

# **INDEPENDENT POLE, POINT ON WAVE, SYNCHRONOUS CLOSING CONTROL INSTRUCTION MANUAL**

## **General**

The purpose of the independent pole, point on wave, synchronous close system is to reduce transformer energization transients. The expected benefits include significantly reduced inrush currents, reduced electromechanical stress on transformer bushings and windings, minimal wear on components decreases maintenance requirements, and reduced stress on all equipment in the closing circuit. We expect timing accuracies of ( $\pm 0.75$ ) to be maintained from the initial set point. The expected inrush currents will be reduced from a theoretical maximum of 8-10pu to 2-3pu.

The control is designed to provide independent pole closing timing control. The control is adjusted to cause transformer phase energization 0.3 milliseconds after each respective phase voltage is at its peak value. In an inductive circuit the voltage and current are 90° apart, so energizing the transformer at peak voltage corresponds to a natural current zero point. Transformer current and flux are normally in phase so the voltage and flux are 90° apart as well. Without synchronized closing, energizing an electric furnace transformer results in core saturation. During saturation, a small increase of flux leads to a large increase in current. Therefore, minimizing the flux will minimize the inrush current. Closing at peak voltage will minimize the transient flux generated by the system, however any residual flux due to transformer magnetization will be unaffected. Therefore, the inrush current cannot be reduced to zero.

The circuit is intentionally energized 0.3 milliseconds after voltage peak to allow for switch variations to have minimal affects on the intended result (see reference for further details).

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## **CIRCUIT DESCRIPTION**

### **CLOCK CIRCUIT**

Referring to the schematic diagram, the clock circuit consists of Q4 and surrounding components. Q4 is a simple transistor switch driven by the 60 hertz timing potential. Q4 will switch on at about 0.7 volts and off at about negative going pulses used to trigger the timing circuits. The positive going pulse is not used. The negative going pulses used to trigger the timing circuits. The positive going pulse is not used. The negative going pulse as seen at the junction of R12 and C13 will start at 15 volts and descend rapidly to about four volts. Timer triggering will not occur if this does not go below five volts. C14 couples a pulse train to the base of Q6. The positive pulse is used to provide a starting point for the enabling timer U4.

### **TIMERS**

Each pole of the switch requires its own separate timer. The timers consist of U1, U2, U3 and surrounding components. Each timer is a -55°C/+125°C SE555 integrated circuit RC timer. The trigger is provided by the clock circuit as described above. The timers are triggered on a negative going pulse at pin #2. The timing RC network consists of (R25 and C26) (R26 and C8) (R27 and C11). R25, R26 or R27 are potentiometers that provide the necessary timing adjustment. The timing interval is adjustable from 0.5 milliseconds to about 11 milliseconds. Throughout most of 25 turn range, one turn equals approximately 0.4 milliseconds. Clockwise rotation advances switch closing (i.e., reduces resistance, shortening the time delay).

### **GATE FIRING CIRCUITS**

The output of the timing circuits found on pin 3 is coupled to a phase inverter, gate firing circuit through C27 (C9, C12). Q1, Q2 and Q3 are the gate firing transistors. These provide a pulse output of about two amps peak for 50 milliseconds. It can be seen that the gate firing output is interrupted by closing relay K1. This provides excellent noise immunity for the SCRs.

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## **ENABLE CIRCUIT**

The enable circuit consists of timer U4, Q5, Q6 and surrounding components. Three conditions must be satisfied to start the enable circuit.

1. The energy discharge capacitors must be fully charged.
2. The closing relay must be closed.
3. A sequencing pulse must be available at Q6. The simultaneous occurrence of these three events will start timer U4 which then releases the reset of timers U1, U2 and U3 for approximately 50 milliseconds. This allows the timing cycle to begin and ensures it is not interrupted prematurely.
  - a. Sequence Initiator - The sequence initiator consists of Q6 and R17. The positive pulses from the clock circuit coupled through C14 will cause Q6 to go into conduction for about 50 microseconds at the opposite zero crossing from the timer trigger pulse. This assures the timing cycles will not begin until at least 8 milliseconds after a closing command. This allows time for K1 to be fully closed. (K1 has a contact bounce time of about 2 milliseconds). It also assures that the pole timing sequence will be identical for every operation. (This is important for ungrounded capacitor energizing).
  - b. Energy Storage Verifier - Q5, C17 and R18 comprise the energy storage verifier. The drain current from the shunt voltage regulator returns through the base of Q5. When the capacitors are fully charged, Q7 will be conducting for 2-3 milliseconds each 60 Hz cycle, thus providing sufficient current to maintain C17 at a charge that will cause Q5 to be in conduction continuously.

## **PLUS 15 VOLT SUPPLY**

The control circuit power supply which normally runs between 12 and 17 volts is provided by a 117-10 volt filament transformer and full wave bridge rectifier into a simple RC filter. C24, a ceramic capacitor, has been added to assure that very high frequency voltages are bypassed. The requirements of the power supply are quite loose, hence a voltage regulator is not necessary. The 555 IC timer operate on a proportional voltage sensing scheme, whereby the timing cycle ends at 2/3 of the supply voltage.

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## **ENERGY STORAGE POWER SUPPLY**

The energy storage power supply consists of a shunt regulator, (Q5, Q7, C17, R18) rectifier D5 and thermistor rt, C21 and R22. D5 and R23 provide half wave rectification and current limiting respectively for capacitor charging. T2 provides isolation and voltage for the energy storage capacitors. The required voltage is 120 volts. Z3 is a full voltage 10 watt reference diode. Thermistor Rt provides some temperature compensation. It will lower the output voltage as the temperature increases to compensate for the rising capacitance of the electrolytic capacitors with temperature, (falling capacitance of the electrolytic capacitors with temperature). The voltage regulator, being the shunt type, only conducts when the capacitors are charged to the regulating voltage. Then current will flow through the Z3 and C21 into Q7. Q7 then conducts the majority of the shunt current to prevent excessive heating in Z3. Regulating current returns through charge verifying transistor Q5. The energy is stored in capacitors C18, C19 and C20 for each pole.

## **ENERGY DISCHARGE CIRCUIT**

Three energy discharge circuits are provided, one for each switch pole. For example, pole 3 closing circuit consists of SCR1, C18, D6, D12 and R19, contributing to the discharge of the other poles. The SCR is fired by a pulse from the gate firing circuit which is connected through a coaxial cable to minimize noise penetration. R19 (10 ohms) is provided to reduce gate sensitivity and aid SCR commutation after discharge. An RC network is connected across the anode to cathode of the SCR to reduce high rate DV/DT transients across the SCR. The SCR will be fired by a two volt pulse at its gate, then C18 will discharge.

Attempted voltage reversal across the closing solenoid is prevented by free wheeling diodes D3, (4, 12). These will continue to carry the current assuring that all the energy is dissipated in the closing coil. Time delay relay contacts from 62 disconnect the power supply during the closing operation and to assure commutation of the SCR after discharging the capacitors. After the capacitors are discharged, the circuit will commutate to allow the SCR to return to nonconducting state. This will be followed by recharging of the energy storage capacitors after the 62 relay times out.

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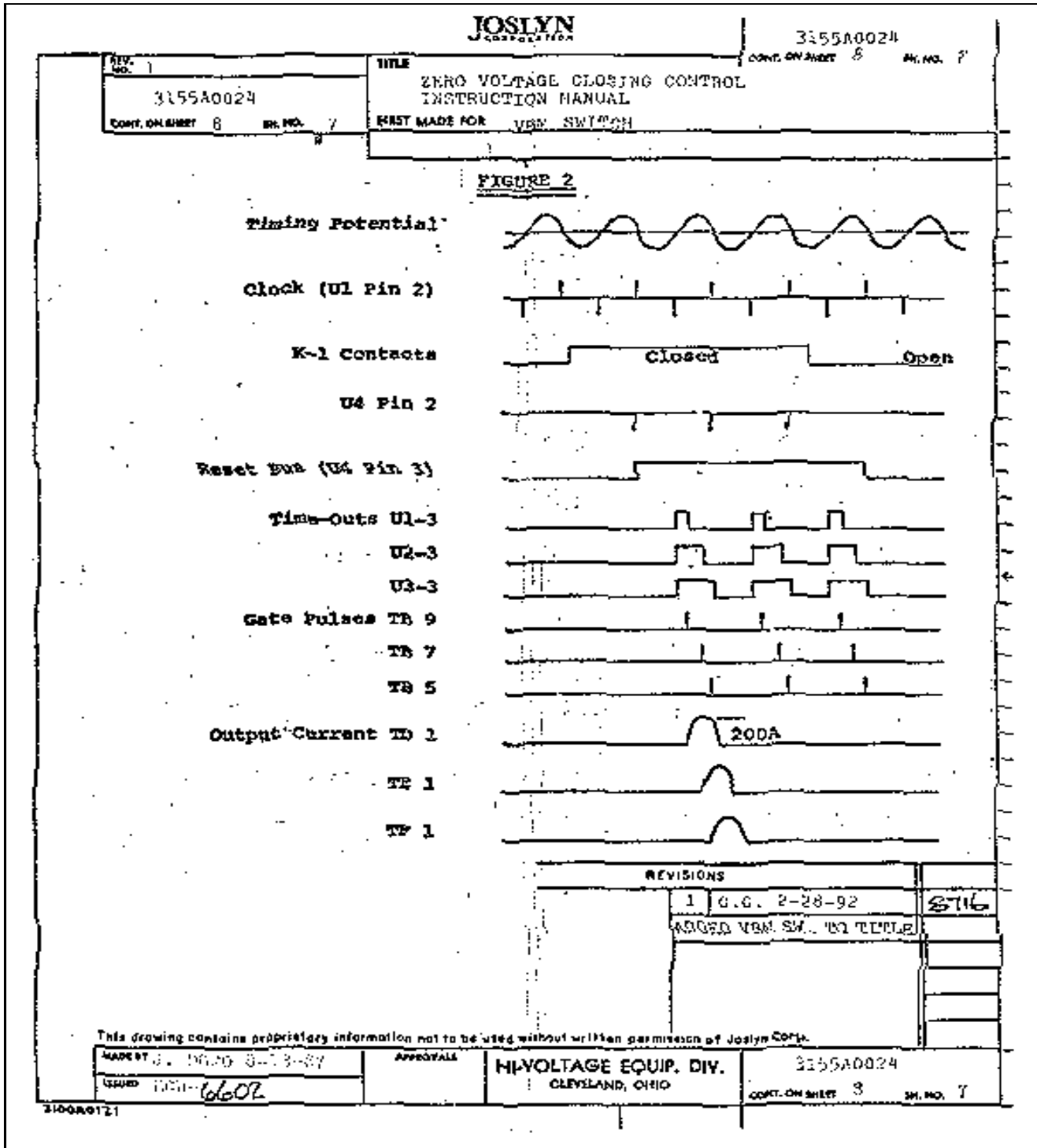
## **CIRCUIT ISOLATION & OVERVOLTAGE PROTECTION**

Transformers T1, T2, and T3 provide ground isolation for the control circuit. Relay K1 provides isolation from the close control signal. MOV 1 protects the clock input from surges on the potential circuit. MOV 2 protects the power supplies from surges on the station service system.

## **TIMING DIAGRAM**

The timing diagram (Fig. 2) shows the normal operation of the synchronous closing circuit. The clock runs continuously, synchronized to the bus potential. When a close is desired, close signal is provided to the coil of K1 which will then close its contacts. (K1 will be energized when the 52/x relay coil is energized). If the energy storage capacitors are fully charged, then the enabling timer will be triggered to start the timing cycle at the next available sequencing pulse. Approximately 8.3 milliseconds after the enabling timer is triggered, the timers U1, U2 and U3 will start. At the end of their timing cycles, gate firing pulses will be issued and the SCRs fired to discharge their respective energy storage capacitors.

## FIGURE 2



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## **INSTALLATION**

### **EQUIPMENT REQUIRED**

- Digital storage oscilloscope. Two channel minimum. Storage required, 20 microsecond per point.
- Inputs required from transformer neutral current and phase potential transformer (input to control cabinet). Ungrounded transformers will require inputs from neutral PT instead of neutral CT.
- Vacuum contact position indication input. Generally a 15 volt supply or greater with current limiting to less than 1 ampere is connected across each phase (See Figure 3).
- Potential clipping network for initial unenergized calibration (See Figure 3) to establish voltage peak reference.
- Isolation transformer for the oscilloscope during the energized calibration measurements.
- Digital volt-ohm meter.
- Resistor, 4000 ohm, ¼ watt minimum.

### **OBJECTIVES**

The objective is to first adjust each of the three individual timing potentiometers without high voltage on the vacuum switches, such that, closing of the individual poles is at the desired location with respect to the reference potential (P.T..... input) peak voltage crossing. The potentiometers are adjusted to cause closing of each pole at 60 degrees (2.77 ms). The desired closing angle is not exactly at voltage peak but at 0.3 ms after voltage peak during an actual energization. Electrically the circuit will be “made” a short time (0.5 ms to 1 ms depending on the application) before the vacuum contacts mechanically “make” due to the high voltage stress as the vacuum contacts approach each other during an actual energized closing operation. Therefore, during the low voltage calibration the control is adjusted to anticipate the actual energized conditions. From experience, it has been found that an additional 0.5 ms delay from the desired closing angle is an ideal timing setting.

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**FIELD WIRING** (Please refer to the interconnection and wiring diagram supplied for the specific control system being installed.)

1. The synchronizing voltage should be supplied by a transformer, such as the substation metering to the Joslyn control. The wiring must be a shielded two conductor twisted pair with the shield tied to ground only at the source end. 18 or 20AWG is normal conductor size to provide a 10mA load. The phase relationship of this voltage source is important since the peak crossing point is our reference to the high voltage peak closing.
2. The control cables between each switch pole and the Joslyn control must be in an individual shielded cable or within a metal conduit run to each pole. Please refer to the interconnection diagram to select the wire size (AWG).

\* Note that if the synchronizing voltage source is not connected to provide a line to ground phase voltage then the appropriate phase shift correction must be made for phase to phase voltage connections or any other phase shift from other transformations that would affect the accuracy of the measured voltage zero crossing.

**TIMING SETPOINTS**

**GROUNDING TRANSFORMER**

System phase rotation: C B A  
Allowable pole closing sequence: A-B-C or B-A-C or C-A-B  
System phase rotation: A B C  
Allowable pole closing sequence: C-B-A or B-A-C or A-C-B

\*\*\*The following are reference times that apply to the low voltage timing settings only. These times should provide actual high voltage energization timing close to the desired time of 0.3 ms after a peak crossing. The final adjustment during actual energization measurements is intended to fine tune the timing to provide a tolerance of 0.3 ms ( $\pm$  0.1ms) after peak voltage crossover points\*\*\*

This table provides reference times to each pole as measured from the peak voltage crossover of the synchronizing phase control input. A sequential closing of any three consecutive times below is appropriate if the pole closing is correct.

	-0.59 ms.	
Low Voltage	+2.19 ms.	
Timing	*+4.97 ms.*	SYNCHRONIZING P.T. PHASE (60 HZ)
(Pick any 3	+7.25 ms.	
Consecutive)	+10.53 ms.	

The following are the desired timing sequences as measured from the synchronizing phase input voltage zero crossover to the actual energizations.

	-1.08 ms.	
High Voltage	+1.69 ms.	
Timing	*+4.47 ms.*	SYNCHRONIZING P.T. PHASE (60 HZ)
(Pick any 3	+7.25 ms.	
Consecutive)	+10.02 ms.	

Contact the factory for 50HZ tables

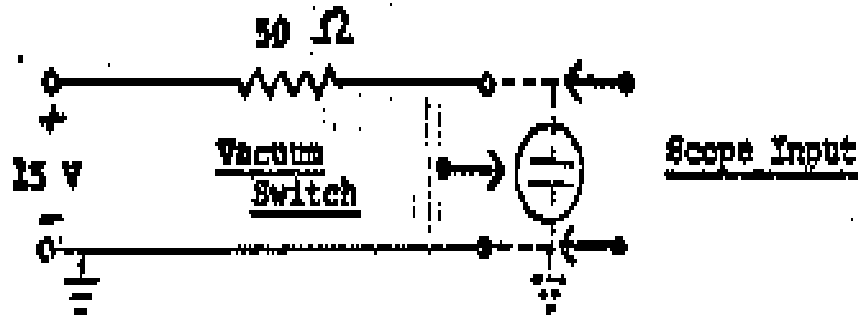
EXAMPLE

ABC ROTATION    SYNCHRONIZING PHASE A

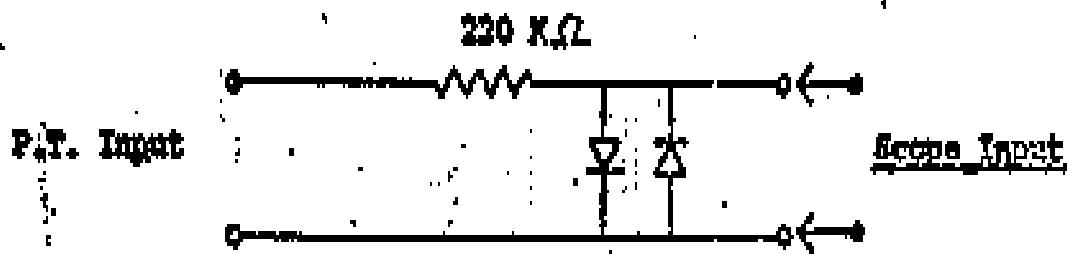
CLOSING SEQUENCES    C-B-A

Low Voltage	C (-0.59 ms.)
Timing	B (+2.19 ms.)
	A (+4.97 ms.)
High Voltage	C (-1.08 ms.)
Timing	B (+1.69 ms.)
	A (+4.47 ms.)

**FIGURE 1 (LOW VOLTAGE TIMING)**



**VACUUM CONTACT POSITION INDICATION CIRCUIT**



**POTENTIAL CLIPPING CIRCUIT**

## **INSTALLATION**

The wiring diagram, interconnection and schematic drawings provide all the necessary specifications for the customer input wiring and interconnection. Requirements for the power inputs, wire interconnections and the voltage synchronizing source must be followed to insure proper operation.

The normal mechanical switch installation procedures should be followed per Joslyn instruction manual I. 750-315 for model VBT Transmaster or I. 750-314 for model VBU Transmaster. The vacuum contacts should be high potential tested and the contact resistance measured.

## **ADJUSTMENT PROCEDURE** \*IMPORTANT- Limit testing to 20 minutes between close operations to prevent calibration errors\*

The following adjustments should be performed with all proper high voltage clearances and grounding practices observed. Access to the high voltage switch with its high voltage terminals isolated will be required for making timing measurements.

1. Some controls include a selector switch that allows operation in one of two models (standard or point on wave). The standard mode operates the switch in the conventional manner with switch closings occurring randomly as a function of the command signal timing only. The point on wave mode will close each switch pole independently referenced from a peak voltage crossing of the high voltage bus potential synchronizing source, following a closing command. Note that the opening circuit is the same in both modes (direct shunt trip).
2. Before energizing the controls, turn each potentiometer R25, R26 and R27 until an audible click is heard and then reverse the rotation exactly 12.5 turns.
3. Set the selector switch to the point on wave position. Place the voltmeter between the tp8 and the negative of C23 on the timing P.C. board. The voltage should be 12-17 volts D.C.
4. Place the voltmeter directly across capacitor C18 followed by C19 and C20. The capacitor voltages should be the same. This voltage should stabilize between 115-125 volts. The initial charging time will be long if the control has been de-energized over a long period. Following the initial charging, the capacitors will charge faster to their normal operating voltage which is zener regulated at a nominal 120 volts.
5. To check the enable circuitry, attempt to close the switch with less than 100 volts on capacitors C18, C19 and C20. The switches should not close. 52/x relay should de-energize.

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## **INSTALLATION ADJUSTMENT PROCEDURE** (Continued)

6. Check the improper sequence relay by removing one lead of any close solenoid. Attempt to close at full capacitor voltage. Two (2) VBT switches should close followed one second later by opening all switches. 52/x relay should de-energize.
7. Set up the digital storage oscilloscope to monitor the bus potential P.T. input through the voltage clipping circuit, and vacuum contact position input. The bus potential P.T. input can be obtained directly from the P.T. input terminals "1&2" noting which one is the ground side. The vacuum contact position trace is obtained from the circuit illustrated in Figure 3.
8. Since all the potentiometers R25, R26 and R27 have been set to the exact micro point of their setting, the three poles will close within close timing of each other. If a digital scope with sufficient channels is used, all of the pole closing times and the synchronizing potential can be displayed. Otherwise, each pole will be timed separately. First measure the time from the peak voltage crossover to the first point of making of each pole.
9. Refer to the timing goal section. The high voltage phase rotation, and the phase voltage being monitored must be known. Evaluate the recorded measurements to determine which closing sequence will require the minimum number of turns on each potentiometer. Each turn of the pot will change the timing of the VBT switch by approximately 0.4 ms. to prevent high wattage dissipation in the U1, U2 and U3 timers, the pots should not be turned in (clockwise) more than 10.5 turns.
10. Turn each individual pot and then close and measure timing until the desired timing goal is achieved. The goal is to close each pole approximately 0.8 ms after voltage peak. If a two channel scope is being used, a final check should be made to measure the time interval between poles which should be 2.77 ms between poles. Note that the timing tolerance is at about  $\pm 0.1$  ms for the initial setting of the poles.

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**HIGH VOLTAGE ADJUSTMENT \*Important - Limit testing to 20 minutes between close operations to prevent calibration errors\***

1. The two parameters that will be measured will be the incoming synchronizing voltage and the neutral current for a grounded transformer. The neutral voltage for the ungrounded transformer is best. The oscilloscope should be plugged into an isolation transformer to avoid induced voltages in the signals. \*If the oscilloscope frame is operated ungrounded, hazardous voltages can exist on the oscilloscope chassis. Therefore, proper connections and safety procedures should be followed according to the manufacturers instructions.\*
2. The synchronizing source should be inputted directly into the oscilloscope without the clipper circuit, preferably into a differential amplifier input. The other input should be the neutral signal. A portable Current Transducer can be used. Individual phase currents could be monitored but the added complexity is not necessary as the closing timing is easily measured only by observing the neutral signal.
3. During the actual energization it is recommended to place the oscilloscope on single shot memory and observe normal personnel safety switching clearances practices from the high voltage transformer and then retrieve the readings after the high voltage switch has been opened.
4. Refer to the desired timing goals which essentially desire the actual energizations to occur at  $0.3 \text{ ms} \pm 0.1 \text{ ms}$  after the peak voltage crossing to the recorded switching steps visible on the current and voltage traces. The closing of each pole will result in an inrush current visible as a transient current on the neutral current trace and some distortion on the voltage trace. (See Figure 5 or Figure 6).

The suggested method of measuring is to locate the peak voltage crossover preceding the switching occurrence. This will provide an accurate reference location since the peak crossover during the switching interval may have some distortion. Advance the cursor exactly  $\frac{1}{2}$  cycle (8.333 ms). This is the reference location from which the peak crossovers of the other phases can be determined. In grounded case, the crossovers will be  $60^\circ$  apart (2.778 ms). The timing goal section provides reference times as measured from this peak reference location to each phase closing time. Note that a tolerance of  $\pm 0.1 \text{ ms}$  is acceptable. To determine the time, move the cursors to the initiation of each transient and measure the time from the peak reference. This time can be subtracted from 2.778 ms to determine the exact closing angle from its respective voltage peak. The timing tables use a convention that if a closing occurs before or after the peak reference, it is considered negative or positive respectively.

5. The measured times may indicate an adjustment is required to advance or delay the closing of one or all poles. The potentiometers (R25, R26, & R27) should be turned clockwise to advance and counterclockwise to delay closing of the switches. Although one turn of each potentiometer should change the settings by 0.4 ms during actual energizations, the timing may not be as sensitive and more turning is required per turn. This is due to the expected voltage withstand properties during closing and is desired as it reduces the actual closing error with switch variations. Note that the timing should be very close within 0.5 ms of the low voltage timing or your measurements are incorrect. Keep a record of times at each closing of the turns on the potentiometers to eliminate overheating the IC timers by never turning the potentiometer closer than within two turns of the minimum resistance. After the desired results are obtained, seal the potentiometer settings with glyptol to prevent any vibration during the turning of the potentiometer.

## POWER SYSTEM BACKGROUND

### A.) Basic System Timing Principles:

- On a balanced three phase electrical system, phases are 60 degrees apart.
- One cycle on a 60Hz system is equal to 16.667 milliseconds and 20 milliseconds on a 50 Hz system.
- One cycle corresponds to 360 electrical degrees.
- Conversion from degrees to seconds is performed by using the following equation:

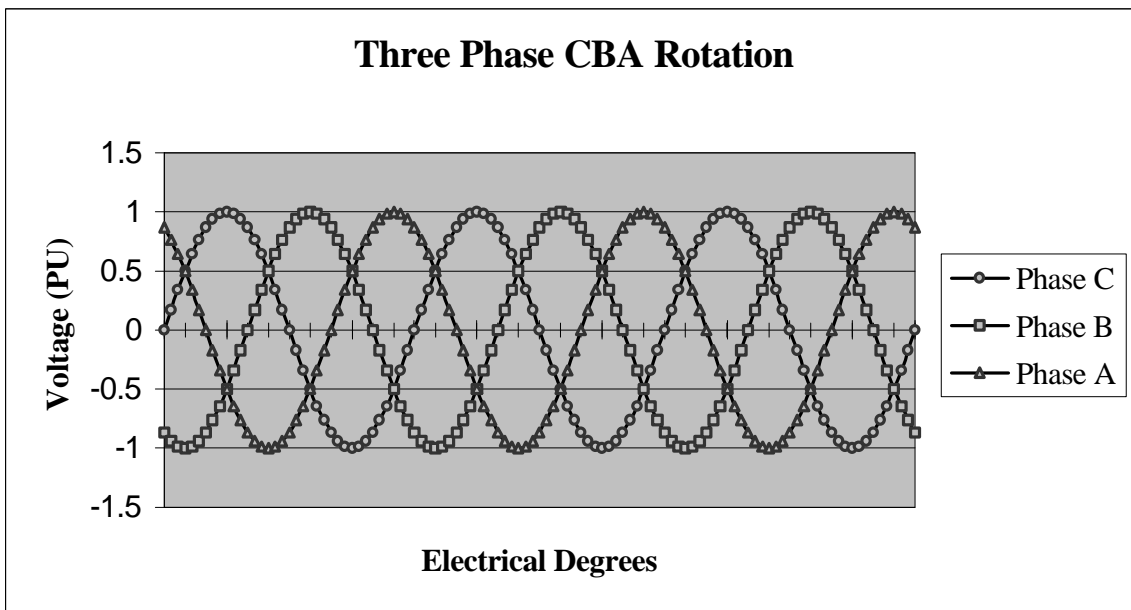
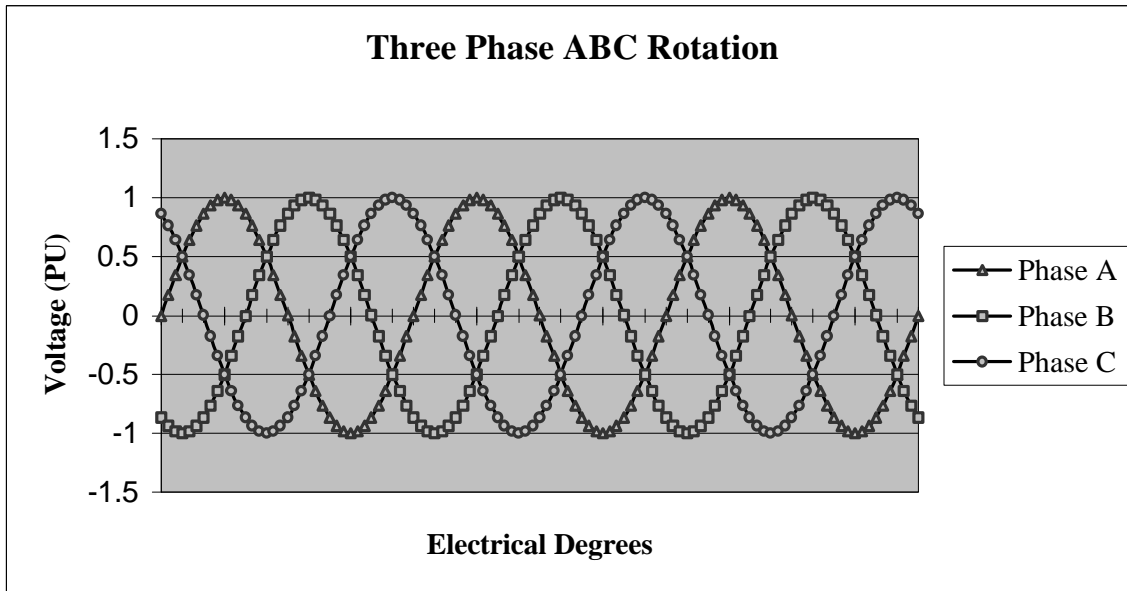
$$X/360 \times 16.667\text{mS} = \text{Equivalent ms (60Hz system)}$$

$$X/360 \times 20.000\text{mS} = \text{Equivalent ms (50Hz system)}$$

Where: X = degrees

### B.) ABC and CBA Voltage rotations:

The following two graphs represent the two possible system voltage rotations. The correct selection of the applicable rotation allows the control to accurately close with respect to the corresponding phase voltages.



### **C.) Phase-to-Phase Reference Sensing:**

The following reference information relates to customer is using Phase-to-Phase voltage sensing consideration:

#### **ABC Rotation:**

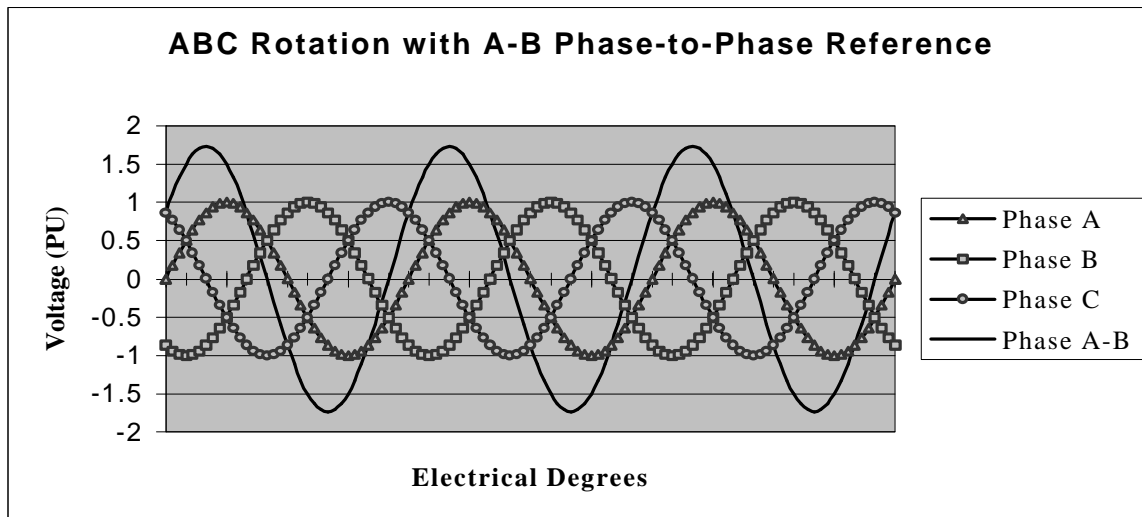
When the voltage reference source is connected phase-to-phase with an ABC rotation system, the resultant wave will lead each phase by 30 degrees. The actual timing equates to + 1.389mS for 60Hz ( $30/360 \times 16.67\text{mS} = 1.389\text{mS}$ ) and + 1.667mS for 50Hz ( $30/360 \times 20\text{mS} = 1.667\text{mS}$ ).

#### **CBA Rotation:**

When the voltage reference source is connected phase-to-phase with an CBA rotation system, the resultant wave will lag each phase by 30 degrees. The actual timing equates to a negative 1.389mS for 60Hz and a negative 1.667mS for 50Hz.

A summary for phase-to-phase transformers sensing with respect to the individual phase voltages is represented in the table below and demonstrated in a sample timing graph:

<u>PT Connection</u>	<u>Phase Rotation ABC</u>	<u>Phase Rotation CBA</u>
A and B	A - 30 degree lead B - 30 degree lag	A - 30 degree lag B - 30 degree lead
B and C	B - 30 degree lead C - 30 degree lag	B - 30 degree lag C - 30 degree lead
C and A	C - 30 degree lead A - 30 degree lag	C - 30 degree lag A - 30 degree lead



**TABLE I**

**UNGROUND TRANSFORMER  
(60 HZ) LOW VOLTAGE TIMING**

POW timing sequence for ungrounded transformer using A-B-C phase rotation, all times in milliseconds.

C L O S I N G	REFERENCE: PHASE A						
	S E Q U E N C E	A	(+0.80 ms)	C	(-4.76 ms)	B	(-1.98 ms)
		C	(+2.19 ms)	B	(-3.37 ms)	A	(-0.59 ms)
		B	(+6.36 ms)	A	(+0.80 ms)	C	(+3.58 ms)
	REFERENCE: PHASE B						
	B	(+0.80 ms)	A	(-4.76 ms)	C	(-1.98 ms)	
	A	(+2.19 ms)	C	(-3.37 ms)	B	(-0.59 ms)	
	C	(+6.36 ms)	B	(+0.80 ms)	A	(+3.58 ms)	
	REFERENCE: PHASE C						
	C	(+0.80 ms)	B	(-4.76 ms)	A	(-1.98 ms)	
	B	(+2.19 ms)	A	(-3.37 ms)	C	(-0.59 ms)	
	A	(+6.36 ms)	C	(+0.80 ms)	B	(+3.58 ms)	

**CBA ROTATION**

REFERENCE: PHASE A					
A	(+0.80 ms)	B	(-4.76 ms)	C	(-1.98 ms)
B	(+2.19 ms)	C	(-3.37 ms)	A	(-0.59 ms)
C	(+6.36 ms)	A	(+0.80 ms)	B	(+3.58 ms)
REFERENCE: PHASE B					
B	(+0.80 ms)	C	(-4.76 ms)	A	(-1.98 ms)
C	(+2.19 ms)	A	(-3.37 ms)	B	(-0.59 ms)
A	(+6.36 ms)	B	(+0.80 ms)	C	(+3.58 ms)
REFERENCE: PHASE C					
C	(+0.80 ms)	A	(-4.76 ms)	B	(-1.98 ms)
A	(+2.19 ms)	B	(-3.37 ms)	C	(-0.59 ms)
B	(+6.36 ms)	C	(+0.80 ms)	A	(+3.58 ms)

**TABLE II**

**UNGROUND TRANSFORMER  
(60 HZ) HIGH VOLTAGE TIMING**

POW timing sequence for ungrounded transformer using A-B-C phase rotation, all times in milliseconds.

**ABC ROTATION**

C L O S I N G		REFERENCE: PHASE A					
	S	A	(+0.30 ms)	C	(-5.26 ms)	B	(-2.48 ms)
	E	C	(+1.69 ms)	B	(-3.85 ms)	A	(-1.09 ms)
	Q	B	(+5.86 ms)	A	(+0.30 ms)	C	(+3.08 ms)
	U	REFERENCE: PHASE B					
	E	B	(+0.30 ms)	A	(-5.26 ms)	C	(-2.48 ms)
	C	A	(+1.69 ms)	C	(-3.85 ms)	B	(-1.09 ms)
	E	C	(+5.86 ms)	B	(+0.30 ms)	A	(+3.08 ms)
		REFERENCE: PHASE C					
		C	(+0.30 ms)	B	(-5.26 ms)	A	(-2.48 ms)
		B	(+1.69 ms)	A	(-3.85 ms)	C	(-1.09 ms)
		A	(+5.86 ms)	C	(+0.30 ms)	B	(+3.08 ms)

**CBA ROTATION**

	REFERENCE: PHASE A					
	A	(+0.30 ms)	B	(-5.26 ms)	C	(-2.48 ms)
	B	(+1.69 ms)	C	(-3.85 ms)	A	(-1.09 ms)
	C	(+5.86 ms)	A	(+0.30 ms)	B	(+3.08 ms)
	REFERENCE: PHASE B					
	B	(+0.30 ms)	C	(-5.26 ms)	A	(-2.48 ms)
	C	(+1.69 ms)	A	(-3.85 ms)	B	(-1.09 ms)
	A	(+5.86 ms)	B	(+0.30 ms)	C	(+3.08 ms)
	REFERENCE: PHASE C					
	C	(+0.30 ms)	A	(-5.26 ms)	B	(-2.48 ms)
	A	(+1.69 ms)	B	(-3.85 ms)	C	(-1.09 ms)
	B	(+5.86 ms)	C	(+0.30 ms)	A	(+3.08 ms)

Please refer to figure 1 schematic diagram. The description discusses only the zero voltage closing control.

