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PM9109BF

MONOCHIP SINGLE PHASE BIDIRECTIONAL KILOWATT HOUR METERING MODULE

FEATURES

- Performs bidirectional energy metering and includes a 7 digit LCD driver with announciators

- 4 externally selectable on-chip tariff registers

- An additional total energy register

- Meets the accuracy requirements for Class 1 AC Watt hour meters

- Optical interface for electronic reading according to IEC1107 Mode D

- Pulse output for calibration

- Total power consumption rating below 600mW

- Uses a shunt resistor for current sensing

- Operates over a wide temperature range

- Demonstration software included

DESCRIPTION

The SAMES monochip single phase bidirectional kilowatt hour metering module, the PM9109BF, provides all the required metering functions including energy measurement, a 7 digit LCD driver, a tariff selection facility, an optical port as well as a pulse output for calibration purposes.

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

This method of calculation takes the power factor into account.

This application utilises the SAMES SA9109BFA monochip single phase bidirectional kilowatt hour metering IC for energy measurement.

As a safety measure, this application shows the current sensor connected to the neutral line. In practice the live line may be used for current sensing, provided that the supply connections (MAINS) are reversed on the module.

BLOCK DIAGRAM

DR-00995
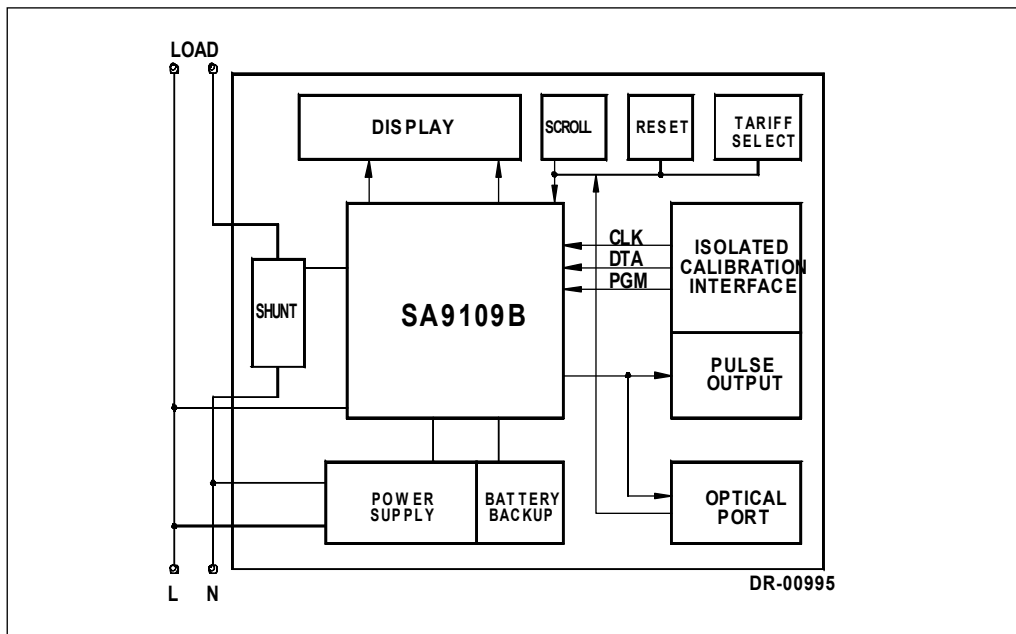
ABSOLUTE MAXIMUM RATINGS*

Parameter	Symbol	Min	Max	Unit
Supply Voltage (Note 1)	V_{AC}		540	V
Current Sense Input (Note 1)	V_{IV}	-2.5		V
Storage Temperature	T_{STG}	-25	+125	°C
Operating Temperature	T_O	-10	+70 (Note 2)	°C
Max Current	I_{MAX}		800 (Note 3)	A
through sensor	I_{MAX}		2000 (Note 4)	A

Note 1:   Voltages are specified with reference to Live.

Note 2:   The SA9109B integrated circuit is specified to operate over the temperature range -10°C to +70°C. The module functionality will however depend upon the external components used.

Note 3:   t = 500ms

Note 4:   t = 1ms

*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 operational sections of this specification, is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability.

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ELECTRICAL CHARACTERISTICS

(Over the temperature range -10°C to +70°C, unless otherwise specified. Power consumption figures are applicable to the PM9109BFE only.)

Parameter	Symbol	Min	Typ	Max	Unit	Condition
Supply Voltage (Continues)	V_{AC}	180	230	265	V	PM9109BFE
Power Consumption[1]				500	mW	V_{AC} = 230V Supply direct from mains
Isolation Voltage[2]	V_{IS}			2500	V	Continuous
Opto-coupler Output Current	I_O			10	mA	V_{OL} = 1V
Opto-coupler Input Current	I_I			10	mA	

Note 1: Power consumption specifications exclude power consumed by the current sensor.

Note 2: Isolation voltage may be specified, depending on customer requirements.

PIN DESCRIPTION

Designation	Description
MAINS	Voltage supply connection to Neutral line
	Voltage supply connection to Live line
NEUTRAL IN	Connection to positive side of current sensor
NEUTRAL OUT	Connection to negative side of current sensor
SK1 5-Pin Header connector	Isolated programming interface
SK2 2-Pin Header connector	Isolated pulse output

FUNCTIONAL DESCRIPTION

1. Energy Calculation

This Application Note should be read in conjunction with the SA9109B Data Sheet.

In the Application Circuit (see Figure 2), the output current from the current sensor will be between 0 and $16\mu A$ (0 to 80A through a shunt resistor of $625\mu\Omega$). The current input stage of the module saturates at input currents greater than 18µARMS. The mains voltage + 15% - 20%) is used to supply the circuitry with power and to perform the energy calculation, together with the current information from the current sensor (shunt resistor).

The SA9109BF integrated circuit may be adjusted to accommodate any voltage or current values. The method for calculating external component values is described in paragraph 9 (Circuit Description).

The accumulated energy is directly displayed on a 7 digit LCD. This unique application offers a host of additional features, which are dealt with below.

2. Electrostatic Discharge (ESD) Protection

The device's inputs/outputs are protected against ESD according to the Mil-Std 883C, method 3015. The modules resistance to transients will be dependant upon the protection components used.

3. Power Consumption

The overall power consumption rating for this power metering application (Figure 2), is under 600mW, excluding the current sensor, when the supply is taken directly from the mains.

4. Isolation

The programming interface and pulse output are isolated from the module which is at mains potential, via opto-couplers. (In the event of the use of a current transformer for current sensing, the opto-couplers would not be required).

5. Isolated Programming Interface

This isolated interface is provided to allow the user to programme the tariff register values, calibration constants and manufacturer/meter identification codes. This port is enabled by inserting the jumpers J8, J9 and J10. The programming may be performed via the parallel port of a personal computer.

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The designation of the pins on connector SK1 are given below:

PM9109B		PC Parallel Connectors (Suggested)	
Pin	**Description**	**Pin**	**Description**
1	$\overline{\text{GND}}$	18	GND
2	$\overline{\text{PB}}$	2	D1
3	PCLK	4	D3
4	PDTA	5	D4
5	$\overline{\text{PGM}}$	3	D2

Note: The recommended connections above are applicable for the demonstration software provided with the PM9109BF.

6. Optical Port
The optical port has been designed to meet the IEC1107 Mode D specification. This facility offers a pulse output as well as a serial data meter reading facility.

Three types of interfacing elements from the PM9109BF are available:

a) Infra-red optical port

b) Red LED

c) Opto-coupler

In order to maximise the intensity of the element, it is suggested that only one of the outputs be used at any one time.

Jumper	Element
J5	Opto Coupler
J6	Infra Red LED
J7	Red LED

7. Liquid Crystal Display (LCD)
The PM9109BF includes a LCD comprising of seven digits with announciators.

To cater for compatibility with future devices, four jumpers are provided for backplane driving configurations. The PM9109BF boards are shipped to the customer with jumpers in a default configuration.

This note refers to the SA9109B data sheet throughout the text and it is recommended that a copy of the data sheet of the SA9109B is on hand when reading through this description.

The SA9109B data sheet uses 80A and 230V for rated current and rated voltage when explaining functionality of the device. This is just for example and any other rated values may be used. All AC voltages and currents are RMS values unless otherwise specified.

Let us assume that we want to measure the energy for current range 0 ... 200A and voltage range 0 ... 120V. In this case I_{LR}=200A is a rated line current and V_{LR}=120V is a rated line voltage. Rated line power is 200A * 120V = 24kW.

Three simple steps must now be followed:

STEP 1

Select the shunt resistor RSH value and adjust the values of resistors R1, R2 in such a way that current flowing into the device's current sense input (pins 9 and 10) is 16µA for rated line current (200A). This should be simple and straightforward task because current sense input of the device (pins 9 and 10) behaves as a virtual short. For this example a shunt resistor with a value of 625µΩ is selected. This will result in the current sense input resistors having a value of R1=R2=1.6kΩ.

It is important to ensure that the voltage drop across the shunt resistor is not too low as the precision may suffer.

STEP 2

Choose resistors R3, R6 and R4 such that current flowing into the voltage sense input (pin 8) is 14µA for rated line voltage (120V). R3 and R4 forms a voltage divider from line voltage to approx. 10-20V and R4 is a serial resistor for setting the required voltage sense current of 14µA. Input to the device again behaves as a virtual short (with respect to GND - pin 11).

The value of capacitor C5 introduces a phase shift which can be used to compensate for current transformers, it is chosen to ensure that it forms a short with respect to R4 for typical mains frequency.

For this example R3 = 106K, R6 = 14K and R4 = 1M.

STEP 3

To calculate how much energy is represented by one pulse on output SDO (pin 39) and one Display increment, the following is now performed:

The formula for f_P, as shown in the data sheet can be simplified if:

FOSC = 3.5795MHz   recommended crystal with this frequency is used

I_I = 16µA   by choice of correct values for RSH, R1 and R2 (STEP 1)

I_V = 14µA   by choice of correct values for R3, R6 and R4 (STEP 2)

I_R = 50µA   recommended reference setting with value of 24K for resistor R7

If these values are substituted into the original formula:

f_P = 40062.5/Ks   **(1)**

Ks is an integer constant which can be programmed into the device. **Range is 1025 ... 16384.**

Display increment frequency is 64 times lower (refer to diagram "Programmable slope divider" in the datasheet).

Display increment = 40062.5/(Ks*64) = 626/Ks   (2)

Substituting Ks into each of these two formulae gives ranges for f_P and Display increment:

f_P = 39.0854Hz ... 3.6659Hz   **(3)**

Display increment = 0.6107Hz ... 0.0573Hz   **(4)**

These values are min and max for f_p at all rated conditions because of properly adjusted resistor values (chosen in STEP 1 and STEP 2) to ensure that I_I = 16µA and I_V = 14µA.

How much energy is now represented by one pulse on SDO?

In this example the rated power is 24000W which gives energy 24000Ws for 1 second. Energy for 1 pulse on SDO is then 24000Ws/f_P. Now substitute ranges given in statement (3) above:

Energy for 1 pulse on SDO   = (24000/39.0854)Ws ... (24000/3.6659)Ws
                                             = 614.04Ws ... 6546.82Ws

Similarly by using (4)

Energy for 1 Display increment $\quad$ = (24000/0.6107)Ws ... (24000/0.0573)Ws
$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad$ = 39299.2Ws ... 418848.2Ws
$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad$ = 0.0109kWh ... 0.1164kWh

Any value in this range can be chosen by programming Ks into the device.

How is the calibration factor, Ks, derived?

Ks = $\quad$ (626 * E_{Ws}) / (V_{LR} * I_{LR}) $\quad\quad\quad\quad\quad\quad$ **(5)**

or Ks = $\quad$ (626 * 3600 * 1000 * E_{kWh}) / (V_{LR} * I_{LR}) $\quad$ **(6)**

where $\quad\quad I_{LR}$ $\quad\quad\quad$ is rated line current
$\quad\quad\quad\quad\;\; V_{LR}$ $\quad\quad\quad$ is rated line voltage
$\quad\quad\quad\quad\;\; E_{ws}$ $\quad\quad\quad$ is energy for one Display increment in Ws
$\quad\quad\quad\quad\;\; E_{kWh}$ $\quad\quad$ is energy for one Display increment in kWh

This formula is valid only if 16μA flows into current sense input for rated line current I_{LR} and 14μA flows into voltage sense input for rated line voltage V_{LR} (in other words - resistor adjustments as shown as example in STEP 1 and STEP 2 must be carried out).

For practical reasons it is standard to use 0.1kWh for 1 Display increment.

Using formula (6) :

$\quad\quad$ Ks = $\quad$ (626 * 3600 * 1000 * 0.1) / (120 * 200) = 9390

It can be derived that a value of Ks=9390 must be programmed into the device for 0.1kWh for $\quad\quad$ one Display increment, if I_{LR} =200A and V_{LR} =120V. This constant may vary ±10% for calibration purposes.

Using this approach it is shown that:

1) the SA9109B device can be adjusted to any rated values (even orders of magnitude higher or lower than in this example);
2) ranges for energy per Display increment can be calculated.

This approach also applies to the SA9110A.

8.   Tariff, Scroll and Reset Functions

Tariff Selection

A dual DIP switch provides the user with the facility to set the active tariff register in which consumption will be accumulated.

The active register is indicated on the LCD.

Scroll Facility

The 4 registers may be sequentially displayed by activating the scroll button. The contents of the register selected for display is retained on the display for a period of 10 seconds, provided that the push button is not activated during this period. After the 10 seconds has elapsed, the display defaults to the "active" register defined by the status of the tariff DIP switches.

The register selected for display via the scroll button is indicated by the relevant announciators.

Reset Function

By pressing the Reset button the contents of the RAM of the SA9109B device is set to the default conditions.

Jumpers J8, J9 and J10 must be removed to use this feature.

It is strongly recommended that the provision of this facility is not made available on production meters.

9.   Circuit Description

The Application Circuit (Figure 2) shows the components required for a power metering application, using a shunt resistor for current sensing. In this application the circuitry requires a +2.5V, 0V, -2.5V DC supply.

The most important external components are:

C_1 and C_2 are the outer loop capacitors for the two integrated oversampling A/D converters. The value of these capacitors is 560pF.

The actual values determine signal to noise and stability performance. The tolerances should be within ± 10%.

C_3 and C_4 are the inner loop capacitors of the A/D converters. The optimum value is 3.3nF. The actual values are uncritical. Values smaller than 0.5nF and larger than 5nF should be avoided.

R_2, R_1 and R_{SH} 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 SA9109B, at rated 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 $\quad I_L \quad$ = $\quad$ Line current
$\qquad\qquad R_{SH}$ = $\quad$ Shunt resistor

R_{3A}, R_{3B}, 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.

R_7 defines all on-chip bias and reference currents. With R_7 = 24kΩ, optimum conditions are set. R_7 may be varied within ±10% for calibration purposes. Any change to R_7 will affect the energy calculation quadratically.

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

10. Demonstration Software

The accompanying diskette requires an IBM or compatible PC with MS-DOS installed. This software, supplied on a 1.4M 3½" disk, will allow the user to read and write settings from/to the demonstration unit.

Context sensitive help screen for each input field or command prompt are available by invoking [alt] H or [F1] key.

An introduction is available by pressing the [F1] key immediately after installation.

INSTALLATION

1. Copy the file SA9109.exe to the directory from which to operate.
2. Connect the demonstration board to either COM1 or COM2 (default) of the PC.
3. The demonstration board may now be connected to the load and the mains supply attached as suggested in the Functional Description section of the appropriate Application Note.
4. At the DOS prompt type SA9109 and carriage return [CR] to invoke the programme.

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RUNNING THE PROGRAMME

On entering the programme, the user will be offered a selection of fields to choose from. A brief description of each field is given below:

Comms   Selection of serial communication port connecting the demoboard containing the SA9109B to the PC.

Read   Start task of reading from attached SA9109B device.

Write   Data stored in the input boxes displayed on the right hand side of the screen will be written via the parallel port connected on SK1.

Capture boxes with a .... on display will write the value displayed in the Read section for that parameter.

Help   Screen of useful keystrokes used in the programme.

A number of input boxes are available to the user to enter register start values, identity numbers, and the slope factor for the output frequency. Input boxes are:

TARIFF 1   Initial value from which the device must start accumulation of data of chosen as "Active" tariff register

TARIFF 4

Sign +/-   The register value input for Tariff 1 -- Tariff 4 may be either a positive (+) or negative (-) value.

Total   As with the tariff registers, an initial value from which accumulation of registers totals will begin may be entered. This register, in practice, will contain the sum of the four tariff registers. Updating of this register takes place automatically when either of the tariff registers increment during power consumption.

I.D. man/
I.D. sys   Numeric code to allow the supplier to individually attach a reference identifier to a metering unit.

Type   This field should remain as per default (SA9109B selected). The SA9109B will increment irrespective of energy direction.

Slope The output frequency at SDO (f_p) may be adjusted during cali
bration according to the formula:

$$f_p = 11.16 \times \frac{FOSC}{3.5795E6} \times \frac{I_I I_V}{I_R^2} \times \frac{40062.5}{K_s}$$

where

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

I_I = Input current for current sensor input
(16µA at rated line current)

I_V = Input current for voltage sensor input
(14µA at rated line voltage)

I_R = Reference current (Typically 50µA)

K_S = Slope constant (1025 --- 16384)
(Default 11389)

For default rated conditions the output frequency on SDO will be 3.5Hz. The
display is incremented after every 64th pulse on SDO as shown in the block
diagram below.

DR-00938
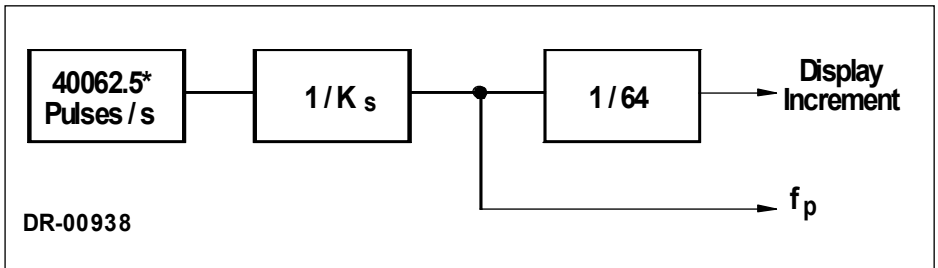
USEFUL NOTES:

1. A context sensitive help screen is available throughout the programme
and is invoked by using [F1] or [ALT]-H.

2. Hot key features are available for a number of functions and can be
identified for use by the highlighted character of the field. For example,
[ALT]C for COMMS field.

3. To exit from the programme [Esc] or [Alt]-X
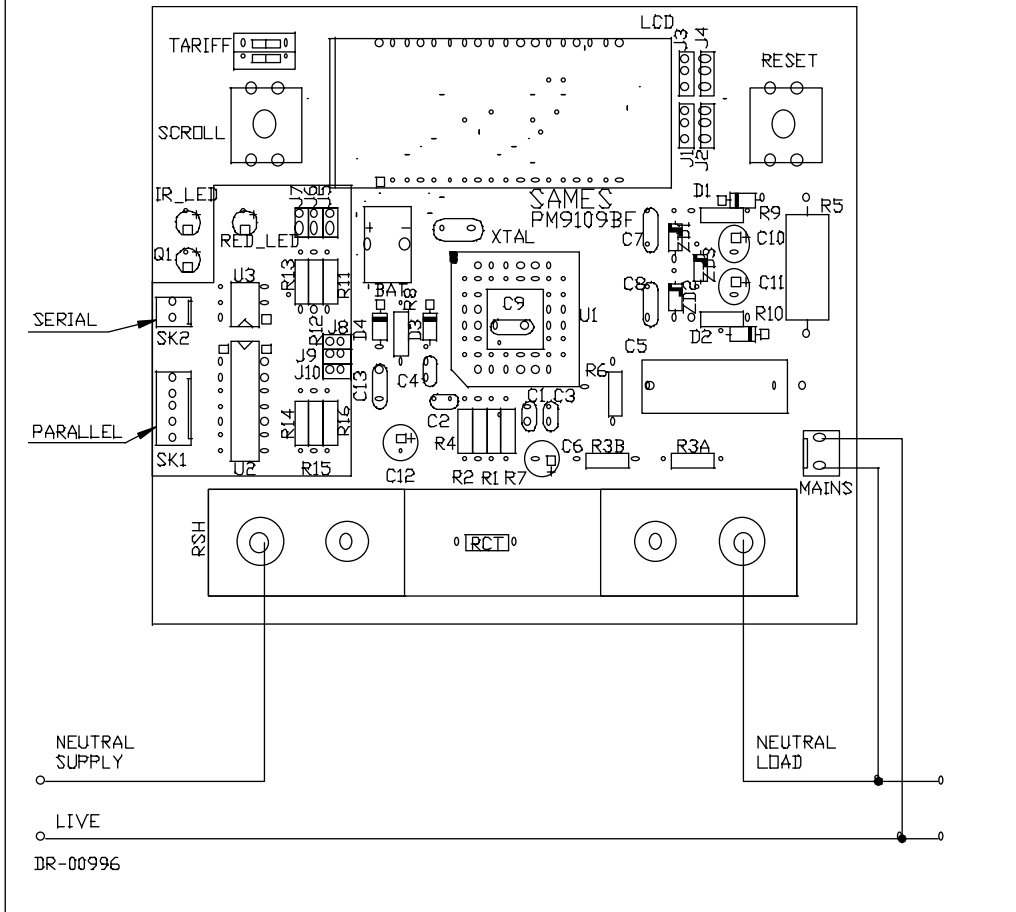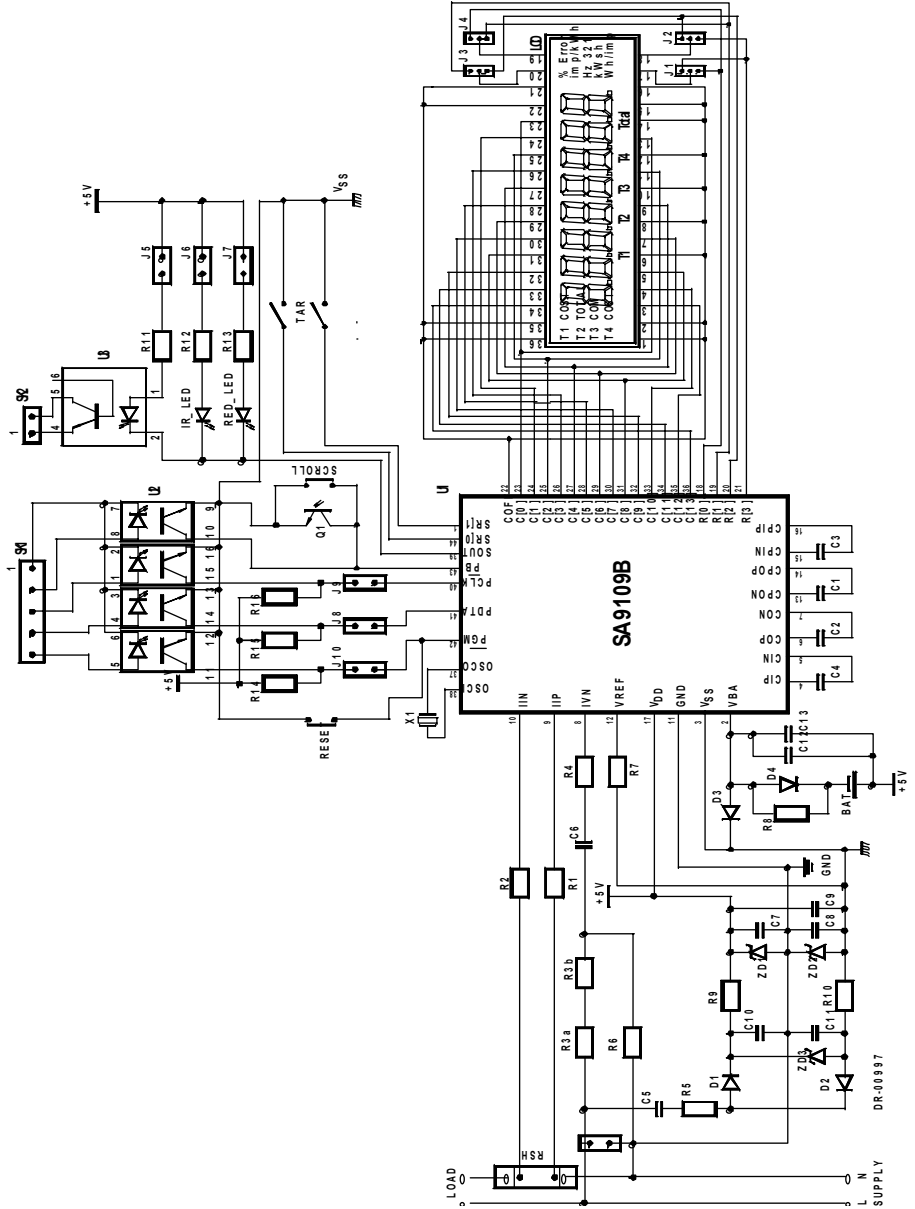
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Figure 1: Connection Diagram

Figure 2: Application Circuit

DR-00997

Parts List for Application circuit: Figure 2

Item	Symbol	Description	Detail
1	U-1	SA9109BF	PLCC-44
2	U-2	ILQ74 (Quad opto-coupler)	DIP-16
3	U-3	4N35 (opto-coupler)	DIP-6
4	XTAL	Crystal 3.5795MHz	Colour burst TV
5	R1	Resistor, 1.6kΩ, 1%, metal	Note 1
6	R2	Resistor, 1.6kΩ, 1%, metal	Note 1
7	R3A	Resistor, 180kΩ, 1%, metal	Note 2
8	R3B	Resistor, 200kΩ, 1%, metal	Note 2
9	R4	Resistor, 24kΩ, 1%, metal	Note 2
10	R5	Resistor, 470kΩ, 2W, 5%	
11	R6	Resistor, 24kΩ, 1%, metal	Note 2
12	R7	Resistor, 24kΩ, 1%, metal	
13	R8	Resistor, 2MΩ, 1%, metal	
14	R9	Resistor, 680Ω, 1%, metal	
15	R10	Resistor, 680Ω, 1%, metal	
16	R11	Resistor, 680Ω, 1%, metal	
17	R12	Resistor, 2.2kΩ, 1%, metal	
18	R13	Resistor, 2.2kΩ, 1%, metal	
19	R14	Resistor, 2.2kΩ, 1%, metal	
20	R15	Resistor, 2.2kΩ, 1%, metal	
21	R16	Resistor, 2.2kΩ, 1%, metal	
22	RSH	Shunt resistor, 80A, 50mV (625μΩ)	Note 1
23	C1	Capacitor, 560pF	
24	C2	Capacitor, 560pF	
25	C3	Capacitor, 3.3nF	
26	C4	Capacitor, 3.3nF	
27	C5	Capacitor, 470nF, polyester, 250VAC	
28	C6	Capacitor, 1μF, 16V	
29	C7	Capacitor, 100nF	
30	C8	Capacitor, 100nF	
31	C9	Capacitor, 820nF	
32	C10	Capacitor, 100μF, 16V	
33	C11	Capacitor, 100μF, 16V	
34	C12	Capacitor, 820nF	
35	C13	Capacitor, 100nF	
36	BAT	Battery, 1.2V	
37	IR LED	Infrared light emitting diode	
38	RED LED	Red light emitting diode	
39	Q1	Photo transistor	
40	D1	Diode, 1N4148	
41	D2	Diode, 1N4148	
42	D3	Diode, 1N4148	

Parts List for Application circuit: Figure 2 (continued)

Item	Symbol	Description	Detail
43	D4	Diode 1N4148	
44	ZD1	Zener Diode, 2.4V	
45	ZD2	Zener Diode, 2.4V	
46	ZD3	Zener Diode, 47V	
47	SCROLL	NO, push button	
48	RESET	NO, push button	
49	TARIFF	DIP switch, 2 pole	
50	LCD	OEL-7678*	

Note 1: Resistor (R1 and R2) values are dependant upon the selected values of RSH. See paragraph 9 (Circuit Description) when selecting the value of RSH.

Note 2: See the table below for resistor values, assuming a 115V/80V metering application is required.

Item	Symbol	Description 115V/80A	Detail
7	R3A	120kΩ	
8	R3B	82kΩ	
27	C5	1μF	

ORDERING INFORMATION

Part Number	Description
PM9109BFE	230V, 80A Module
PM9109BFA	115V, 80A Module

*The LCD display is available from:
JEBON CORPORATION
Unit 709, Poongsan Factoria Town,
1141-2, Baegsok-Dong, Ilsan-District,
Koyangcity, Kyonggi-Do, 411-360, Korea
Tel: +82-31-902-9161 (12 lines)
Fax: +82-31-902-7775/7776

Web site: http://www.jebon.com

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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:
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