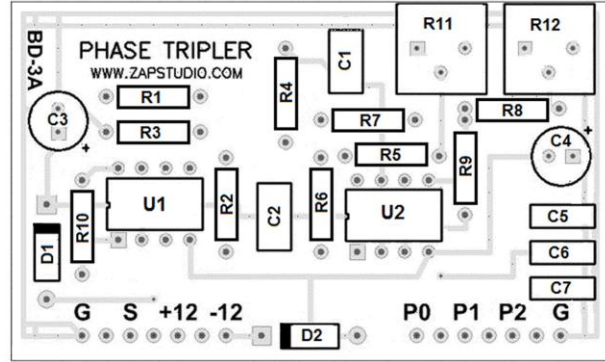


## 400Hz Phase Tripler BD-3A400 Kit

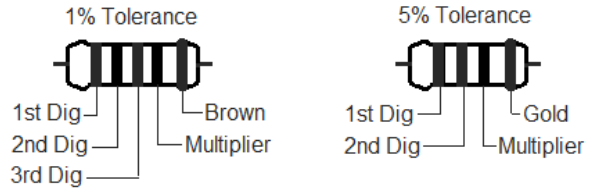
**Basic knowledge of electronics and soldering experience is required. Use a 25 watt soldering iron with a pencil tip and good quality solder. Verify that each component is inserted correctly before soldering. Observe the orientation of the IC's and the polarity of the capacitors C9 and C10.**

### Assembly Instructions

1. Mount and solder the two 7-pin headers. The plastic part of the header must firmly touch the top side of the pc board.
2. Mount and solder U1 and U2 on the top of the circuit board. Observe location of IC pin 1.
3. Mount and solder pots R11 and R12. Cut off excess leads. Mount and solder diodes, D1 and D2. Observe location of cathode band.
4. Use the resistor color code to identify the resistors. Use the ohmmeter if in doubt.



- |          |          |
|----------|----------|
| 1 Brown  | 6 Blue   |
| 2 Red    | 7 Violet |
| 3 Orange | 8 Grey   |
| 4 Yellow | 9 White  |
| 5 Green  |          |



5. Insert and solder resistors. Cut off excess leads. Insert capacitors. Observe polarity of C3 and C4. Solder and cut off excess leads.

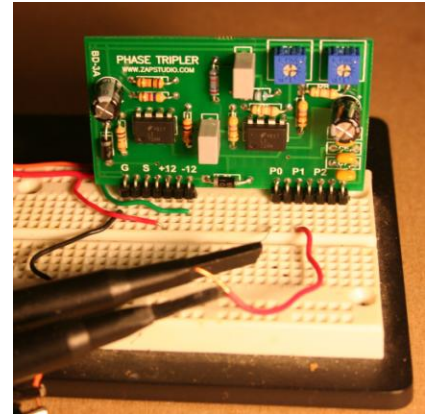
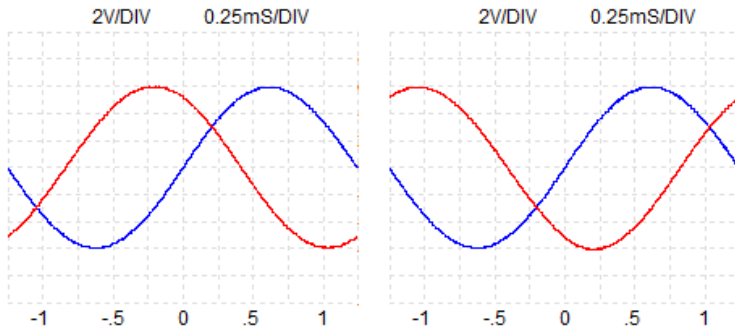
### Parts List

U1, U2: L272M R1, R2: 10K, ¼, 5%. R3: 4.7K, ¼ watt, 5%. R4, 18.8K, ¼ watt, 1%. R5, R8: 39K, ¼ watt, 5%.	R6, R9: 47K, ¼ watt, 5%. R7, 5.9K: ¼ watt, 1%. R10, 1 ohm, ¼ watt, 5%. R11, R12: 20K trim-pots.	C1, C2: 39nF, 2%. C3, C4: 100µF, 25V. C5, C6, C7: 220nF, 10% D1, D2: 1N4001 diodes.
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### Test and Calibrate

1. Plug Phase Tripler into a breadboard. Connect it the power supply. Connect a function generator to the input and set it to produce a 12V p-p, 400Hz, sine wave. Connect the oscilloscope channel 1 to P0 and channel 2 to P1. Set both channels to AC input and 2V/DIV. Set the trigger to channel 1 and the time base to 0.5mS/DIV. Center both traces. The output P0 should be exactly 12V p-p.
2. Adjust pot R11 so that the amplitude of P1 is exactly 12V p-p. Check that the positive slope zero crossing of P1 occurs about 0.83mS before the positive slope zero crossing of P0. Refer to the diagram on the next page.

- Connect oscilloscope channel 2 to output P2. Adjust pot R12 so that the amplitude of output P2 is exactly 12V p-p. Check that the positive slope zero crossing of P2 occurs about 0.83ms after the positive slope zero crossing of P0. Refer to the diagram below.

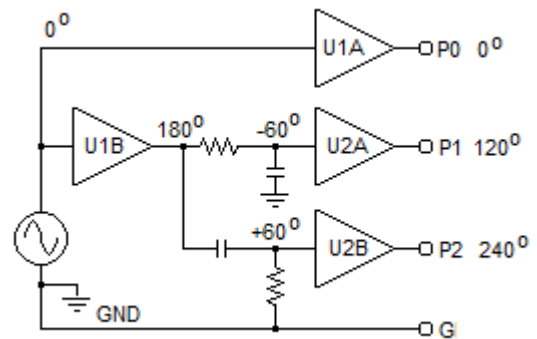


### BD-3A400 Phase Tripler Description

This phase tripler circuit converts single-phase 400Hz ac to three-phase 400Hz AC. The single-phase source may be a function generator or the ac voltage from a step down transformer.

The diagram on the right is a block diagram of the phase tripler circuit. The 400Hz input is buffered by the op-amp, U1A, and output at P0.

Phase inverter, U1B, shifts the phase of the input by 180 degrees. This phase shifted voltage is applied to a 60 degree lag network to obtain a net phase shift of 120 degrees, and to a 60 degree lead network to obtain a net phase shift of 240 (-120) degrees.



### Load Limitations

Loads may be any configuration with the limitation that the power should not exceed 125mW per phase. At 12 volts peak-to-peak this is about 30mA RMS per phase. Each phase output is supplied by a very low output impedance power op-amp. Excessive current will cause the op-amp to over heat and shut down. The op-amp may resume operation when the excessive current is removed and the op-amp cools down.

The lowest impedance per phase that can be connected to the power supply depends on the load configuration. For example, at 12V p-p, the lowest impedance for a 4-wire wye would be about 140 ohms per phase (4.24VRMS/0.03A RMS). As a general rule, any impedance greater than 300 ohms per phase is safe to use with any load configuration. ***The op-amps will get hot and should not be touched with loads above 100mW per phase.***

Another consideration is the power dissipation of the load components. Lab experiments using ¼ watt resistors should be designed so that the resistors don't get too hot. To avoid hot op-amps and hot ¼ watt resistors, use impedances greater than 400 ohms per phase.

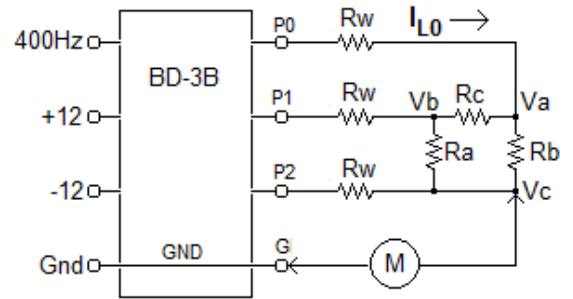
### Measurements

This is a wye-connected source with a common connection that is also the circuit ground for the power supply and op-amps. Non-isolated instrument grounds cannot be connected to the output of an op-amp because that would cause a short circuit. **Measurements should be made with respect to the common ground, G, unless the measuring instrument is known to be isolated.**

The Phase Tripler may be used as a delta source by not using the neutral, G, connection. However, measurements should be made with respect to the neutral, G, unless the instrument is isolated from the lab electrical system ground.

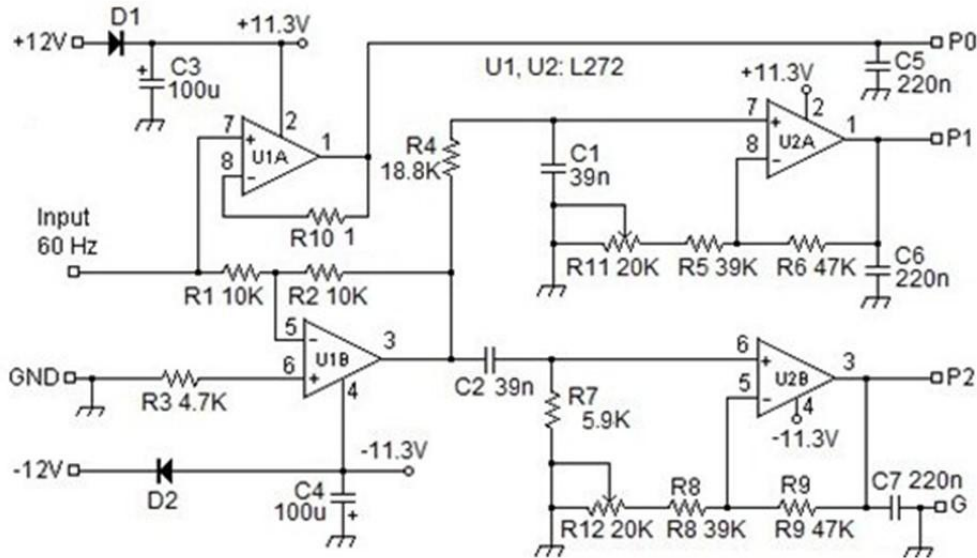
**Example:**

A delta load (Ra, Rb, Rc) is connected to the BD-3A as shown on the right. Resistors Rw represent line resistance. If your measuring instrument is not known to be isolated, all measurements must be made with respect to the common ground (G). Line voltages and currents can be determined by phasor calculations:



$$V_{bc} = V_b - V_c \quad I_{L0} = \frac{V_{P0} - V_a}{R_w} \quad 0^\circ \text{ reference phase may be } V_{P0}.$$

**Circuit Schematic Diagram**



**Specifications: BD-3A400**

Output voltage: 0 to 18V p-p, each phase output, P0, P1, P2 to common, G.  
 Output power: 125mW maximum, each phase output, P1, P2, P3.  
 Output frequency: 400Hz, ±1%. P0 = 0 deg. P2 = 120 deg. P3 = 240 deg.  
 Input: 0 to 18V p-p, 400Hz, ±1%.  
 Input power: +12VDC and -12VDC, 100mA maximum.

**Limited Warranty**

ZAP Studio kit warranty is limited to the replacement of defective parts. The correct assembly and soldering of a kit is the responsibility of the assembler.

ZAP Studio will, without charge, replace missing or defective component parts for a period of 60 days after the date of purchase. Defective parts under warranty must be shipped to ZAP Studio with a copy of the original invoice or receipt, at the purchaser's expense. ZAP Studio will send the replacement parts at its expense.

To report missing or defective parts, contact support: support@zapstudio.com

Exclusion: This warranty does not apply in the case of misuse or abuse of this kit product.

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