◆ FEATURES

1 High accuracy, less than 0.1% error over a dynamic range of 500 : 1

2 Exactly measure the real power in the positive orientation and negative orientation, calculate the energy in the same orientation

3 18 × 4 bit RAM for display data storage

4 Single 5V supply

The BL6533 is a low cost, high accuracy, high stability, simple peripheral circuit electrical energy meter IC. The meter based on the BL6533 is intended for using in single-phase, two-wire distribution systems.

The BL6533 adopts the oversample technology and digital signal processing technology. It can exactly measure the real power in the positive orientation and negative orientation and calculate the energy in the same orientation.
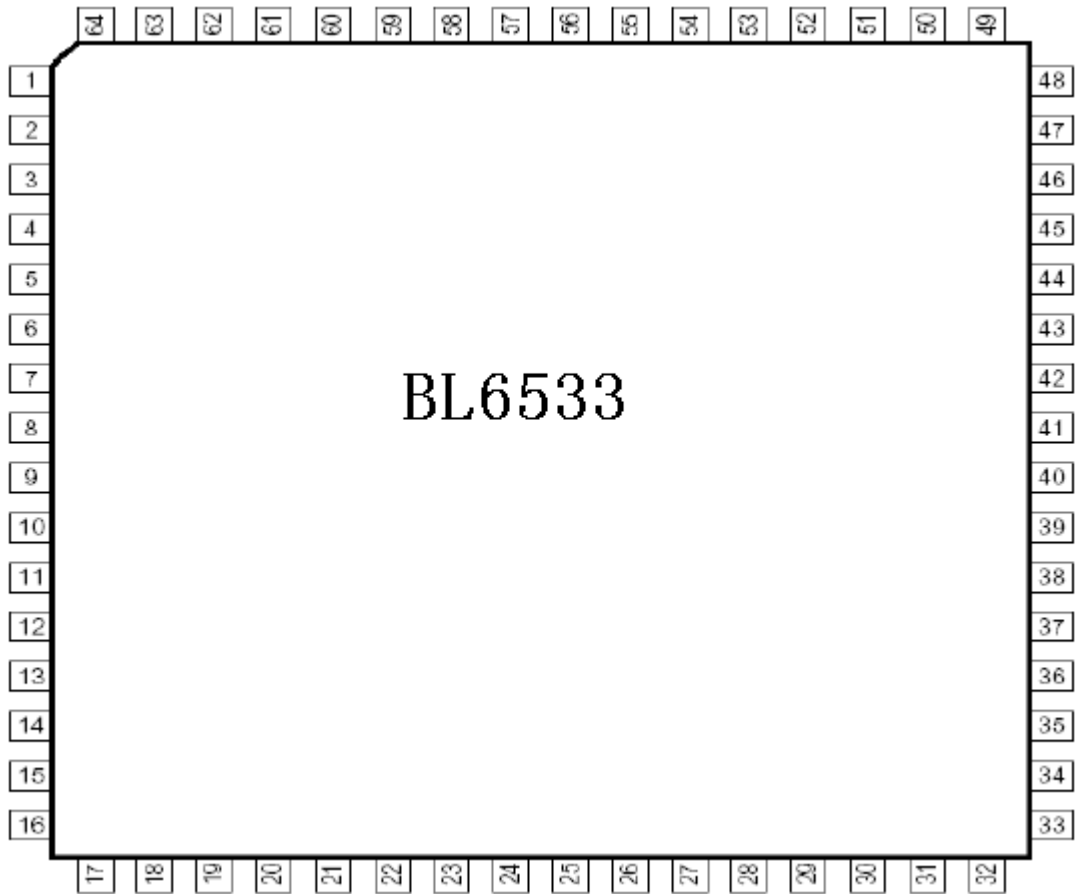
BL6533 thinks over the stability of reading error in the process of calibration.. An internal no-load threshold ensures that the BL6533 does not exhibit any creep when there is no load.

◆ BL6533   System
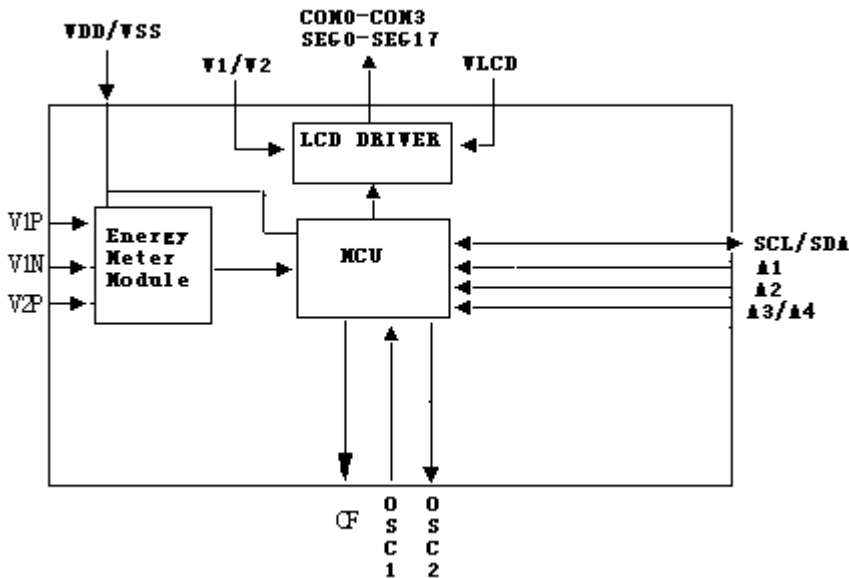
◆ **BLOCK DIAGRAM**

◆ **LQPF64**

◆ **PIN DESCRIPTIONS**

◆

Pin	Symbol	DESCRIPTIONS
1	VDD	Provides the supply voltage for the circuitry. It should be maintained at 5 V ±5% for specified operation.
2,3,4,5	NC	Unused
6,7	V1P,V1N	Inputs for Current Channel. These inputs are fully differential voltage inputs with a maximum signal level of ±660 mV
8	NC	Unused
9	V2P	Positive Inputs for Voltage Channel. These inputs provide a input. The maximum differential input voltage is 330 mV for specified operation.
10,11	NC	Unused
12	GND	Provides the ground reference for the circuitry.
13,14,15,16	NC	Unused
17	GND	Provides the ground reference for the circuitry.
18	VLCD	LCD power source
19,20	V1,V2	Earth capacity，Ameliorate LCD output waveform
21	Com0	Common terminal driving output
22	Com1	Common terminal driving output
23	Com2	Common terminal driving output
24	Com3	Common terminal driving output
25	Seg17	Segment terminal driving output
26	Seg16	Segment terminal driving output
27	Seg15	Segment terminal driving output
28	Seg14	Segment terminal driving output
29	Seg13	Segment terminal driving output
30	Seg12	Segment terminal driving output
31	Seg11	Segment terminal driving output
32	Seg10	Segment terminal driving output
33,34	NC	Unused
35	Seg9	Segment terminal driving output
36	Seg8	Segment terminal driving output
37	Seg7	Segment terminal driving output
38	Seg6	Segment terminal driving output
39	Seg5	Segment terminal driving output
40	Seg4	Segment terminal driving output
41	Seg3	Segment terminal driving output

42	Seg2	Segment terminal driving output		
43	Seg1	Segment terminal driving output		
44	Seg0	Segment terminal driving output		
46,46	NC	Unused		
47	VDD	Provides the supply voltage for the circuitry. It should be maintained at 5 V ±5% for specified operation.		
48	OSC2	Oscillator crystal on		
49	OSC1	Oscillator crystal in		
50	VPP	Reset to the device		
51	A1	Reset computation setting: High Voltage: clear Low Voltage: keep		
52	SCL	IIC Serial Clock Output		
53	SDA	IIC Serial Data		
54	CF	Calibration Frequency. The CF logic output gives instantaneous real power information.		
55	A2	Decimal digits setting: High Voltage: Twain decimal digits Low Voltage: one decimal digits		
56,57,58	NC	Unused		
59	A3	A3	A4	Pulse constant
60	A4	0	0	3200 imp/kwh
		0	1	800 imp/kwh
		1	0	1600 imp/kwh
		1	1	6400 imp/kwh
61,62,63,64	NC	Unused		

电性能参数

极限参数

Parameter	Symbol	Value	Unit
Analog &Digital power Voltage VDD	V_{DD}	$V_{SS}-0.3$ to $V_{SS}+6.5$	V
Analog Input Voltage	V_I	$V_{SS}-0.3$ to $V_{DD}+0.3$	V
Operating Temperature Range	T_A	-40 to $+75$	℃
Storage Temperature Range	T_S	-50 to $+125$	℃
Power Dissipation		400	mW

ABSOLUTE MAXIMUM RATINGS

(T_A=25℃ VDD=5.0V)

Parameter	Symbol	Test Condition	Min Value	Typical Value	Max Value	Unit
1. Power Current	V_{DD}	–	4.7	–	5.5	V
2.LCD POWER	V_{LCD}	–	2.7	–	5.5	V
3. Input High Voltage 1	V_{IH1}	Input Pin	$0.7V_{DD}$	–	V_{DD}	V
Input Low Voltage 1	V_{IL1}	Input Pin	0	–	$0.3V_{DD}$	V
4. Input High Voltage 2	V_{IH2}	RES	$0.9V_{DD}$	–	V_{DD}	V
Input Low Voltage 2	V_{IL2}	RES	0	–	$0.4V_{DD}$	V
5. Analog Input Pins V1P,V1N V2P		Pin6,7, 9				
Maximum Input Voltage	V_{AIN}				±1	V
DC Input Impedance				330		Kohm
Input Capacitance			6		10	pF
6. dynamic current	I_{DD}	4MHz, No load	–	7	10	mA

◆ **TERMINOLOGY**

1) Measurement Error

The error associated with the energy measurement made by the BL6533 is defined by the following formula:

$$Pencentage\ Error = \frac{Energy\ Re\,gistered\ by\ the\ BL6533 - True\ Energy}{True\ Energy} \times 100\%$$

2) Nonlinear Error

The Nonlinear Error is defined by the following formula:

eNL% = [(Error at X-Error at Ib) / (1+Error at Ib)]*100%

When V(v)= ±110mV, cosφ=1, over the arrange of 5%Ib to 800%Ib, the nonlinear error should be less than 0.1%.

3) Positive And Negative Real Power Error

When the positive real power and the negative real power is equal, and V(v) =±110mV, the test current is Ib, then the positive and negative real power error can be achieved by the following formula:

eNP%=|[(eN%-eP%)/(1+eP%)]*100%|

Where: eP% is the Positive Real Power Error, eN% is the Negative Real Power Error.

4) Power Supply Monitor

BL6533has the on-chip Power Supply monitoring The BL6533 will remain in a reset condition until the supply voltage on VDD reaches 4 V. If the supply falls below 4 V, the BL6533 will also be reset and no pulses will be issued on CF.

◆ **THEORY OF OPERATION**

◆ **Principle of Energy Measure**

In energy measure, the power information varying with time is calculated by a direct multiplication of the voltage signal and the current signal. Assume that the current signal and the voltage signal are cosine functions; Umax, Imax are the peak values of the voltage signal and the current signal; ω is the angle frequency of the input signals; the phase difference between the current signal and the voltage signal is expressed as Φ. Then the power is given as follows:

$$p(t) = U_{\max} \cos(wt) \times I_{\max} \cos(wt + \varphi)$$

If $\Phi = 0$:

$$p(t) = \frac{U_{\max} I_{\max}}{2} [1 + \cos(2wt)]$$

If $\Phi \neq 0$:

$$
\begin{aligned}
p(t) &= U_{\max} \cos(\omega t) \times I_{\max} \cos(\omega t + \Phi) \\
&= U_{\max} \cos(\omega t) \times [I_{\max} \cos(\omega t) \cos(\Phi) + I_{\max} \sin(\omega t) \sin(\Phi)] \\
&= \frac{U_{\max} I_{\max}}{2} [1 + \cos(2\omega t)] \cos(\Phi) + U_{\max} I_{\max} \cos(\omega t) \sin(\omega t) \sin(\Phi) \\
&= \frac{U_{\max} I_{\max}}{2} [1 + \cos(2\omega t)] \cos(\Phi) + \frac{U_{\max} I_{\max}}{2} \sin(2\omega t) \sin(\Phi) \\
&= \frac{U_{\max} I_{\max}}{2} \cos(\Phi) + \frac{U_{\max} I_{\max}}{2} [\cos(2\omega t) \cos(\Phi) + \sin(2\omega t) \sin(\Phi)] \\
&= \frac{U_{\max} I_{\max}}{2} \cos(\Phi) + \frac{U_{\max} I_{\max}}{2} \cos(2\omega t + \Phi)
\end{aligned}
$$

P(t) is called as the instantaneous power signal. The ideal p(t) consists of the dc component and ac component whose frequency is 2 ω. The dc component is called as the average active power, that is:

$$P = \frac{U_{\max} I_{\max}}{2} \cos(\varphi)$$

The average active power is related to the cosine value of the phase difference between the voltage signal and the current signal. This cosine value is called as Power Factor (PF) of the two channel signals.
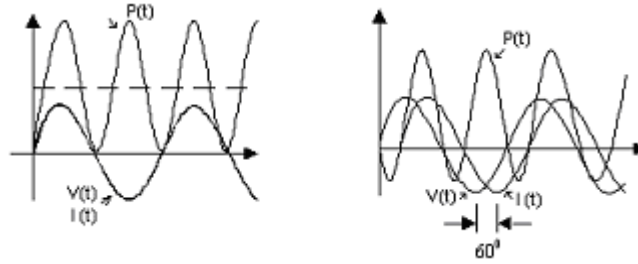

Figure1.   The Effect of phase

When the signal phase difference between the voltage and current channels is more than 90°, the average active power is negative. It indicates the user is using the electrical energy reversely.

◆   **Operation Process**

In BL6533, the two ADCs digitize the voltage signals from the current and voltage transducers. These ADCs are 16-bit second order sigma-delta with an oversampling rate of 900 kHz. This analog input structure greatly simplifies transducer interfacing by providing a wide dynamic range for direct connection to the transducer and also simplifying the antialiasing filter design. A programmable gain stage in the current channel further facilitates easy transducer interfacing. A high pass filter in the current channel removes any dc component from the current signal. This eliminates any inaccuracies in the real power calculation due to offsets in the voltage or current signals.

The real power calculation is derived from the instantaneous power signal. The instantaneous power signal is generated by a direct multiplication of the current and voltage signals. In order to extract the real power component (i.e., the dc component), the instantaneous power signal is low-pass filtered. Figure 2 illustrates the instantaneous real power signal and shows how the real power information can be extracted by low-pass filtering the instantaneous power signal. This scheme correctly calculates real power for nonsinusoidal current and voltage waveforms at all power factors. All signal processing is carried out in the digital domain for superior stability over temperature and time.
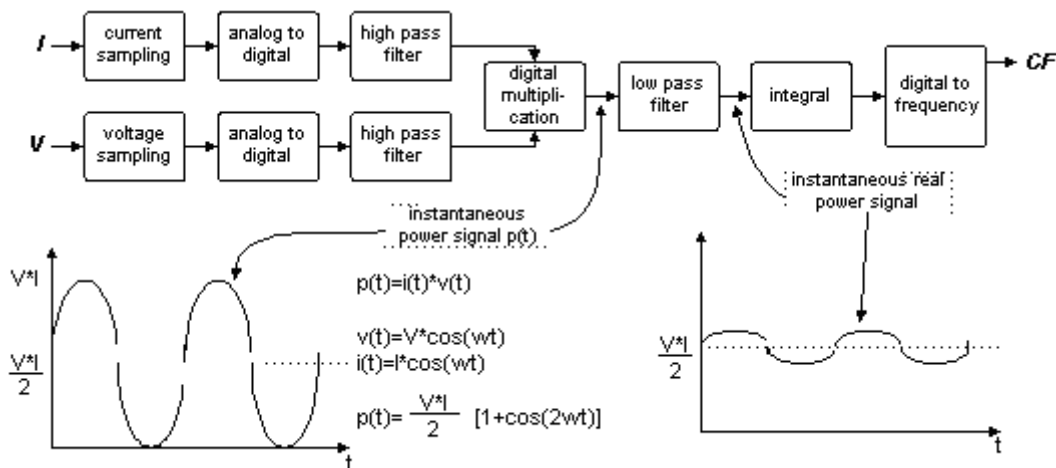

$p(t)=i(t)*v(t)$

$v(t)=V*\cos(wt)$

$i(t)=I*\cos(wt)$

$p(t)=\dfrac{V*I}{2}[1+\cos(2wt)]$

Figure 2.   Signal Processing Block Diagram

The low frequency output of the Bl6533 is generated by accumulatingm this real power information. This low frequency inherently means a long accumulation time between output pulses. The output frequency is therefore proportional to the average real power. This average real power information can, in turn, be accumulated (e.g., by a counter) to generate real energy information. Because of its high output frequency and hence shorter integration time, the CF output is proportional to the instantaneous real power. This is useful for system calibration purposes that would take place under steady load conditions.

◆ **VOLTAGE CHANNEL INPUT**

The output of the line voltage transducer is connected to the BL6533 at this analog input. The maximum peak signal on Channel 2 is 330mV.

◆ **CURRENT CHANNEL INPUT**

The voltage outputs from the current transducers are connected to the BL6533 here. The maximum differential voltage on Current Channel 2 is $\pm$660mV. The maximum common-mode voltage is $\pm$ 100mV.

◆ **Power Supply Monitor**

The BL6533 contains an on-chip power supply monitor. If the supply is less than $4V\pm5\%$ then the BL6533 will go in an inactive state, i.e. no energy will be accumulated when the supply voltage is below 4V. This is useful to ensure correct device operation at power up and during power down. The power supply monitor has built-in hysteresis and filtering. This gives a high degree of immunity to false triggering due to noisy supplies.

The trigger level is nominally set at 4V, and the tolerance on this trigger level is about $\pm5\%$. The power supply and decoupling for the part should be such that the ripple at VDD does not exceed $5V\pm5\%$ as specified for normal operation.

Package Dimensions

DETAIL: F

SECTION B-B
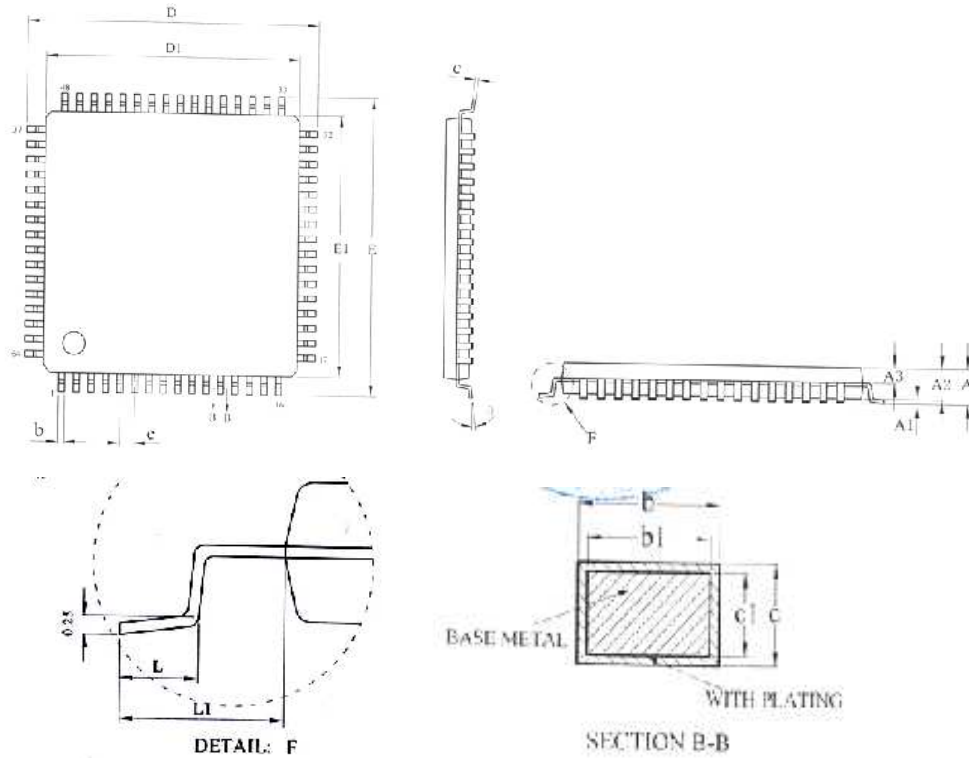
SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.60
A1	0.05	0.15	0.25
A2	1.30	1.40	1.50
A3	0.54	0.64	0.74
b	0.19	—	0.27
b1	0.18	0.20	0.23
c	0.13	—	0.18
c1	0.12	0.13	0.14
D	11.80	12.00	12.20
D1	9.80	10.00	10.20
E	11.80	12.00	12.20
E1	9.80	10.00	10.20
e	0.50BSC		
L	0.45	0.60	0.75
L1	1.00BSC		
θ	0	—	8°

Application sketch map

PIN	1	2	3	4	5	6	7	8	9
COM1	COM1				5F	5A	6F	6A	7F
COM2		COM2			5G	5B	6G	6B	7G
COM3			COM3		5E	5C	6E	6C	7E
COM4				COM4	5D		6D	P	7D
PIN	10	11	12	13	14	15	16	17	18
COM1	7A	1F	1A	2F	2A	3F	3A	4F	4A
COM2	7B	1G	1B	2G	2B	3G	3B	4G	4B
COM3	7C	1E	1C	2E	2C	3E	3C	4E	4C
COM4	kWh	1D		2D		3D		4D	

FRONT POLARIZER WITH UV FILTER
DISPLAY TYPE: TN/POSITIVE
DISPLAY MODE: REFLECTIVE
VIEWING DIRECTION: 6:00
DRIVING METHOD: 1/4 DUTY 1/3 BIAS

OPERATING VOLTAGE: 3.0V
OPERATING TEMPERATURE: -25°~80°C
STORAGE TEMPERATURE: -30°~85°C
CONNECTOR: PIN
UNMARKED SITE TOLERANCES: ±0.1
UNMARKED SIZE TOLERANCES: ±0.05