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SA9602E

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

FEATURES

- Pin and functionally compatible with the SA9102E with reduced external components
- Performs unidirectional 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 25mW
- Adaptable to different types of current sensors
- Operates over a wide temperature range
- Precision voltage reference on-chip
- Different pulse rate options available

DESCRIPTION

The SAMES SA9602E is an enhancement of the SA9102E, as no external capacitors are required for the A/D converters.

The SAMES SA9602E Single Phase unidirectional Power/Energy metering integrated circuit generates a pulse rate output, the frequency of which is proportional to the power consumption. The SA9602E performs the calculation for active power.
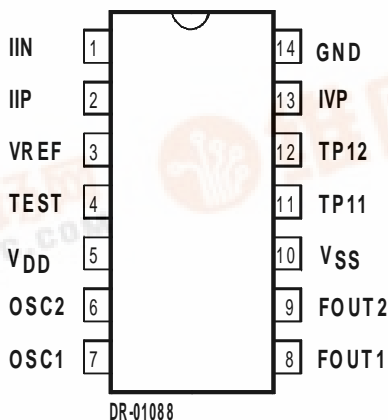
The method of calculation takes the power factor into account.

Energy consumption can be determined by the power measurement being integrated over time.

This innovative universal single phase power/ energy metering integrated circuit is ideally suited for energy calculations in applications such as residential municipal metering and factory energy metering and control.
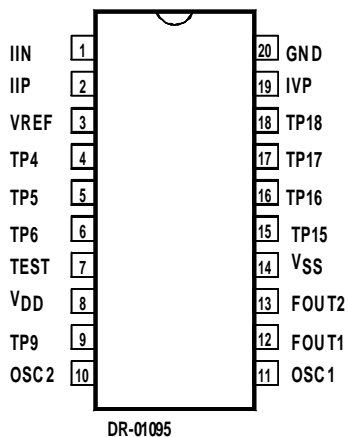
The SA9602E integrated circuit is available in both 14 and 20 pin dual-in-line plastic (DIP-14/ DIP-20), as well as 20 pin small outline (SOIC-20) package types.
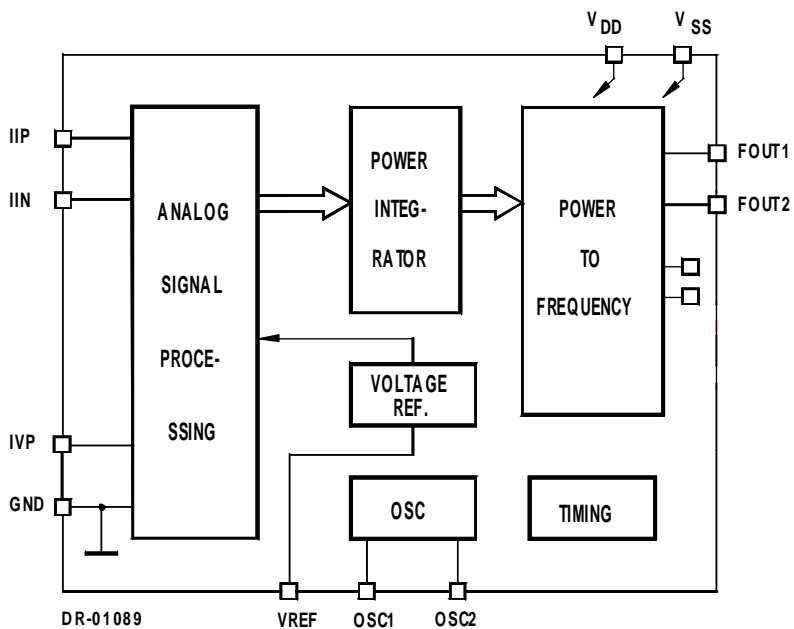
PIN CONNECTIONS

IIN	1		14	GND
IIP	2		13	IVP
VREF	3		12	TP12
TEST	4		11	TP11
VDD	5		10	VSS
OSC2	6		9	FOUT2
OSC1	7		8	FOUT1

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Package: DIP-14

PIN CONNECTIONS

IIN	1		20	GND
IIP	2		19	IVP
VREF	3		18	TP18
TP4	4		17	TP17
TP5	5		16	TP16
TP6	6		15	TP15
TEST	7		14	V_{SS}
V_{DD}	8		13	FOUT2
TP9	9		12	FOUT1
OSC2	10		11	OSC1

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Package: DIP-20

SOIC-20

BLOCK DIAGRAM

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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 condition above those indicated in the operational sections of this specification, is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability.

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	Max	Unit	Condition
Operating temperature range [#]	T_O	-25		+85	°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 Input (Asymmetrical)						
Input Current Range	I_{IV}	-25		+25	µA	Peak value
Pins FOUT1, FOUT2 Output Low Voltage Output High Voltage	V_{OL} V_{OH}	V_{DD}-1		V_{SS}+1	V V	I_{OL} = 5mA I_{OH} = -2mA
Pulse Rate FOUT1	f_P	10 0.5		1160 3000	Hz Hz	Specified linearity Min and max limits
FOUT2[1]	f_{P2}		f_P/290			

ELECTRICAL CHARACTERISTICS (Continued)

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

Parameter	Symbol	Min	Typ	Max	Unit	Condition
Pin VREF						With R = 24kΩ
Ref. Current	$-I_R$	45	50	55	µA	connected to V_{SS}
Ref. Voltage	V_R	1.1		1.3	V	Referred to V_{SS}
Oscillator	Recommended crystal: TV colour burst crystal f = 3.5795 MHz					

Note1:   Two additional bondout options of FOUT2 are available on request: $f_p/4$ and $f_p/16$.

[#] Extended Operating Temperature Range available on request.

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	
7	11	OSC1	Connections for crystal or ceramic resonator
6	10	OSC2	(OSC1 = Input ; OSC2 = Output)
8	12	FOUT1	First pulse rate output
9	13	FOUT2	Second pulse rate output
3	3	VREF	Connection for current setting resistor
4	7	TEST	Test Pin. Tie to VSS for protection in case of HV transients
	5	TP5	Test Pin (Leave unconnected)
	6	TP6	
	9	TP9	
11		TP11	
12		TP12	
	15	TP15	
	16	TP16	
	17	TP17	
	18	TP18	

FUNCTIONAL DESCRIPTION

The SA9602E 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 SA9602E in both DIP-20 and SOIC-20 package options is a direct replacement for the SA9102E with the advantage of no external loop capacitors.

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 SA9602E generates pulses, the frequency of which is proportional to the power consumption. Two frequency outputs (FOUT1 and FOUT2) are available, with a third frequency option available on request. The pulse rate follows the instataneous power consumption measured.

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 SA9602E power meter chip at FOUT1 (Pin 12) is 1.16kHz. In this case 1 pulse will correspond to an energy consumption of 18.4kW/1160Hz = 15.9Ws.
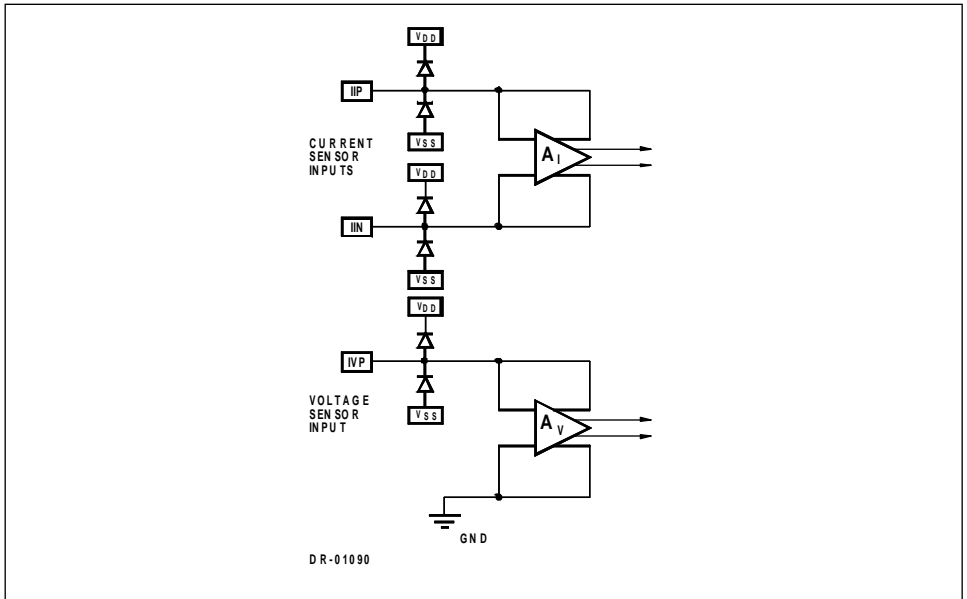
The output frequency at FOUT2 is FOUT1 /290 (i.e. The frequency ouput at FOUT1 divided by 290).

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.

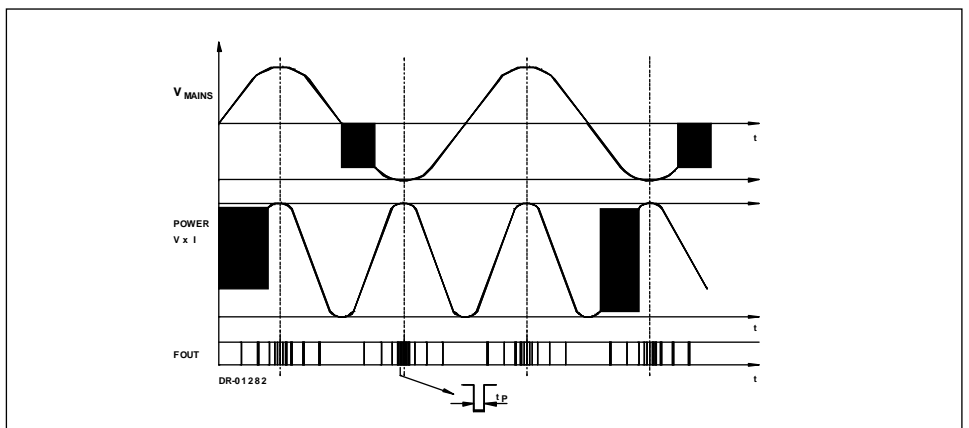DR-01090

3. Electrostatic Discharge (ESD) Protection

The SA9602E integrated circuit's inputs/outputs are protected against ESD .
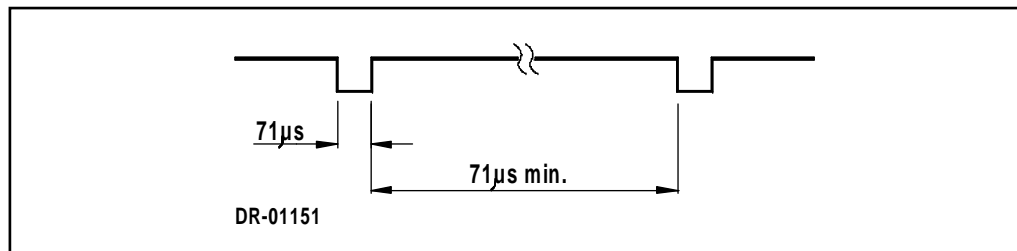
4. Power Consumption

The power consumption rating of the SA9602E integrated circuit is less than 25mW.

5. Pulse Output Signals

The diagram below shows the behaviour of the instantaneous pulse output, FOUT1, with respect to the power consumption.

DR-01282

The output on pin FOUT is a pulse density signal representing the instantaneous power/energy measurement. The minimum timing characteristics are shown in the following diagram.

71µs

71µs min.

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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 SA9602E 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 $16µA_{RMS}$ into the SA9602E at maximum line current.

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

$R_1 = R_2 = (I_L/16µA_{RMS}) * R_{SH}/2$

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 $14µA_{RMS}$.

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:

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

Where   FOUTX   =   Normal rated frequency (4Hz or 1160Hz)

FOSC = Oscillator frequency (2MHz ...... 4MHz)

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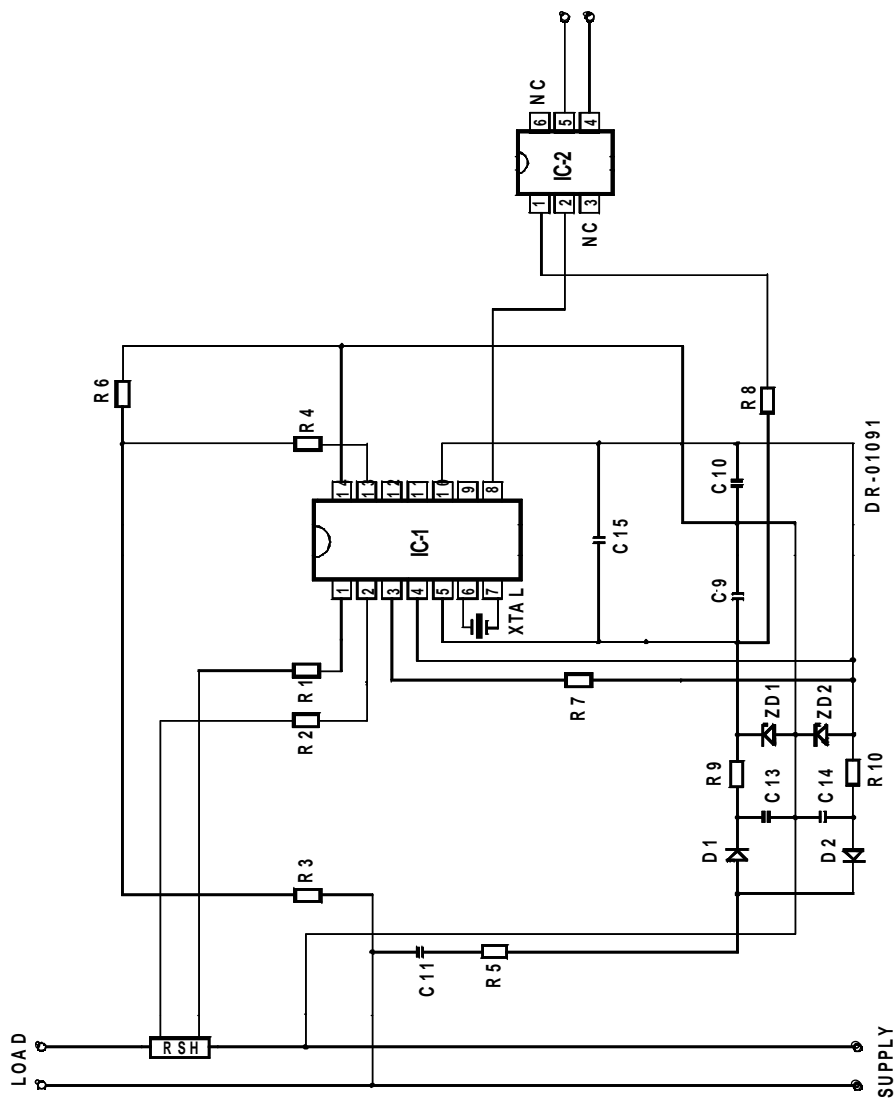
I_V = Input current for voltage input (14µA$_{RMS}$ at rated)

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.
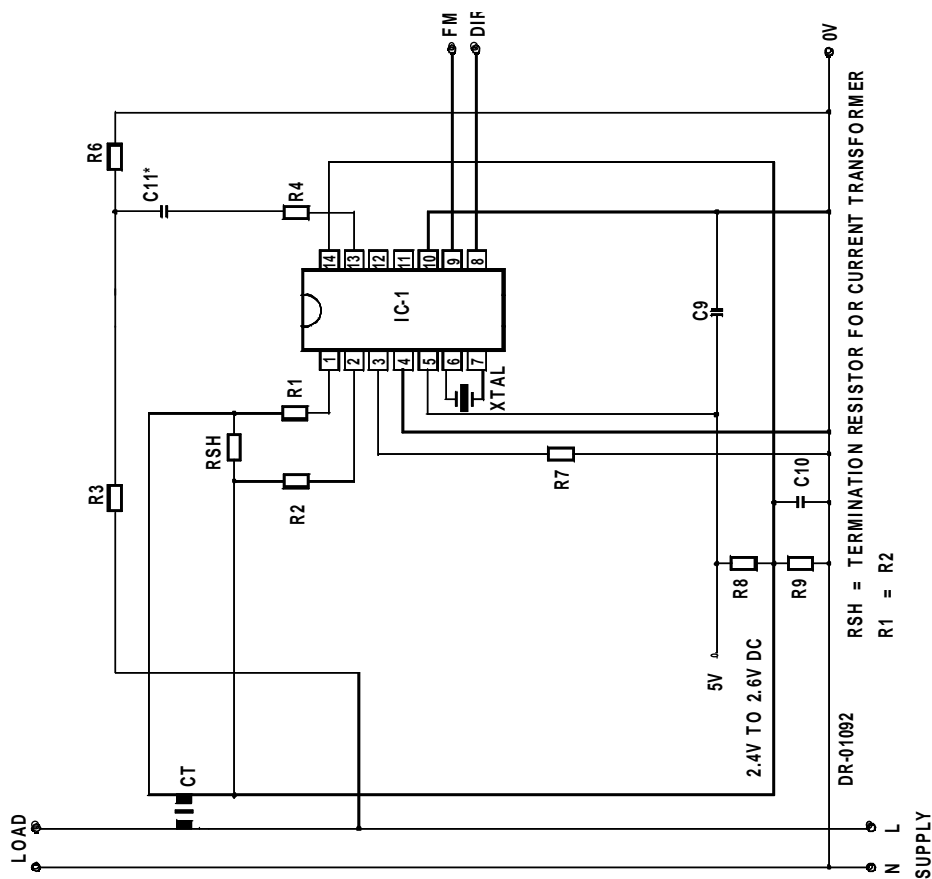
Parts List for Application Circuit: Figure 1

Item	Symbol	Description	Detail
1	IC-1	SA9602E	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, 470Ω, 2W, 5%, carbon	
13	R6	Resistor, 24k, 1/4W, 1%, metal	
14	R7	Resistor, 24k, 1/4W, 1%, metal	
15	R8	Resistor, 680Ω, 1/4W, 1%	
16	R9	Resistor, 680Ω, 1/4W, 1%	
17	R10	Resistor, 680Ω, 1/4W, 1%	
18	C9	Capacitor, 100nF	
19	C10	Capacitor, 100nF	
20	C11	Capacitor, 0.47μF, 250VAC, polyester	
21	C13	Capacitor, 100μF	
22	C14	Capacitor, 100μF	
23	C15	Capacitor, 820nF	Note 2
24	RSH	Shunt Resistor	Note 3

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.

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

FM
DIF
0V

R6
C11*
R4

IC-1

C9

R1
RSH
XTAL
R7

R3
R2

C10

5V
R8
R9

2.4V TO 2.6V DC

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RSH = TERMINATION RESISTOR FOR CURRENT TRANSFORMER

R1 = R2

CT

LOAD

L
N
SUPPLY

Parts List for Application Circuit: Figure 2

Item	Symbol	Description	Detail
1	IC-1	SA9602E	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).

ORDERING INFORMATION

Part Number	Package
SA9602EPA	DIP-14
SA9602EPA	DIP-20
SA9602ESA	SOIC-20

Note: When ordering, the Package Option should be specified along with the Part Number.

Note:

Any sales or technical questions may be posted to our e-mail address below:
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For the latest updates on datasheets, please visit our web site:
http://www.sames.co.za

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