this project. Besides, the sensitivity level is reached to 0.1 V and 0.007 V respectively for more sensitive measurements by using 12 or 16 bit A / D converters externally and the average of all the measured values is found and this information is presented to the user as the mean value of the voltage.

ACS712 hall-effect current sensor is used for current measurement. The operation principle of hall-effect current sensor is finding a current that flows according to the amount of magnetic field generated by the current passing through a conductor. As the intensity of the current passing through the conductor increases, the effect of the magnetic field around the conductor also increases. The intensity of the current that is passing through the conductor can be calculated by measuring this generated magnetic field. The advantages of these sensors are that they can measure both AC and DC currents, they are sensitive and stable, and they provide good insulation even at high current ratings which are caused by the measurement of the magnetic field that is generated basically. Since it is calculated that the driven current in this project is 20A, it is decided to use the ACS712 current sensor of 30A by adding the safety margin. Since the alternating current measurement is performed, the current information from the sensor is continuously measured over a period of 1 second, and the current value is calculated by taking the average of all the measured values. Eventually, this average current value is sent to the user.

The voltage value which is obtained from the output of step down transformer for the measurement of frequency is applied directly to the inverting and non-inverting inputs of an Operational Amplifier (OPAMP), and an output voltage that is parallel to input voltage is obtained continuously except when the input voltage is 0. Because of corresponding of this obtained output voltage to each alternance of grid voltage that is given from input, frequency is double of input grid frequency. Researches on choosing proper OPAMP is completed and as a result, LM741 integrated circuit is preferred due to its wide operating voltage range, high input impedance and sensitivity, easy and cheap availability, rich documentation and application examples.

It is provided to generate an output signal for both positive and negative alternance which are supplied from input by supplying OPAMP +/- 5VDC with a symmetrical power supply. In addition, the values that are higher than 5 V are truncated and reduced to 5 V through this symmetrical feedback voltage. This produced output signal is given to one of the digital inputs of the microcontroller. The microcontroller has a function that can measure how long the signal applied to the digital inputs come both in negative and positive direction. It is reached to total number of positive and negative alternance by getting the duration of coming signal as microsecond and dividing it to 1 second time period. After that, this total number of alternans is divided by two to obtain the number of full alternans, that is, the network frequency. Since the measurement is made in microseconds, frequency measurement can be performed very sensitively. Firstly, a literature review is performed and a practically applicable circuit design was not encountered for power factor measurement. The phase angle between current and voltage must be known for the power factor measurement. It is decided to design a circuit that can follow both current and voltage based on this theoretical knowledge. Based on the idea that the OPAMP circuitry that is used in the frequency measurement circuit can generate signals for both voltage and current, one of these two OPAMP is connected to input voltage same as frequency measurement circuit and another one is connected to output of a current transformer which is used in order to detect the current drawn by the load

Output signals of both OPAMPs are 0 where the input voltage is 0. In other words, if the one of these two signals is 0, the counter begins to count until the other signal is being 0. If we find the duration time between first signal zero points and second signal zero points, we can find the duration between these two signals. That is phase difference. There are two different methods to do this calculation.

In the first method [1], the output signals of the OPAMPs are given to the digital inputs of the microcontroller. When one of these inputs is zero as a reference, a counter is operated and the other signal is expected to be zero and when the other signal is zero, the counter is stopped and the counter value is read. Thus, the phase difference can be measured as microseconds. It is necessary to work with a microcontroller which is fast and has a hardware interrupt support and sensitive counter for using of this method. This circuit is shown in Fig.3.

In Turkey, grid frequency value is 50 Hz and this means that one period is completed in 20 milliseconds. In the realized project, measurement period is one second. One second is a thousand milliseconds. If thousand milliseconds divides into twenty milliseconds, result obtains fifty. Because of measuring twice per period, a total of 100 measurements have been made. As a result of all measurement, the average value of total milliseconds are calculated. Obtained value is converted to radian value and radian value is also converted into degree value. In order to obtain power factor, the cosines of obtained degree value should be calculated.

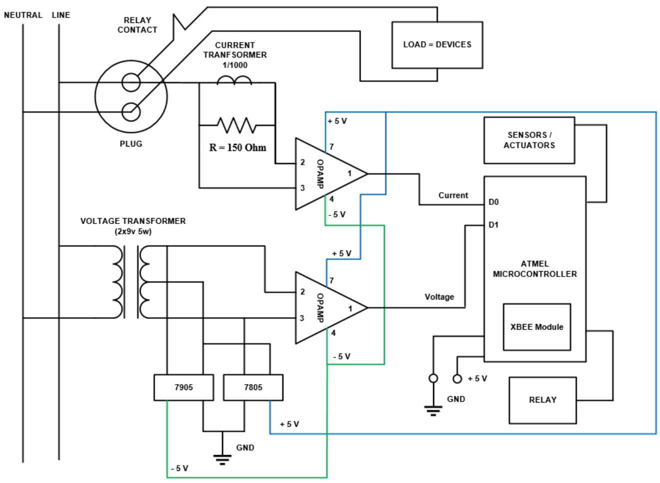

Fig.3. Circuit Design I of intelligent energy measurement device (iDev)

The other method used in the project is to connect an XOR gate to the output of the OPAMPs. It is seen that there is a logic structure that gives 0 when the inputs are the same, and 1 when the inputs are different according to the truth table of the XOR gate. Since the aim of the power factor measurement is to find the difference between voltage and current, it is correct to use the XOR gate.