# Three Phase Meter

## Introduction

A friend has a lathe with a 3 phase motor and lives in a country area with only a 1 phase supply. Provision of a 3 phase supply was prohibitive. So he bought a device that converts a single phase mains supply to 3 phases. However, it needs manual adjustment of the phase angle when under load. So he asked me to design and build a phase meter for him.

## Circuit Description

The 3 phase mains are even more dangerous than the single phase since there is 415 Volt between the phases. Thus a safe isolation unit is required between the mains and the low voltage section. This isolation is provided by Opto Couplers OP1, OP2 and OP3.

The 3 phase signals from the Opto Couplers are squared by the Schmitt triggers IC1a, b & c and then applied to the exclusive OR gates IC5a & b via IC4. The output of the exclusive OR gates is a square wave signal whose mark to space ratio is proportional to the phase difference. These signals are applied to the averaging amplifiers IC6a & b. Diodes D4 & D5 prevent a reverse current through the meters if the phase angle is less than 90º. NB. the exclusive OR gates cannot determine the sign of the phase angle, ie. -120º will result in the same waveform as +120º. Hence IC3a & b are employed to detect the sign. When S2 is open, IC5c inverts the IC4/10 signal so that the D Types are clocked on the negative edge of this signal. Hence if the sign of the phase is correct, $O_5$ will go Low and $O_6$ High thus illuminating the LEDs. See Figure 5.

In order to calibrate the meters, IC2a is configured as 3 stage Twisted Ring Counter which generates a 3 phase test waveform. Refer to Figure 4. Note that the phase difference between $O_1$, $O_2$ and $O_3$ is 60º but since $O_2$ is inverted by IC5d, the correct phase differences (120º) are obtained. See Figure 5.

The power on reset is generated by IC1f. This necessary because the counter could start in state 010 or 101. If so, the counter would oscillate between these states rather than count in the correct sequence.

When S1 is set to the Test position, IC4 switches the test waveforms to IC5a, 5b & 5c. The meters are calibrated by adjusting RV2 & RV3 to set the meters to centre scale (0.5 mA which represents 120º) and both LEDs should be lit indicating that the sign of the phase is correct. If switch S2 is closed while S1 is in the test position, IC5c inverts the phase of the clock signal to IC3a & 3b thus extinguishing the LEDs.

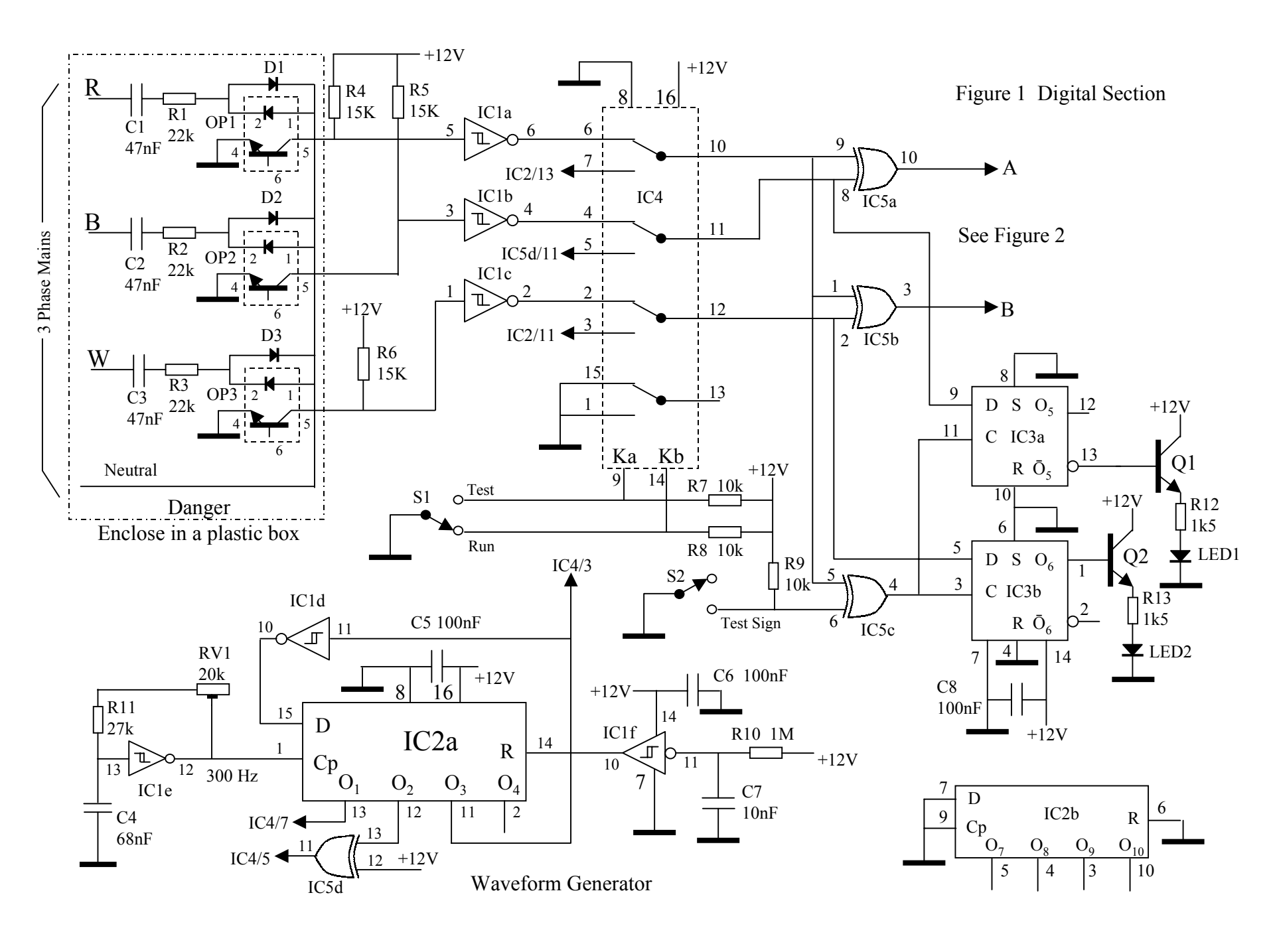
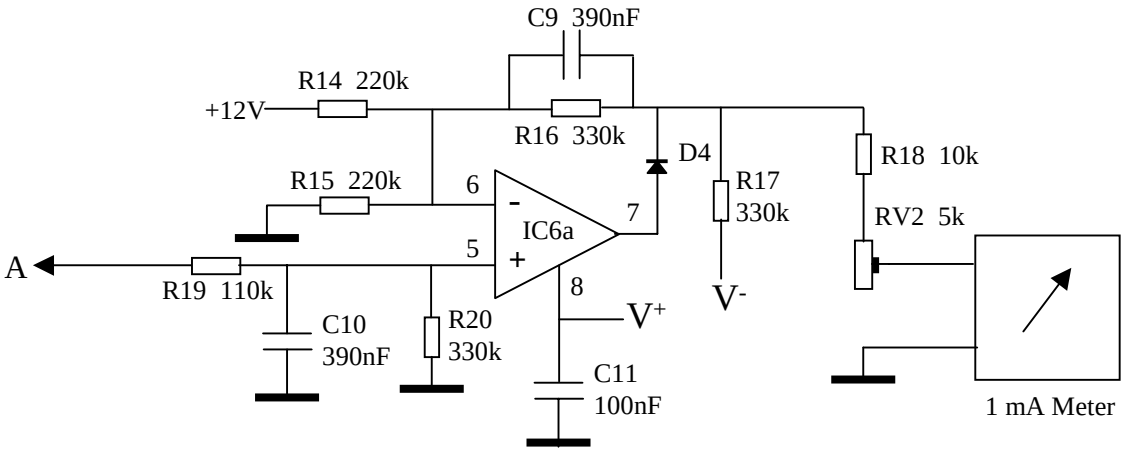
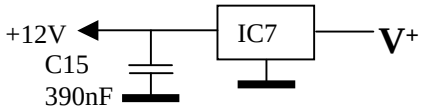



Figure 1 Digital Section




$V^+$ &$V^-$ are unregulated
$V^+$ = 15 ~ 20 Volt
$V^-$ = -7 ~ -12 Volt

See Figure 1

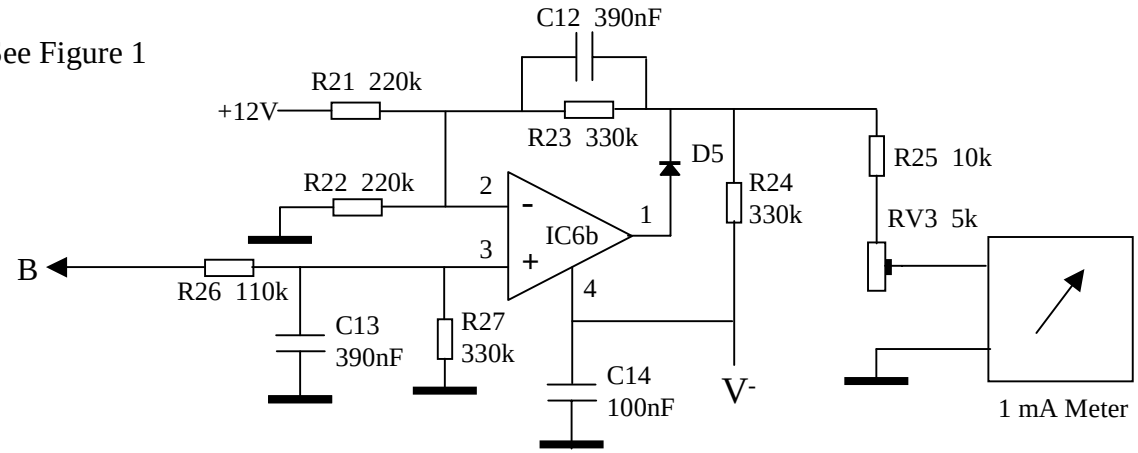



Figure 2 Analogue Section

| $O_1$ | $O_2$ | $O_3$ |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |
| 1 | 1 | 1 |
| 0 | 1 | 1 |
| 0 | 0 | 1 |

Figure 3 Count Sequemce

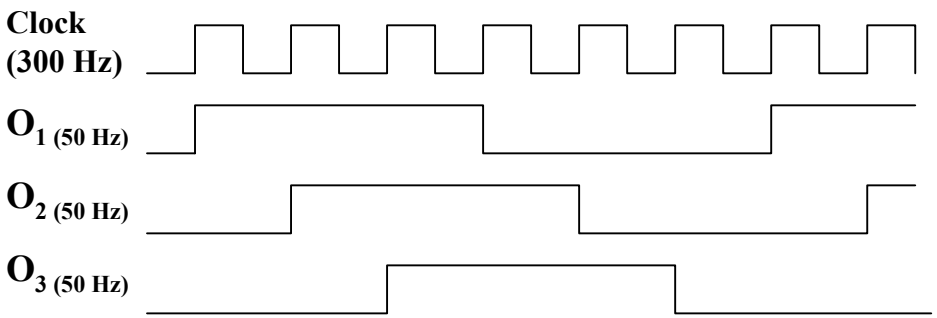



Figure 4 Waveforms of Twisted Ring Counter

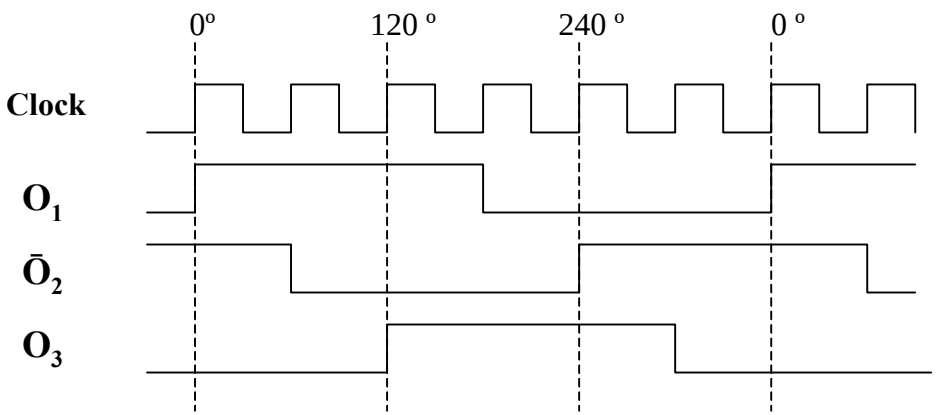



Figure 5 Waveforms Showing $O_2$ inverted & phase angle

Parts List

| | |
|---|---|
| OP1, 2, 3 | 4N25 Opto Coupler |
| IC1 | 40106 Hex Schmitt Trigger |
| IC2 | 4015 Dual 4 Bit Shift Register |
| IC3 | 4013 Dual D Type Flip Flop |
| IC4 | 4019 Quad 2 input Multiplexer |
| IC5 | 4030 Quad Exclusive OR gate |
| IC6 | LF353 Dual Op Amp |
| IC7 | 78L12 Voltage Regulator |
| C1, 2, 3 | 47 nF Capacitor 250 V Mains rated |
| C4 | 68 nF 50 Volt |
| C5, 6, 7, 8 | 100 nF 50 Volt ceramic |
| C9, 10, 12, 13 | 390 nF 50 Volt ceramic |
| C11, 14 | 100 nF 50 Volt ceramic |
| R1, 2, 3 | 22 k ½Watt 5% |
| R14, 15, 21, 22 | 220 k ¼ Watt, 1% |
| R16, 20, 23, 27 | 330 k ¼ Watt, 1% |
| R19, 26 | 110 k ¼ Watt, 1% |
| All other resistors are ¼ Watt, 5% | |
| D1, 2, 3, 4, 5 | 1N4148 |
| Q1, Q2 | PN100 |
| RV1 | 20 k Trim pot |
| RV2, 3 | 5 k Trim pot |