Energy Metering IC
ADE7756

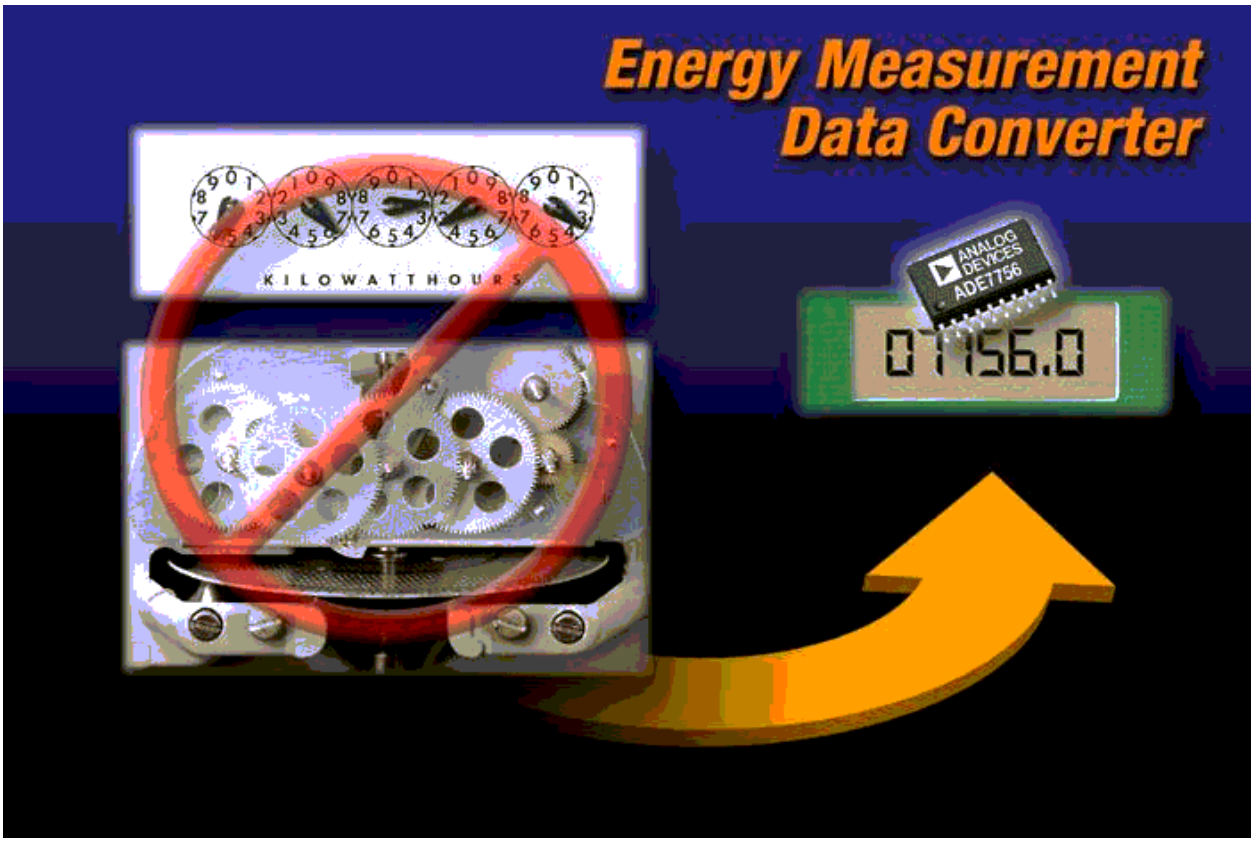

Figure 1 Energy Meter IC *

Introduction

ADE7756 is an IC recently released by Analog Devices for energy metering applications. The salient features of the device and its evaluation platform are presented here.

ADE7756

Housed in a small 20-pin SSOP (or 20 pin DIP) package, ADE7756 is a high integration energy measurement device. It is designed to be used in a system with an external microcontroller. Key specifications are:

- Less than 0.1% error over a dynamic range of 1000:1
- Two sigma-delta A/D converters for voltage and current measurement with 16-bit resolution
- Programmable gain amplifiers
- On-board voltage reference

- On-board temperature sensor
- High accuracy energy calculations & accumulation (temporary)
- Programmable undervoltage detection & interrupt request
- Gain, offset, phase, and power calibration
- Programmable power to frequency output
- SPI interface
- Single 5 V supply

Block Diagram

Figure 2 presents the block diagram of ADE7756. Programmable gain amplifiers feed to both A/D converters (ADC). One of the ADC is used for load current measurement while the other is used for voltage measurement. A multiplier calculates the instantaneous active power being used by the load circuit. A high pass filter (HPF1) is available to cancel offset error, while the low pass filter (LPF2) extracts the average active power.

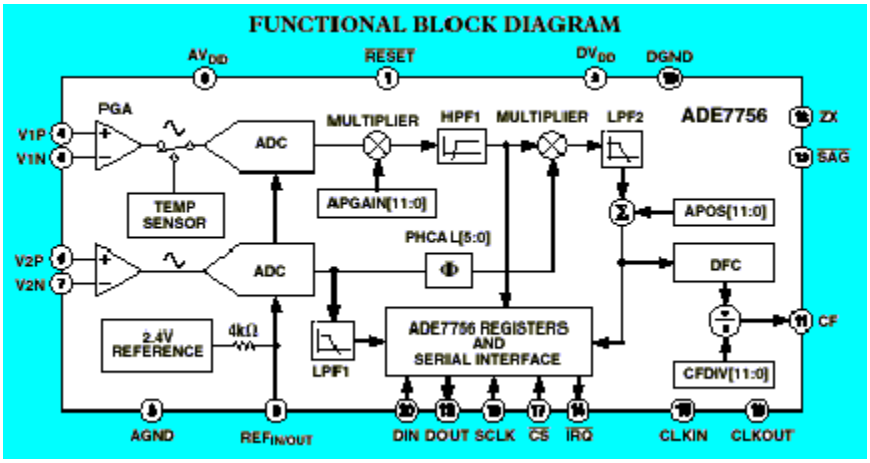

Figure 2 Block diagram *

A temperature sensor is available to monitor the IC temperature. Even though the temperature measurement needs to be calibrated with offset. Even though, the overall accuracy of temperature measurement is poor, the temperature sensor can achieve an accuracy of ± 3 °C.

Current Measurement

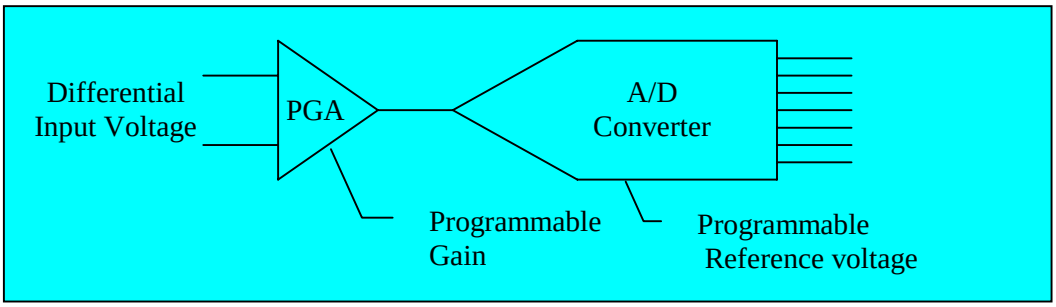

Figure 3 Current measurement

Channel 1 is normally used for current measurement. A current transducer can be either a current transformer or it can be a shunt resistance with a low ohmic value and very low inductance. The AD converter has a nominal full-scale input range of ± 1V, but can be set to full-scale input ranges of ± 1 V, ± 0.5 V, and ± 0.25 V by changing reference voltage. Furthermore, the PGA with a fully differential input can have its gain set to any one of four values 1, 2, 4, 8, and 16.

Voltage Measurement

Voltage measurement is normally carried out through Channel 2. This AD converter has a fixed input range of ± 1 V full-scale. The PGA associated with this channel also has a fully differential input can have its gain set to any one of five values 1, 2, 4, 8, and 16.

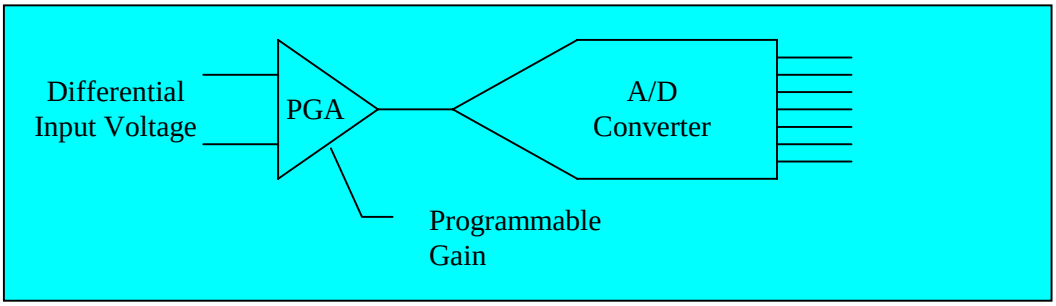

Figure 4 Voltage measurement

Voltage Sag Detection

The ADE7756 can be programmed to detect, when the line voltage sags below a user-defined threshold for a certain length of time (assigned as the number of half cycles). The device can be further programmed to generate an interrupt to the controlling microcontroller so that an appropriate action may be taken.

Active Power Signal

The instantaneous power is calculated by ADE7756 by multiplying the instantaneous load voltage and load current. The result is passed through a low pass filter to generate average (active) power. If desired, the result of active power calculation can be read by the microcontroller through the serial interface. The IC can be programmed to update the active power calculations at a rate of 27,900 samples/second to 3500 samples/second (with CLKIN = 3.579 MHz).

Energy Calculations

The output of the active power calculations is fed to the energy calculation block. Energy is calculated as the continued sum of the product of active power and power calculations sample time, which is 1.4 µs. A 40-bit signed active energy register maintains the result of energy used since the previous read of the energy register. The length of the register ensures that at least 10 second worth of energy data can be maintained within the register, before it overflows. Thus a microcontroller has to read the register at least once every 10 second. Obviously, at lower power consumption rate, the time interval between successive reads of energy register will be longer. The IC can be programmed to generate an interrupt, whenever the energy register is either half-full or has just overflowed. The controlling microcontroller can then immediately read the energy value and add to its own running total.

Pulse Output
Sometimes it is desirable to maintain an electromechanical counter that records the total energy used. Such counters are essentially tamper proof and provide visual readout, even in case of a power failure. The energy to frequency conversion can be programmed to generate a wide range of pulse rates such as 10 to 410,000 pulses /kWh. Pulse output has a further advantage that the output can be optically isolated using a single opto-coupler.

Calibration
ADE7756 meets the accuracy requirements of IEC1036 standards for a class 1 meter. The accuracy of an energy meter designed around ADE7756 can be improved by calibrating the IC for active power calculation, gain and offset adjustments. Unfortunately, all the calibrations coefficients entered into ADE7756 registers are lost on a power failure and need to be reprogrammed.

Microcontroller Interface
ADE7756 communicates with the controlling microcontroller through a 4-wire SPI (Serial Peripheral Interface). The following interface signals are required:

- $\overline{\text{CS}}$ Output from microcontroller to select ADE7756
- SCLK Clock input to ADE7756
- DIN Data input to ADE7756
- DOUT Data output from ADE7756

Microcontroller initiates every communication and does so by sending a command data byte to the ADE7756 communication register. The command byte indicates, whether the next operation is a write operation or a read operation and also specifies the address of the register. It then can read or write information to the designated register. The internal register addresses range from 00h to 12h. When controlled by a 3.57 MHz crystal, an SPI transfer rate of greater than 3 MHz can be used.

Evaluation Board

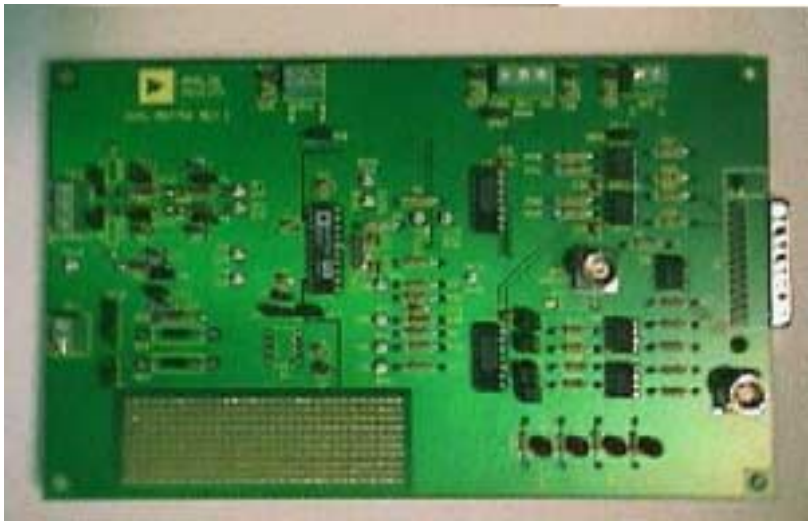

Figure 5 ADE7756 evaluation board *

Analog Devices provides an evaluation board that comes with the National Instruments LabView software. It can be used to rapidly demonstrate the capability of the ADE7756 IC, under Windows environment. The board connects to a PC parallel port through a parallel port cable. The software requires a LabView runtime engine. If not available on the user system, a version is provided on the accompanied CD and can be installed on demand.

The software provides a visual indication of the metering operation. All the significant parameters, such as current and voltage, power, energy, and line frequency are monitored and continually displayed. The calibration of the device can also be easily carried out including the power measurement and reduction of phase errors that are characteristic of most current transformers.

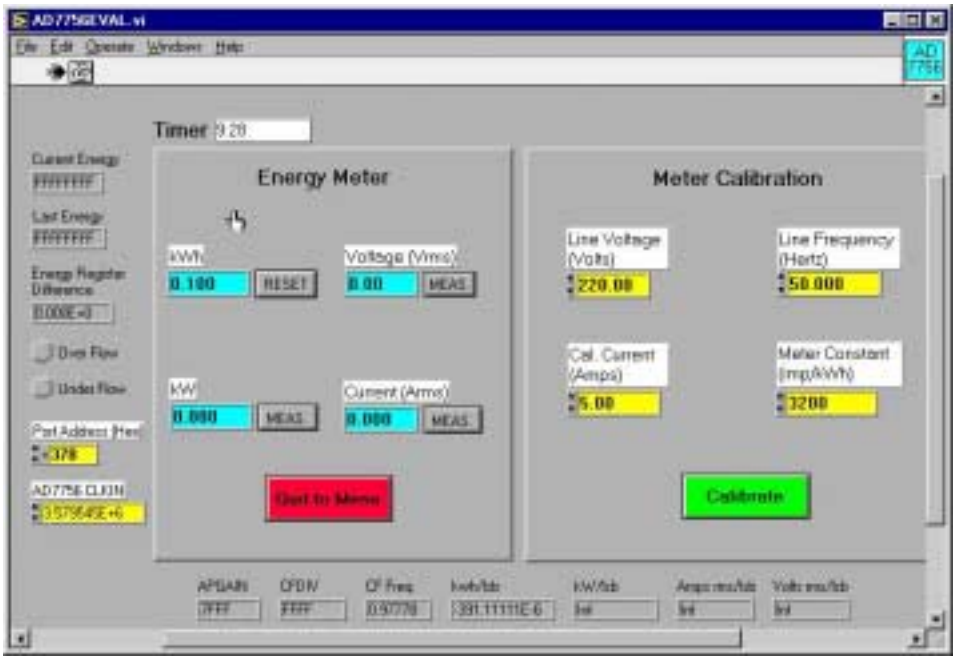

Figure 6 ADE 7756 evaluation software

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