Applications of a Reverse Biased Opto-Coupler

The PC817 is a very popular Opto-Coupler; the data sheet provides detailed information related to the digital applications of this device with the output transistor forward biased. This project idea proposes several novel analog circuit applications using the reverse biased characteristics of the output transistor.

Figure 1 shows the experimental plot of Collector-Current IC versus Collector-Emitter voltage VCE for different values of Diode-current IF over a VCE range of ±2V.

The forward characteristics show that the output transistor goes into saturation for I_F > 0.3mA and the reverse characteristics show excellent low-gain transistor characteristics.

Analog applications are therefore possible using the reverse characteristics with the unique advantage that the equivalent base current provided by I_F could be opto-isolated.

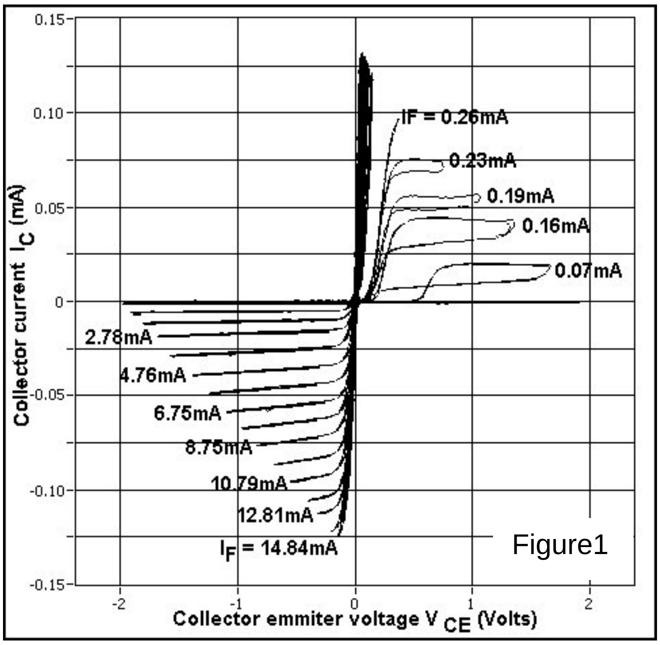

Figure1

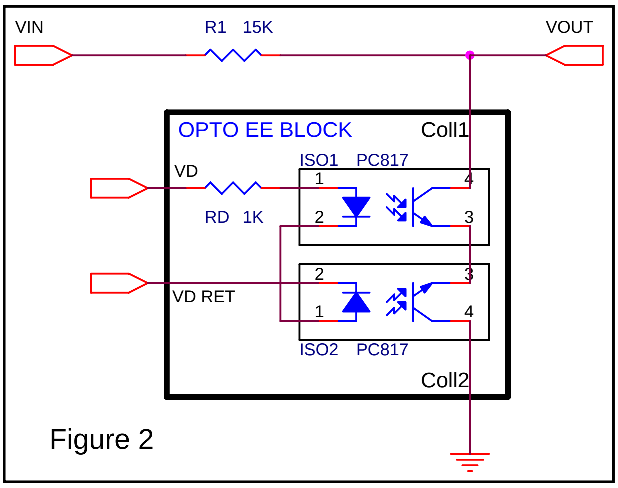

Figure 2

Figure 2 shows two PC 817 opto-couplers connected emitter-emitter in a push pull configuration. The input waveform VIN is fed at one terminal of R1 and the other terminal is the output VOUT. The light emitting diodes are connected in series and the current IF is controlled by DC control voltage VD through RD. For a given IF, when VIN is positive ISO1 is forward biased and ISO2 is reverse biased. For IF > 0.3mA ISO1 goes into saturation and ISO2 operates as a reverse biased transistor. For a given R1, VIN and IF the intersection of the load line with the IF curve determines the VCE value. When VIN is negative ISO2 saturates and the VCE of ISO1 varies with IF. Several practical applications are possible with this configuration by suitable choice of VIN and VD.

Voltage Controlled Dead-zone Circuit:

Figure 3 shows the output of the circuit for a 2V P-P triangular wave. A central dead-zone increases with IF and a truncated triangular wave is seen at the output.

A voltage-controlled dead-zone is subtracted from the input.

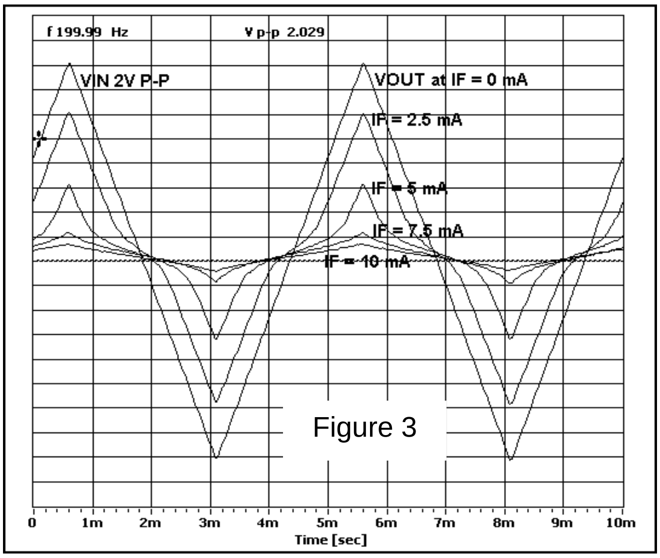

Figure 3

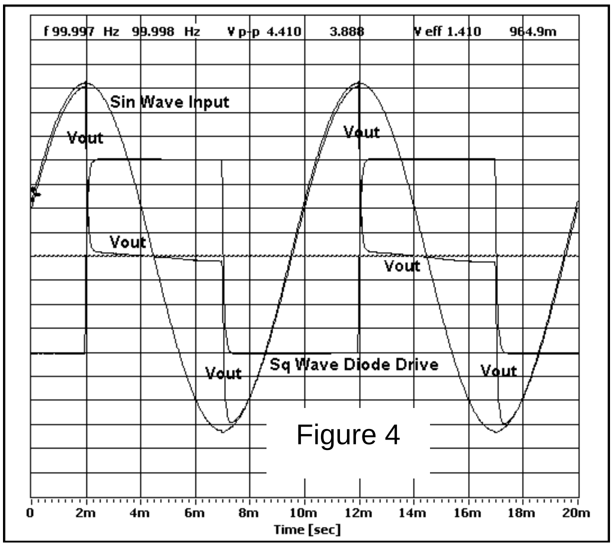

Figure 4

Phase Detector circuit:
Figure 4 shows the circuit operating as a Phase Detector with 90deg phase difference. A Sin wave input of 4V P-P is fed at VIN and a Sq wave reference signal of ±15V is fed at VD. The output follows the input whenever the reference signal is negative and is close to zero when the reference signal is positive. For Zero phase shift the output would be the close to zero and at 180deg phase shift the output would the positive half cycles of the input. The average value of the output would vary from 0V to +0.55 Vin-peak for 0-180deg phase difference. For Sin wave inputs which have ±180deg to the reference this circuit operates as a phase-sensitive-detector.

Amplitude Modulator:

Figure 5 shows the circuit operating as an Amplitude Modulator. A 4V P-P Sin wave of 1 kHz is fed at VIN and a 4V DC with superimposed 1V P-P 100Hz signal is fed at VD. The average value of IF is 1.76mA. Vout shows the AM waveform.

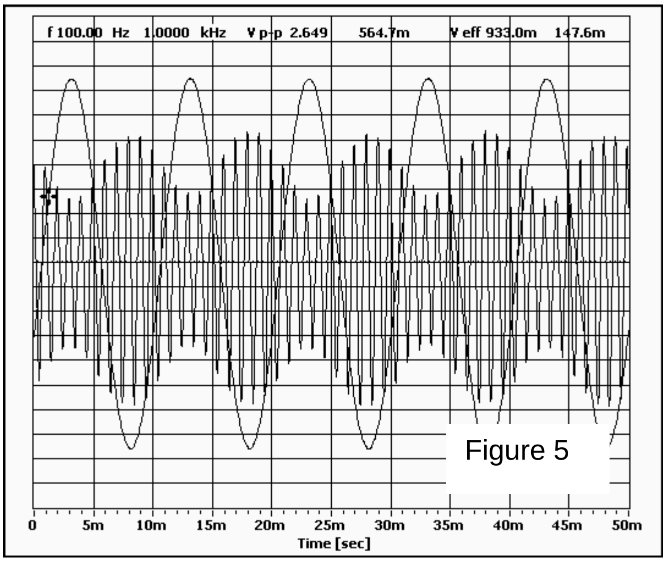

Figure 5

Alternate Configuration:

Figure 6 shows an alternate configuration with the opto EE block and R1 interchanged.

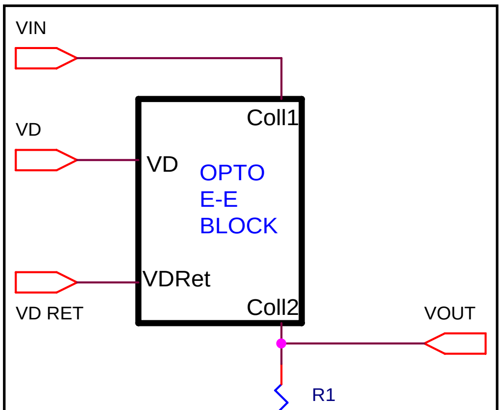

Figure 6

Voltage Controlled symmetrical limiter:

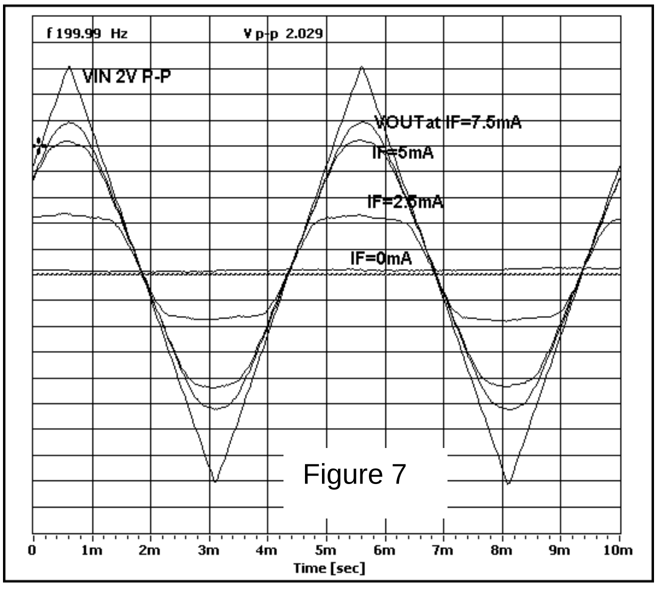

Figure 7

In Figure 7 when IF=0mA no current flows in the opto couplers and the output is zero. VOUT shows a symmetrically clipped output increasing with IF.

This configuration could also be used as a Triangle-Sin converter with suitable input and IF conditions.

Wein-Bridge Oscillator:

Figure 8 shows a Wein-Bridge Sin-Wave oscillator circuit. C2-R4 and C3-R5 set the oscillation frequency. Theoretically a gain of 3 is required for oscillation. Resistors R2-R3 set up a gain of 3.2 which guarantees startup and oscillation. The output at Pin 6 is rectified and filtered and fed as a control signal to the opto block. The control signal varies IF in such a way that Opto transistors conduct beyond a threshold voltage thereby reducing effective resistance of R3 and stabilizing the amplitude of oscillations.

With the values of components shown the circuit produces a sin wave d at a frequency of 4.335 KHz, an amplitude of 4.84 V P-P and a distortion of 0.3%.

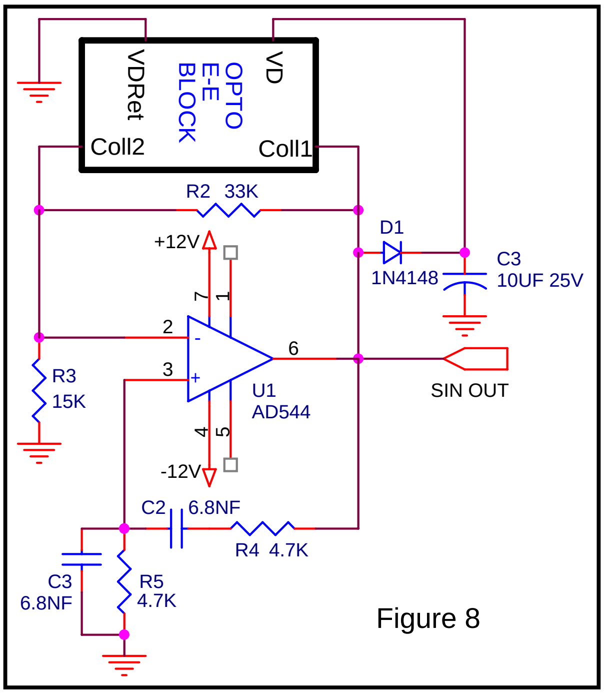

Figure 8

Summary:

The PC817 opto-coupler though primarily for use in digital applications has several applications in the analog domain. Specifically the reverse biased output transistor exhibits a low gain transistor characteristic which permits several applications where the bias being opto-coupled can be isolated from the primary circuitry.