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DESIGN OF PROGRAMMABLE BINARY INPUT MODULE FOR SMART GRID APPLICATIONS

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Abstract: - The Binary Input Module (BIM) is a compact module that is used in protection relays for protection from high voltages. The DC-DC Converter, rectifier, attenuator, peak detector, AC/DC control, comparator and reference generator are the main blocks of the designed BIM. In this paper the DC-DC converter, peak detector, AC/DC control, Comparator with hysteresis is explained in detail.

Keywords: Attenuator, Binary Input, Comparator, Peak Detector, Reference Generator

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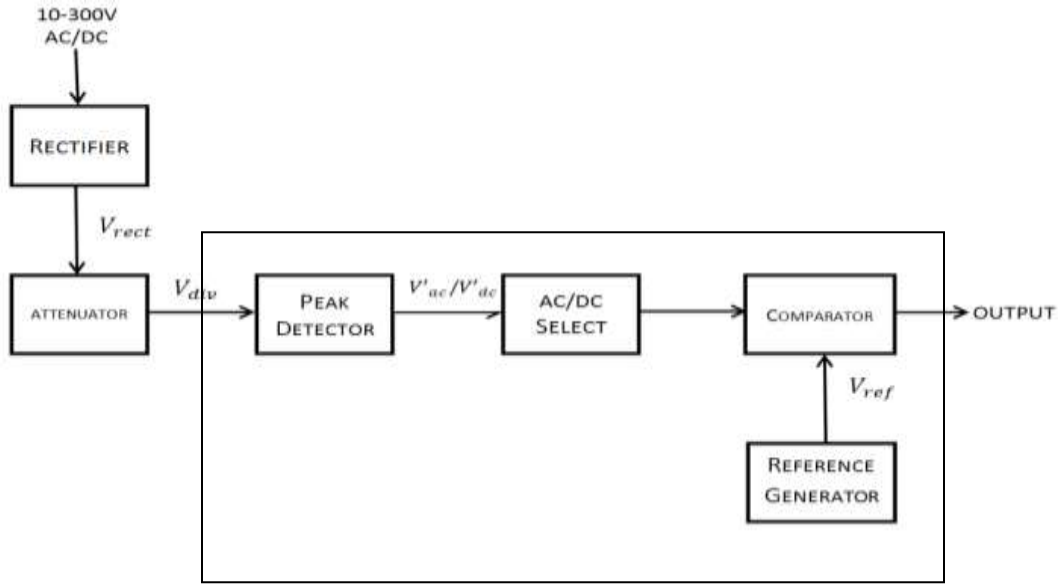
INTRODUCTION

The electric grid is a network of transmission lines, substation, transformers, and distribution lines etc. that deliver electricity from the power plant to the load. The digital technology that provides two way communications between utility and customer and the sensing along the transmission line makes the grid smart [7]. IED (Intelligent Electronic Device) is a term used in the electric power industry to describe microprocessor- based controllers of power system equipment, such as circuit breakers and transformers [8][13]. The Protection Device is an important component of Smart Grid.

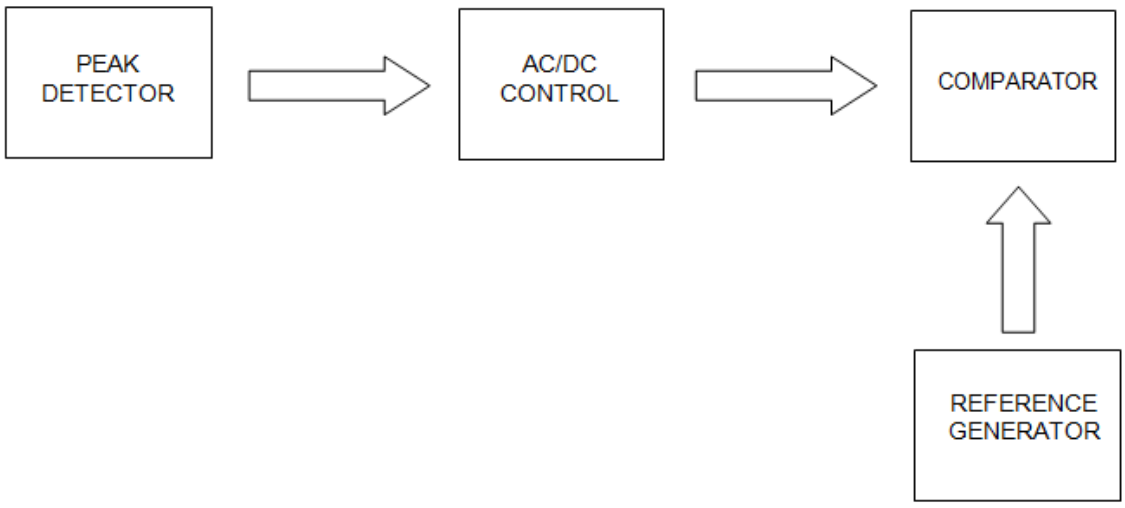
This paper deals with the Binary Input Module which is the indispensable part of the IED which is currently used in industries [2]. The idea is to design a BI module with variable threshold capability which allows the user to change the threshold as per his needs by software configuration.

The existing Smart Grid protection device uses a Binary Input module which has factory settable threshold that demands multiple variants of PCB. This makes the system bulkier and the system becomes costly.[1]

BLOCK DIAGRAM



(a)



(b)

Fig. 1(a). Main Block Diagram (b) Blocks which are explained in the paper

Fig.1 shows the block diagram of the above mentioned modules along with the signal flow. This module has the feature of selecting AC or DC as its input signal. The input voltage varies from 10-300V in case of DC and 10-300V RMS in case of AC. In case of DC, we directly capture the DC value and for AC we capture the peak of the AC waveform. Therefore, the output of the peak detector is the peak value of the input AC signal.

DC-DC CONVERTER

A push pull type converter is used to generate the supply to the op-amps used in the design.

Advantages:

1. Even harmonics are absent in the output. [14]
2. The problem of core saturation and non-linear distortions will not appear because of cancellation of D.C. components of collector current. [14]
3. The output is double as that offered by a single ended stage. [14]
4. The effect of ripple voltage of the power supply due to inadequate filtering are balanced out because of flow of ripple current in opposite direction in the primary of the output transformer. [14]

Disadvantages:

1. Two transistors have to be used. [14]
2. It requires two equal and opposite voltages at the input. Therefore push pull circuit requires the use of driver stage to furnish these signals. [14]
3. If the parameters of the two transistors are not the same, there will be unequal amplification of two halves of the signal.[14]
4. The circuit gives more distortion.[14]
5. Transformer used is bulky and expensive. **[14]**

PEAK DETECTOR

Peak-detector circuits are used in many applications such as amplitude measurement, automatic gain control, and data regeneration in Electronics [3]. Peak detectors are used to obtain the peak voltage of the rapidly changing AC input signals [3].This divider voltage is then given to the peak detector circuit[1].

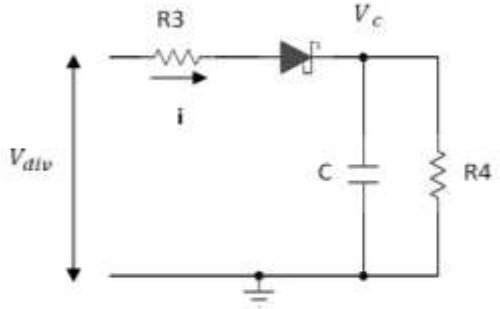


Fig. 2 Peak Detector circuit

COMPARATOR WITH HYSTERESIS

A comparator with hysteresis is used to avoid the continuous toggling i.e. continuous ON-OFF state at the output. The upper and lower threshold level is measured for all the four threshold voltages and the maximum difference between Vth and Vtl is taken as the hysteresis voltage. The resistors are then calculated for the specified hysteresis voltage.

$$\mathbf{V_{ref}} = \frac{\left((\mathbf{V_2} - \mathbf{V_1}) * \mathbf{R_1}\right)}{\mathbf{R_1} + \mathbf{R_f}} + \mathbf{V_1}$$

Where V2 is the voltage at the output when the comparator should be high. In this case it is 12V. V1 is the voltage input voltage to the comparator with which the reference voltage is compared.

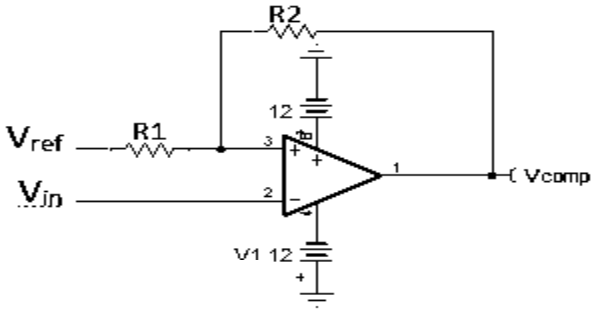


Fig. 3 Comparator with hysteresis

AC/ DC CONTROL

In this the user has to specify the mode in which he has to operate the circuit. The user has to give either a high or a low to the circuit to specify if he is giving an AC or a DC at the input.

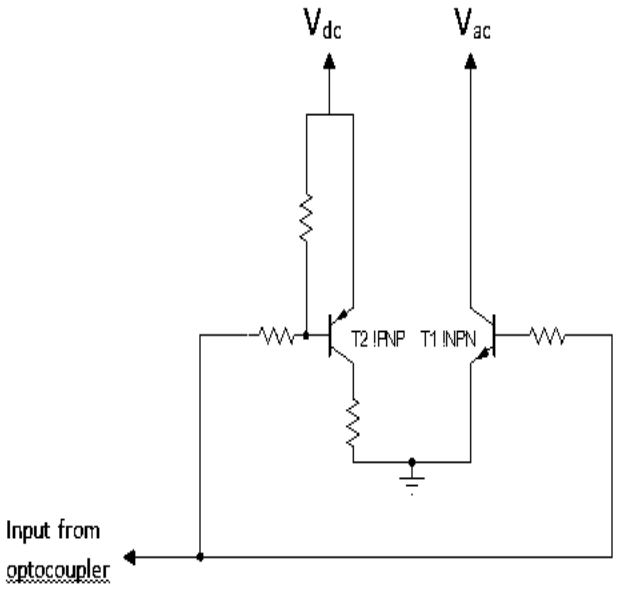


Fig. 4 AC/DC Control circuit

REFERENCE GENERATOR

The Reference Generator consists of resistor divider network as shown in the diagram given below. The resistors for the divider are selected to obtain the desired reference voltage for the comparator which will be compared with the input attenuated voltage.

Resistors R_1 , R_2, R_3, R_4, R_5 form the resistor divider [3]. Transistor switches are used to select which switch has to be ON so that the other resistors gets shorted since the transistor switch offers the least resistance path [10].

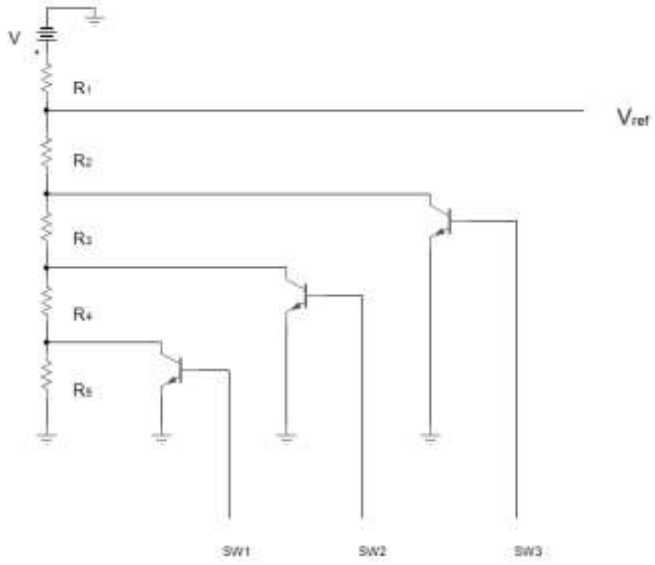


Fig. 5. Reference Generator

CONCLUSION

The push pull type circuit was chosen for the advantages that it offers over the disadvantages it has. The peak detector helps in converting the AC signal into the signal with ripples which helps the comparator to compare it with the DC reference. The AC/DC control circuit allows the AC signal to go to the comparator and obstructs the DC when the input is AC and vice-versa. The comparator with hysteresis was designed such the hysteresis voltage was maintained at maximum peak to peak ripple voltage so that the frequent ON-OFF of the output is avoided.

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