Power Resonator CRO-1

A Self resonating Power Oscillator

Features and Specifications

- Automatically resonates low impedance reactive circuits
- Wide supply voltage range (12V – 30V)
- ZVS (Zero Voltage Switching)
- Current up to 14A continuous*, 180A peak
- Optional Modulation input
- High quality double layer PTH, 2oz Copper PCB
- Dimensions: L83 x W46 x H60 mm

** Max current varies with frequency.*

The CRO-1 is a type of **collector resonance oscillator** circuit which will automatically drive low impedance reactive circuits at their resonant frequency. This is ideal for making a **DIY Induction Heater** or Solid State Tesla Coil. It is designed to drive a parallel LC circuit (a coil and capacitor connected in parallel). It can be used in different configurations so it is also able to work with loads that have a centre tapped coil.

The circuit will **automatically drive at resonance** even if the resonant frequency changes such as when a metal object is placed inside an induction heater.

The circuit is designed to work with LC circuits which have a relatively low inductance and a large capacitance. For example an induction heater with a few turns on the coil and a large capacitor bank. While this circuit has been designed to be as versatile as possible, there may be certain LC combinations that will not be driven to resonance by the circuit.

It is important to read ALL these instructions carefully to ensure that the circuit will operate properly. If there is anything you are not sure about, please contact us for support.

Example Applications

- Induction Heating
- DRSSTC (Solid State Tesla Coils)
- DC-AC Power Inverters
- Resonant Energy Experiments
- Wireless Power Transmission
- And more…

ELECTRICAL CHARACTERISTICS

NB: Figures may vary under different loading conditions and environments.

Symbol	Parameter	Min	Max
V_{in}	Input Supply Voltage	12V [1]	30 V
V_{out}	Output Voltage	-	V_{in} - V_{drop}
V_{sec}	Secondary Switching Voltage	0 V	100 V
I_{sup}	Supply Current (no load)	100 mA	150 mA
I_{out}	Continuous Output Current	0 A	14 A [3]
I_{pulse}	Pulse Current [2]	-	180 A

Table 1: Electrical Characteristics

[1] 12V is absolute minimum. 14 to 24V recommended. [2] Pulse current is transistors max rated DC current at 25℃.

[3] Max current varies with frequency. In high frequency applications such as induction heating this value could be much lower

Connections

Below you can see the main power input connections V+ and GND. There is also a connection marked DIS. This is used to activate and deactivate the circuit. DIS is held high internally when powered on which will prevent the power output from activating. To activate the output, DIS should be connected to GND via a switch. We recommend a momentary action push to make type of switch so that the output is only active while the switch is being pushed. Alternately you can use a microcontroller or other logic to control the DIS function.

You can also use a PWM circuit to connect to DIS which allows regulation of the power output. More detail of this is on the last page.

The power input connections GND and V+ should connect to a suitable DC power supply which is rated for at least 5A (preferably more) and ideally has built in current limiting. It is not recommended to power the circuit using large batteries as the large current surge could destroy the circuit if it fails to oscillate.

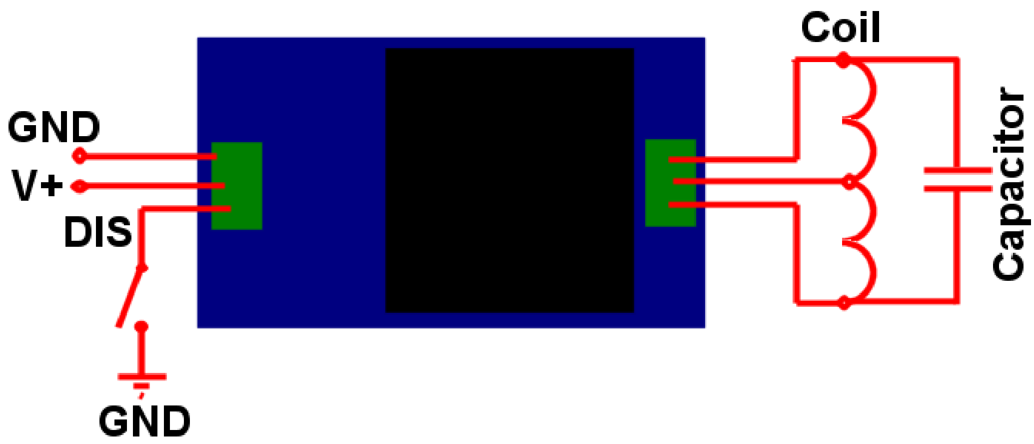

Figure 1: Connection diagram for centre tapped coils

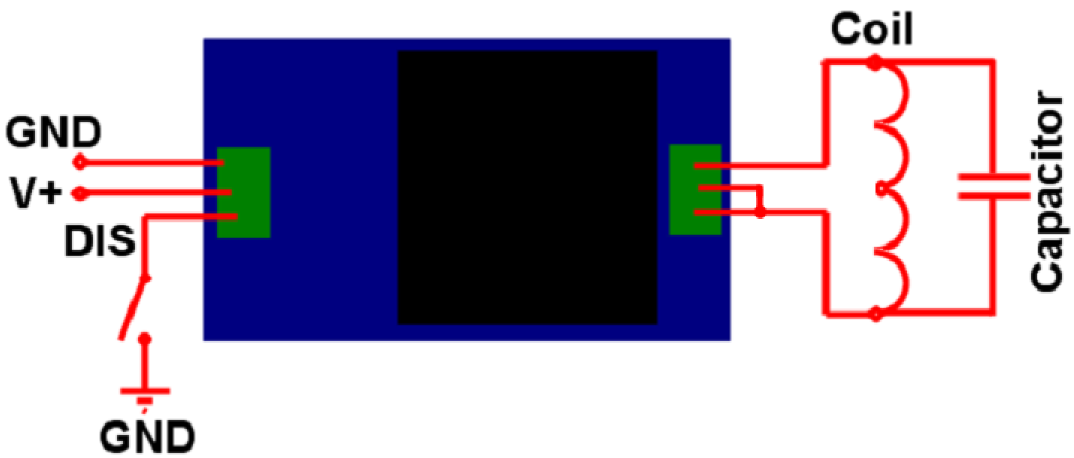

Figure 1b: Connection diagram for standard coils

The output connections are labelled T1, T2, and C. T1 and T2 are connections for the ends of a load coil, and the C connection supplies power to the coil. If using a coil without a centre tap, you will need to make a connection between C and either, T1 or T2 as shown in figure 1b. This

The CRO-1 has one built in 330nF capacitor which helps to ensure good sine waveforms. The coil to be resonated should also have suitable capacitors in parallel with it. It is the inductance of your coil and the total capacitance that will determine the operating frequency.
When connecting to a resonant load such as an induction heater or DRSSTC the coil and capacitors should be connected to each other as close as is practically possible and should also connect reasonably close to the circuit. Long wires can cause problems with oscillations starting up or poorly shaped waveforms. The image below shows a typical setup where the CRO-1 is used to make an induction heater that can heat a steel nut red hot.

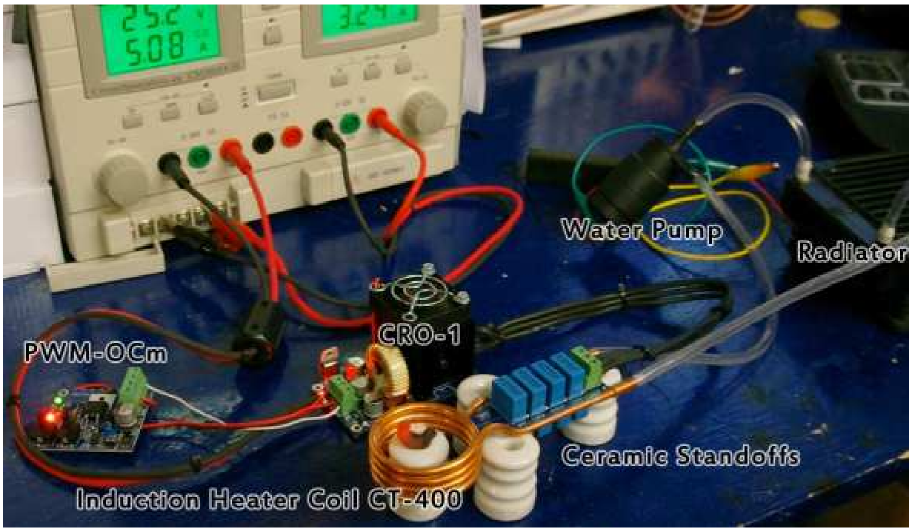

Figure 2: Example Induction Heater Setup

Note the use of a water cooling system which is required to keep the copper coil and capacitors from overheating. This example is running at about 8A from a 25V input with a resonant frequency of 100kHz. At this power and frequency, the heatsinks on the CRO-1 would heat to around 110 degrees Celsius in a relatively short time. **It should only be used for short duty cycles at these power levels (30 seconds on, 5min off) in such situations as this puts a great deal of stress on the components which can cause them to fail.** If required the existing heatsinks can be replaced with larger ones to help reduce the operating temperature.
You can find more details and support for a DIY Induction Heater on our website.

Output Load Considerations

The current oscillating between the coil and capacitor bank will be much higher than the input current to the circuit and therefore the coil must be made of very thick wire or copper pipe and may need to be water cooled.

It is important to use good quality polypropylene (or equivalent) capacitors that are capable of withstanding large currents and show good temperature stability. Using low quality capacitors will result in no resonance, or possible circuit damage.

Induction Coil Shapes and Sizes
The size of the coil used will determine its inductance. Larger coils have more inductance for the same number of turns. The example in the photo above is about 4cm in diameter and is about the smallest size that will work with only 4 turns. This had an inductance value of around 700nH. If a smaller diameter is required, then a larger number of turns will be needed to keep the inductance high enough. If the inductance is too low, then the circuit will fail to oscillate and a large DC current will flow. If your PSU is not current limited, then this could destroy the circuit. Ready-made coils and kits for high power are available in our shop.

Important Usage Notes

- **Use a current limited power supply to protect from accidental short circuit , overload or failed oscillation. You should also use a 10A to 15A quick blow fuse, but these can be much slower to respond.**
- **Take care to only power the load for short periods and leave time for the CRO-1 to cool otherwise the transistors could fail. The CRO-1 does not have any self protection mechanisms so you must take care to ensure proper operation.**
- **This device is designed for experiments and demonstrations. It is not meant for use in any industrial process or machinery and should never be left powered on and unattended.**
- The PSU must be able to deliver enough current to suit your LC load. If it is not sufficient, this could prevent oscillation and damage the circuit
- The heat generated in the switching transistor will vary with your loading conditions and the operating frequency. Higher frequencies will produce more heat.
- The transistor/heatsink, copper surface, and LC load will rise to a higher voltage than the input supply. This will typically be 3.142 times the input voltage. Do not touch the PCB, heatsinks, or your load coil when powered.
- The output coil should typically be a small number of turns (<100). It should ideally have an inductance of around 1uH.
- To drive more current into coils with more turns, you may need to use our impedance matching transformer kit.
- Always use the DIS connection to power on and off the load. Do not connect DIS to GND before powering on the circuit.

Power Modulation

It is possible to vary the average power output of the circuit by using a modulation signal provided by an external PWM circuit such our PWM-OCm or PWM-OCX v2. This is ideal for controlling the temperature of an induction heater.

Connect both the CRO-1 and the PWM circuit to the same power supply so that they share a common ground connection then connect "DIS" on the CRO-1 to "L-" on the PWM (see figure 3 above). When the PWM output is on, it will connect DIS to ground and therefore enable the power output. By setting the PWM to a very low frequency like 1Hz or lower, you can then adjust the duty setting to give a proportional adjustment in output power. **Note that you should not use higher frequencies for modulation as the voltage spikes generated could damage the circuit.** It is not recommended that modulation is used with supply voltages over 15V, or with loads with only a small amount of capacitance.

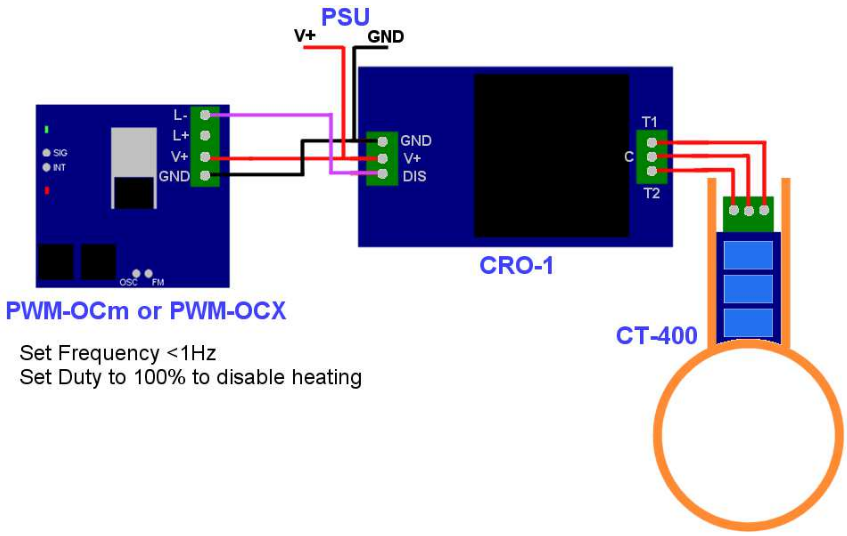

Figure 3: Connections to PWM and CT-400 for Modulated Induction Heating

To protect the circuit from transient voltages, a bidirectional TVS diode, MOV, or back to back zener diodes can be used. They should be connected from each T terminal to GND. The TVS should be rated so that it prevents voltages rising over 100V. You can also use a small neon indicator bulb instead of a TVS. This can give an indication of when the voltage gets too high allowing you to make adjustments to your setup to avoid that.

Troubleshooting

If your setup fails to oscillate or has other problems, there are a number of possible causes that will be discussed below.

Insufficient PSU
If the power supply used cannot deliver enough current, then this will cause a large voltage drop on start-up which could prevent oscillation from starting. The only way to remedy this is to use a larger PSU rated for more current.

Very Low Inductance or Resistance Coil
If the coil has too little inductance and/or resistance, this may prevent oscillation. You can remedy this by increasing the size of your coil, or even adding some small resistance between the centre tap of the coil and the "C" connection on the circuit. Note that adding a resistor will reduce efficiency as a lot of heat could be generated in the resistor.
Even a tiny bit of additional inductance or resistance can make the difference between no oscillation and a working system. Just simply bending the connecting wires into a single loop between the coil and CRO-1 can sometimes add enough extra inductance to get the system running.

Too Much Inductance or Resistance
If the coil is made from too many turns, the inductance and resistance may be too large to support oscillation with this circuit.

Too Little Capacitance, or Poor Quality Capacitors
If there is not enough capacitance parallel with the coil, the oscillation frequency could be very high. This would cause significantly more heating in the transistors in the circuit.
Small, or cheap capacitors may also heat up quickly in use. By using more capacitors the frequency is reduced and the current flow is shared between them.

Blown MOSFET
If a MOSFET is blown from overheating or voltage spikes, the DIS connection will no-longer be able to deactivate power to the load coil. The typical symptoms of this would be that your PSU voltage drops due to it being shorted through the coil via the bad transistor. You would need to replace these MOSFETs to get the circuit running again. To test for a blown MOSFET, remove all connecting wires, and use a multimeter to check for conductivity between T1 and GND or T2 and GND. Whichever one shows conduction needs to be replaced. The transistors used are IRFB4110PBF, but you can use almost any MOSFET with similar ratings.