ILA19002

SINGLE PHASE BIDIRECTIONAL POWER/ENERGY METERING IC WITH INSTANTANEOUS PULSE OUTPUT

FEATURES

- Performs bidirectional power and energy measurement
- Meets the IEC 521/1036 Specification requirements for Class 1 AC Watt hour meters
- Protected against ESD
- Total power consumption rating below 25 mW
- Adaptable to different types of current sensors
- Operates over a wide temperature range
- Precision voltage reference on-chip

FUNCTIONAL DESCRIPTION:

The ILA19002 Single Phase Bidirectional Power/Energy metering integrated circuit generates a pulse rate output, the frequency of which is proportional to the power consumption. The ILA19002 performs the calculations of active power.
The method of calculation takes the power factor into account.
Energy consumption is determined by the power measurement being integrated over time.
This universal single phase bidirectional power/energy metering integrated circuit is ideally suited for energy calculation in applications such as residential municipal metering and factory energy metering and control.

The ILA19002 Single Phase Bidirectional Power/Energy metering integrated circuit is a CMOS mixed signal Analog/Digital integrated circuit, which performs power/energy calculations over a range of 1000:1, to an overall accuracy of better than Class 1.
The integrated circuit includes all the required functions for 1-phase power and energy measurement such as two oversampling A/D converters for the voltage and current sense inputs, power calculation and energy integration. Internal offsets are eliminated through the use of cancellation procedures.
The ILA19002 Single Phase Bidirectional Power/Energy metering integrated circuit generates pulses, the frequency of which is proportional to the power consumption. The pulse rate follows the instantaneous power consumption measured. Direction information is also provided. A voltage zero crossover signal, relevant to the positive going half cycle, is available on pin FMO. This signal can be used to synchronise circuit breaker switching.

IC is available in both 14 and 20 pin dual-in-plastic (DIP-14/DIP-20), as well as 20 pin small outline (SOIC-20) package types.

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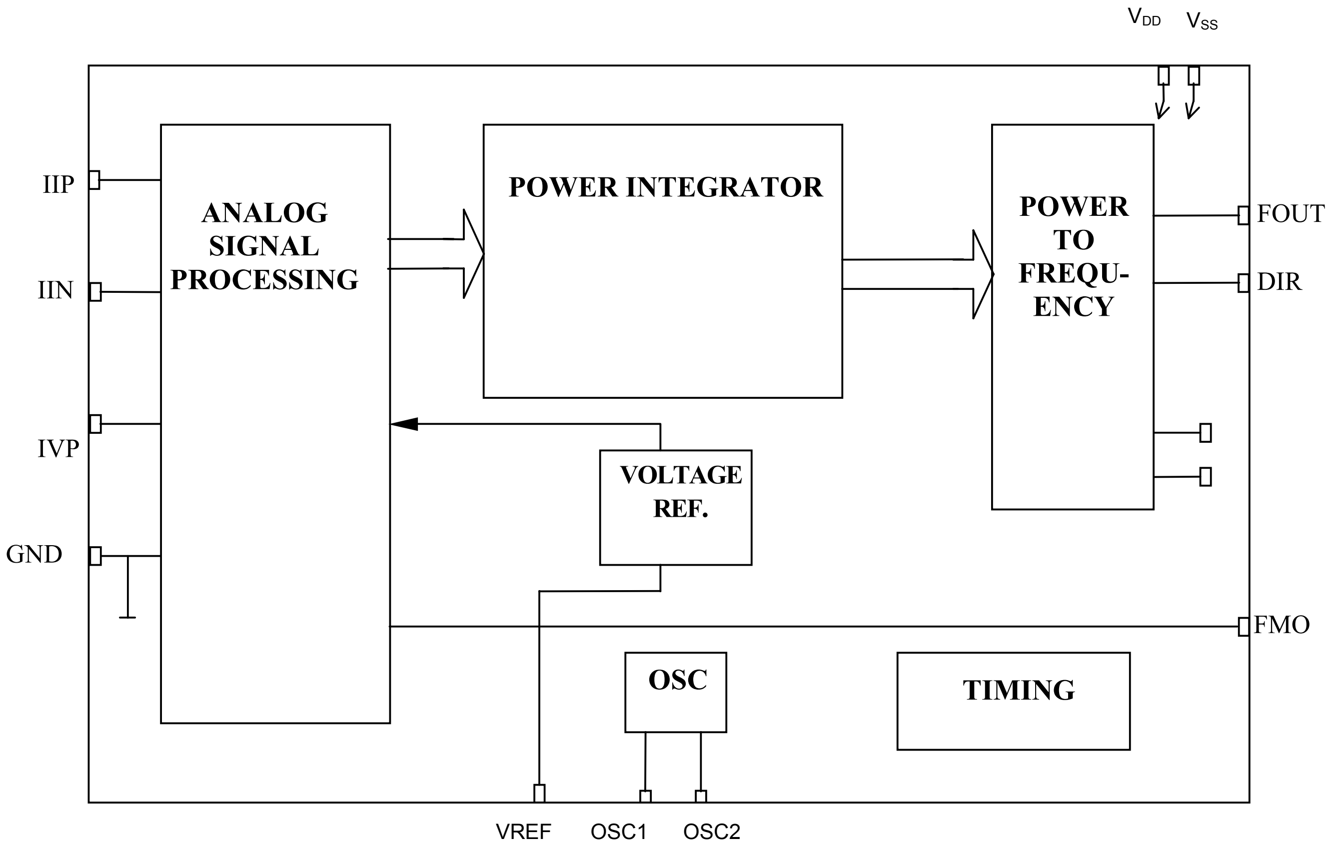
BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS*

Parameter	Symbol	Min	Max	Unit
Supply Voltage	V_{DD} -V_{SS}	-0.3	6.0	V
Current on any Pin	I_{PIN}	-150	+150	mA
Storage Temperature	T_{STG}	-40	+125	°C
Operating Temperature	T_O	-40	+85	°C

* Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only. Functional operation of the device at these or any other conditions above those indicated in the operation sections of this specification, is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability.

ILA19002

ELECTRICAL CHARACTERISTICS

(V_{DD}=2.5V, V_{SS}=-2.5V, over the temperature range -10°C to +70°C, unless otherwise specified.)

Parameter	Symbol	Min	Typ	Maxf	Unit	Condition
Operating Temperature Ranges	T_O	-25		+85	^{0}C	
Supply Voltage: Positive	V_{DD}	2.25		2.75	V	
Supply Voltage: Negative	V_{SS}	-2.75		-2.25	V	
Supply Current: Positive	I_{DD}		5	6	mA	
Supply Current: Negative	I_{SS}		5	6	mA	
Current Sensor Inputs	(Differential)					
Input Current Range	I_{II}	-25		+25	μA	Peak value
Voltage Sensor Inputs	(Asymmetrical)					
Input Current Range	I_{IV}	-25		+25	μA	Peak value
Pins FOUT, FOUT2 Output Low Voltage Output High Voltage	 V_{OL} V_{OH}	 V_{DD}-1		 V_{SS}+1	 V V	 I_{OL}=5 mA I_{OH}=-2 mA
Pulse Rate FOUT	fp	0 0		1160 3000	Hz Hz	Specified linearity Min and max limits
Pulse Width tp	t_{PP} t_{PN}		71:55 143.1		μs μs	Positive Energy Flow Negative Energy Flow
Pin VREF Ref. Current Ref. Voltage	 $-I_R$ V_R	 45 1.1	 50	 55 1.3	 μA V	With R = 24 kΩ connected to V_{SS} Referred to V_{SS}
Oscillator	Recommended crystal: TV colour burst crystal, f=3.5795 MHz					

PIN DESCRIPTION

14 Pin	20 Pin	Designation	Description
14	20	GND	Ground
5	8	V_{DD}	Positive Supply Voltage
10	14	V_{SS}	Negative Supply Voltage
13	19	IVP	Analog Input for Voltage
1	1	IIN	Inputs for current sensor
2	2	IIP	
3	3	VREF	Connection for current setting resistor
4	7	TEST	Test Pin. Tie to V_{SS} for protection against HV transients and noise
7	11	OSC1	Connections for crystal or ceramic resonator (OSC1=Input; OSC2=Output)
6	10	OSC2	
8	12	FOUT	Pulse rate output
9	13	DIR	Direction indication output
11	15	FMO	Rising edge of mains frequency
	4	TP4	Test pins (Leave unconnected)
	5	TP5	
	6	TP6	
	9	TP9	
12		TP12	
	16	TP16	
	17	TP17	
	18	TP18	

Note: arrangement of pins according to analog SA9602H (Sames)

FUNCTIONAL DESCRIPTION

The ILA19002 is a CMOS mixed signal Analog/Digital integrated circuit, which performs power/energy calculations across a power range of 1000:1, to an overall accurancy of better than Class 1.
The integrated circuit includes all the required functions for 1-phase power and energy measurement such as two oversampling A/D converters for the voltage and current sense inputs, power calculation and energy integration. Internal offsets are eliminated through the use of cancellation procedures. The ILA19002 generates pulses, the frequency of which is proportional to the power consumption. The pulse rate follows the instantaneous power consumption measured. Direction information is also provided.
A voltage zero crossover signal, relevant to the positive going half cycle, is available on pin FMO. This signal can be used to synchronise circuit breaker switching.

1. Power Calculation

In the Application Circuit (Figure 1), the voltage drop across the shunt will be between 0 and 16mV $_{RMS}$ (0 to 80A through a shunt resistor of 200μΩ). This voltage is converted to a current of between 0 and 16μA $_{RMS}$, by means of resistors R_1 and R_2.
The current sense input saturates at an input current of ±25μA peak.
For the voltage sensor input, the mains voltage (230VAC) is divided down through a divider to 14V. The current into the A/D converter input is set at 14μA $_{RMS}$ at nominal mains voltage, via resistor R4 (1MΩ).
In this configuration, with a mains voltage of 230V and a current of 80A, the output frequency of the ILA19002 power meter chip at FOUT is 1.16kHz. In this case 1 pulse will correspond to an energy consumption of 18.4kW/1160Hz = 15.9Ws.

2. Analog Input Configuration

The input circuitry of the current and voltage sensor inputs are illustrated below.
These inputs are protected against electrostatic discharge through clamping diodes.
The feedback loops from the outputs of the amplifiers A_I and A_V generate virtual shorts on the signal inputs. Exact duplications of the input currents are generated for the analog signal processing circuitry.

3. Electrostatic Discharge (ESD) Protection

The ILA19002 integrated circuit's inputs/outputs are protected against ESD

4. Power Consumption

The power consumption rating of the ILA19002 integrated circuit is less than 25mW.

5. Pulse Output Signals

The diagram below shows the behavior of the instantaneous pulse output, FOUT, with respect to the power consumption.

Pulse Output Signals

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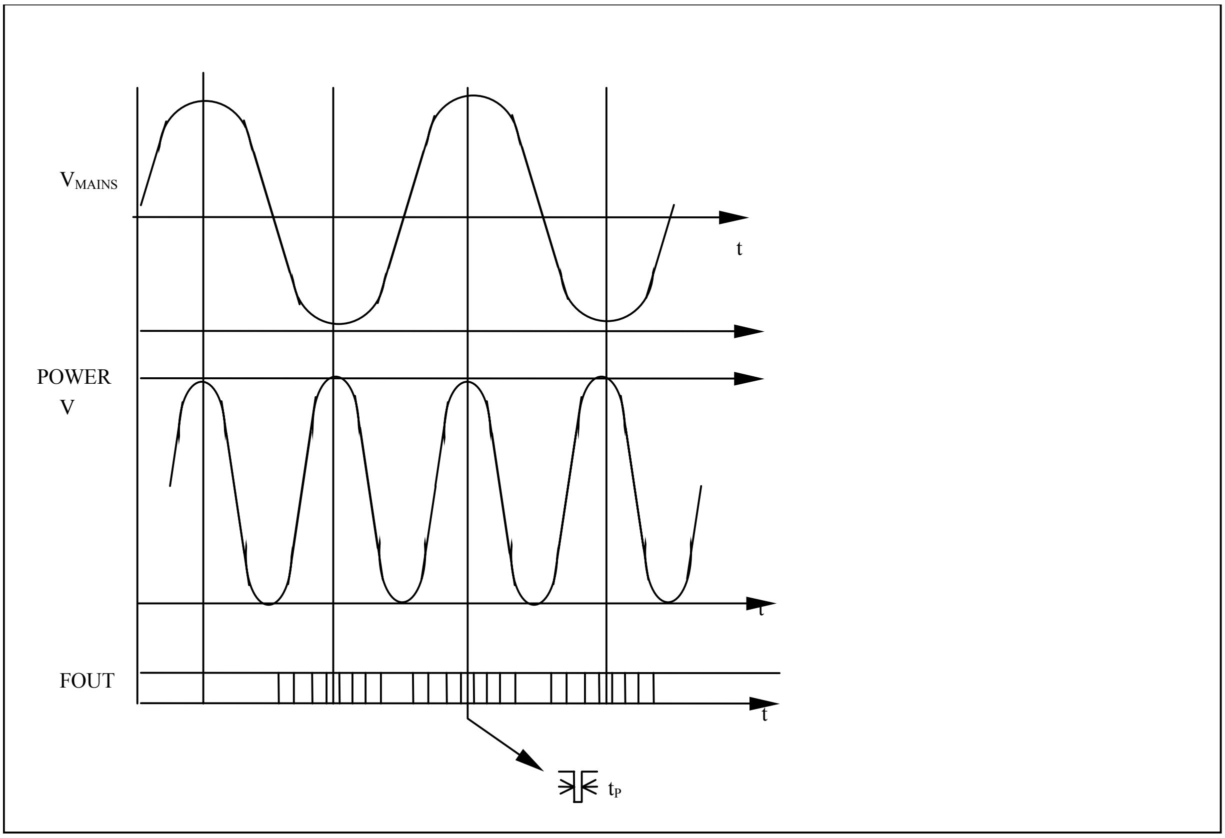

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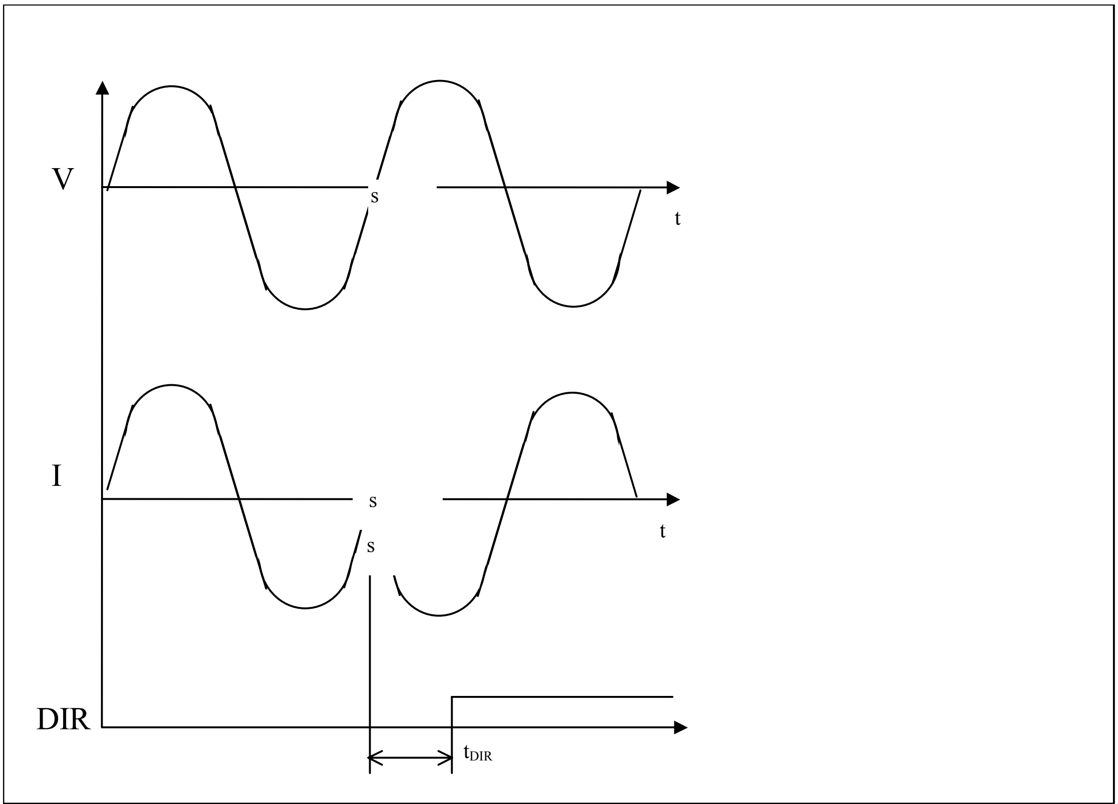
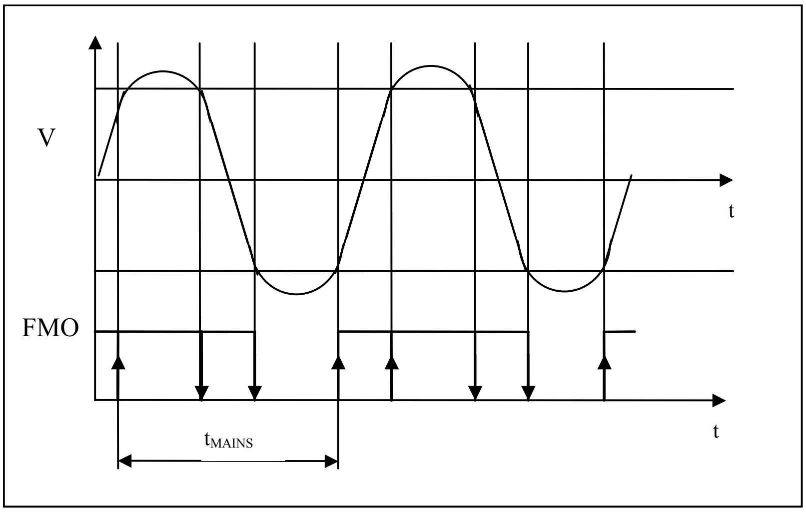
The diagram below shows the behavior of the direction indicator, DIR, when energy reversal takes place. The timing period for the DIR signal to change state, t_{DIR}, will be defined by the time it takes for the integrator to count down from its value at the time of energy reversal. This is determined by the energy consumption rate.



The square wave signal on FMO indicates the polarity of the mains voltage.



Due to comparator offset, the FMO low to high transition can be occur within a range as shown above. The time between successive low to high transitions will be equal to the mains voltage period.

TYPICAL APPLICATIONS

In the Application Circuits (Figures 1 and 2), the components required for power metering applications, are shown.

In Figure 1 a shunt resistor is used for current sensing. In this application, the circuitry requires a +2.5V, 0V, -2.5V DC supply.

In the case of Figure 2, when using a current transformer for current sensing, a +5V, 0V DC supply is sufficient.

The most important external components for the ILA19002 integrated circuit are:

R_2, R_1 and RSH are the resistors defining the current level into the current sense input. The values should be selected for an input current of $16\mu A_{RMS}$ into the ILA19002 at maximum line current.

Values for RSH of less than $200\mu\Omega$ should be avoided.

$R_1 = R_2 = (I_L / 16\mu A)_{RMS} * R_{SH} / 2$

Where I_L = Line current
RSH = Shunt resistor/termination resistor

R_3, R_6 and R_4 set the current for the voltage sense input. The values should be selected so that the input current into the voltage sense input (virtual ground) is set to $14\mu A_{RMS}$.

R_7 defines all on-chip bias and reference currents. With $R_7 = 24k\Omega$, optimum conditions are set. R_7 may be varied within ±10% for calibration purposes. Any change to R_7 will affect the output quadratically (i.e.: R_7 = +5%, f_P = +10%).

The formula for calculating the output frequency is given below:

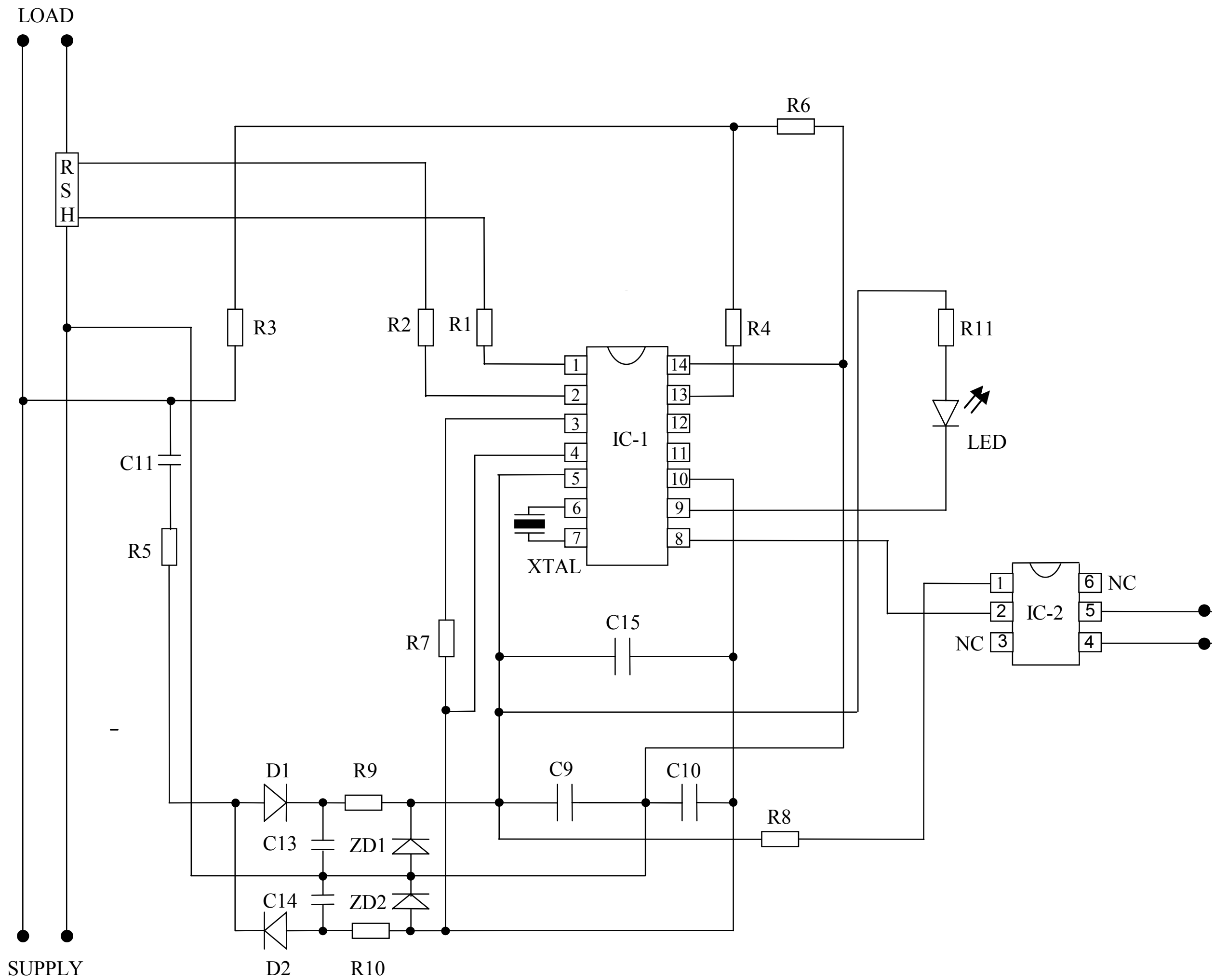
$$f = 11.16 * FOUTX * \frac{FOSC}{3.58MHz} * \frac{I_I \cdot I_V}{I_R^2}$$

Where FOUTX = Normal rated frequency (1160Hz)
FOSC = Oscillator frequency (2MHz ...... 4MHz)

I_I = Input current for current input (16μA$_{RMS}$ at rated)
I_V = Input current for voltage input (14μA$_{RMS}$ at rated)
I_R = Reference current (typically 50μA)

XTAL is a colour burst TV crystal (f = 3.5795 MHz) for the oscillator. The oscillator frequency is divided down to 1.7897 MHz on-chip, to supply the digital circuitry and the A/D converters.

Figure 1: Application Circuit using a Shunt Resistor for Current Sensing.



Parts List for Application Circuit: Figure 1

Item	Symbol	Description	Detail
1	IC-1	ILA19002	DIP-14
2	IC-2	Optocoupler 4N35	DIP-6
3	D1	Diode, Silicon, 1N4148	
4	D2	Diode, Silicon, 1N4148	
5	ZD1	Diode, Zener, 2.4V, 200mW	
6	ZD2	Diode, Zener, 2.4V, 200mW	
7	XTAL	Crystal, 3.5795MHz	Colour burst TV
8	R1	Resistor, 1% metal	Note 1
9	R2	Resistor, 1% metal	Note 1
10	R3	Resistor, 390k, (230VAC) 1%, metal	
11	R4	Resistor, 1M, 1/4W, 1%, metal	
12	R5	Resistor, 470W, 2W, 5%, carbon	
13	R6	Resistor, 24k, 1/4W, 1%, metal	
14	R7	Resistor, 24k, 1/4W, 1%, metal	
15	R8	Resistor, 680W, 1/4W, 1%	
16	R9	Resistor, 680W, 1/4W, 1%	
17	R10	Resistor, 680W, 1/4W, 1%	
18	R11	Resistor, 2.2K, 1/4W, 1%	
19	C9	Capacitor, 100nF	
20	C10	Capacitor, 100nF	
21	C11	Capacitor, 0.47µF, 250VAC, polyester	
22	C13	Capacitor, 100µF	
23	C14	Capacitor, 100µF	
24	C15	Capacitor, 820nF	Note 2
25	RSH	Shunt Resistor	Note 3
26	LED	Light Emitting Diode	

Note 1: Resistor (R1 and R2) values are dependant upon the selected value of RSH.
Note 2: Capacitor (C15) to be positioned as close to Supply Pins (V_{DD} & V_{SS}) of IC-1 as possible.
Note 3: See TYPICAL APPLICATIONS when selecting the value of RSH.

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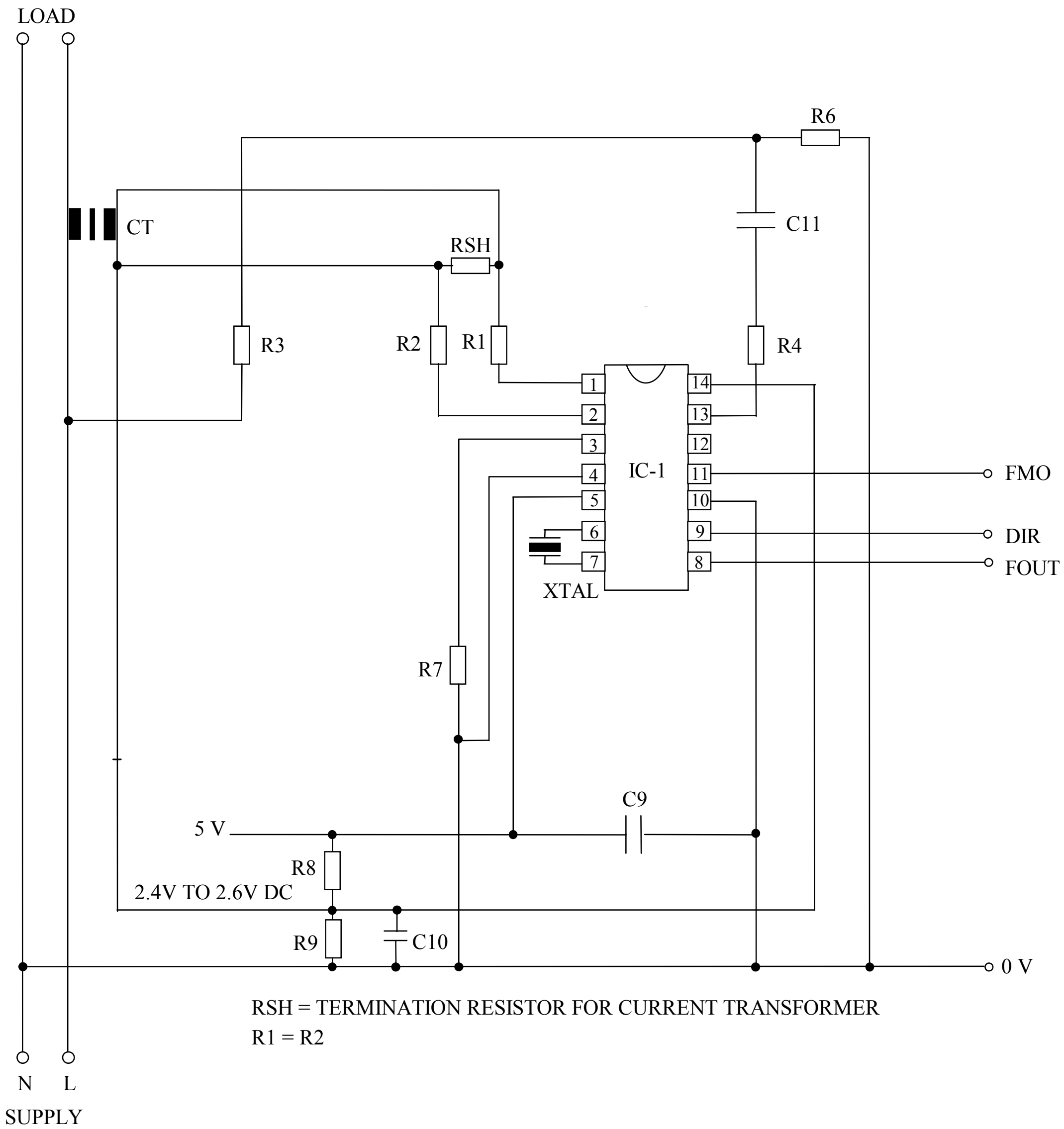
Figure 2: Application Circuit using a Current Transformer for Current Sensing.



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Parts List for Application Circuit: Figure 2

Item	Symbol	Description	Detail
1	IC-1	ILA19002	DIP-14
2	XTAL	Crystal, 3.5795MHz	Colour burst TV
3	RSH	Resistor	Note 1
4	R1	Resistor, 1%, metal	Note 2
5	R2	Resistor, 1%, metal	Note 2
6	R3	Resistor, 390k, (230VAC), 1%, metal	
7	R4	Resistor, 1M, 1/4W, 1%, metal	
8	R6	Resistor, 24k, 1/4W, metal	
9	R7	Resistor, 24k, 1/4W, 1%, metal	
10	R8	Resistor, 2.2k, 1/4W, 1%, metal	
11	R9	Resistor, 2.2k, 1/4W, 1%, metal	
12	C9	Capacitor, 820nF	Note 3
13	C10	Capacitor, 100nF	
14	C11	Capacitor	Note 4
15	CT	Current transformer	

Note 1: See TYPICAL APPLICATIONS when selecting the value of RSH.
Note 2: Resistor (R1and R2) values are dependant upon the selected value of RSH.
Note 3: Capacitor (C9) to be positioned as close to Supply Pins (V_{DD} & V_{SS}) of IC-1, as possible.
Note 4: Capacitor (C11) selected to minimize phase error introduced by current transformer (typically 1.5μF).