SA2007H Application Note:
Energy Meter Evaluation Module with Pulse Output

PM2007HPE

INTRODUCTION

This Application Note describes the functionality of the SA2007H metering integrated circuit using the PM2007HPE evaluation module. The SA2007 family is a low cost solution specifically designed to meet the needs of markets that require both live and neutral energy measurement to detect possible meter tampering.

Using the SA2007H family the meter manufacturer is able to build a meter that measures the energy consumption, on both live and neutral, with a separate pulse output for each channel.

The PM2007HPE module is designed for a single-phase application monitoring both live and neutral lines. The mains voltage easily connects to the module by way of a Molex connector (CON1). The 2 on-board current transformers measure the current in both the live and neutral. A transformer based power supply supplies the SA2007H energy metering IC with power. The SA2007H forms the energy/power metering front-end of the module.

The PM2007HPE module can easily be connected to a micro-controller via connector CON2 thereby creating a complete power meter.

THE SA2007H ENERGY METER IC

The SAMES SA2007H is a single phase bidirectional dual element energy metering integrated circuit. It provides a simple analog interface to a micro-controller and is specifically designed for meter manufacturers to have full control over the meter functionality.

The SA2007H has two current sensor inputs. The power consumption on both inputs are continuously measured. A typical application would be to monitor Live and Neutral lines for tamper detection.

For each current sensor input the SA2007H integrated circuit has a corresponding pulse output, each generating a pulse rate with a frequency proportional to the power consumption measured on the specific channel.

More detailed information specific to the SA2007H can be found in its datasheet.

MAINS CONNECTION TO MODULE

The PM2007HPE module connects directly to live and neutral on CON1. The module is referenced to neutral and this should be kept in mind when connecting test equipment to the module.

CON2 is used for connection to a micro-controller.

Name	Function Description	SA2007H
Con1	Connector for the 230VAC power for the module	1 Live 2 Neutral
Con2	Connector for micro-controller	VDD Fm0 P1 D1 P2 D2 VSS

Table 1: Connector Descriptions

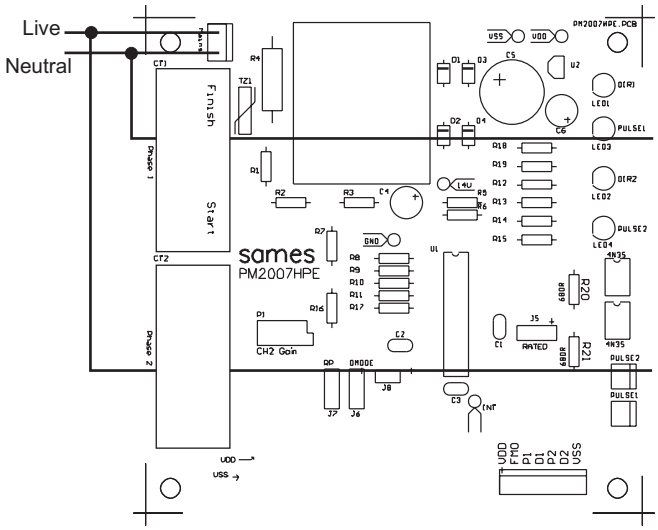

Figure 1: Connection diagram for normal metering application

MODULE SETUP

The PM2007HPE module is setup for use with the SA2007H integrated circuit. Resistor values used on the module is calculated for rated conditions of 60A/230V.

Name	Function Description	SA2007H setting
J5	Test input, pin 15	
J6	Select between latched or unlatched mode (OMODE)	
J7	RP jumper, pin 7. Reset latched mode.	
J8	TCLK to VSS for normal operation.	

Table 2: Jumper settings for various device options

MODULE OVERVIEW

ANALOG SECTION

The analog (metering) interface described in this section is designed for measuring 230V/60A with precision better than Class 1.

The most important external components for the SA2007H integrated circuit are the current sense resistors, the voltage sense resistors and the bias setting resistor. The resistors used in the metering section should be of the same type so temperature effects are minimized.

Current Input IIN1, IIP1, IIN2, IIP2

Two current transformers are used to measure the current in the live and neutral phases. The output of the current transformer is terminated with a low impedance resistor. The voltage drop across the termination resistor is converted to a current that is fed to the differential current inputs of the SA2007H.

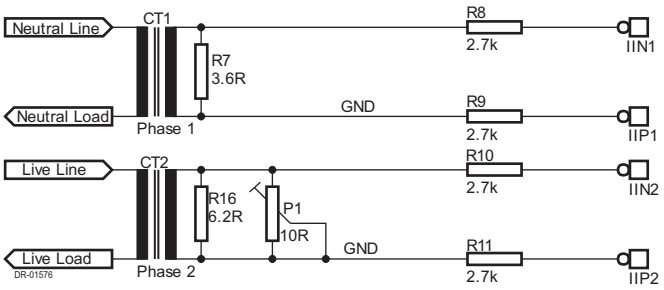

Figure 2: Current input configuration

CT Termination Resistor

The voltage drop across the CT termination resistor at rated current should be at least 20mV. The CTs have low phase shift and a ratio of 1:2500. The CT is terminated with a 3.6Ω resistor giving a voltage drop of 86.4mV across the termination resistor at rated conditions (I_{max} for the meter).

The termination resistor on the second current channel is adjustable by means of P2 to facilitate channel equalization calibration. The termination resistor is chosen so that a 10Ω trimpot in parallel will provide a sufficient channel range.

Current Sensor Input Resistors

The resistors R8, R9 and R10, R11 define the current level into the current sense inputs of the SA2007H. The resistor values are selected for an input current of 16µA on the current inputs of the SA2007H at rated conditions. For a 60A meter at 2500:1 CT the resistor values are calculated as follows:

$R8 = R9 = (I_L / 16\mu A) \times R_{SH} / 2$

$= 60A / 2500 / 16\mu A \times 3.6\Omega / 2$

$= 2.7k\Omega$

I_L = Line current

RSH = CT Termination resistor

2500 = CT ratio

The two current channels are identical so R8 = R9 = R10 = R11.

Voltage Input (IVP)

The voltage input of the SA2007H (IVP) is driven with a current of 14µA at nominal mains voltage. This voltage input saturates at approximately 17µA. At a nominal voltage current of 14µA allows for 20% overdriving. The mains voltage is divided with a voltage divider to 14V that is fed to the voltage input pins via a 1MΩ resistor.

Voltage Divider

The voltage divider is calculated for a voltage drop of 14V. Equations for the voltage divider in figure 3 are:

RB = R1 + R2 + R3 + R4

RB = R6 || R5

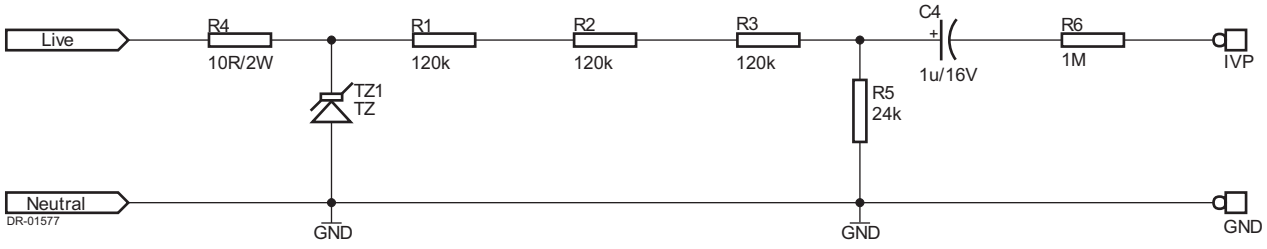

Figure 3: Mains voltage divider

Combining the two equations gives:

(RA + RB) / 230V = RB / 14V

Values for resistors R4 = 10Ω, R5 = 24kΩ and R6 = 1MΩ are chosen.

Substituting the values result in:

RB = 23.437kΩ

RA = RB x (230V / 14V – 1)

RA = 361.607kΩ.

Standard resistor values of R1, R2, R3 and R4 are chosen to be 120kΩ, 120kΩ, 120kΩ and 10Ω.

The capacitor C4 is used to compensate for phase shift between the voltage sense inputs and the current sense inputs of the device, in cases where CTs with phase errors are used. The phase shift caused by the CT may be corrected by inserting a capacitor in the voltage divider circuit. To compensate for a phase shift of 0.18 degrees the capacitor value is calculated as follows:

C = 1 / (2 x π x Mains frequency x R5 x tan (Phase shift angle))

C = 1 / (2 x π x 50 x 1MΩ tan (0.18 degrees))

C = 1.013µF

Reference Voltage VREF

The VREF pin of the SA2007H is connected to a resistor R17 that determines the on chip bias current. For optimum settings, R17 = 24k.

Ground GND

The GND pin of the SA2007H is connected to the neutral phase, which is halfway between VDD and VSS. Note that supply bypass capacitors C1 and C2 are positioned as close as possible to the supply pins of the device, and connected to a solid ground plane.

Protection

A MOV together with R4 protects the transformer and the voltage divider circuit against voltage transients.

Common mode and asymmetrical transients are attenuated by the current setting resistors R8, R9, R10 and R11.

POWER SUPPLY

The PM2007HPE module uses a transformer based power supply. The maximum current that is drawn by the circuit is as follows:

The average power consumption of the module is usually less that those indicated in Table 3. The current indicated in Table 3 is worst-case peak pulse current. The normal operating current of the module is closer to 10mA. A 78LC05-voltage regulator is used to regulate the voltage from the transformer. Two resistors R18 and R19 generate the analog ground voltage for the SA2007H. The SA2007H operates between 5 Volt and 0 Volt with its GND pin connected to mid-rail.

Source	Max current	Unit
SA2007H IC	5	mA
DIR 1 LED	5	mA
DIR 2 LED	5	mA
Pulse 1 LED	5	mA
Pulse 2 LED	5	mA
GND ref	3	mA
Total	28	mA

Table 3: Maximum peak current drawn by components on the module

CALIBRATION AND SETUP

The P1 pot can be used to calibrate CT2 in order to get the two channels to measure equal amounts of energy. Pulse1 and Pulse2 are the optically isolated outputs of each channel.

LED CONSTANT

A fast output is given for each channel (1360 Hz) with a pulse width of 71µS for positive and 142µS for negative energy.

LED Outputs	LED Functionality
LED1	Direction, Channel 1
LED2	Direction, Channel 2
LED3	Pulse output, Channel 1
LED4	Pulse output, Channel 2

Table 4: LED output description

Any lower output frequency can be obtained by connecting on external micro-processor to the module. All the necessary signals for the external micro is taken to an on-board connector for convenient use.

PCB DESIGN

The module is designed to demonstrate the functionality and performance of the SA2007H single phase metering circuits. The SA2007H requires external settings and gain adjustment.

GROUND PLANE

The ground plane, which is connected to neutral, protects the device from external noise and is used to connect the power supply bypass capacitors C1 and C2. On the current input resistors and the CT termination resistor loops are introduced to cancel out the signal induced by the transformers magnetic field.

The 5V supply is de-coupled and routed directly to the power pins of the IC.

COMPONENT LISTS

The following component list covers all components fitted on the PM2007HPE module as shipped and configured for the SA2007H device.

Symbol	Description	Detail
U1	SA2007HPA	PDIP20
IC2	78C05, Voltage regulator	
D1, D2, D3, D4	Diode, Silicon, 1N4148	
R1, R2, R3	Resistor, 120k, 1/4W, 1%, metal	
R4	Resistor, 10R, 2W, Wire wound	
R5	Resistor, 24k, 1/4W, 1%, metal	
R6	Resistor, 1M, 1/4W, 1%, metal	
R7	Resistor, 3.6R, 1/4W, 1%, metal	
R16	Resistor, 6.2R, 1/4W, 1%, metal	
R17	Resistor, 24k, 1/4W, 1%, metal	
R8, R9, R10, R11	Resistor, 2.7k, 1/4W, 1%, metal	
R12, R13, R14, R15	Resistor, 680R, 1/4W, 1%, metal	
R18, R19	Resistor, 1k, 1/4W, 1%, metal	
R20, R21	Resistor, 680R, 1/4W, 1%, metal	
P1	10R, Trimpot	
C1, C2	Capacitor, 220nF	
C3	Capacitor, 220nF	
C4	Capacitor, 1uF, 16V, electrolytic	
C5	Capacitor, 2200uF, 16V, electrolytic	
C6	Capacitor, 220uF, 16V, electrolytic	
LED1, LED2, LED3, LED4	3mm Light emitting diode	
T1	Transformer, 230V/9V, 1.5VA	
TZ1	S10K275 MOV	
Con1	Molex 3 pin connector, 200 mil pin spacing	
Con2	Molex 7 pin connector, 100 mil pin spacing	
CT1, CT2	Current Transformer, TZ-76, PCB Mount	
4	Jumpers	
U2, U3	4N35	

Table 5: Components for SA2007H functionality, 60A rated setup

PCB LAYOUT

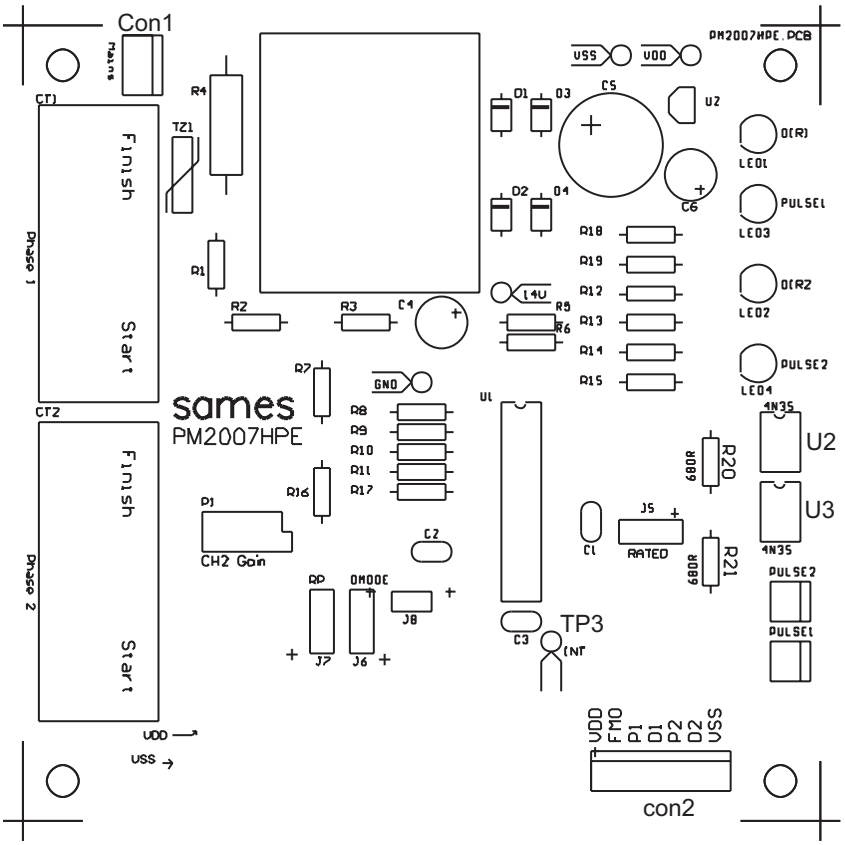

Figure 4: Component layout

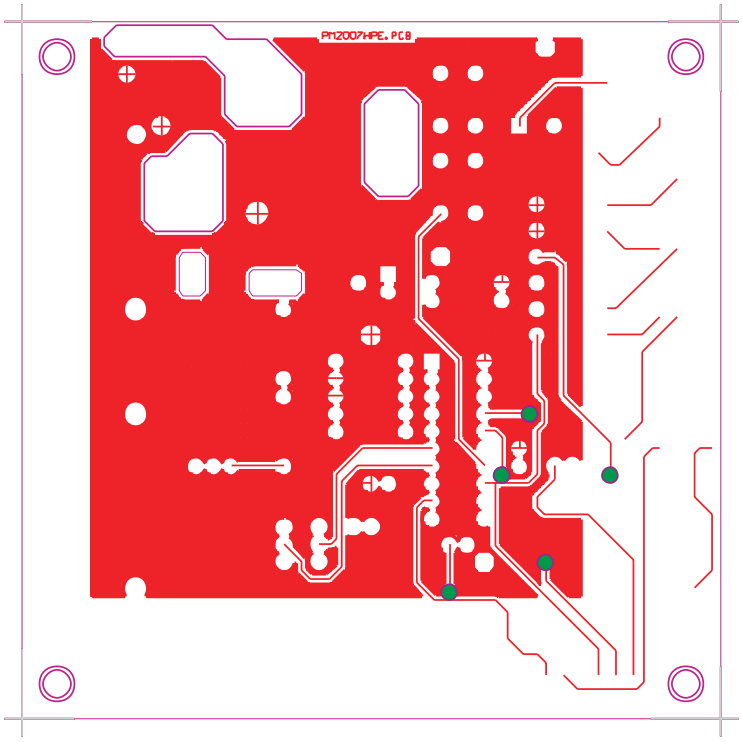

Figure 5: PM2007HPE top side

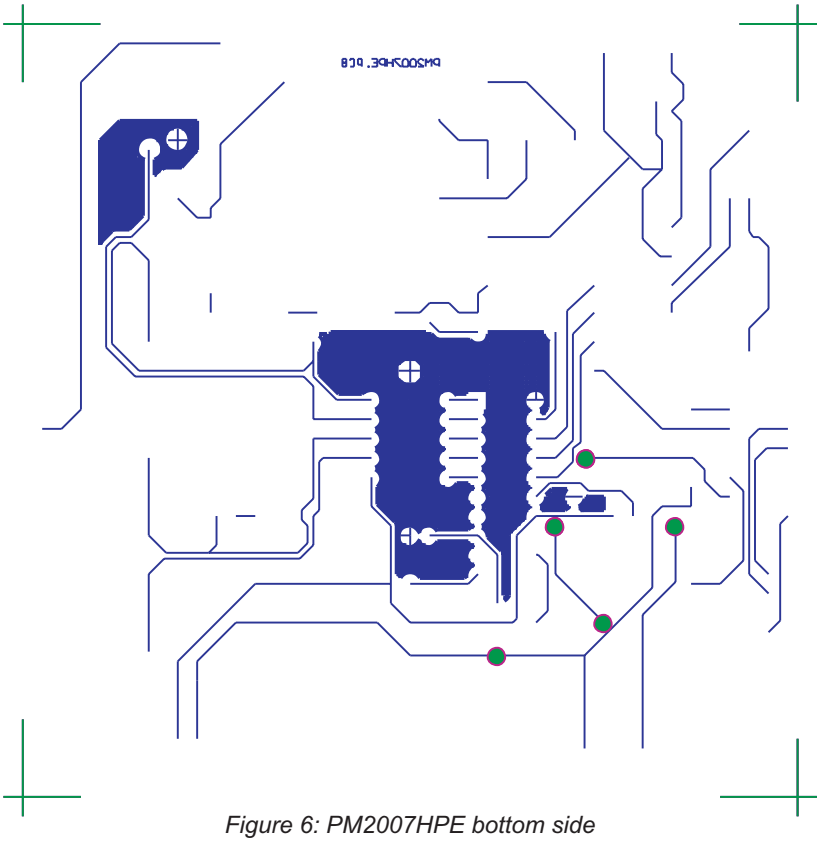

Figure 6: PM2007HPE bottom side

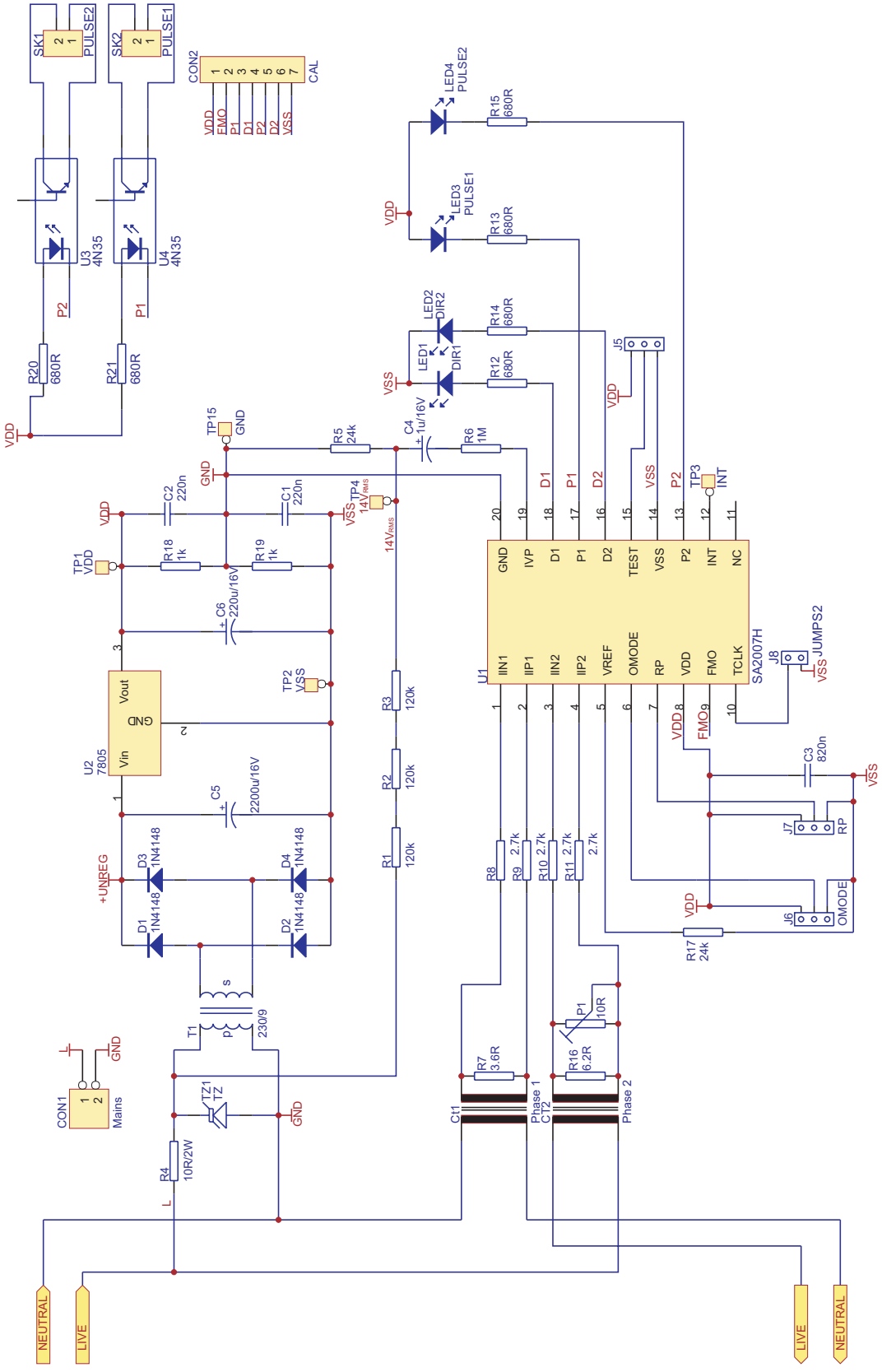

Figure 7: Schematic diagram of the complete PM2007HPE module

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