

# TWO PHASE BIDIRECTIONAL POWER/ENERGY METERING IC WITH INSTANTANEOUS PULSE OUTPUT

## FEATURES

- Performs bidirectional one or two phase power and energy measurement
- Meets the IEC 521/1036 Specification requirements for Class 1 AC Watt hour meters
- Operates over a wide temperature range
- Adaptable to different types of current sensors
- Excellent long term stability
- Easily adaptable to different signal levels
- Precision voltage reference on-chip
- Two pulse rate output formats available
- Protected against ESD

## DESCRIPTION

The SAMES SA9108F Two Phase bidirectional Power/Energy metering integrated circuit generates pulse rate outputs for positive and negative energy directions, the frequency of which is proportional to the power consumption. The SA9108F performs the calculation for active power.

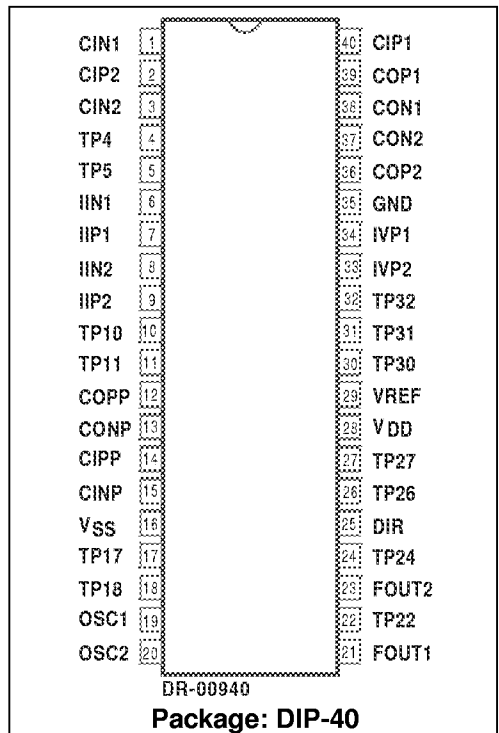
The method of calculation takes the power factor into account.

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

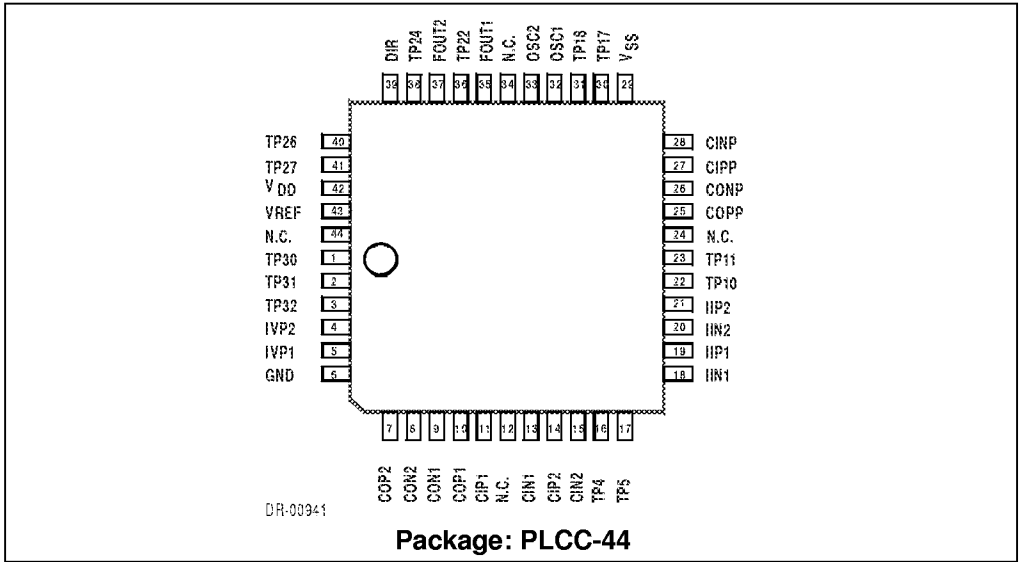
The output of this innovative universal two phase power/energy metering integrated circuit is ideally suited for applications such as residential and industrial energy metering and control.

The SA9108F integrated circuit is available in 40 pin dual-in-line plastic (DIP-40), as well as 44 pin plastic leaded chip carrier (PLCC-44) package types.

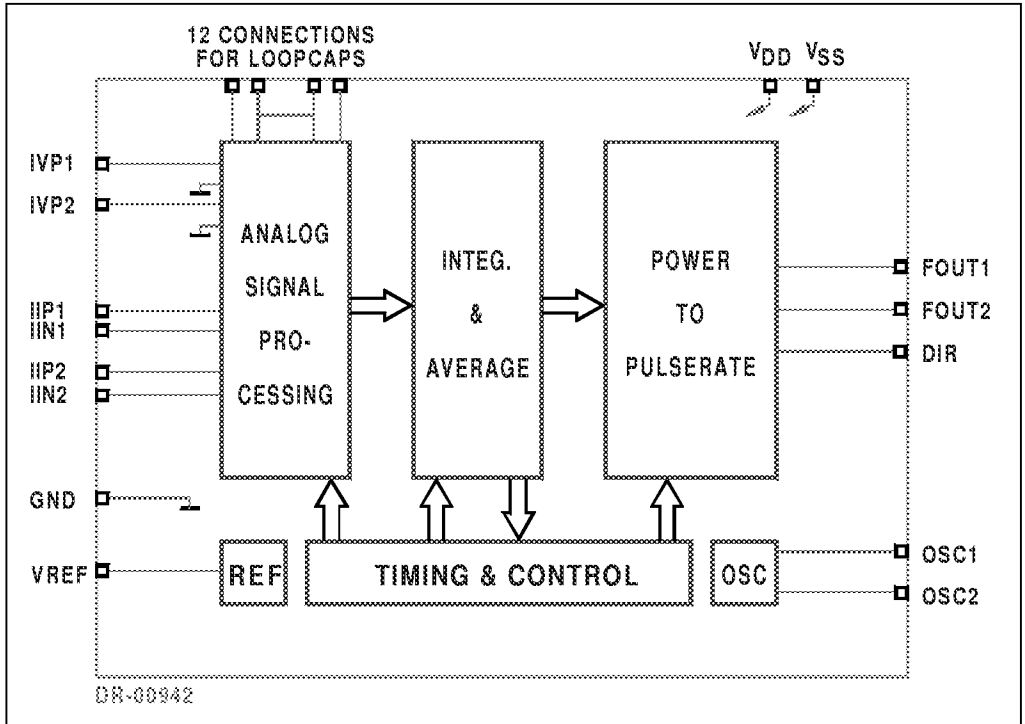
## PIN CONNECTIONS



PIN CONNECTIONS



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.

**ELECTRICAL CHARACTERISTICS**

( $V_{DD} = 5V$  over the temperature range  $-10^{\circ}C$  to  $+70^{\circ}C$ , unless otherwise specified.)

Parameter	Symbol	Min	Typ	Max	Unit	Condition
Supply Voltage	$V_{DD}-V_{SS}$	4.5		5.5	V	
Supply Current	$I_{DD}$			10	mA	
Nonlinearity of Power Calculation		-0.3		+0.3	%	1% -100% of rated power
Current Sensor Inputs (Differential)						
Input Current Range	$I_{II}$	-25		+25	$\mu A$	Peak value
Voltage Sensor Inputs (Asymmetric)						
Input Current Range	$I_{IV}$	-25		+25	$\mu A$	Peak value
Digital Outputs:						
Output Low Voltage	$V_{OL}$			$V_{SS}+1$	V	$I_{OL} = 5mA$
Output High Voltage	$V_{OH}$	$V_{DD}-1$			V	$I_{OH} = -2mA$
Pulse Rate: FOUT1, FOUT2	$f_p$	0		64	Hz	Specified linearity Min and max limits
		0		180	Hz	
Oscillator	Recommended crystal: TV colour burst crystal, $f = 3.5795$ MHz					
Pin VREF						With $R = 24$ k $\Omega$ connected to $V_{SS}$ Referred to $V_{SS}$
Ref. Current	$-I_R$	45	50	55	$\mu A$	
Ref. Voltage	$V_R$	1.1		1.3	V	

# Extended Operating Temperature Range available on request.

## PIN DESCRIPTION

Pin PLCC-44	Pin DIP-40	Designation	Description
6	35	GND	Ground
42	28	V <sub>DD</sub>	Positive Supply Voltage
29	16	V <sub>SS</sub>	Negative Supply Voltage
5	34	IVP1	Analog input for Voltage : Phase 1
4	33	IVP2	Analog input for Voltage : Phase 2
18	6	IIN1	Inputs for current sensor : Phase 1
19	7	IIP1	
20	8	IIN2	Inputs for current sensor : Phase 2
21	9	IIP2	
32	19	OSC1	Connections for crystal or ceramic resonator (OSC1 = Input; OSC2 = Output)
33	20	OSC2	
35	21	FOUT1	Pulse rate outputs
37	23	FOUT2	
39	25	DIR	Direction indication
9	38	CON1	Connections for outer loop capacitors of A/D converters
10	39	COP1	
8	37	CON2	
7	36	COP2	
26	13	CONP	
25	12	COPP	
13	1	CIN1	Connections for inner loop capacitors of A/D converters
11	40	CIP1	
15	3	CIN2	
14	2	CIP2	
28	15	CINP	
27	14	CIPP	
43	29	VREF	Connection for current setting resistor
41	27	TP27	Test Pin. Connect to V <sub>SS</sub>
16	4	TP4	Manufacturer's test pins (Leave unconnected)
17	5	TP5	
22	10	TP10	
23	11	TP11	
30	17	TP17	
31	18	TP18	
36	22	TP22	
38	24	TP24	
40	26	TP26	
1	30	TP30	
2	31	TP31	
3	32	TP32	



**PIN DESCRIPTION (Continued)**

Pin PLCC-44	Pin DIP-40	Designation	Description
12		NC	Not connected
24		NC	
34		NC	
44		NC	

**FUNCTIONAL DESCRIPTION**

The SAMES SA9108F is a CMOS mixed signal Analog/Digital integrated circuit, which performs two phase power/energy calculations over a dynamic range of greater than 1000:1, to an overall accuracy of better than Class 1.

The integrated circuit includes all the required functions for 2-phase power and energy measurement such as 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 SA9108F generates pulses, the frequency of which is proportional to the power consumption. The pulse rate follows the instantaneous power measured. Direction information is also provided.

**1. Power Calculation**

In the Application Circuit (Figure 1), the mains voltages from Line 1 and Line 2, are converted to currents and applied to the voltage sense inputs IVP1 and IVP2. The mains voltage ( $2 \times 115 \text{ V}$ ) is divided down through voltage dividers to 14V. The resulting input currents into the A/D converters are  $14\mu\text{A}_{\text{RMS}}$  through the resistors  $R_9$  and  $R_{10}$ .

For the current sense inputs the voltage drop across the current transformers' terminating resistors are converted to currents of  $16\mu\text{A}_{\text{RMS}}$  for rated conditions, by means of resistors  $R_5$ ,  $R_6$ , (Phase 1) and  $R_7$ ,  $R_8$  (Phase 2).

The signals providing the current information are applied to the current sensor inputs IIN1, IIP1 and IIN2, IIP2.

In this configuration, with the mains voltage of  $2 \times 115 \text{ VAC}$  and rated currents of 80A, the output frequency of the SA9108F energy metering integrated circuit at FOUT1 is 64Hz. In this case 1 pulse will correspond to an energy consumption of  $2 \times 9.2 \text{ kW}/64\text{Hz} = 287.5 \text{ Ws}$ .

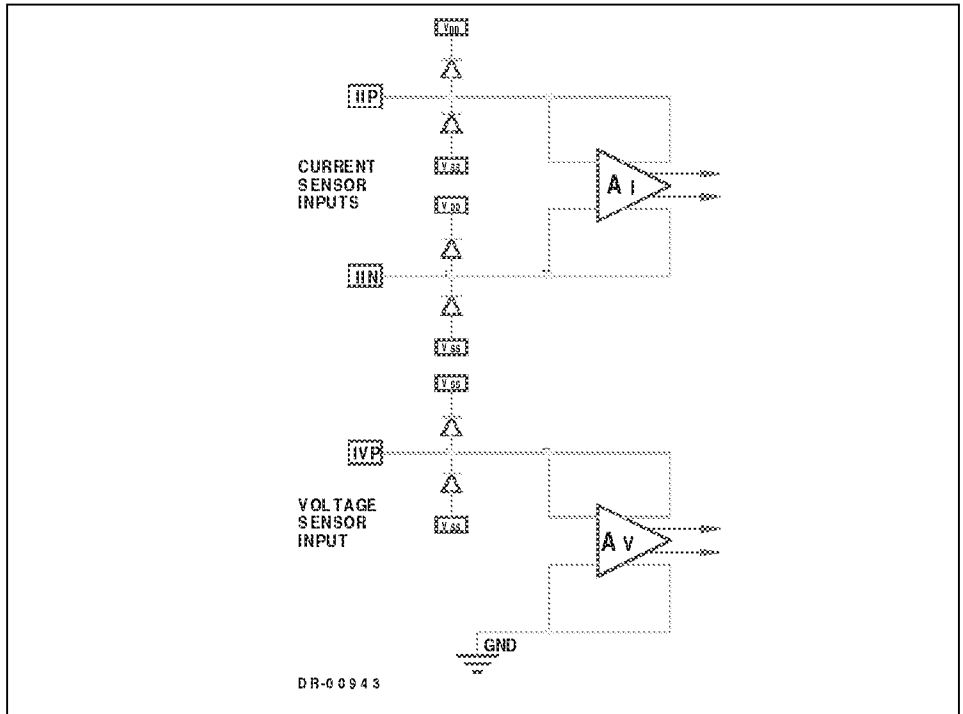


## 2. Analog Input Configuration

The current and voltage sensor inputs are illustrated below.

These inputs are protected against electrostatic discharge through clamping diodes, in conjunction with the amplifiers input configuration.

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 processing circuitry.



## 3. Electrostatic Discharge (ESD) Protection

The SA9108F integrated circuit's inputs/outputs are protected against ESD .

## 4. Power Consumption

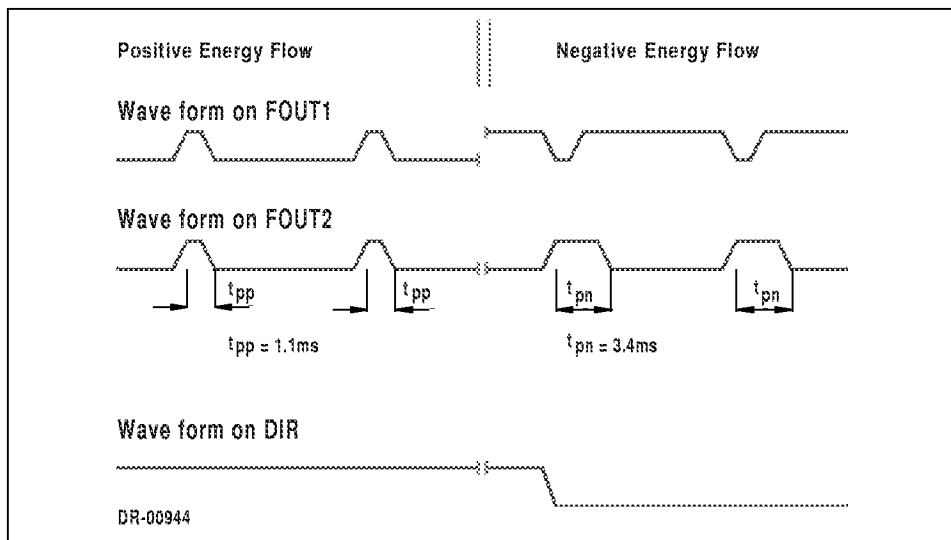
The overall power consumption rating of the SA9108F integrated circuit is less than 40mW having a 5V supply.

## 5. Pulse Output Signals

The calculated power is divided down to a pulse rate 64Hz, for rated conditions on FOUT1 and FOUT2.

Two formats of pulse output signals are available which provide both power/energy and direction information.

The direction of the energy flow is defined by the mark/space ratio on FOUT1 while the pulse width defines the direction on FOUT2.



An integrated anticreep function ensures no metering at zero line currents.

The formula for calculating the Output Frequency (f) is given below:

$$f = 11.16 * FOUTX * \frac{FOSC}{3.58\text{MHz}} * \frac{(I_{11} I_{V1}) + (I_{12} I_{V2})}{2 * I_R^2}$$

Where FOUTX = Nominal rated frequency (64Hz)

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

$I_{11}, I_{12}$  = Input currents for current sensor inputs (16μA at rated line current)

$I_{V1}, I_{V2}$  = Input currents for voltage sensor inputs (14μA at rated line voltage)

$I_R$  = Reference current (typically 50μA)

**TYPICAL APPLICATION**

In the Application Circuit (Figure 1), the components required for a two phase power metering application, are shown. Terminated current transformers are used for current sensing.

The most important external components for the SA9108F integrated circuit are:

$C_2$ ,  $C_6$  and  $C_7$  are the outer loop capacitors for the integrated oversampling A/D converters. The typical value of  $C_2$  is 2.2nF and the value of  $C_6$  and  $C_7$  is 560 $\mu$ F.

The actual values determine the signal to noise and stability performance. The tolerances should be within  $\pm 10\%$ .

$C_1$ ,  $C_3$  and  $C_4$  are the inner loop capacitors for the integrated oversampling A/D converters. The typical value of  $C_1$ ,  $C_3$  and  $C_4$  is 3.3nF. Values smaller than 0.5nF and larger than 5nF should be avoided.

Terminated current sensors (current transformers) are connected to the current sensor inputs of the SA9108F through current setting resistors ( $R_5$ ,  $R_6$  and  $R_7$ ,  $R_8$ ).

The resistor values should be selected for an input current of  $16\mu A_{RMS}$  into the SA9108F, at the rated line current.

The values of these resistors should be calculated as follows:

Phase 1:

$$R_5 = R_6 = (I_{L1} / 16\mu A_{RMS}) * R_3 / 2$$

Phase 2:

$$R_7 = R_8 = (I_{L2} / 16\mu A_{RMS}) * R_4 / 2$$

Where  $I_{LX}$  = Secondary CT current at rated conditions.

$R_3$  and  $R_4$  = Current transformer termination resistors for the two phases.

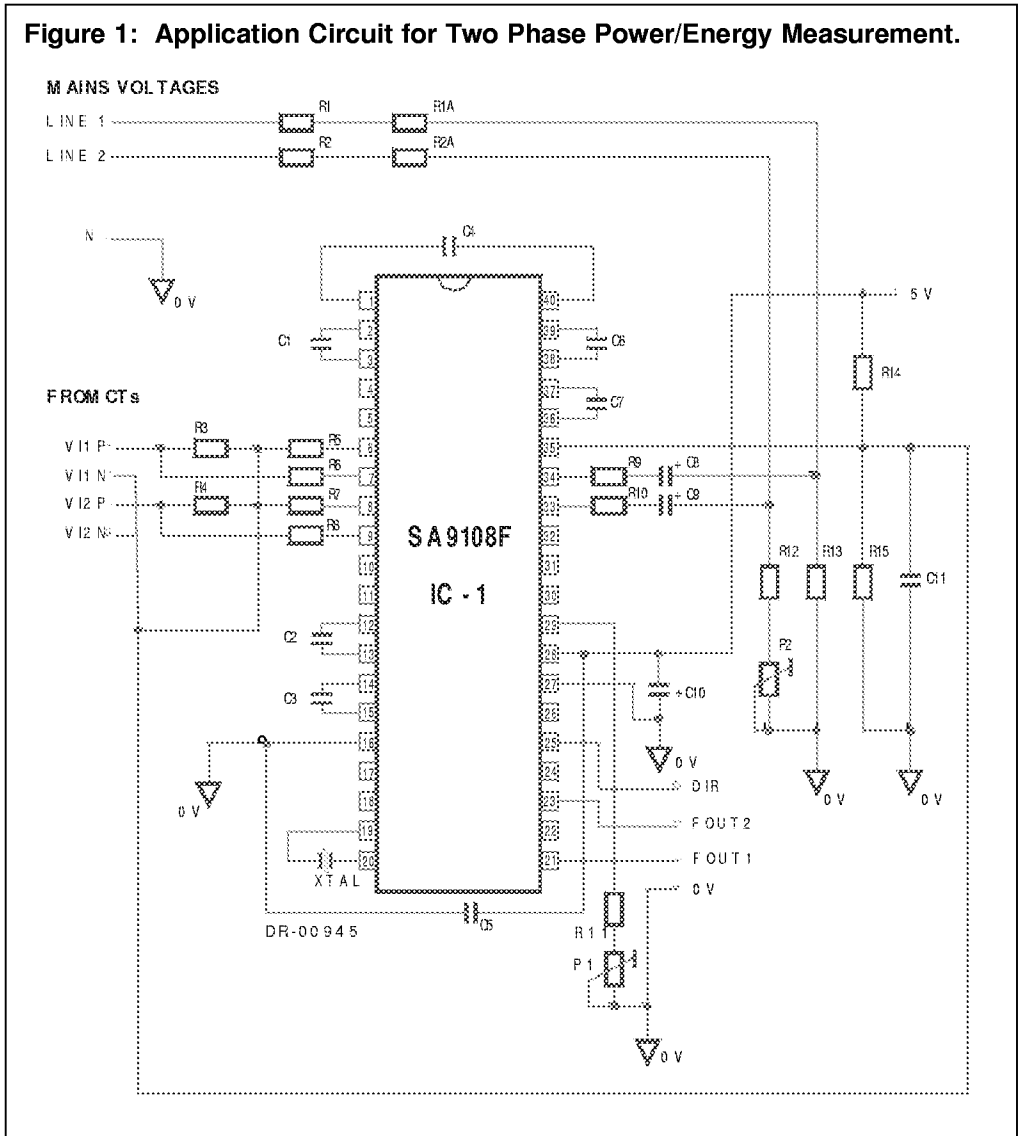
$R_1 + R_{1A}$ ,  $R_{13}$  and  $R_9$  set the current for the phase 1 voltage sense input.  $R_2 + R_{2A}$ ,  $R_{12} + R_2$  and  $R_{10}$  set the currents for phase 2. The values should be selected so that the input currents into the voltage sense inputs (virtual ground) are set to  $14\mu A_{RMS}$  for nominal line voltage. Capacitors  $C_8$  and  $C_9$  are for decoupling and phase compensation.

$R_{11}$  and  $P_1$  defines all on-chip bias and reference currents. With a total resistance of 24k $\Omega$ , optimum conditions are set.  $R_{11} + P_1$  may be varied within  $\pm 10\%$  for calibration purposes. Any change in resistance will affect the output quadratically (i.e:  $\Delta R = +5\%$ ,  $\Delta f = +10\%$ ).

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 for Two Phase Power/Energy Measurement.**



## Parts List for Application Circuit: Figure 1

Item	Symbol	Description	Detail
1	IC-1	SA9108FPA	DIP-40
2	XTAL	Crystal, 3.5795 MHz	Colour burst TV
3	R1	Resistor, 120k, 1%, 1/4W	
4	R1A	Resistor, 82k, 1%, 1/4W	
5	R2	Resistor, 120k, 1%, 1/4W	
6	R2A	Resistor, 82k, 1%, 1/4W	
7	R13	Resistor, 24k, 1%, 1/4W	
8	R12	Resistor, 22k, 1%, 1/4W	
9	R14	Resistor, 820Ω, 1%, 1/4W	
10	R5	Resistor	Note 1
11	R6	Resistor	Note 1
12	R7	Resistor	Note 1
13	R8	Resistor	Note 1
14	R11	Resistor, 22k, 1%, 1/4W	
15	R9	Resistor, 1M, 1%, 1/4W	
16	R10	Resistor, 1M, 1%, 1/4W	
17	R3	Resistor	Note 1
18	R4	Resistor	Note 1
19	R15	Resistor, 820Ω, 1%, 1/4W	
20	P2	Potentiometer, 4.7k	Multi turn
21	P1	Potentiometer, 4.7k	Multi turn
22	C8	Capacitor, electrolytic, 1μF, 16V	Note 2
23	C9	Capacitor, electrolytic, 1μF, 16V	Note 2
24	C4	Capacitor, 3.3nF	
25	C1	Capacitor, 3.3nF	
26	C2	Capacitor, 2.2nF	
27	C3	Capacitor, 3.3nF	
28	C6	Capacitor, 560pF	
29	C7	Capacitor, 560pF	
30	C5	Capacitor, 820nF	Note 3
31	C10	Capacitor, 100nF	
32	C11	Capacitor, 100nF	

Note 1: Resistor ( $R_5$ ,  $R_6$ ,  $R_7$  and  $R_8$ ) values are dependant upon the selected values of the current transformer termination resistors  $R_3$  and  $R_4$ .

Note 2: Capacitor values may be selected for DC blocking and to compensate for phase errors caused by the current transformers.

Note 3: Capacitor ( $C_5$ ) to be positioned as close to Supply Pins ( $V_{DD}$  &  $V_{SS}$ ) of IC-1, as possible.



**ORDERING INFORMATION**

<b>Part Number</b>	<b>Package</b>
SA9108FPA	DIP-40
SA9108FFA	PLCC-44

