THREE PHASE INVERTER (DC-AC CONVERTER)

1. Three Phase Inverter

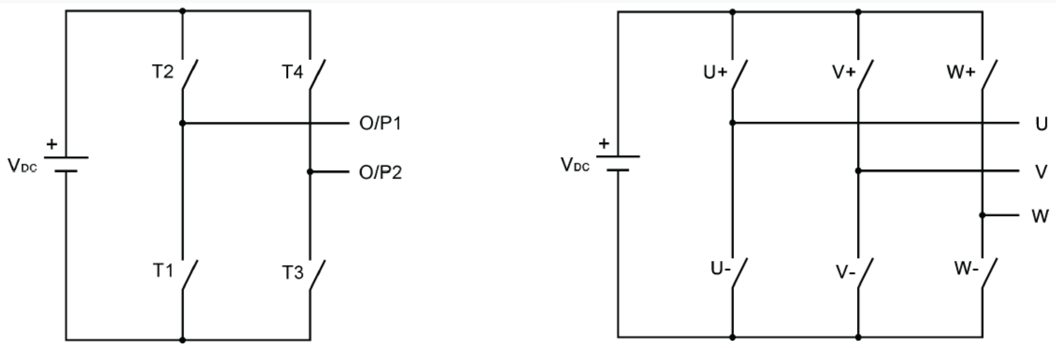
1.1. The Purpose of The Experiment

- Understanding the three-phase inverter's gating signals.
- To understand the working principle of three-phase inverter.
- To measure phase voltages and gating signals of a three-phase inverter with a delta connected resistive load.
- To control the speed and direction of rotation of the three-phase squirrel cage motor.

1.2. General Information

Inverters are also called DC-AC converters. The inverter converts a fixed DC voltage to a symmetrical AC voltage with the desired frequency and amplitude. Inverters are widely used in industrial applications such as uninterruptible power supplies (UPS), induction motors and variable-speed AC motor drives.

Inverters can be divided into two groups: 1) single-phase inverters, 2) three-phase inverters. The basic circuits of single-phase and three-phase inverters are shown in Figures 1.a and 1.b, respectively. The DC input voltage is fixed and can be battery, solar cell, fuel cell or other DC sources. On-off controlled elements such as thyristor, BJT, MOSFET and IGBT can be used as switching elements.



(a) Single phase inverter **(b)** Three phase inverter

Figure 1. Single and three phase inverters

The output of the single-phase inverter is a symmetric AC voltage with a square or sinusoidal wave shape. The three-phase inverter can be thought of as three single-phase inverters, each with their output offset by 120 degrees. The switching elements of the same branch (example, T1 and T2, U+ and U-) cannot be in conduction at the same time. Since the closing time of the power switching elements is greater than the opening time, a delay called **dead time** must be added to prevent short circuit. Depending on the closing time of the power element, the dead time is usually determined as 2~3 times the on time.

To control the on and off time of each switching element, the gating signal must be applied at an appropriate time. The gating signal can be a square or PWM voltage. Generally, inverters are controlled by Sinusoidal Pulse Width Modulation (SPWM) technique. The SPWM waveform is generated by comparing a sinusoidal reference signal with a higher frequency triangular carrier wave. The frequency of the reference signal determines the output frequency of the inverter, the peak value of the reference signal controls the average output voltage, and the number of pulses P in each half-period is determined by the carrier frequency. SPWM can eliminate harmonics less than or equal to 2P-1.

SPWM can be divided into two groups: 1) one-way (unipolar) SPWM control and 2) two-way (bipolar) SPWM control. Figure 2 shows the one-way SPWM control process. During the positive alternance of the sinusoidal reference wave, the triangular carrier wave can only be positive. When the amplitude of the sinusoidal reference wave is greater than the amplitude of the triangular carrier wave, the output is high; Conversely, when the amplitude of the sinusoidal reference wave is smaller than the amplitude of the triangular carrier wave, the output is low.

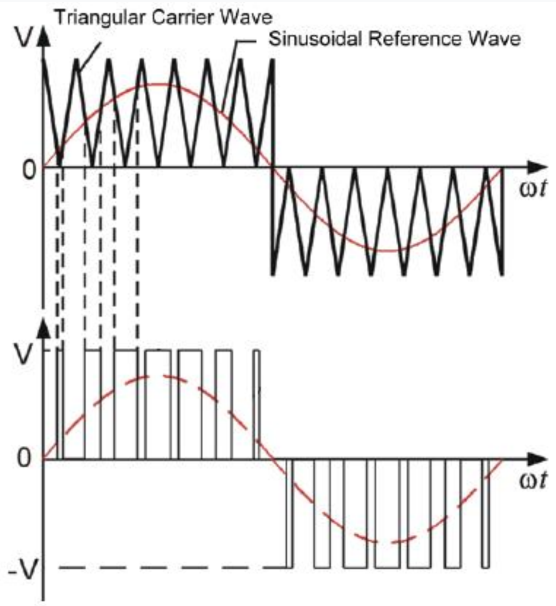


Figure 2. Unipolar PWM control

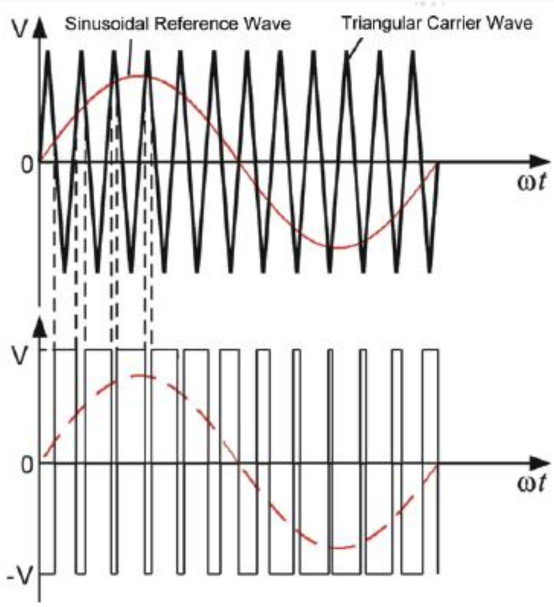
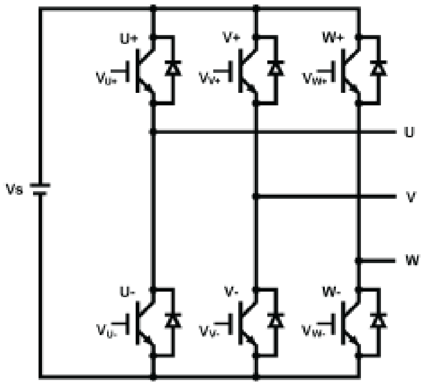


Figure 3. Bipolar PWM control

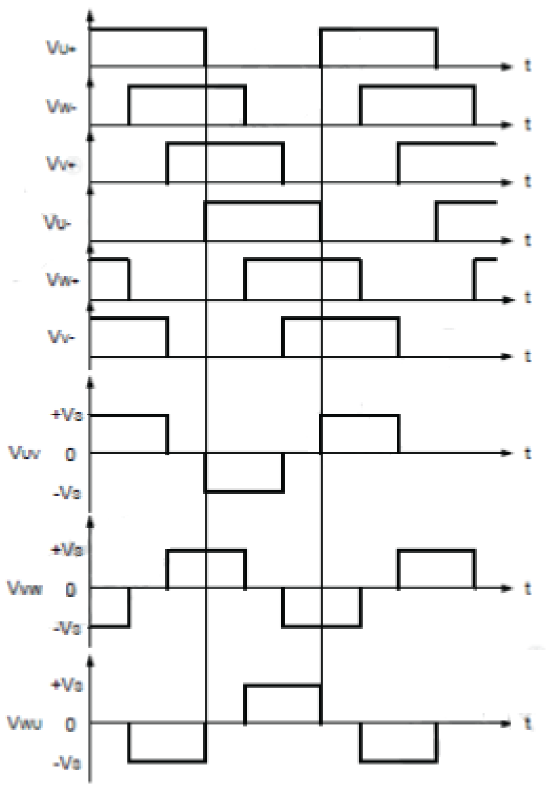
The bidirectional SPWM control process is shown in Figure 3. In bidirectional SPWM control, the triangle carrier wave can be positive and negative, and the output PWM wave has positive and negative voltages. Apart from SPWM, different PWM techniques can be used to control the inverters. These;

- Third harmonic injection PWM
- Space Vector PWM
- Hysteresis PWM

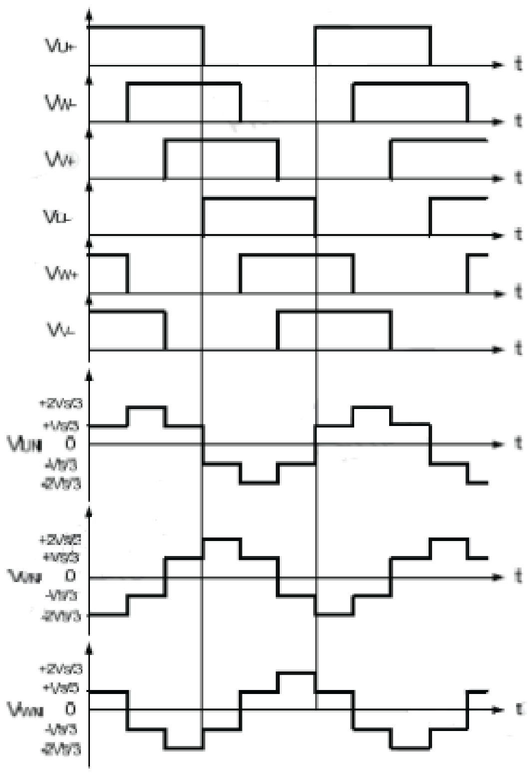
A three-phase inverter can be thought of as a combination of three single-phase inverters, each with their output offset by 120 degrees. The power circuit, the gating signals for **180º conduction (square inverte**r), the phase-to-phase voltages of the delta connected load and the load phase voltages of the three-phase inverter are shown in Figure 4.



(a) Power circuit



(b) Gating signals for 180º transmission and phase to phase voltages of the delta connect loaded system

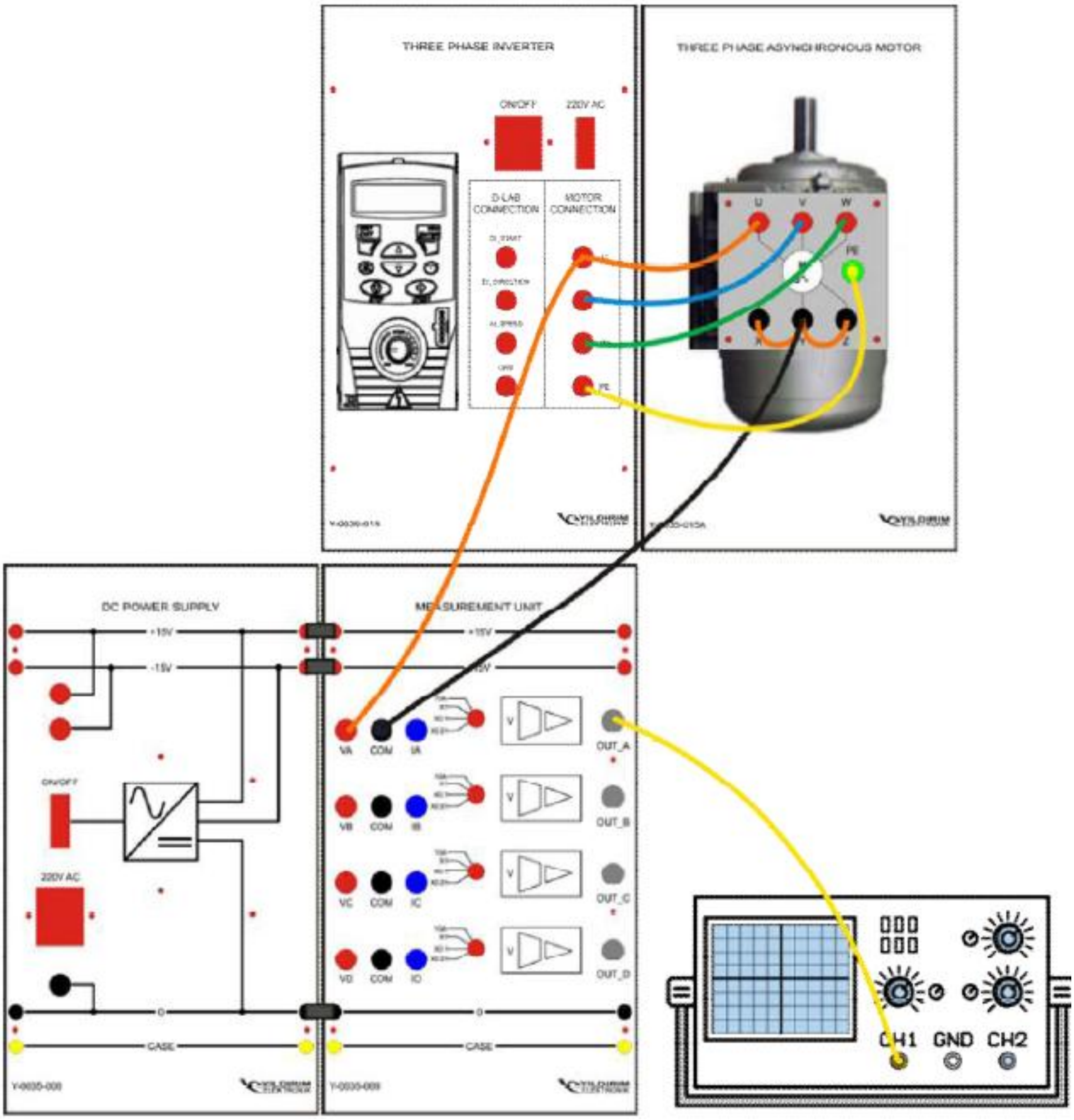


(c) Gating signals for 180º transmission and phase voltages of the star connected system

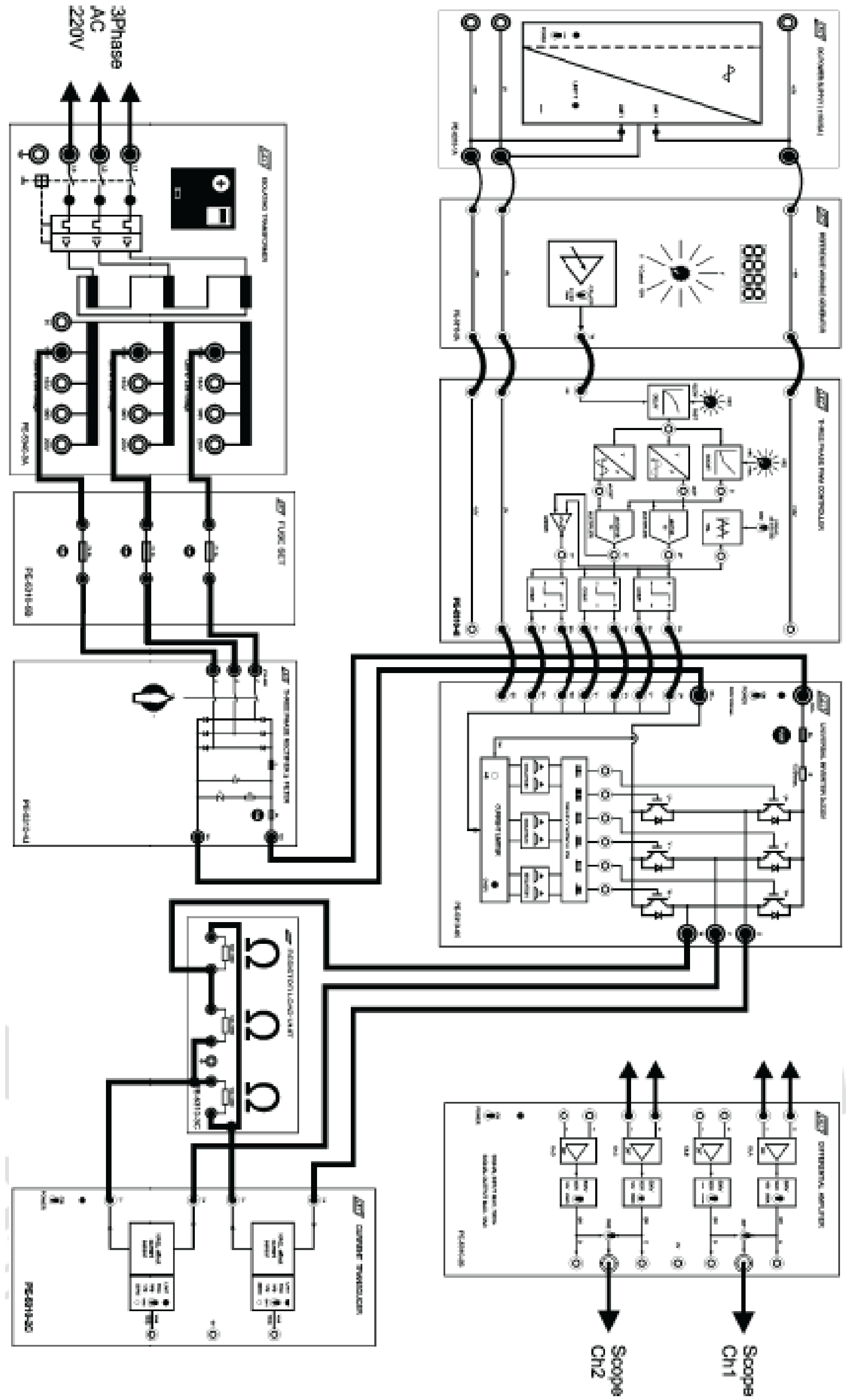
Figure 4. Three phase inverter

2. Experimental Procedure

Set up the circuit given in Figure 5. Take the required measurements in the report.



(a) Wiring diagram for experiment set # 1



(b) Wiring diagram for experiment set # 2

Figure 5. Necessary wiring diagrams for the inverter test