ADE795 Energy Metering IC

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Introduction

We aim to use the ADE795 IC in this project for current,voltage and energy measurement applications and is designed for single phase.The IC provides features such as active,reactive and apparent energy measurement along with 3 Σ-Δ ADCs , which are used for measuring current and voltage values.There are a total of 2 channels for current measurement and one for voltage.The second current input channel simultaneously measures neutral current and enables tamper detection and neutral current billing.For communication with the chip, it is possible to use UART,SPI and I2C communication protocols.

In addition to this, it also provides overvoltage and overcurrent protection with programmable thresholds.

The Test Circuit

The datasheet for the ADE795 provides a test circuit which is given below :

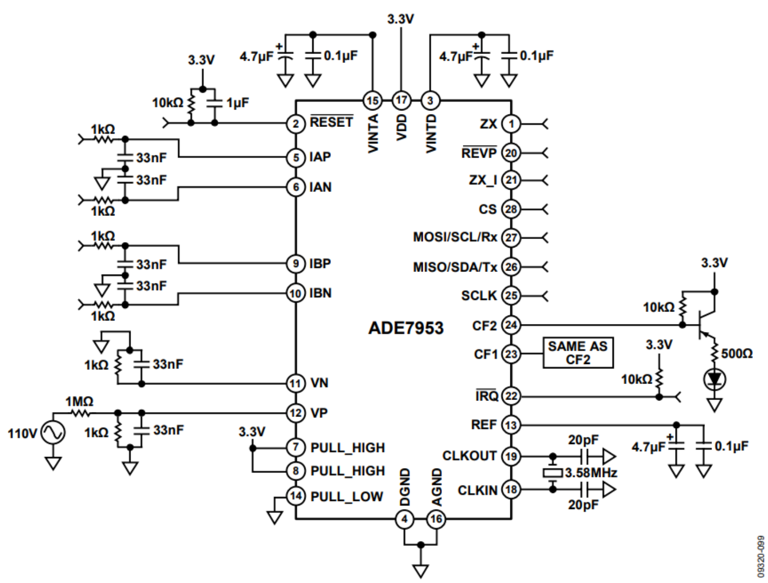


Figure 35. Test Circuit

Measuring Voltage And Current

The IC uses differential ADCs.It supports a maximum differential voltage of +500mV to -500mV on all measurement channels.

For current measurement, it expects that the current resulting from a current transformer will be passed through a burden resistor which will create a differential voltage across its ends which will depend upon the current passing through the resistor and the resistor value itself.

For voltage measurement the test circuit describes connecting the Vn pin to ground and the Vp pin to a voltage divider which is used for stepping down the lines voltage to a measurable value.

The values for voltage measurement resistors given in the circuit are for 110V rms input, these will have to be changed as our board is being designed for a 230V rms input.

Considering a 110V rms input the peak to peak and rms value of input voltage at Vp is calculated as given below : ->

$$V_{VP(\text{peak})} = V_{\text{in(peak)}} \times \frac{R_{\text{bottom}}}{R_{\text{top}} + R_{\text{bottom}}} = V_{\text{in(peak)}} \times \frac{1\,k\Omega}{1\,M\Omega + 1\,k\Omega}$$

- $V_{\text{in(RMS)}} = 110\,V$
- $V_{\text{in(peak)}} = 110 \times \sqrt{2} \approx 155.56\,V$

So:

$$V_{VP(\text{peak})} \approx 155.56 \times \frac{1000}{1\,001\,000} \approx 0.1554\,V = 155.4\,\text{mV (peak)}$$

And:

$$V_{VP(\text{RMS})} \approx \frac{155.4}{\sqrt{2}} \approx 110\,\text{mV (RMS)}$$

So we will modify the value of 1Mohm resistor so as to get 110mV rms on the Vp pin for a 230V rms input. This can be done by changing the resistor value of 1Mohm to approximately 2 Mohm.

$$V_{\mathrm{VP}} = V_{\mathrm{in}} \times \frac{R_{\mathrm{bottom}}}{R_{\mathrm{top}} + R_{\mathrm{bottom}}}$$

Rearranged to solve for R_{top}:

$$R_{\mathrm{top}} = R_{\mathrm{bottom}} \left(\frac{V_{\mathrm{in}}}{V_{\mathrm{VP}}} - 1 \right)$$

Plug in values:

$$R_{\mathrm{top}} = 1\,000 \times \left(\frac{325.27}{0.1554} - 1 \right) \approx 1\,000 \times (2093.6 - 1) \approx \mathbf{2.0926\,M\Omega}$$

So a voltage divider consisting of 2 Mohm and 1k Ohm resistor can be used for the purpose of measuring 230V rms mains voltage.

Now for the purpose of current measurement two approaches can be used : ->

1) Current Transformer
   A current transformer can be used to step down the high mains AC current to a lower AC current before passing it through a resistor to create a differential voltage corresponding to the mains current across its ends.
   This approach ensures minimum power loss and provides isolation from live mains circuitry.

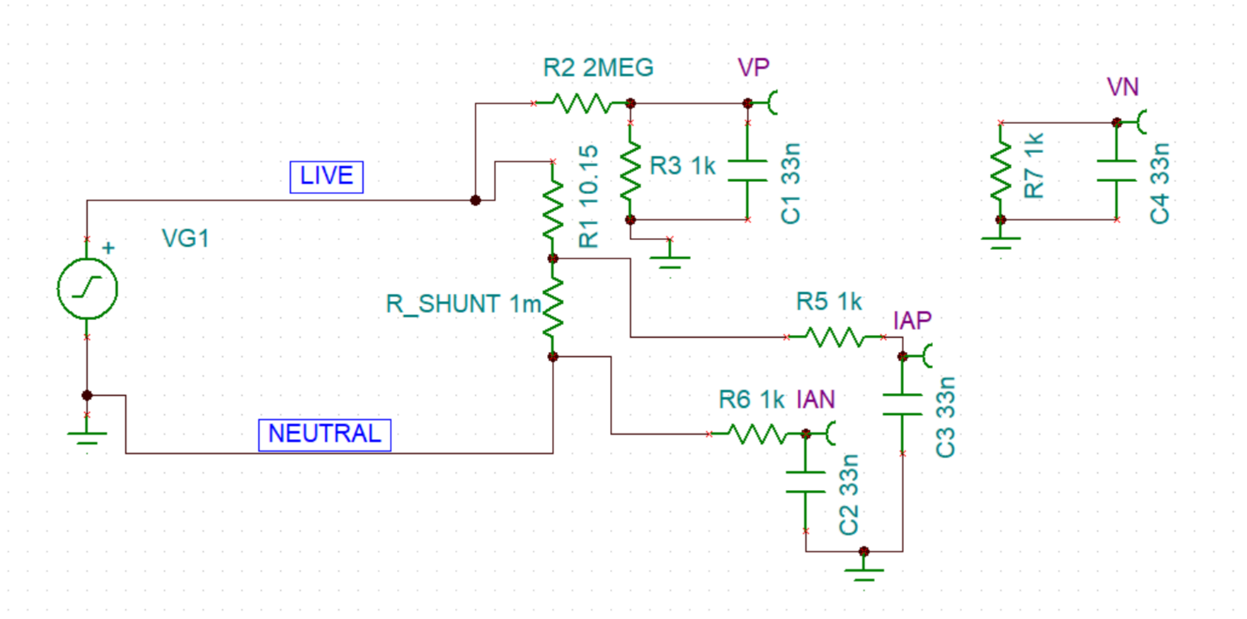
2) Shunt Resistor
   Another way of measuring mains current is to place a low value shunt resistor on the AC mains line and measure the voltage difference across it.While this approach is simpler it raises the issue that the measurement circuitry will be at live potential and no isolation will be available.Also the power dissipated by the shunt resistor will be very high.

One way to use a shunt resistor safely for current measurement is to apply it on the neutral line instead of the live line.

Simulation

The values for resistors and other components have been tested in simulation.They have been calculated in consideration of a maximum current of 32A.

The simulation circuit has been given below :

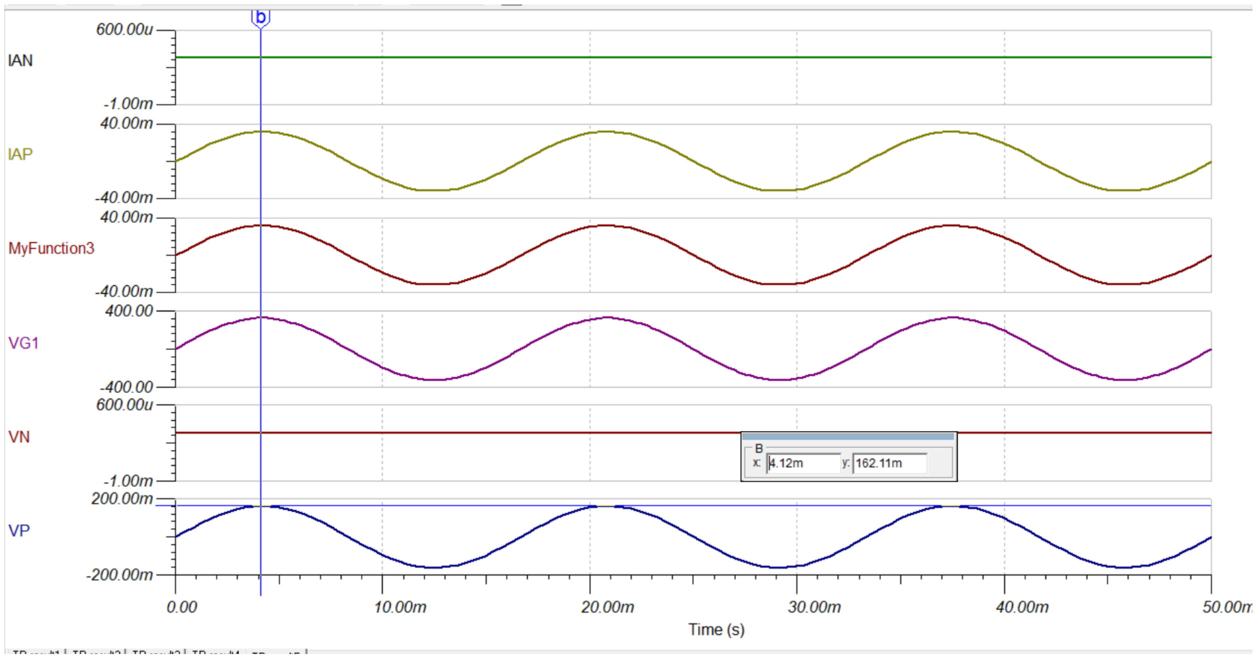


The specific circuits for the current and voltage measurement pins are identical to those provided in the test circuit.The load resistance (Rload) value has been set to allow for a current of approximately 32A through the load.

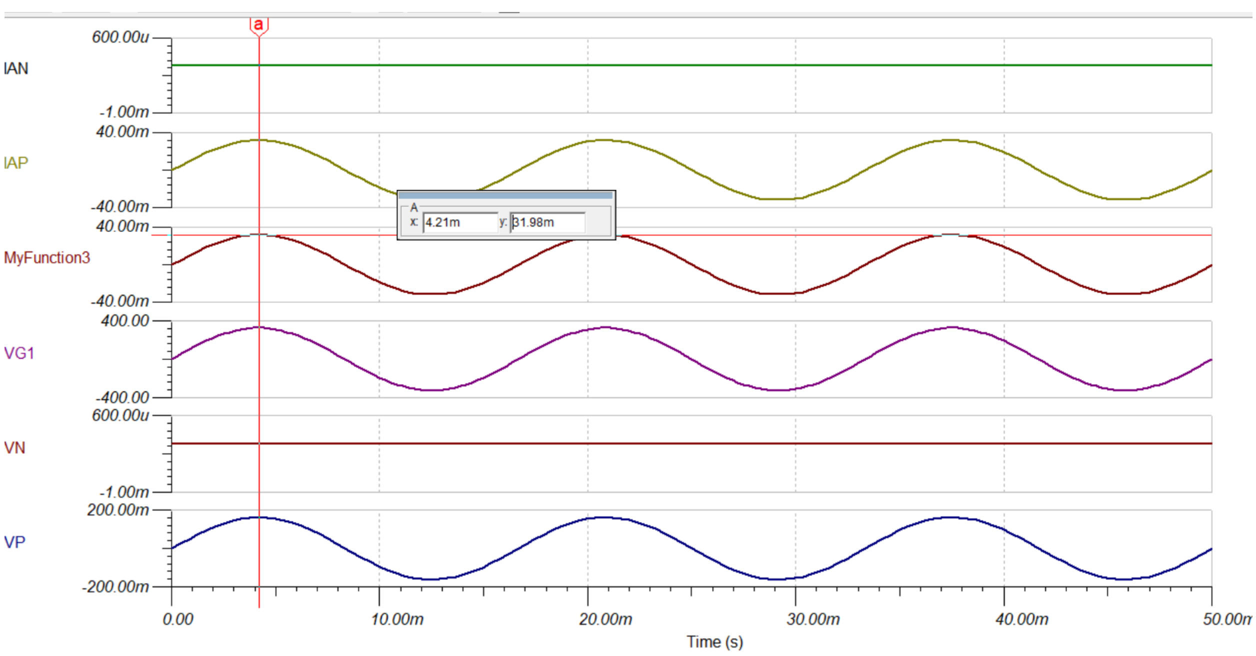
We will be using a the PGA amplifier provided in the ADE795 IC at a factor of 16, so our actual differential voltage input across the SHUNT can theoretically be reduced by a factor of 16 from the input differential voltage limit of 500mV.So in this case, we should have a maximum input differential voltage of at least 31.5mV at 32A.

The discussions for voltage measurement remain the same as discussed above.
The results of the simulation have been given below :

We can see that the maximum value of differential voltage for the voltage channel measured is 162.11mV.



Also, the maximum differential voltage for the current channel is measured to be 31.98mV which is above our 31.5mV limit.



Clipper Circuit Design(not implemented currently)

The datasheet also provides an absolute maximum rating of voltage on the measurement pins ->

ABSOLUTE MAXIMUM RATINGS

$T_A = 25°C$, unless otherwise noted.

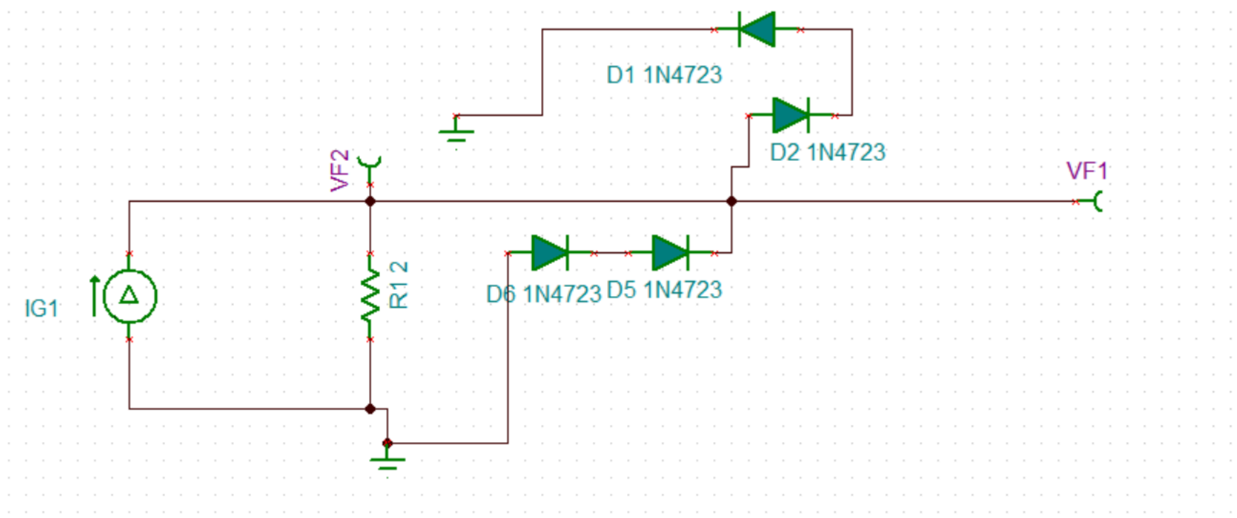
Table 4.

Parameter	Rating
VDD to AGND	−0.3 V to +3.7 V
VDD to DGND	−0.3 V to +3.7 V
Analog Input Voltage to AGND, IAP, IAN, IBP, IBN, VP, VN	−2 V to +2 V
Reference Input Voltage to AGND	−0.3 V to VDD + 0.3 V
Digital Input Voltage to DGND	−0.3 V to VDD + 0.3 V
Digital Output Voltage to DGND	−0.3 V to VDD + 0.3 V
Operating Temperature	
Industrial Range	−40°C to +85°C
Storage Temperature Range	−65°C to +150°C

Note that regarding the temperature profile used in soldering RoHS-compliant parts, Analog Devices, Inc., advises that reflow profiles should conform to J-STD 20 from JEDEC. Refer to the JEDEC website for the latest revision.

Which is from -2V to 2V. To handle input transients that may cause our circuit to exceed this voltage a clipper circuit can be used in between this circuit and the IC pins, which will clip the waveforms above 2V and below -2V.

A circuit that can be used for this has been given below : ->



This circuit limits the voltage at VF2/ VF1 between -1.5V to 1.5V.This can be seen from the simulation results :