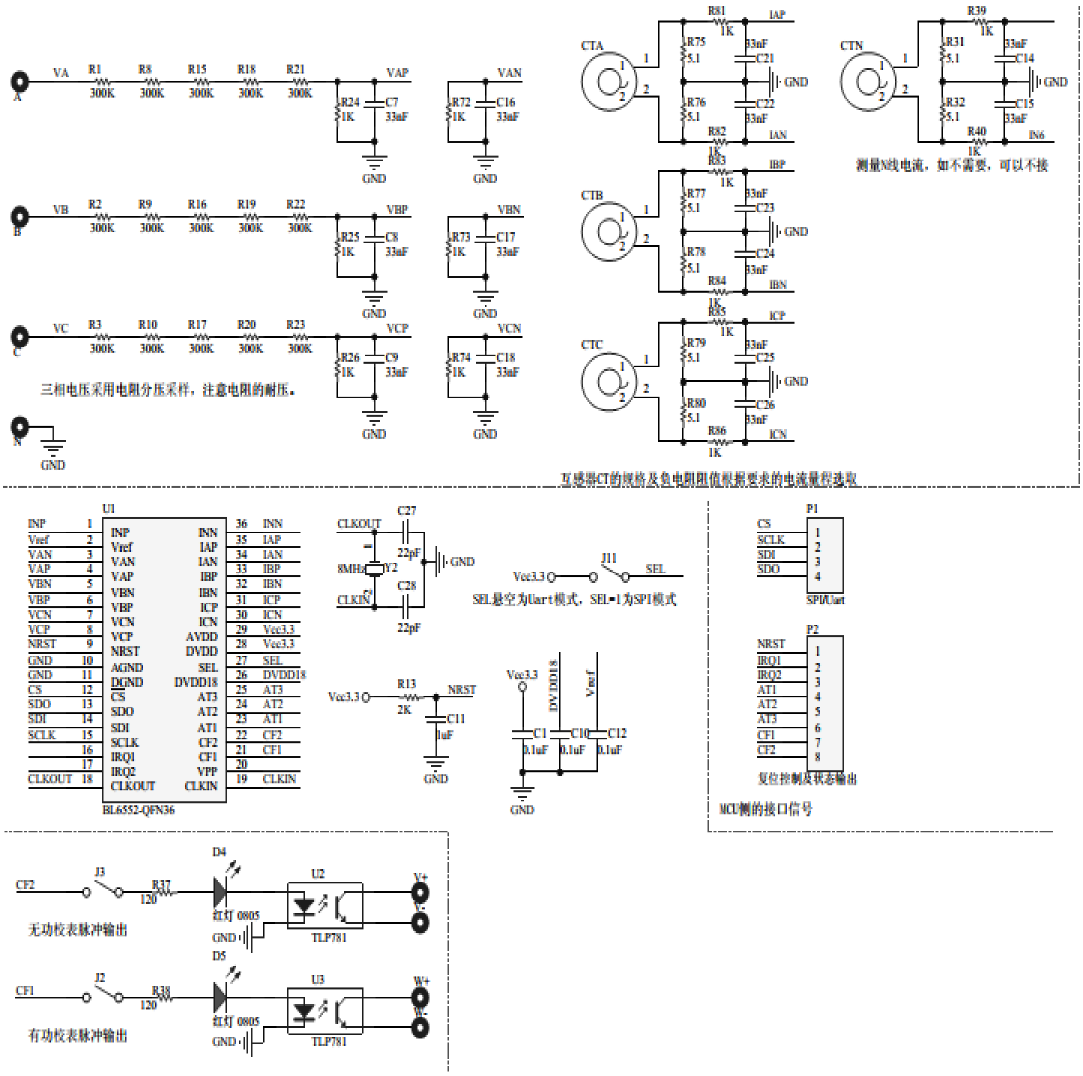


Figure 3. Metering sampling circuit

Description:

1、Voltage channel full-scale input ±0.7V (495mV rms), it is recommended that the chip pin input voltage is less than 200mV rms at Un voltage, and the voltage channel gain is set to 1 times;

2、The full amplitude input of the current channel is ±0.7V (495mV rms), taking 5 (30A) as an example, using a 1000:1 current transformer and a load resistance of 5.1 ohm*2, then the signal of the current input pin at the standard current Ib is about 51mV rms, current channel gain is set to 1 time;

3、The SPI communication cable should be short, and the surroundings should be wrapped with a ground wire, otherwise, the SPI transmission signal line may be interfered. You can connect a 10 ohm resistor in series with the SPI signal line and a coupling capacitor near the IC input to form a low-pass filter, which can eliminate high-frequency interference from the received signal.

4、In order to reset BL6552 reliably when powered on, it is necessary to connect a 1uF capacitor to the NRST pin of BL6552 and use a 2K resistor to pull up to the power supply to ensure effective reset of BL6552. If possible, the NRST pin of BL6552 can be controlled by the MCU pin.

5、When voltage sampling adopts resistor string divider, the last series resistor of each phase voltage sampling resistor string must be placed near the capacitor side, near the chip pin.

6、The 3 transformers of the power supply part should be placed as far away as possible from the metering part to reduce their impact on the metering.

3. Software design

3.1 Communication Interface

3.1.1 SPI communication

The communication rate of BL6552 can reach up to 1.5M bps.

The SPI interface communication data frame is fixed at 8 bytes, and the data byte is fixed at 3 bytes. For register data less than 3 bytes, the bits are not used during communication and 0 is added to make up to 3 bytes to send; the last byte is the correction Check and byte.

3.1.2 Uart communication

The Uart communication rate of BL6552 can be set through the pins, 4800/9600/19200/38400bps; For specific timing and protocol analysis, please refer to the "Communication Interface" chapter of the BL6552 data manual.

3.2 Measurement parameters

3.2.1 Features

All measured values of BL6552 can be read from the metering parameter register, and the data update time is configurable. These parameters include: power (including full-wave active power, reactive power, and apparent power, among which are divided into phases and combined phases). Value), current, voltage, line voltage frequency and power factor, etc.

Power is a signed quantity. All active and reactive power have directions. They are stored in the register in the form of complements. The highest bit of the data indicates the direction of the power, 0 indicates the forward direction, and 1 indicates the reverse direction. The combined phase power is the algebraic and/absolute sum of the power of each phase. When choosing algebra and mode, use the direction of combined active power and reactive power to make four-quadrant power measurement. BL6552 has specially set the power direction change permission indication (see MASK2) and the power direction change indication register (see STATUS2), which integrates the active and reactive power direction changes of each phase and the combined phase, which is convenient for users to use.

BL6552 has a line voltage drop detection function. The logic output pins AT1~AT3 can be configured to output various event states; IRQ1 and IRQ2 interrupt output pins can be configured to output interrupt events; ;

BL6552 can be indicated by programming. When the effective value of the line voltage is lower than a certain peak value for more than a certain number of half cycles, it will give an indication of the line voltage drop.

BL6552 can be programmed to set the current and voltage RMS peak threshold, which is set by the peak threshold register (I_PKLVL, V_PKLVL).

3.2.2 Initialization instructions for metering chip

BL6552 needs to be initialized after power-on, the main sequence and content are as follows:

1）Reset the control of the NRST pin, pull it low for 10ms, then pull it up to high for 2ms

2）Turn on write protection and write data sequentially:

Register address	Register data
0x9E	0x005555
0xE1	0x000950
0xDD	0x000D82

Confirm that the write protection is turned on successfully.

3）Initialize the simulation parameters of chip work

Register address	Register data
0xE7	0x000003
0xD1	0x0037C0
0xD2	0x000000
0xD3	0x000000
0xD4	0x001010
0xD5	0x007B40
0xD6	0x00000C
0xD7	0x006B1F
0xD8	0x000012

0xD9	0x000030
0xDA	0x000005
0x93	0x0000C3

4）Set the working mode, channel gain, etc. according to the design parameters of the whole machine;

Register address	Register name
0x60	GAIN1
0x61	GAIN2
0xCE	CFDIV
0x96	MODE1
0x97	MODE2
0x98	MODE3
0x88	VAR_CREEP/WA_CREEP

Typical value of main registers:

GAIN1: 0x000000 1 times gain for each channel

GAIN2: 0x000000

MODE3: 0x011200 Full-wave reactive power, combined phase pulse output, CF enable, absolute energy accumulation method

VAR_CREEP/WA_CREEP is set according to the actual situation and phenotype;;

CFDIV is configured according to the table constant; for example, 1600 constant, CFDIV=0x10;

5）Load calibration parameters

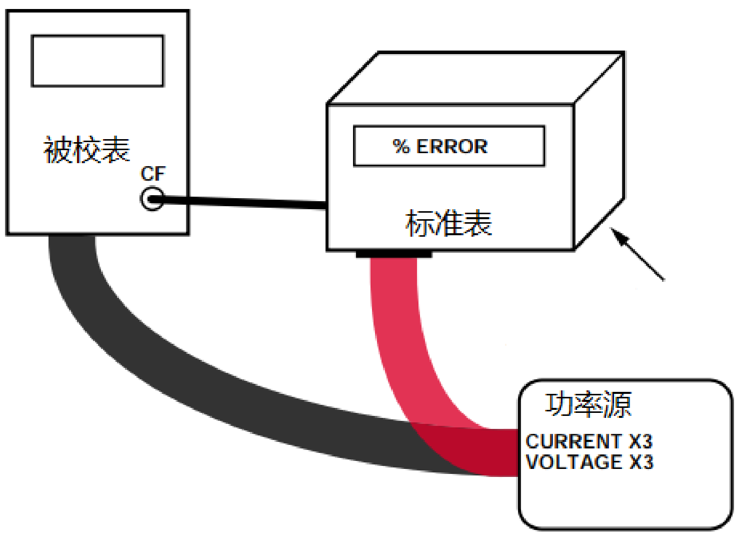
Initialize the relevant registers according to the calibration data obtained during the calibration process;

Then initialize the channel gain register, then initialize the calibration registers of each phase, and finally initialize the reactive power creep control register, CFDIV, MODE3, MODE2, MODE1 and other registers;

6）Write protection is turned off, write sequentially: 0xDD register write 0x000000; 0xE1 register write 0x000000; turn off write protection.

3.3 Calibration method

In order to ensure the measurement accuracy of the whole machine and eliminate the difference caused by external components and chip reference voltage, each electric meter needs to be calibrated. Generally, special calibration equipment is required for calibration work.



The conventional calibration method uses a standard meter to determine the required compensation parameters. This method requires the use of CF1 and CF2 output. The standard meter determines the error Err based on the CF pulse.

Take the three-phase four-wire watt-hour meter, the overall parameters of 220V 5 (30A) 1600imp/kWh as an example to illustrate:

Nominal voltage Un = 220V, rated current In=5A, maximum current Imax=30A; the meter constant is 1600; the hardware circuit diagram is shown in section 2.2 Metering Circuit

Err is the percentage error output by the calibration equipment;

A typical calibration procedure generally requires three steps

Calibration	voltage	current	power factor

procedure			
Gain calibration	Nominal voltage Un	Rated current In	1.0
Phase calibration	Nominal voltage Un	Rated current In	0.5L
Offset calibration	Nominal voltage Un	Minimum current with accuracy requirement 5%In	1.0

The following calibration is carried out under the condition that the content of the corresponding calibration register is zero, for the reference of designers.

3.3.1 Active Power

（一） Under rated current In, nominal voltage Un

Register 0xCE: Calibrating CF pulse output frequency (CFDIV, different bits are 1 to control CF pulse output of different frequencies, the larger the value, the faster the frequency.) When the meter constant of the typical application circuit is 1600, set it to 0x10 (16);

Register 0x98: Bit[13:10]=0100 of the working mode (MODE3) register, Bit[9]=1 to allow the active CF1 pin and reactive CF2 pin to output the corresponding combined pulse;

Calibrate each phase one by one;

① Under power factor 1.0

Adjustment method: Ua, Ub, Uc three-phase plus nominal voltage Un, current Ia, Ib, Ic only one-phase rated current In, according to the added current channel, adjust the corresponding current channel register 0xA3 (IA_CHGN), 0xA2 (IB_CHGN)), 0xA1 (IC_CHGN) value,

Calculate the calibration value according to the error reading Err of the standard meter:

X_CHGN= -Err*65536/(1+Err) ;   when Err<0;

X_CHGN= 65536-Err*65536/(1+Err) ;   when Error>0.

② Under power factor 0.5L

Adjust the phase delay caused by current transformer, capacitance, resistance difference and PCB trace:

Calculate the calibration value according to the error reading Err of the standard meter

X_PHCAL=|Err|/0.000136

When Err>0, write the corresponding current channel angle difference correction register 0x64 (IA_PHCAL), 0x65 (IB_PHCAL), 0x66 (IC_PHCAL);

When Err<0, write the corresponding voltage channel angle difference correction register 0x67 (VA_PHCAL), 0x68 (VB_PHCAL), 0x69 (VC_PHCAL)；

Note: BL6552 supports phase segment compensation. If segmentation is not needed, then the three compensations [23:16], [15:8], and [7:0] of the angle difference correction register are all written with the same compensation value. The entire measurement interval is phase compensated according to this compensation value.

（二） Small signal adjustment under the condition of 5%In current, nominal voltage Un, and power factor 1.0

According to the error reading Err of the standard meter, calculate the compensation value for active small signal compensation:

WATTOS_X=WATT_X*2*（-Err）/（1+Err）； when Err<0；

WATTOS_X=65536 + WATT_X*2*（-Err）/（1+Err）； when Err>0；

WATT_X is the active power register value when the corresponding split phase is at 5% In, Un, 1.0；

0xC2 is the A phase active power small signal compensation register WATTOS_A；

0xC3 is the B-phase active small signal compensation register WATTOS_B；

0xC4 is the C phase active small signal compensation register WATTOS_C.

Register 0x88: The split-phase active anti-creep threshold value of the direct-connected meter WA_CREEP = (WATT_A*2‰)/2;

3.3.2 Reactive Power

Generally, after the active power error is adjusted, the reactive power error is basically automatically adjusted. If the reactive power error of each phase needs to be fine-tuned, the values of registers 0xB9 (VARGN_A), 0xBA (VARGN_B) and 0xBB (VARGN_C) can be adjusted. The adjustment value is the same as the active power error adjustment, which can be obtained by the formula -Err*65536/(1+Err).

Small signal compensation, the method is the same as active small signal compensation.

0xC5 is the phase A reactive power small signal compensation register VAROS_A; 0xC6 is the phase B reactive power small signal compensation register VAROS_B; 0xC7 is the phase C reactive power small signal compensation register VAROS_C.

3.3.3 Apparent Power

After the active power error is adjusted, the apparent power error is usually automatically adjusted, but in reality, only small signal error adjustment is enough.

Register 0x8A: RMS small signal threshold (REVP_CREEP/RMS_CREEP), when no current signal is applied, the current RMS registers 0x0F (IA_RMS), 0x0E (IB_RMS) and 0x0D (IC_RMS) are set to 0.

The apparent power error small signal adjustment method is similar to the active small signal adjustment, but the adjustment register uses 0xCB (VAOS_A), 0xCC (VAOS_B) and 0xCD (VAOS_C).

3.4 Electric parameter calculation method

Power factor calculation: The data of the power factor register is a 24-bit signed number, and the highest bit is the sign bit. When the highest bit of the reading is 1, the sign is negative, and the 24-bit valid data of the register reading needs to be inverted and added by 1 . Divide the restored data by 223 to get the actual power factor value.

Calculation of line voltage frequency: refer to the "Line Frequency Measurement" chapter of BL6552 data manual;

The calculation of power, current, and voltage is to take out the register reading (that is, the register reading is a binary number. When the power register value is at the highest digit of the reading, the register reading needs to be reversed and added to the operation. When the highest digit of the reading is 0, The reading itself is the original code) and then calculated with the corresponding coefficient K, the calculation formula is:

Real-time parameters = Corresponding register value / Correspondence coefficient K

Among them, the method of obtaining the coefficient K required to calculate the real-time parameters above is:

After the calibration is completed, the standard signal is added to obtain the conversion coefficient:

① Under the rated current In, voltage U and PF=1.0 (add signal when the three are the same):

Read the IA_RMS of 0x0F, VA_RMS of 0x13, WATT_A of 0x22, and VA_A of 0x26 to calculate the corresponding coefficients at this time.:

A phase current effective value conversion factor IA_K=IA_RMS/In;

A phase voltage effective value conversion factor VA_K=VA_RMS/Un;

A phase active power conversion coefficient WA_A_K=WATT_A/(Un*In*PF)

A phase active power conversion coefficient VA_A_K=VA_A/(Un*In)

The correlation coefficient of B phase is also obtained IB_K、VB_K, WA_B_K, VA_B_K;

Correlation coefficient of C phase IC_K、VC_K, WA_C_K, VA_C_K;

Read the WATT value of the register value 0x25 at this time, and calculate the combined active power conversion coefficient WATT_K=WATT/(Un*In*PF*3)

Read the VA value of the register Reg29 at this time, and calculate the combined apparent power conversion coefficient VA_K=VA/(Un*In*3)

② Under the rated current Ib, voltage Un and PF=0.5L (add signal when the three are the same):

Read the VAR_A of 0x5A, VAR_B of 0x5B, and VAR_C of 0x5C at this time, and calculate the corresponding coefficients:

A phase reactive power conversion factor VAR_A_K=VAR_A/(Un*In*0.866)

B phase reactive power conversion factor VAR_B_K=VAR_B/(Un*In*0.866)

C phase reactive power conversion factor VAR_C_K=VAR_C/(Un*In*0.866)

Combined phase reactive power conversion factor VAR_K=VAR_A/(3*Un*In*0.866)

In summary, all coefficients K must be stored in EEPROM. After calibration, this coefficient K will be used as a constant coefficient for calculating real-time parameters.

Remarks: After general active power calibration, reactive power and apparent power should be basically accurate. At this time, if high-precision requirements are not required, reactive power and apparent coefficients can be related to active power. Then step ② can be omitted.

3.5 Energy calculation

BL6552 has fast pulse output of active energy and reactive energy (programmable adjustment of the frequency of pulse output), and the meter can calculate active and reactive energy by calculating pulses.

For BL6552, energy can also be calculated by reading the register. BL6552 provides pulse counts of active, reactive, and apparent energy. These pulse count registers respectively include total phase combined active energy, phase A, B, C positive active energy and combined positive active energy, A, B, C reverse active energy and combined reverse active energy, A, Phase B and C reactive energy and combined reactive energy, four-quadrant reactive energy, A, B, and C phase apparent energy and combined apparent energy, active line period energy, reactive line period energy, a total of 24 electric energy calculations register.

The energy pulse count register can be set to continuous accumulation or cleared after reading.

The calculation methods are:

(一) If the active and reactive energy is calculated by counting the number of pulses, the calculation can be done through the external interrupt of the MCU (capturing rising or falling edges), counting the number of pulses, and calculating the active and reactive energy.

(二) If you calculate the electric energy by reading the register, you can calculate the above-mentioned different types of electric energy values to meet the different needs of the three-phase meter.

If the continuous accumulation method is used, pay attention to handling the accumulation overflow in the software;

The first method is only suitable for calculating total active energy and total reactive energy. The total active energy of the combined phase, the positive active energy of the phases A, B, and C and the positive active energy of the combined phase, the opposite active energy of A, B, C and the opposite active energy of the combined phase, the non-functional energy of the A, B, and C phases Quantities and combined reactive energy, four-quadrant reactive energy, A, B, and C phase apparent energy and combined apparent capacity, active line cycle energy, reactive line cycle energy, all need to be done by reading the register accumulation method.

Take the example of a three-phase four-wire watt-hour meter, the overall parameters of 220V 5 (30A) 1600imp/kWh for explanation (after the calibration is completed):

The electric energy corresponding to each combined pulse count is 1/meter constant=1/1600 ℃;

The electric energy corresponding to each split-phase pulse count is 1/(table constant*4)=1/(1600*4) ℃;

3.6 Active/reactive power anti-creep threshold setting

Due to the impact of the noise floor power caused by the on-site use environment or board-level noise, the electric energy meter standard has clear requirements for the creeping and starting experiment of the electric energy meter;

1) Creeping: no current is applied to the current circuit, 115% of the reference voltage is applied to the voltage circuit, and the test output of the electric energy meter should not generate more than one pulse within the specified time limit;
2) Starting: Under the conditions of reference frequency, reference voltage and cosΦ=1 (for active energy meters) or sinΦ=1 (for reactive energy meters), the current line is energized with starting current, and electric energy within the specified time limit The meter should be able to start and record continuously. The starting current of the directly connected level 1 electric energy meter is 0.004In.

BL6552 has related registers to set the active/reactive anti-creeping threshold. Take the threshold set to 0.002In as an example;

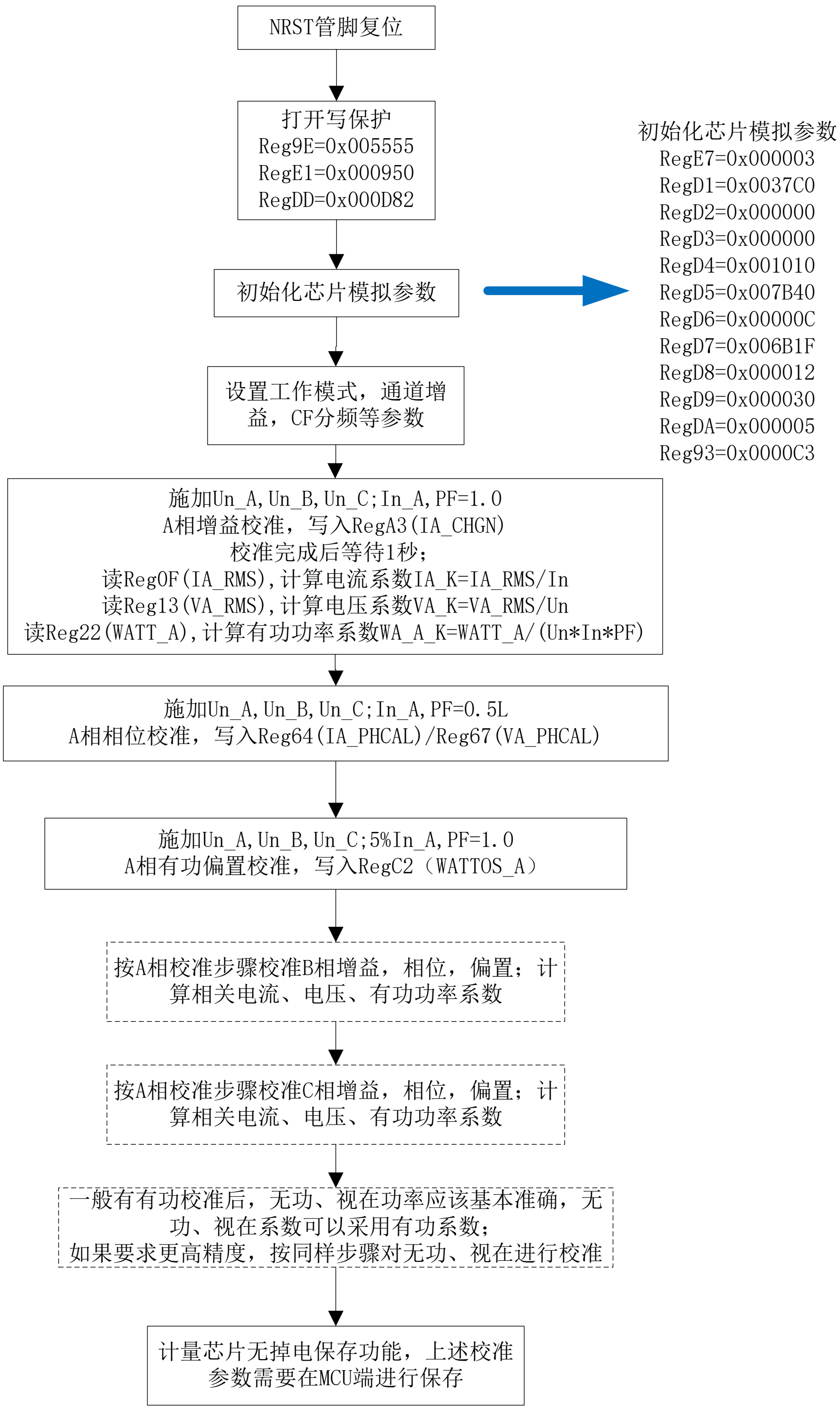
Reactive power anti-creep thresholdReg88[23:12]=(Un*In*VAR_A_K*0.002) /2;

Active power anti-creep threshold Reg88[11:0]= (Un*In*WATT_A_K*0.002) /2;

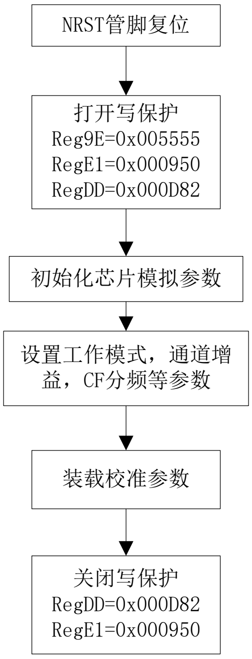
4. Software flow chart

The following process is for reference only and can be adjusted according to specific applications

BL6552校准流程



BL6552上电工作初始化



定时读取电参数