SA9108F

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.

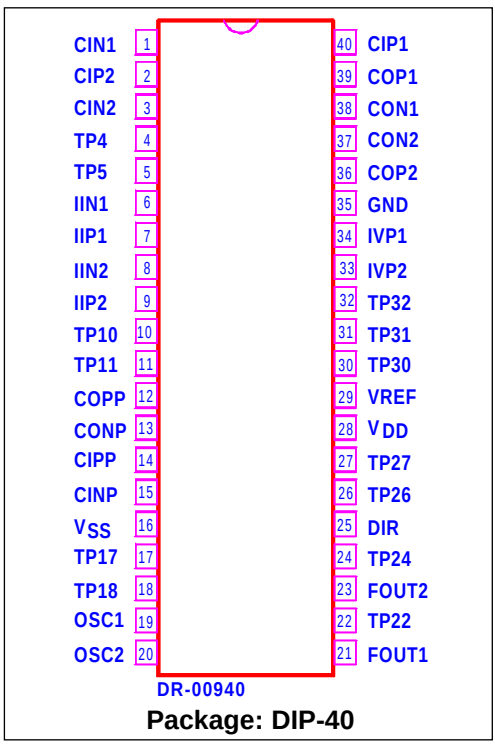
The method of calculation takes the power factor into account.

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.

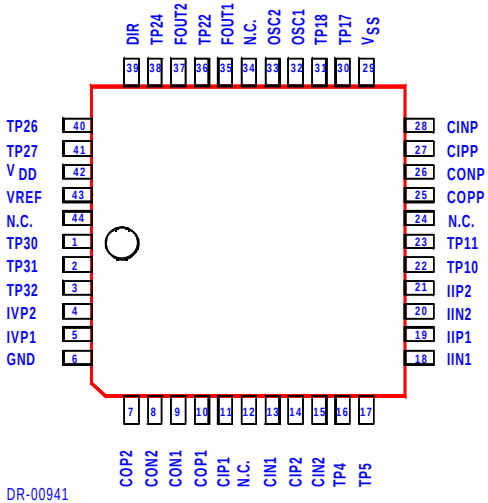
The SA9108F integrated circuit is available in 40 pin dual-in-line plastic (DIP-40), as well as 44 pin plastic leaded chip carrier (PLCC-44) package types.

PIN CONNECTIONS



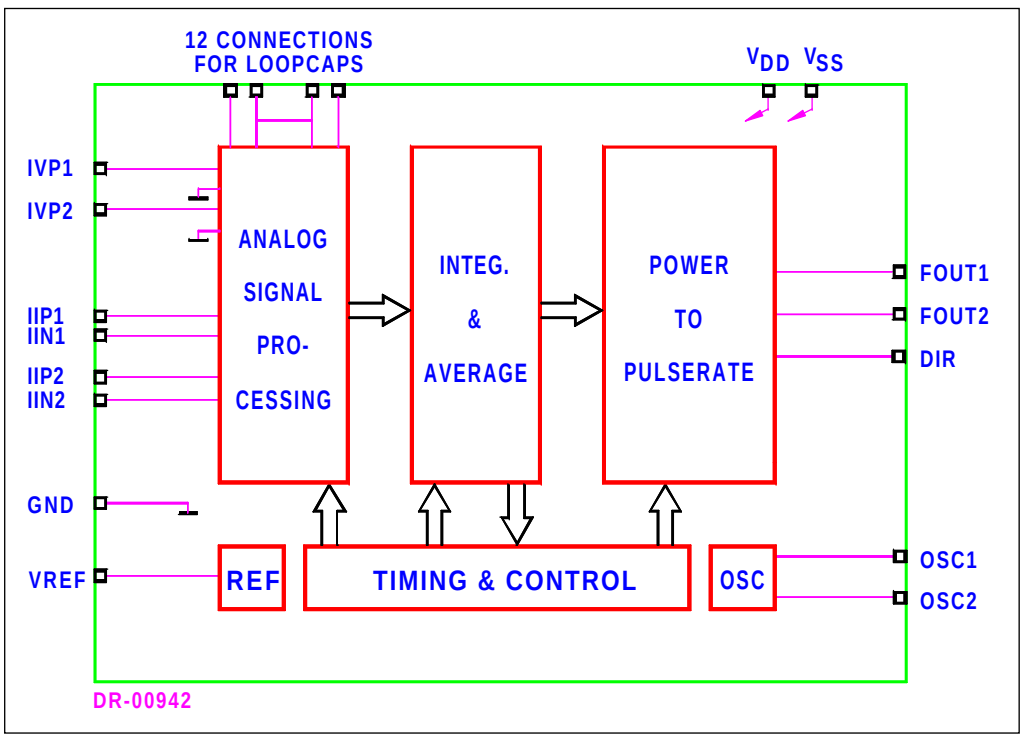
Package: DIP-40

PIN CONNECTIONS



Package: PLCC-44

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°C to +70°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	µA	Peak value
Voltage Sensor Inputs (Asymmetric)						
Input Current Range	I_{IV}	-25		+25	µA	Peak value
Digital Outputs: 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, FOUT2	f_p	0 0		64 180	Hz Hz	Specified linearity Min and max limits
Oscillator	Recommended crystal: TV colour burst crystal, f = 3.5795 MHz					
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}

Extended Operating Temperature Range available on request.

PIN DESCRIPTION

Pin PLCC-44	Pin DIP-40	Designation	Description
6	35	GND	Ground
42	28	V_{DD}	Positive Supply Voltage
29	16	V_{SS}	Negative Suply 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
33	20	OSC2	(OSC1 = Input; OSC2 = Output)
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
10	39	COP1	converters
8	37	CON2	
7	36	COP2	
26	13	CONP	
25	12	COPP	
13	1	CIN1	Connections for inner loop capacitors of A/D
11	40	CIP1	converters
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_{SS}
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 instantenous 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 x 115 V) is divided down through voltage dividers to 14V. The resulting input currents into the A/D converters are $14\mu A_{RMS}$ 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 $16\mu A_{RMS}$ 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.

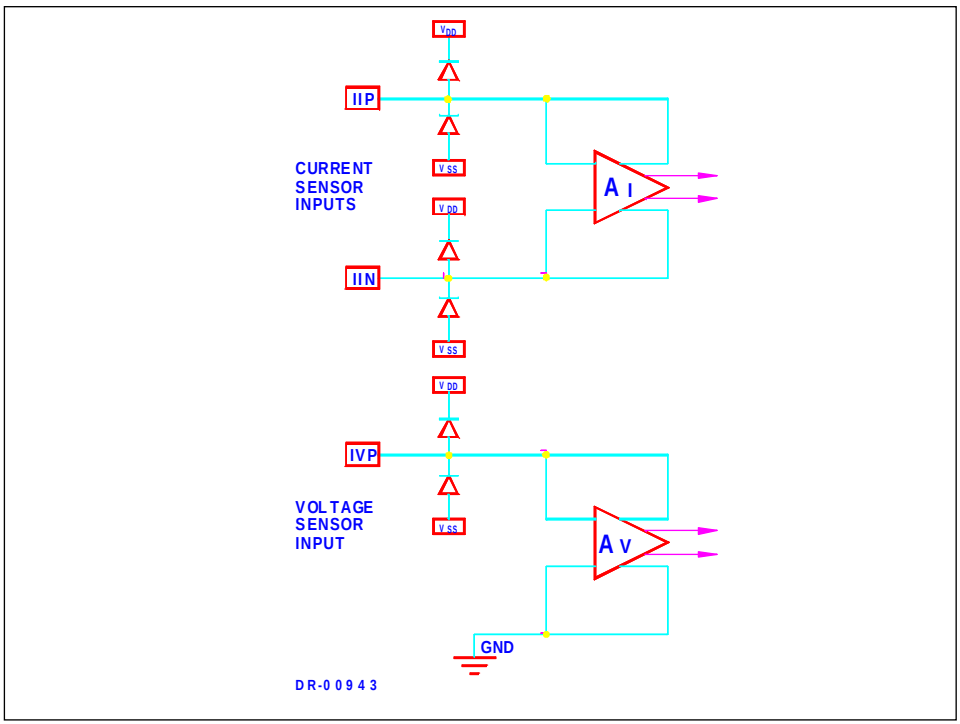
In this configuration, with the mains voltage of 2 x 115 VAC and rated currents of 80A, the output frequency of the SA9108F energy metering integrated circuit at FOUT1 is 64Hz. In this case 1 pulse will correspond to an energy consumption of 2 x 9.2 kW/64Hz = 287.5 Ws.

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

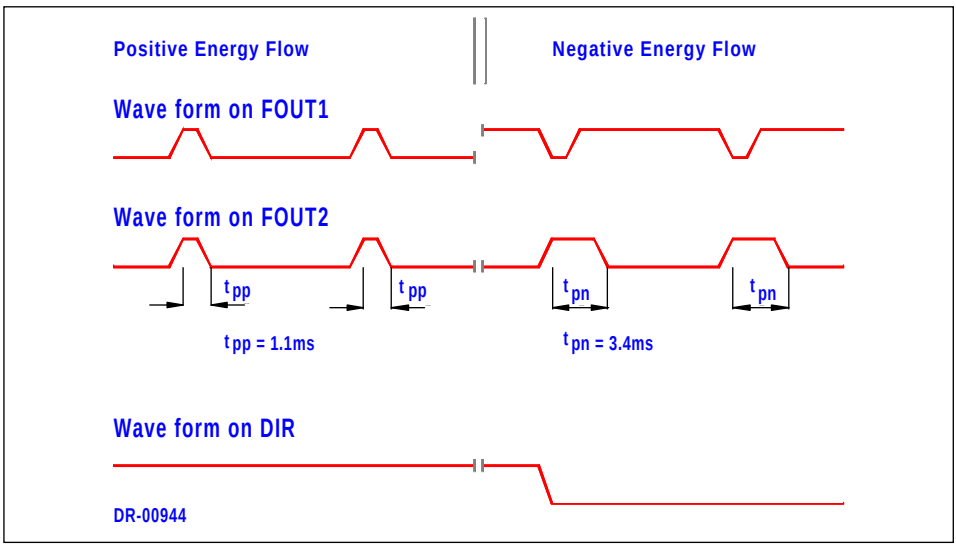
The overall power consumption rating of the SA9108F integrated circuit is less than 40mW having a 5V supply.

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:

$$f = 11.16 * FOUTX * \frac{FOSC}{3.58MHz} * \frac{(I_{I1}\, I_{V1}) + (I_{I2}\, I_{V2})}{2 * I_R^2}$$

Where FOUTX = Nominal rated frequency (64Hz)

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

I_{I1}, I_{I2} = 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 560µF.

The actual values determine the signal to noise and stability performance. The tolerances should be within ± 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.

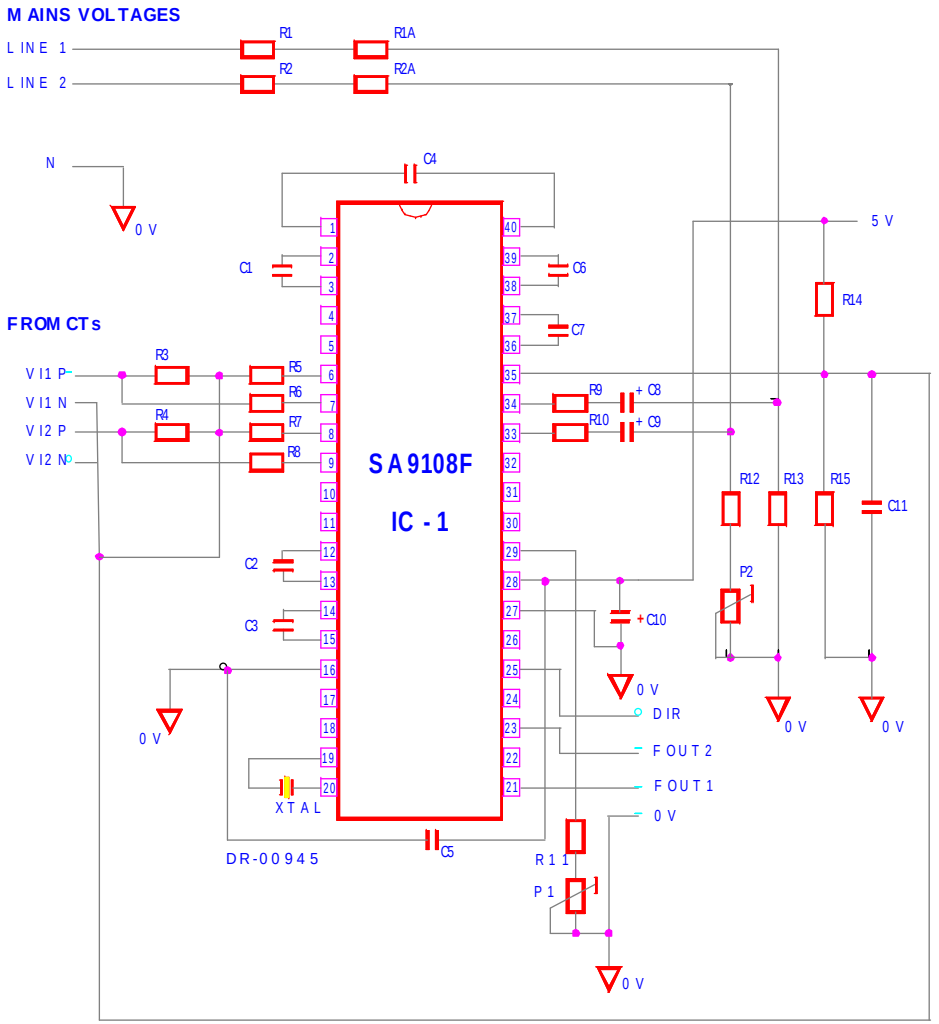
R_3 and R_4 = Current transformer termination resistors for the two phases.

$R_1 + R_{1A}$, R_{13} and R_9 set the current for the phase 1 voltage sense input. $R_2 + R_{2A}$, $R_{12} + P_2$ 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 C8 and C9 are for decoupling and phase compensation.

R_{11} and P_1 defines all on-chip bias and reference currents. With a total resistance of 24kΩ, optimum conditions are set. $R_{11} + P_1$ may be varied within ± 10% for calibration purposes. Any change in resistance will affect the output quadratically (i.e: ΔR = +5%, Δf = +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 (C5) to be positioned as close to Supply Pins (V_{DD} & V_{SS}) of IC-1, as possible.

ORDERING INFORMATION

Part Number	Package
SA9108FPA	DIP-40
SA9108FFA	PLCC-44

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 out web site:
http://www.sames.co.za

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