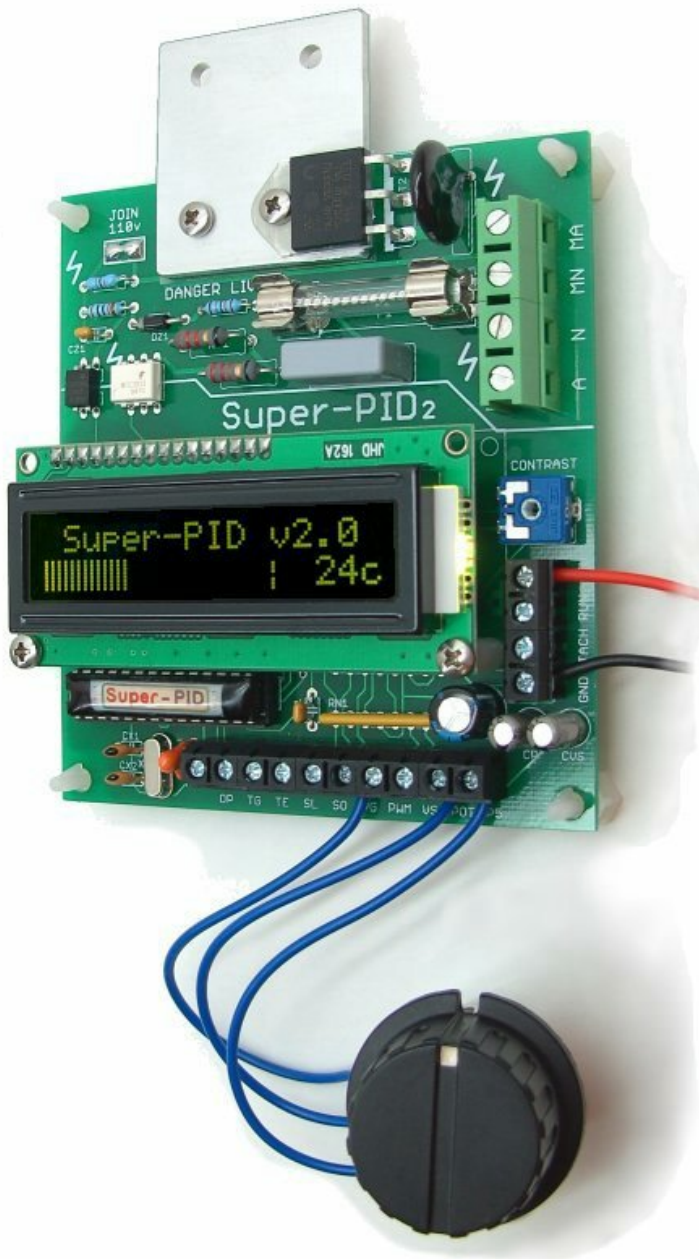


# Super-PID closed-loop router speed controller



## Super-PID

### Closed-loop router speed controller

**Reduced router noise  
Longer bearing life**

**Cool running**

**Increased cutting power**

**Precise speed control**

**Mach3 speed control  
5000 - 30000 RPM**

**Accurate RPM display  
RPM feedback to PC**

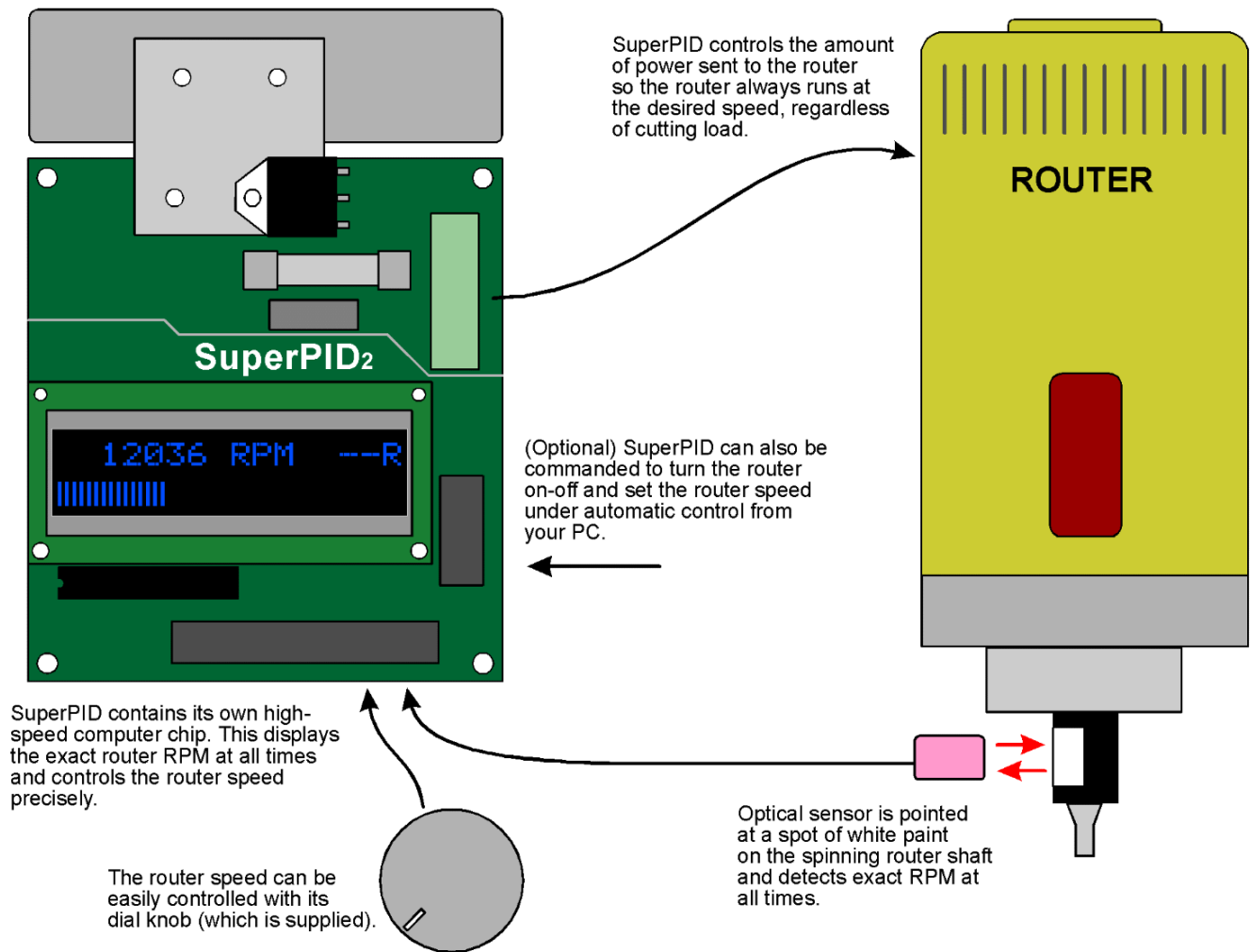
**Many display colours  
Temperature sensor  
Router hours timer**

**[www.SuperPID.com](http://www.SuperPID.com)**

# Overview - what is Super-PID?

Super-PID is a speed controller for routers and other power tools. It is closed loop, which means it monitors the actual RPM of the router and controls the power supplied to the router to make it run at an exact speed. This means the router can be run at lower than normal speeds and still produce excellent cutting power. It also means the router speed will not be affected by load so it will maintain a constant speed even when cutting.

## Overview of closed loop speed control.



When running, the Super-PID display shows the exact router RPM and also shows a bargraph indicating the power sent to the router, (as a percentage of full power).

Super-PID also has some advanced features that allow it to be connected to a PC and controlled by most standard PC software for CNC, including Mach3 and EMC software.

# Specs and requirements

## Super-PID specs;

Models available for 120 volt and 240 volt AC mains to suit all countries  
Suitable for routers up to 1800 Watt (120v) and 2000 Watt (240v)  
Rated for continuous production use  
Opto-isolation for electronic inputs  
Closed loop router speed range; 5000 to 30000 RPM  
Tacho display accuracy; typically +/- 1 RPM  
Open loop router speed range; 0 to MAX  
Size; 94 x 120mm (3.7 x 4.75 inches)

## Super-PID requirements;

120v or 240v AC mains power (not a portable generator)  
Regulated +5v DC power supply, minimum 150 mA  
Speed control pot (supplied)  
Small heatsink (generally a 94 x 25 x 6 mm aluminium bar)  
A safe insulated box  
Small 40mm or 50mm fan recommended with larger routers  
Wiring suitable for a mains powered router

## Router requirements;

The Super-PID works with any router or power tool that has a "universal motor". These motors are identified by having 2 brushes, being noisy and air cooled with their own internal rotor fan, and running from AC mains. This means all typical routers.

The other type of common AC motor used on drill presses is not suitable! These motors are normally made from cast metal, are much larger and heavier, and have no brushes.

## Router modification;

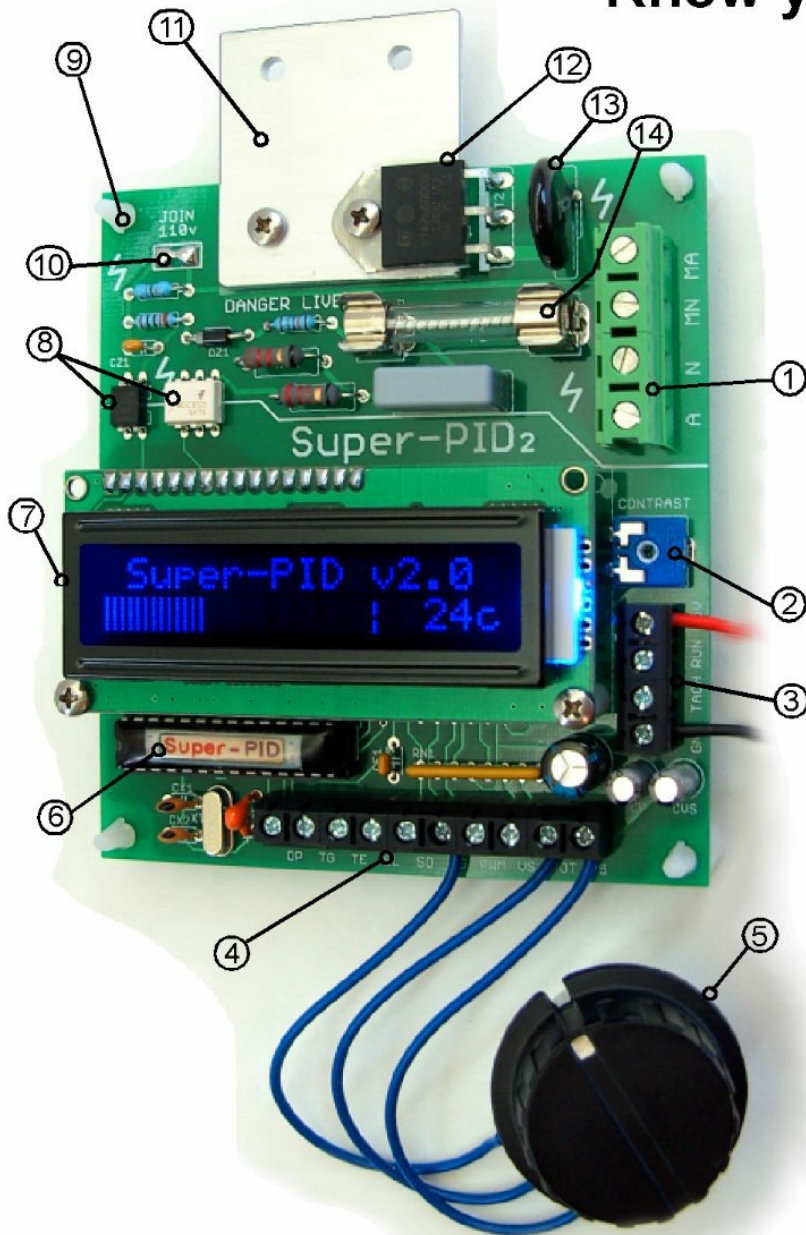
Many routers will work directly with the Super-PID. However, any router that has internal electronics needs to have this electronics removed or bypassed. This electronics includes any form of speed control, or any electronics called "soft start feature".

Modifying the router is usually a very straightforward procedure, and around 70 percent of Super-PID owners are using routers that have been modified this way. Please see the section **Router speed control bypass or removal**.

The other router modification that is required by all users is to add a white-black area on the router shaft so the Super-PID optical sensor can detect the router RPM. This can be as easy as putting some white paint on the router's black shaft, or a more complex procedure to put the optical sensor near the top of the router as many users prefer. Please see the section **Spindle RPM sensor**.

# Know your Super-PID

## Know your Super-PID v2



### Components;

1. AC mains voltage connector
2. LCD contrast adjust
3. Low voltage connector 1
4. Low voltage connector 2
5. Speed control pot
6. Microcontroller
7. LCD display
8. Opto isolation
9. PCB mounting holes
10. Selector (JOIN for 110v AC)
11. Heatsink Bracket
12. TRIAC device
13. MOV surge protector
14. Mains fuse, slow-blow 8A (240v models) or 15A (110v models)

### Warning!

Some areas of the Super-PID PCB operate at lethal mains voltages. The Super-PID PCB must be enclosed in a safe plastic case before use so it cannot be touched by the user.

The heatsink bracket and heatsink should be treated as live!

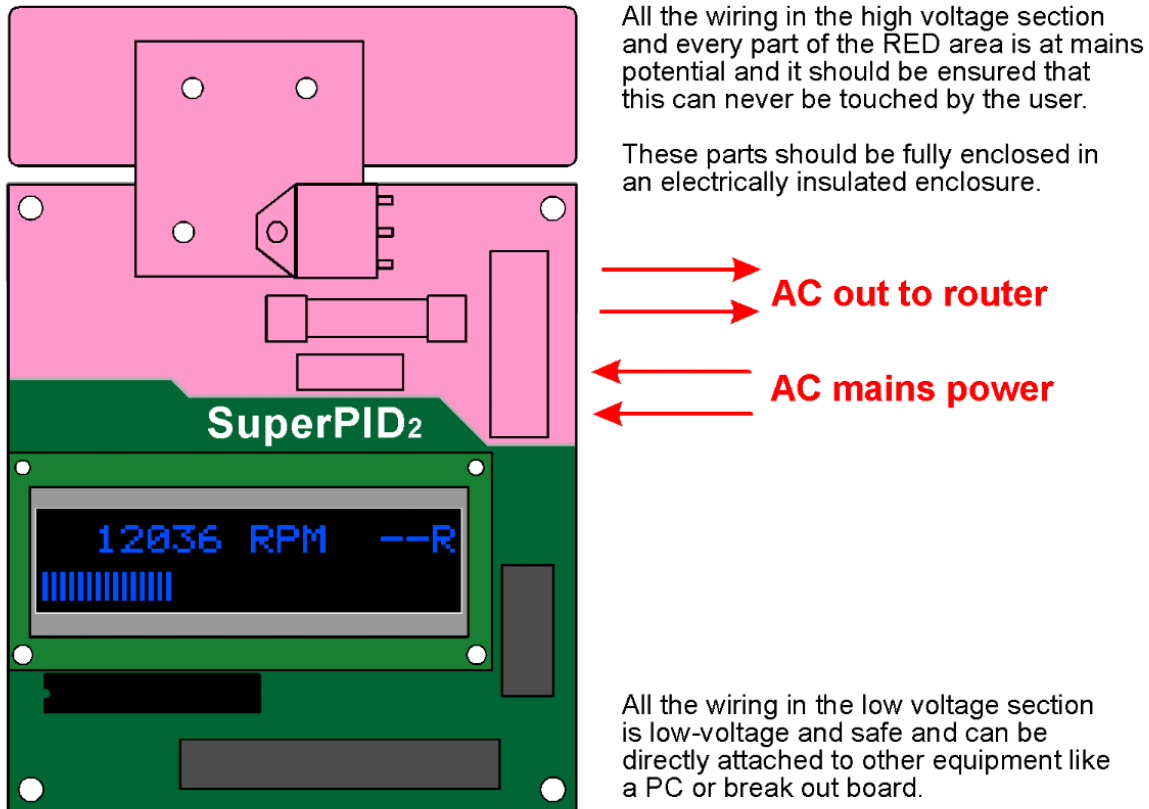
All wiring to the AC mains connector must be rated for mains voltages and 15 amps (for 110v versions) or 10 amps (for 240v versions).

# High voltage safety!

**Important!** Some parts of the Super-PID PCB are at mains voltage, this will be 120v AC or 240v AC depending on your country.

Please read this section carefully as it is important for the Super-PID to be treated as live equipment.

## Super-PID high-voltage section



## Super-PID low-voltage section

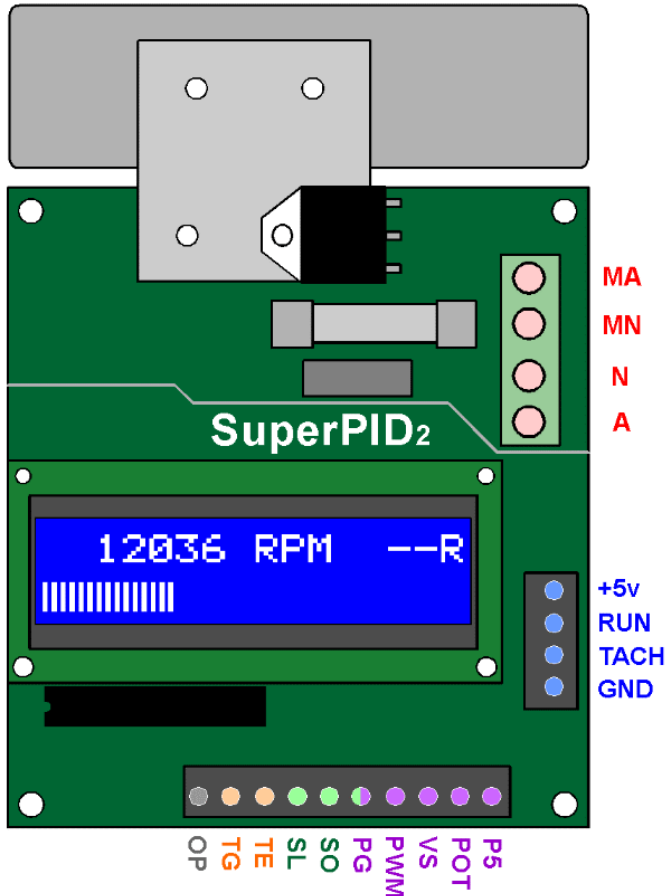
Good safety requires that the Super-PID is fully enclosed in an insulated enclosure, made from plastic or some safe material that cannot conduct electricity. This enclosure may have small holes for wiring and air cooling as needed, but it should be ensured that the user can never come in contact with the mains voltages.

The Super-PID has opto-isolation, so the wiring to the low voltage section is safe and can be directly connected to a PC or other equipment. Even though the low voltage wiring is safe it is best to treat the entire Super-PID board as live equipment and have it fully enclosed.

If after receiving this product you do not feel confident that you can install and use this product safely please return it (unused) for a full refund.

# Super-PID Terminals

Please refer to the diagram below for what each terminal does. Some connections are optional and do not need to be connected.



## SuperPID v2 Terminals

**MA** output, Motor Active (Live or Line) AC  
**MN** output, Motor Neutral AC

**N** AC Mains power, Neutral  
**A** AC Mains power, Active (Live or Line)

**+5v** Regulated +5v DC power to SuperPID  
**RUN** input, 0v = RUN, 5v = STOP  
**TACH** output pulse, 1 pulse per rev  
**GND** Regulated supply Ground

**P5** +5v connection to Pot  
**POT** input, wiper (signal) from Pot  
**VS** output, Variable Speed voltage  
**PWM** input, PWM speed control from Mach3  
**PG** ground wire to Pot

**SO** Spindle Sensor signal, white wire  
**SL** Spindle Sensor LED, red wire

**TE** Temp Sensor output (signal)  
**TG** Temp Sensor Ground

**OP** input, 0v = Open-Loop mode

Notes; If using Mach3 speed control from a parallel port, connect Mach3 control signal into **PWM**, and join **VS** to **POT** (and remove the Pot). Alternatively if you already have a 0v to 5v analog speed control voltage then just connect it into the **POT** input (and remove the Pot).

Spindle Sensor ground is connected to share the **PG** terminal.

**OP** can be shorted to **TG** (with a switch or a jumper) to select Open-Loop mode.

### Terminal details;

**MA, MN** These are the two wires that supply power **out** to the router. These must be rated for full router power, generally 120v 15 amps (or 240v 10 amps).

**N, A** These are the two mains power wires that bring AC power **in** to the Super-PID. These must be rated for full router power, generally 120v 15 amps (or 240v 10 amps).

(continued)

**+5v** This is the regulated +5v DC power supply that supplies the Super-PID circuitry, and powers the microcontroller and display etc. This power supply must be **regulated** which means it is suitable for computer power because it is a smooth, precise 5 volts.

**RUN** This is an input that controls the router ON - OFF. This is normally driven from a logic level signal where 0v = router RUN and 5v = router OFF. This input can also be driven from an open-drain (or pulldown) control like a switch to ground, or an open drain control wire (like an output from a G540).

**TACH** This is a logic level square wave output. It pulsates in time with the spindle RPM, and can be connected to an external tacho display. It can also be connected to a PC. This output will drive logic level (0v to 5v) inputs, and it also functions as an open-drain (pulldown) which can drive G540 inputs.

**GND** This is the Ground for the regulated 5v DC supply. Normally this is connected to the main ground as used by all the other control electronics on the machine. If the 5v supply comes from a PC this ground is normally the PC case ground.

**P5** This is the +5v output to the speed control pot.

**POT** This is the speed control voltage input to the Super-PID that controls router speed. This voltage should be in the range 0v to 5v. Normally this connects to the middle (wiper) of the pot, but it could instead receive a speed control voltage from another device.

**VS** This is the Variable Speed voltage output from the Super-PID. This is only used when there is a PWM input into the PWM terminal. The output voltage will be from 0v to 5v.

**PWM** This is the logic level PWM input into the Super-PID. This allows a PC generated PWM signal to control the router speed. (please see **Speed control and PWM**).

**PG** This is a ground terminal used for the pot ground and the spindle RPM sensor ground.

**SO** This is an analog input from the spindle RPM sensor signal (white wire).

**SL** This is power out to the infra-red LED used in the spindle RPM sensor (red wire).

**TE** This is an analog input of the signal from the optional temperature sensor.

**TG** This is a general ground terminal used for the temperature sensor.

**OP** This is a logic level input that selects open-loop mode, 0v = open loop, and 5v (or not connected) = normal PID operation. It can be controlled from a logic level output or from a switch to ground. It can be connected to the **TG** terminal to select open-loop mode.

(Please see the following sections for details regarding specific terminals).

# First connection

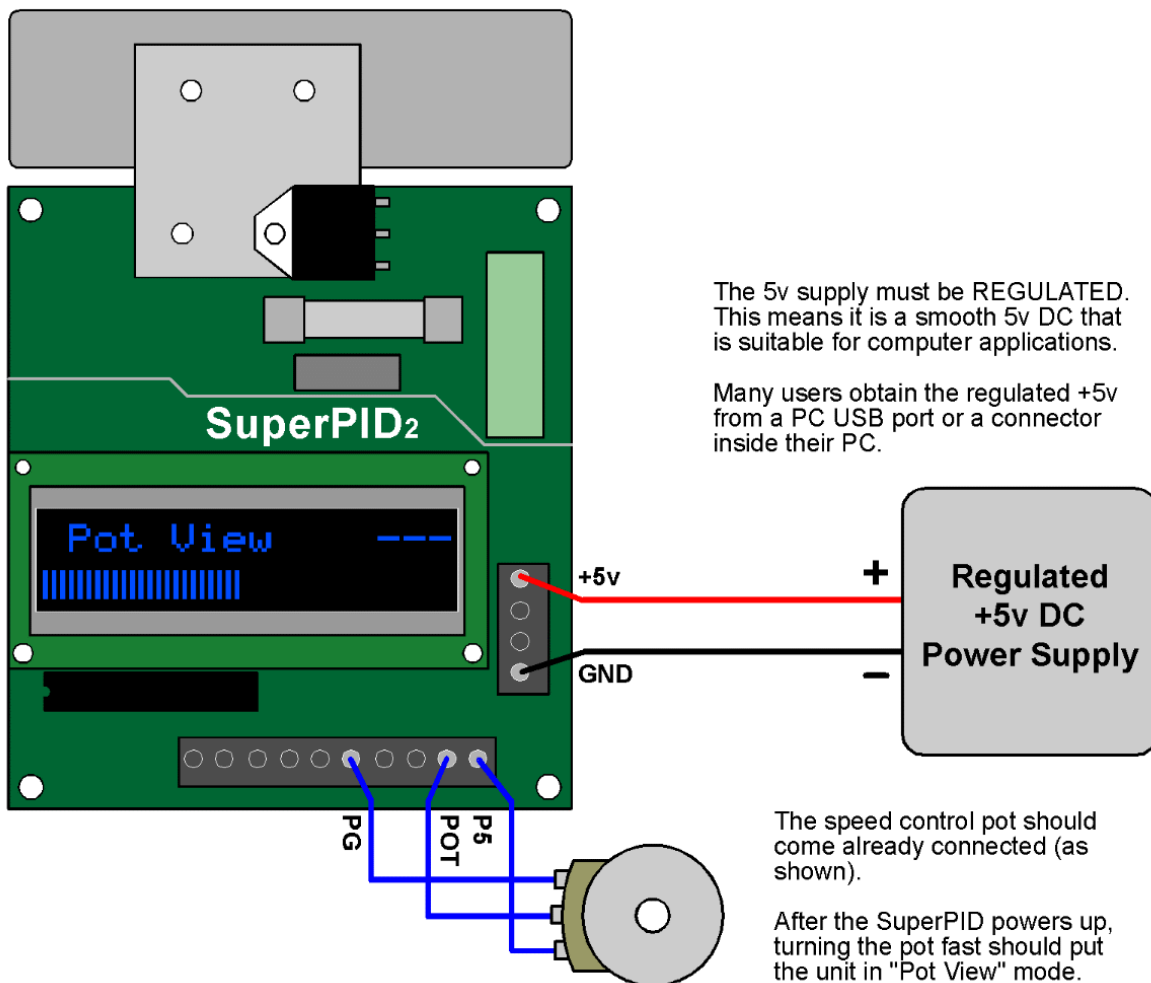
Super-PID can be first set up with no mains voltages connected. We suggest you first connect your Super-PID to a regulated +5v DC supply and get to know it's features.

This first connection will also allow you to check and adjust the spindle RPM sensor and (if connected) calibrate the temperature sensor.

## Regulated +5v DC supply.

It is important that the +5v DC supply be regulated. A regulated +5v DC supply is available from a PC USB port, or some users obtain it from a hard drive connector inside their PC. If you use another power supply or plug-pack (wall-wart) you must make sure it specifies that it is a **regulated** +5v DC supply.

**To setup and test the SuperPID all you need is a 5v DC supply.**





# Boot up sequence

Once the +5v supply is connected the Super-PID will go through a boot up sequence. This is normal and happens every time it is powered up (every time the +5v DC supply is turned on).

It is not necessary at this point for the AC mains to be connected, and we advise for safety that the mains is not connected at this point until after you have set up your Super-PID and become familiar with its operation.



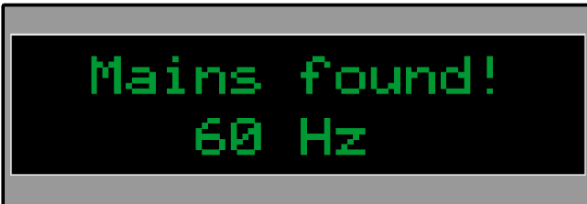
During power-up the firmware version number is displayed.

Also a router run hours timer is shown, this will show a few minutes run time from when the SuperPID was tested.



Next the mains frequency is tested, to determine if you have 50 Hz or 60 Hz mains.

If the mains is detected it is shown.



If there is no mains detected, the display will say "No Mains". This is ok as the mains will be tested again later.

## Router run hours timer.

This is shown only during boot up. The Super-PID will log the total number of **Hours:Minutes:Seconds** that the router has run. This is a precise timer that is crystal locked (like a clock) and will display up to 1 million router run hours. It's memory remains even when there is no power applied, and it is not possible to reset this timer.

## Spindle View mode.

After the boot up sequence is complete the Super-PID will remain in the "Spindle View" mode. This is the normal display whenever the router is not running. This is explained later in the section **Spindle RPM sensor connecting**.

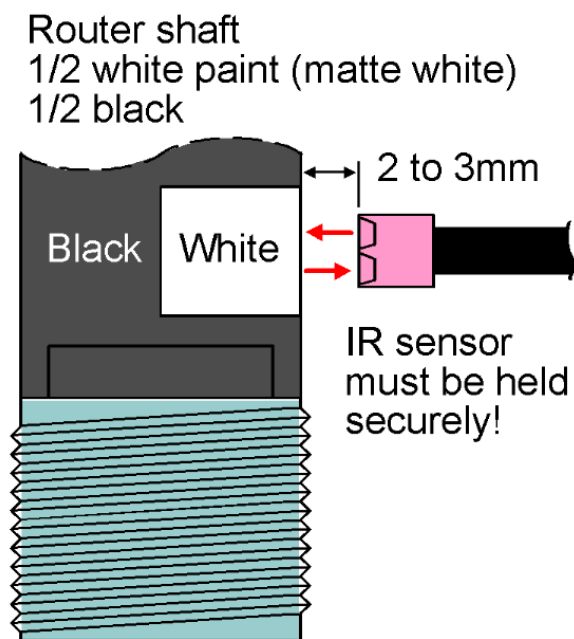
## Pot View mode.

If the speed control pot is turned fast the Super-PID will go into "Pot View" mode. This allows you to see the pot setting on the bargraph, to see that the pot is working correctly.

# Spindle RPM sensor

The **spindle RPM sensor** supplied as standard with your Super-PID is a reflective IR (Infra-Red) type.

It bounces a tiny Infra-Red beam off a surface and can detect if the surface is black or white. If this surface is a spinning shaft, the sensor can detect its RPM with great accuracy.



## Sensor mounting.

There are a number of options for mounting the RPM sensor. In many cases you can paint white paint on a black router shaft so that the sensor sees half white and half black as the shaft spins.

The sensor will tolerate a wide ratio of white to black, so it will still work correctly with 1/4 white and 3/4 black.

However it is **important** that there is only one white area and one black area, to ensure only **one pulse** per rotation.

## Paint types.

It is important to use a highly reflective white paint, matte white is best and many people use the commonly available fast drying white "correction paint" like Liquid Paper or Wite-Out. However gloss white paint also works well and may be more durable.

The black paint is not as important, any dark surface like black paint or a black metal shaft will work fine.

## Sensor adjustment.

There is no electronic adjustment for the sensor. The sensor has been designed and pre-calibrated to detect white and black from around 2mm to 3mm distance.

The sensor may be adjusted mechanically simply by changing its distance from the surface to give the best sensor reading. Once this has been done the sensor can be securely mounted at that distance.

# Connecting the spindle RPM sensor

The spindle RPM sensor is usually supplied already connected, as it was tested during the manufacturing testing procedure.

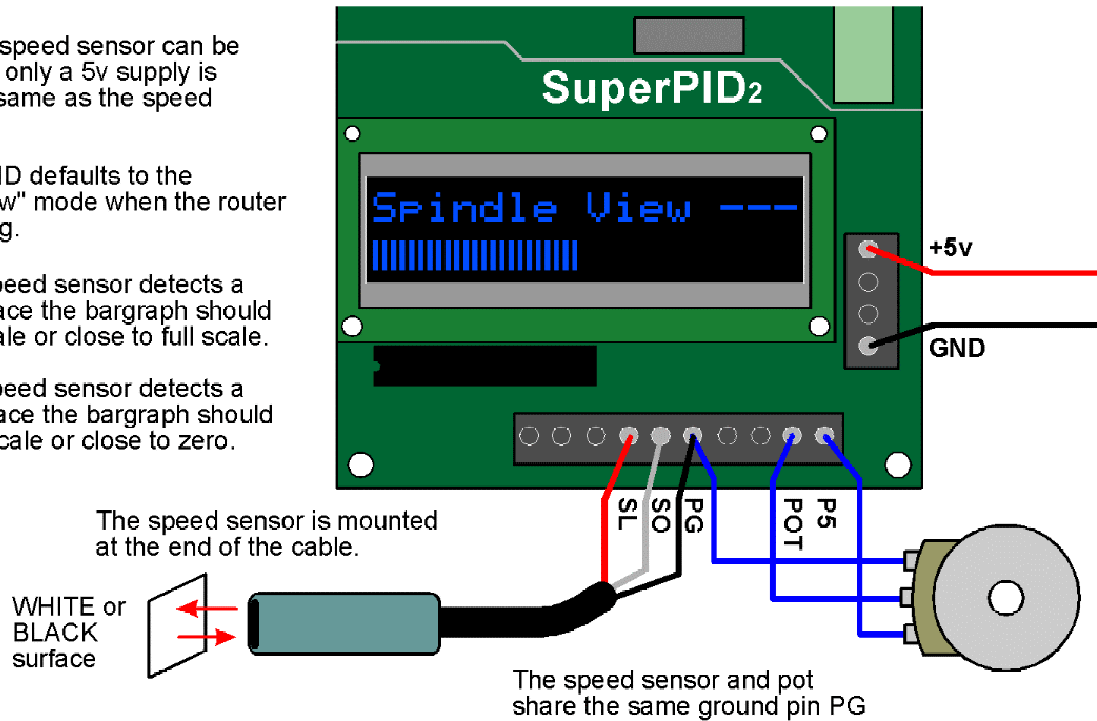
If your sensor cable is an optional long length type it may be supplied separately and needs to be connected as shown below.

The spindle speed sensor can be tested when only a 5v supply is connected (same as the speed control pot).

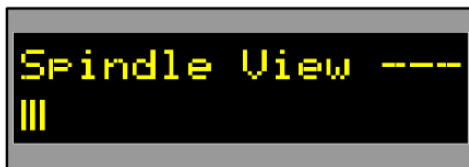
The SuperPID defaults to the "Spindle View" mode when the router is not running.

When the speed sensor detects a WHITE surface the bargraph should show full scale or close to full scale.

When the speed sensor detects a BLACK surface the bargraph should show zero scale or close to zero.



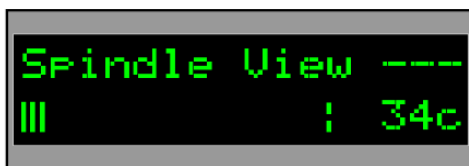
It is not necessary to get a perfect reading for the white or black surfaces, but you should aim to get results similar to those shown below. If you cannot get these exact results then adjust the sensor distance to get the black bargraph as low as possible and the white bargraph as high as possible. Super-PID is quite tolerant of an imperfect sensor.



A black surface should give a low bargraph reading like this.



A white surface should give a high bargraph reading like this.



# Mounting the spindle RPM sensor

## Bottom mounting on the output shaft.

This is the easiest option on many routers, and all you need to do is paint some white paint on the black router shaft and mount the sensor pointed at it.

However this option makes the sensor more exposed to damage from wrenches used on the shaft collet nut, and as the sensor is closer to the cutting job it will need more frequent cleaning especially if you cut MDF or other materials that make fine wood dust and do not have dust extraction.

## Top mounting.

Top mounting involves a little more work and the sensor is mounted inside or partially inside the top dust cover of the router, pointed at some spinning part of the router shaft. About two out of three Super-PID users prefer top mounting.

Note! Some router types are better suited for one particular mounting method.

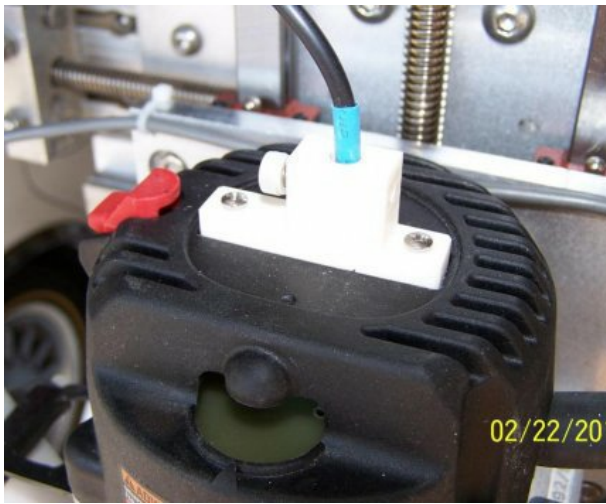
## Sensor mounting tube.

Super-PID is now supplied with a plastic tube (impact resistant poly carbonate) that can simplify sensor mounting. The mounting option is up to you, but most people glue or clamp the tube in the right place and slide the sensor down the tube. Once the sensor distance has been tested then glue or other means can secure it at the correct distance. It can be used for top or bottom mounting.

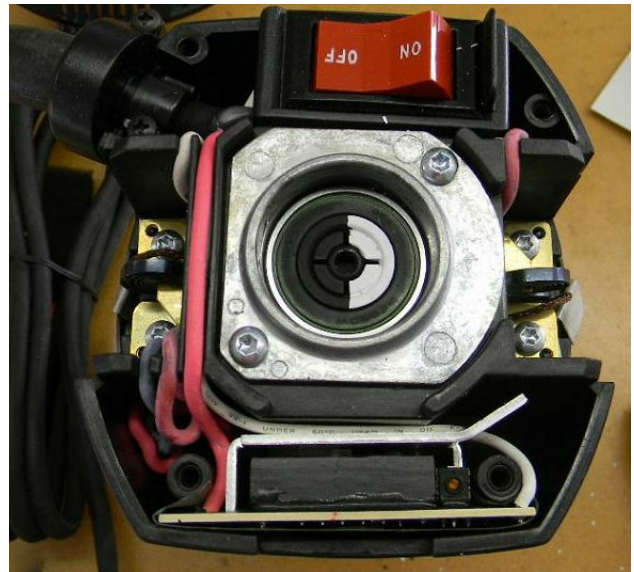
## Photos of SuperPID user's mountings.

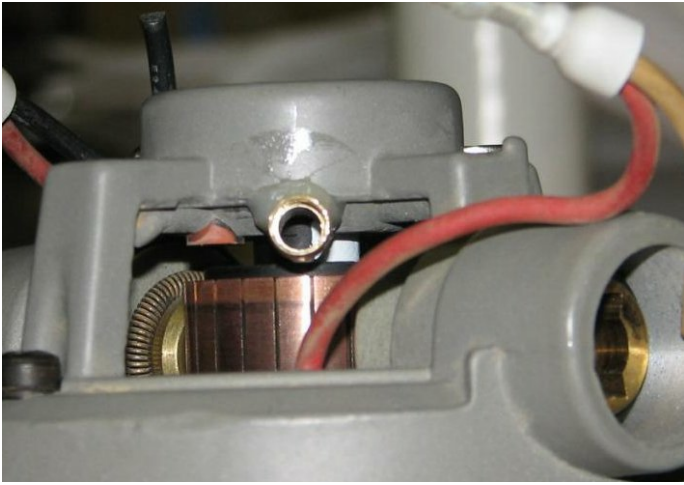
Following you can see some sensor mounting setups on common routers.





Here are some spindle RPM sensor mountings, at the top or bottom of the router.





# Router speed control bypass or removal

If your router has an internal electronic speed control it must be bypassed or removed.

Some electronic speed controls where the dial has a "click" at the fastest speed setting already have an inbuilt disable switch, so they do not need to be modified. Generally if your router has a speed control dial, or has a "soft start feature" that means it has internal electronics and this needs to be bypassed or removed.

Tech support is available through the [www.SuperPID.com](http://www.SuperPID.com) web site.

## **Bypassing the router electronics.**

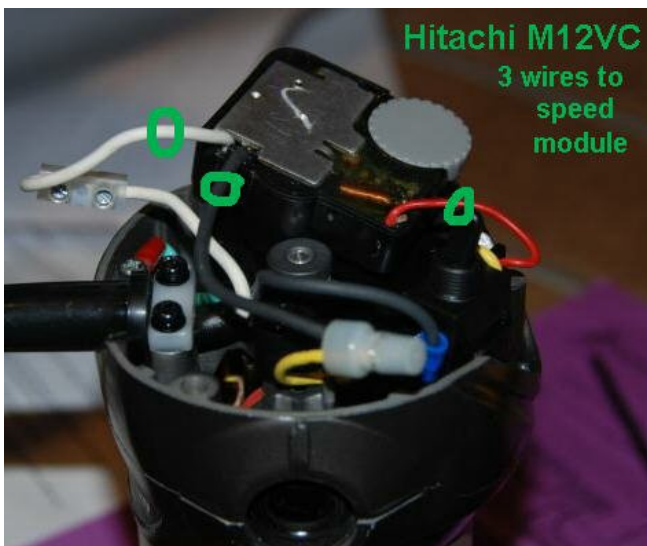
Bypassing the router electronics is usually quite straightforward. Normally there is a large black 3-pin TRIAC device that can be bypassed by joining all 3 legs of the TRIAC device together with solder. Many Super-PID users choose this method of bypassing their routers.

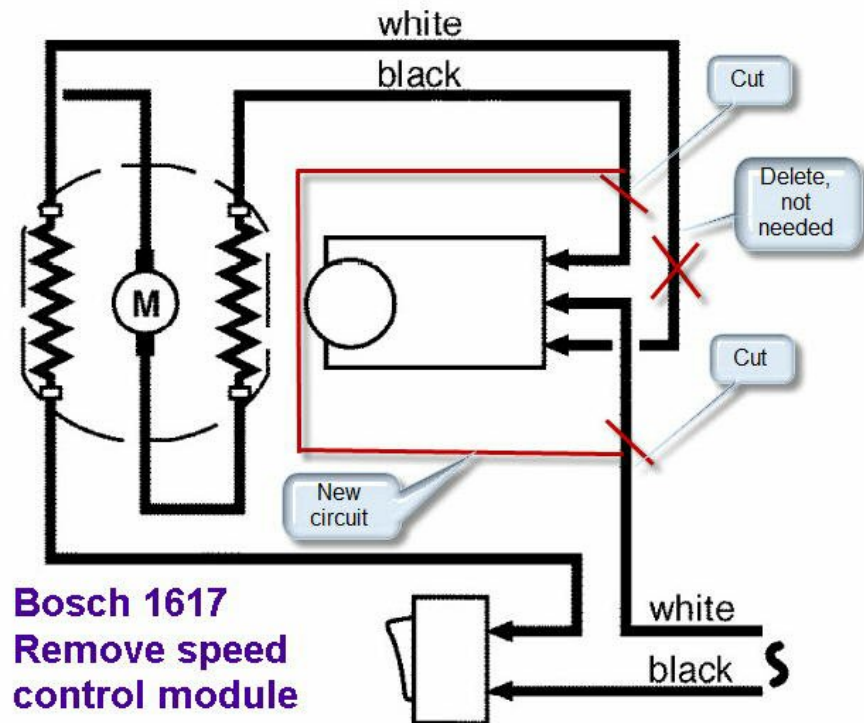
This is also an easy modification to reverse if you want to return your router to original condition at a later date. See photos below.

## **Removing the router electronics.**

Some users prefer to remove the electronics module from their router. This is usually quite simple and can help provide room to put the SuperPID spindle RPM sensor inside the top of the router and improve airflow through the router.

The router's speed control module usually has 3 wires. To remove it, the 2 large wires that carry motor current are joined together, and the smaller wire is simply disconnected and made safe so it cannot touch anything. See photos and diagrams below.







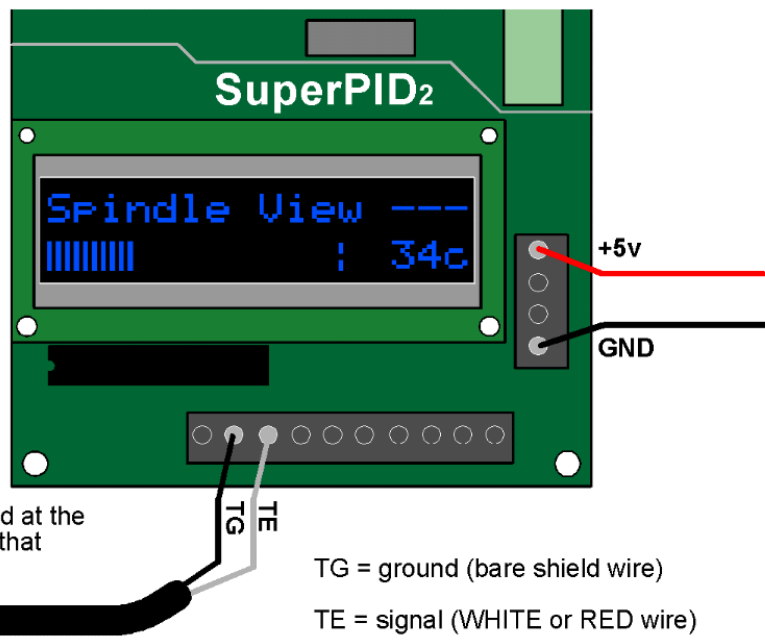
# Temperature sensor - (optional)

The Super-PID version 2 has the ability to connect an external temperature sensor. The sensor and pre-made cable is available from SuperPID.com.

Normally this sensor will be mounted pressed against the lower metal frame of the Router where it will detect average router heat including lower bearing heat. Some people may choose to mount the sensor in the exhaust air stream so it measures the temperature of the air leaving the router. Or alternatively the sensor may be mounted on the heatsink of the SuperPID to display the heatsink temperature (in this case it must be electrically insulated from the heatsink).

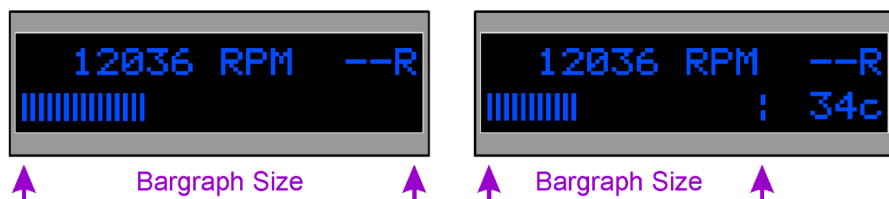
Mounting usually requires pressing the sensor body against the surface with a tiny screw-down clamp of some type. The sensor has one flat side for this purpose. The sensor can also be mounted using glue or silicone and will still be accurate, but will take slightly longer to respond to temperature changes.

The temperature sensor is optional.  
It is detected when the SuperPID is turned on, and if the temperature sensor is connected it will be displayed.  
If the temperature sensor is connected the display shows a shorter bargraph.  
The temperature sensor will display 2 digits and read from 0 degrees Celcius to 99 degrees Celcius.



The temperature sensor is mounted at the end of the cable. It has a flat side, that can be clamped against a surface.

If this optional sensor is connected it is detected when the Super-PID powers up. The display will appear different; the bargraph will be shown as a shorter length and there will be a temperature reading shown on the right hand side.



# Temperature sensor calibration

The temperature sensor used for the Super-PID is a standard and proven industrial sensor that is very rugged and tolerant of noise, and it produces a linear temperature reading that is in degrees Celsius.

However this sensor requires that the regulated +5v that powers the Super-PID is smooth and remains at a constant voltage. This is expected as regulated +5v has these characteristics. However your regulated +5v may not be exactly 5.00 volts it may be a fraction higher or lower, typically in the range 4.95 to 5.10 volts.

In this case there is a simple temperature calibration function that you can use to trim the temperature sensor to match your particular +5v supply.

## Procedure;

1. Power up the SuperPID with the temperature sensor connected. You do not need mains voltage, only the +5v supply.
2. Examine the temperature displayed, compare it to the correct temperature.
3. While the SuperPID is still powered up, short a wire jumper across the TG and TE terminals, and keep this wire jumper applied. This wire can be held in place by hand.
4. The display will change to show "Temperature Calibrate".
5. Turn the pot to change the calibration setting up or down.
6. Remove the wire jumper, wait a few seconds and the SuperPID should now display the correct temperature.



Calibration turned off.



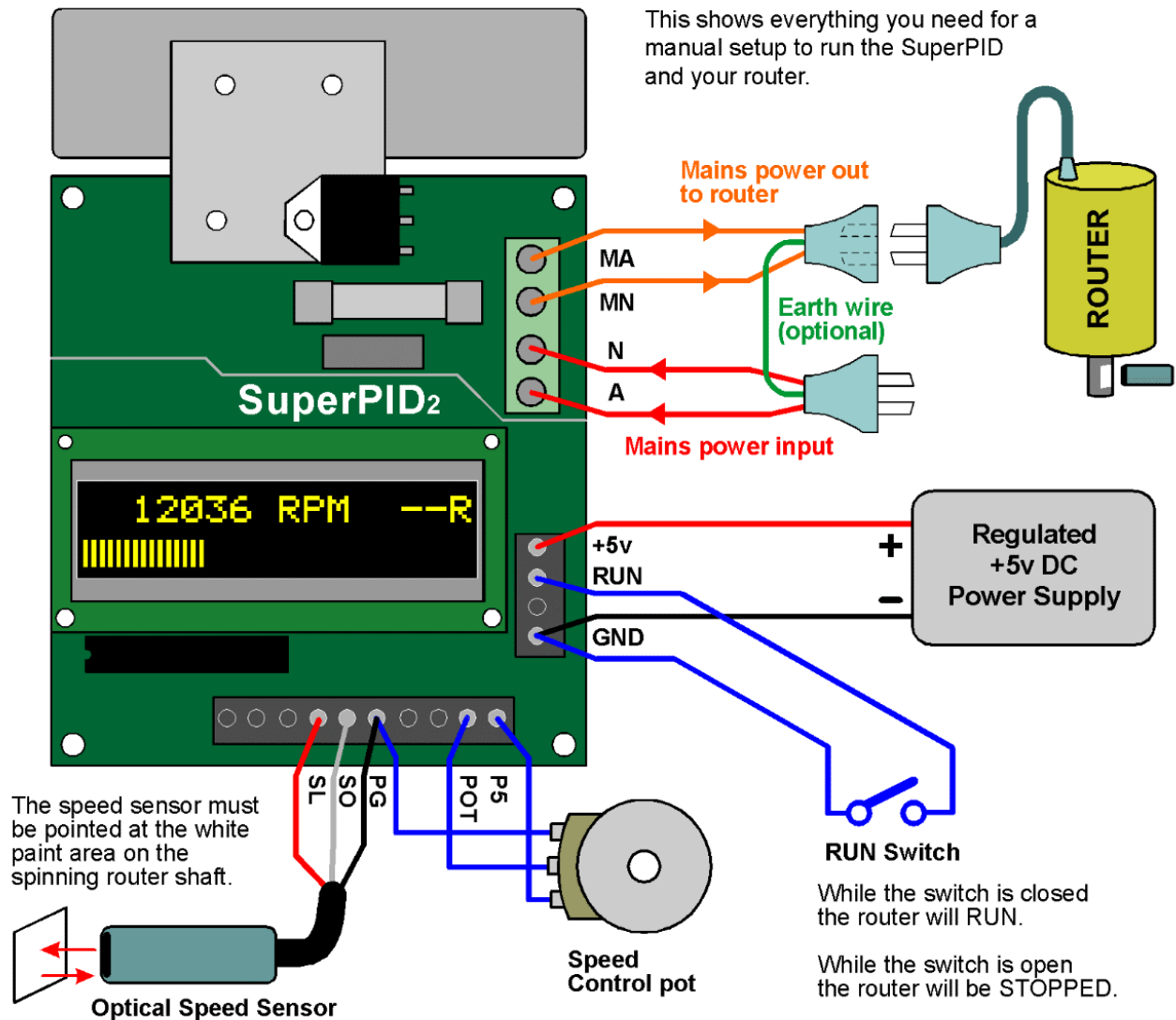
Corrects for sensor reads 3'C low.

The calibration will always be remembered even when the Super-PID is turned off. It can be re-calibrated whenever you choose, as many times as you choose.

Once calibrated the sensor should be accurate generally within about one or two degrees Celsius, through it's normal operating range 0'C to 99'C. If your power supply or equipment changes we recommend that you check the sensor from time to time and (if needed) re-calibrate again.

Also please note that the sensor and mounting will take time to heat up or cool down, and is also processed in software to average many temperature readings over time. It is perfectly normal (and desired) that the sensor takes a number of seconds to respond to heat changes.

# Basic connection - no PC

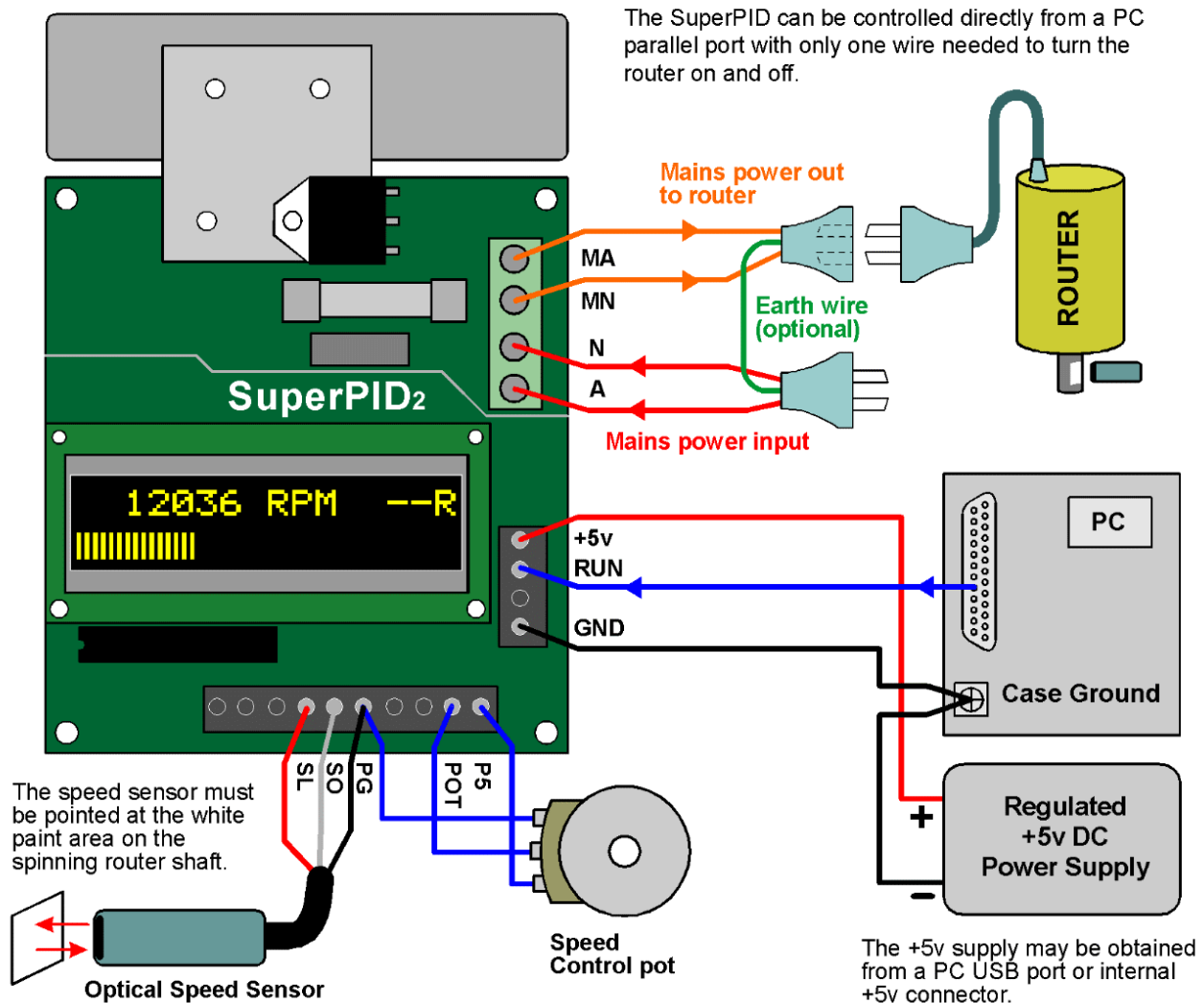


This is the minimum setup to operate the Super-PID manually.

You need to supply a "RUN" switch which can be any small toggle or slide switch.

The speed control pot and optical sensor are supplied with the Super-PID.

# Typical PC connection



This is a popular method of connecting the Super-PID. The PC can turn the router on and off, but the speed control is still adjusted by hand.

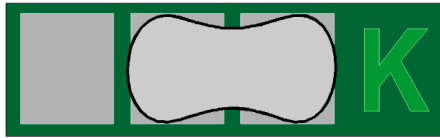
The regulated +5v DC supply must share the same ground as the PC. Since many users get the +5v DC from the PC (USB port, or PC hard drive connector etc) this is standard.

A single wire is needed from one of the PC parallel port pins, to the "RUN" input on the Super-PID. Please see your PC CNC software instructions for Mach3 or EMC etc. to select the right parallel port pin.

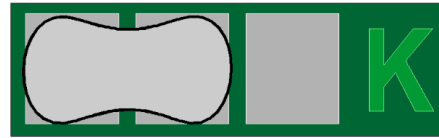
# Speed control knob modes

Super-PID version 2 has a solder jumper on the bottom of the PCB which is used to select the knob control mode. This would have been pre-set when you ordered your Super-PID. You can change this selector at a later date if needed.

There are two speed control modes;



Solder jumper selects "Knob Mode"

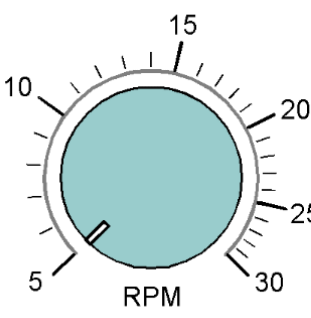
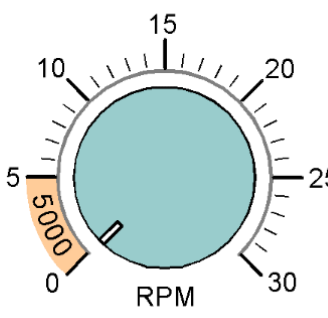


Solder jumper selects "Mach3 Mode"

These modes set the speed curve used for the speed control system. One curve is best suited for manual use (with a knob) the other curve is optimised for computerised speed control using Mach3 or EMC or other PC CNC software.

### Super-PID version 2 speed control curve modes

The only difference between the two modes is the curve used for the speed control knob.

<p style="text-align: center;"><b>"Knob mode" k--</b></p>  <p style="text-align: center;">RPM</p> <p>The knob uses a semi-log curve. This is optimised to give excellent feel and ease of control. The range is expanded around the important 7000 - 17000 RPM range giving the ability for fine speed adjustment in that range.</p> <p>This also gives a similar percentage speed change for similar knob rotation - a very "human" feel.</p> <p>Definitely recommended if you will be manually using the knob as your main speed control.</p>	<p style="text-align: center;"><b>"Mach3 mode" ---</b></p>  <p style="text-align: center;">RPM</p> <p>This speed curve is linear by RPM over the entire range 0 - 30000 RPM. This is the way a computer likes it.</p> <p>The range below 5000 RPM is fixed at 5000 RPM.</p> <p>This allows direct speed control from PWM software like Mach3 and others, so the Super-PID responds accurately and linearly to the PWM control voltage.</p> <p>This does not give good feel or ease of control for manual knob use, but may still be usable if a large enough diameter knob is used.</p>
--	---

The mode is detected from the solder jumper when the Super-PID powers up.

The Super-PID display will indicate the speed control mode;

k-- indicates "Knob mode"

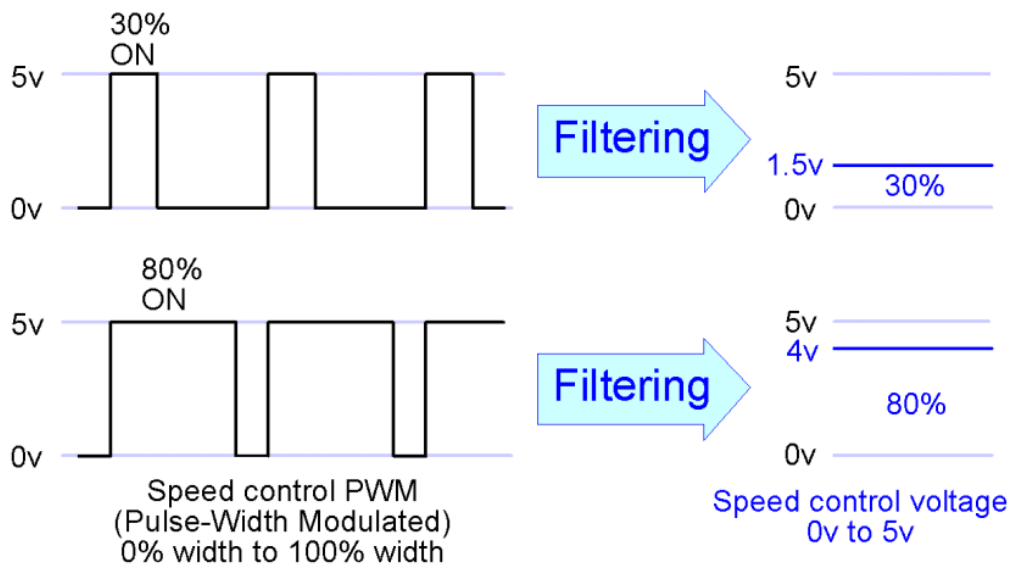
--- indicates "Mach3 mode"

# PC speed control and PWM

Super-PID accepts two different types of speed control from your PC;

**1. Speed control voltage.** This is a smooth DC voltage which is in the range 0v to 5v. This can be a control voltage from the pot, or from any source that produces a 0v to 5v analog control voltage (like some break out boards). This voltage controls the router speed.

**2. PWM signal.** This is a pulsating signal that is logic level. This pulsating signal is produced by your PC CNC software and can come directly from the PC parallel port or from a break out board. This pulsating PWM signal is filtered inside the Super-PID to convert it to the speed control voltage.



The PWM Pulse-Width is filtered to make an average DC voltage, the speed control voltage. This is done automatically inside the Super-PID. Then the speed control voltage is used to control the router speed.

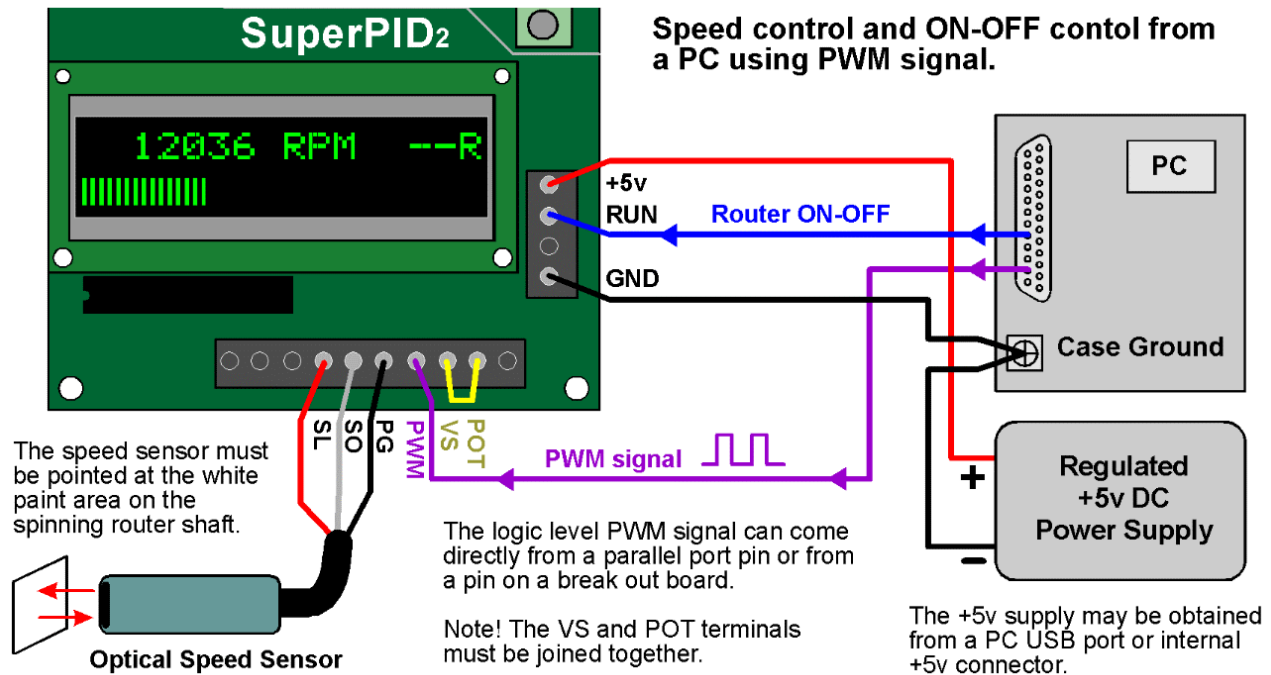
## Options for PC speed control;

1. Super-PID can directly accept a PWM signal from a parallel port, or PWM from a break out board.
2. Super-PID can directly accept a speed control voltage of 0v to 5v from a break out board or other controller.
3. Super-PID can accept a speed control voltage of 0v to 10v (or 0v to 12v) from a controller, but this needs to be reduced to 0v to 5v by using 2 resistors, as a simple voltage reducer.

Please see the following pages for details of each method.

# PC speed control using PWM signal

This is a common and popular way of wiring connecting the Super-PID and requires two control wires from the PC (or from the break out board).



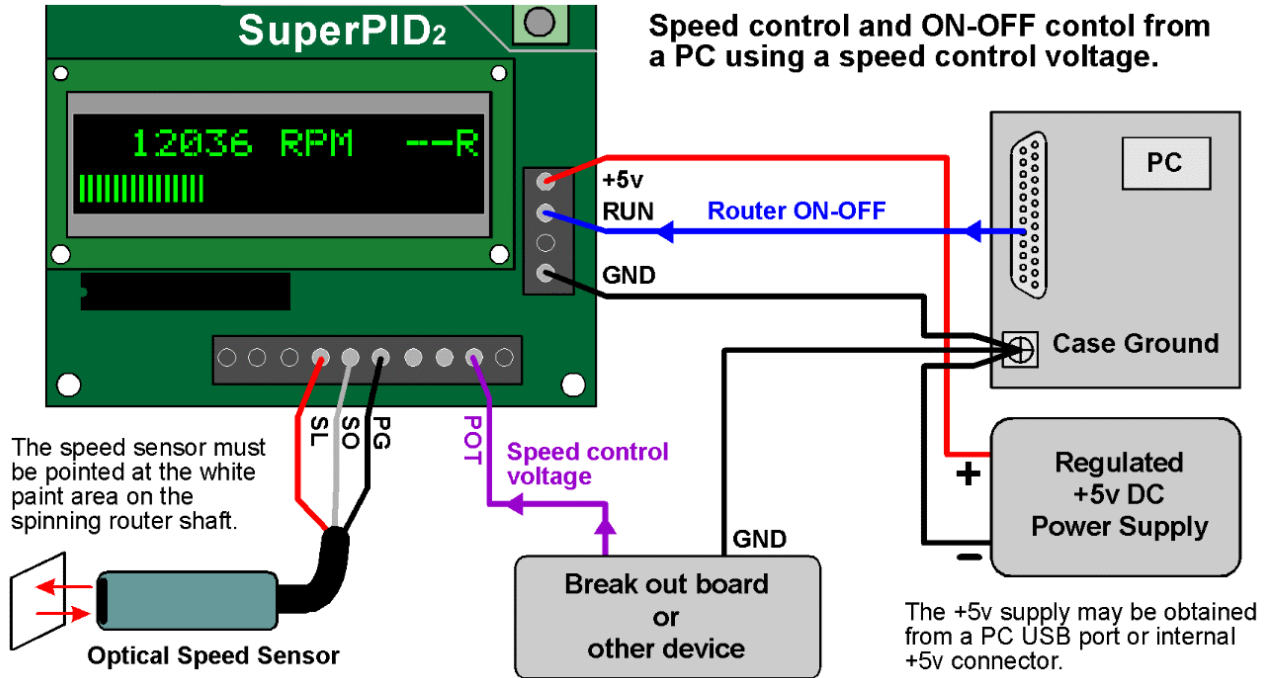
One wire turns the **router ON and OFF**, usually called "Spindle on-off" in your PC CNC software, Mach3 or EMC or other software.

The second wire carries the **PWM control signal**. This is usually called "Spindle speed control" in the PC software.

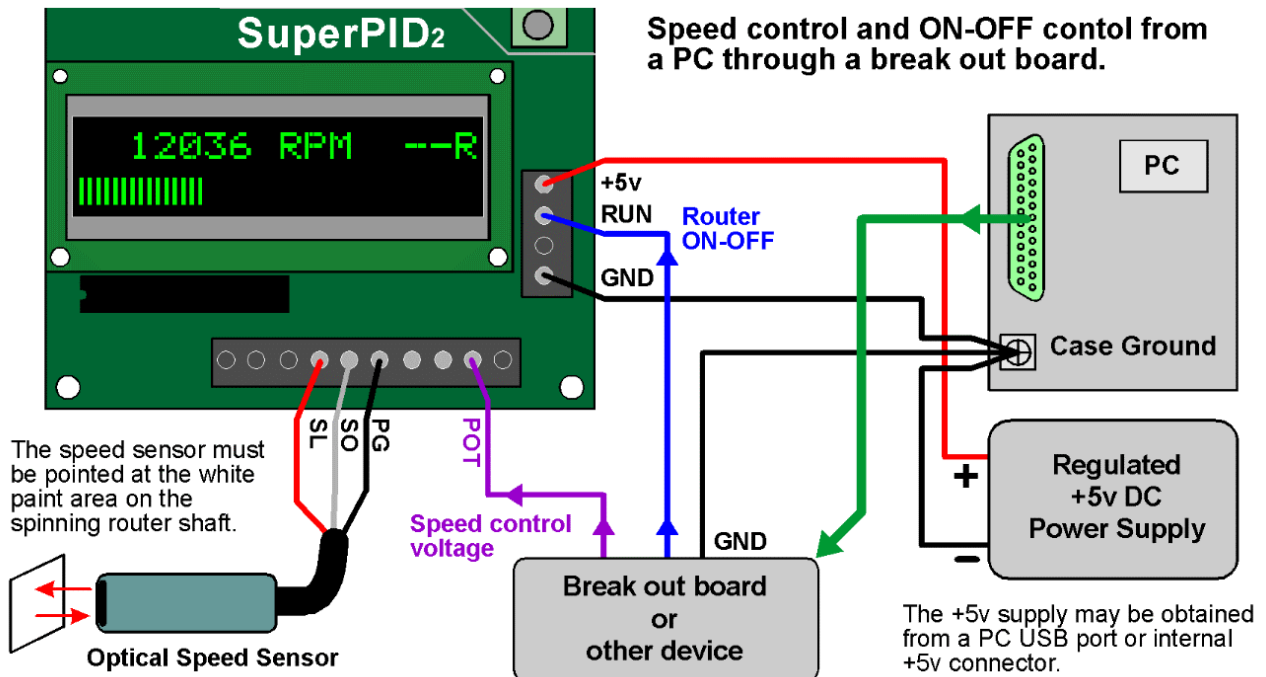
These 2 control signals may come directly from the PC parallel port, or from another device or breakout board.

Please see your PC CNC software instructions for details on which two parallel port pins to connect to.

# PC speed control using control voltage



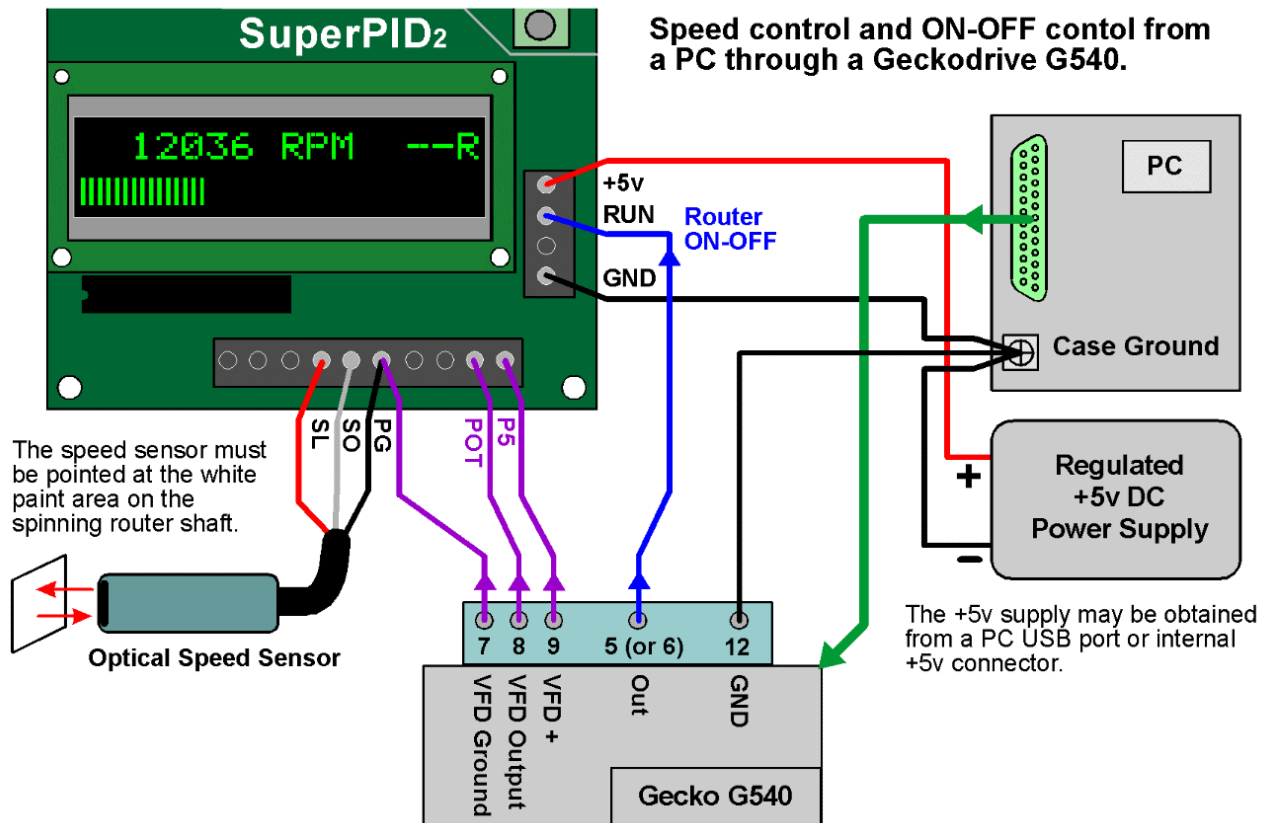
This shows connection to a PC parallel port to provide router ON - OFF control, and to a separate device that produces the 0v to 5v speed control voltage, sometimes called a "VFD control voltage". Below shows a popular alternative connection where both signals are produced by the break out board or other device.





# PC speed control from Gecko G540

Owners of the Gecko G540 stepper motor driver can connect it directly to the Super-PID using the wiring shown below;



This is a common and popular setup where the G540 produces the 0v to 5v speed control voltage and also produces the router ON - OFF control signal.

This requires that the G540 power ground (its pin 12) is connected to the PC ground and +5v supply ground.

This setup allows the G540 to control machine E-stop function in the normal way and means that the Super-PID will turn the router OFF when E-stop is activated.

## Setting up Mach3 for speed control

Note! Please refer to the Mach3 software instructions or Mach3 technical support for more details, as this procedure may change with different versions of the Mach3 software.

The Mach3 software provides support for spindle ON - OFF control and for PWM spindle speed control.

Please refer to section 5.3.6 of the Mach3 manual; "Configuring the Spindle" specifically the screenshot (Figure 5-7) showing "Spindle setup tab of the ports and pins dialog". You need to select "Use spindle motor output" and select "PWM Control". Then set the "PWM base freq" to 50 (which is 50 Hz).

Then refer to section 5.5.5 "Spindle motor speed control setup" and specifically 5.5.5.2 "Pulse width modulated spindle controller" for more information.

Then see figure 5-21 "Config > spindle pulleys... Dialog" and set the pulley max speed to about 30000 RPM. This figure may need to be tweaked slightly to get the calibration exact.

Many users are reporting that values like these work well;

Pulley Min = 0 to 300 RPM

Pulley Max = 30100 to 30200 RPM

## Setting up other PC software

Your PC CNC software needs to be set to produce a PWM output signal that is proportional to the desired spindle RPM. This will usually be done with a calibration value. Super-PID calibration needs the max PWM (100%) to correspond with 30000 RPM, and the minimum PWM (0%) corresponds with 0 RPM.

You may also need to set up a spindle ON - OFF output, Super-PID will turn the router ON when this output is 0v, and turn the router OFF when this output is 5v.

## Spindle calibration (all PC software)

The RPM tacho on the Super-PID display is quite accurate. Calibrating your PC software can be done simply by setting the RPM on the PC software, then checking what the actual router RPM is on the Super-PID tacho.

Then the PC software calibration value can be adjusted (if needed) to give a good correlation between the desired RPM and the actual RPM.

# Advanced connections

## TACH - output terminal

The TACH output terminal outputs a logic level (0v to 5v) pulsating signal that matches the RPM signal from the spindle RPM sensor. Like the spindle sensor, this is one pulse per rotation so at 6000 RPM it outputs 6000 pulses per minute or 100 pulses per second.

The TACH output is an optional output, it is not needed for normal Super-PID operation but it is provided to allow the connection of an external RPM tacho display. Also, some users connect the TACH output back to the PC to allow real-time RPM display on the PC screen, please check that your PC CNC software supports this feature. On Super-PID version 2 the TACH output is a logic level output but is also an open-drain (pulldown) driver, so it can be connected directly to most drivers and parallel ports.

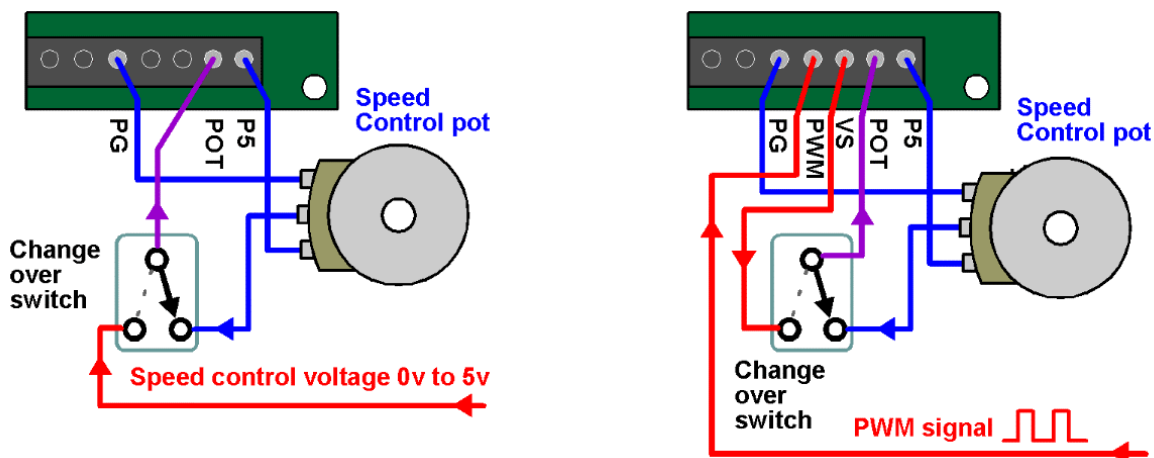
## OP - Open-Loop input terminal

If the OP terminal is connected to ground (usually to the TG ground terminal next to it) the Super-PID is put into Open-Loop mode. This can be done at any time, even when the router is running.

Open-loop mode means the Super-PID ignores the spindle RPM sensor, and does not require the spindle RPM sensor. It is a simple mode where the amount of power supplied to the router depends on the speed knob position. This is similar to many old fashioned motor speed controllers. Open-loop mode can be used for testing, or for emergencies to run the router if the spindle RPM sensor has failed or become fouled from dust buildup.

## Switching between speed knob control and PC speed control

Some Super-PID users prefer to have both speed control systems available. To do this you need to add a change-over switch, usually called a SPDT type switch. This switch connects either the speed control voltage from the pot (knob) or it connects the speed control voltage from the PC.



The diagram shows how to switch between a speed control voltage and the speed pot, or how to switch between a PWM speed control signal and the speed pot.

# Speed control systems

## **About open loop speed control.**

Open loop speed control is the most common system and is used in many low cost speed controllers and inbuilt into most modern routers.

Open loop means that the amount of power to the router is adjusted, and the router runs faster or slower as a result. Although open loop is simple and cheap it has a serious problem at lower speeds. To run the router at low speeds the router is given very little power, and then if any cutting load is applied the router speed drops dramatically or even stalls. So with open loop speed control there is very little cutting power available at low speeds. Most manufacturers will limit their open loop speed controls to about 15000 RPM as a minimum speed, and even then the router will have much less usable power at the lower speeds.

## **About compensated open loop speed control.**

Because of the lack of power at low speeds with standard open loop control, most of the better quality speed controllers use a compensation system. They measure the motor current, and if the motor current rises (due to cutting load) the power to the router is adjusted upward in an attempt to compensate for the speed drop. This system works reasonably well with medium router speeds, and is used on most decent quality routers but is still limited to speeds of around 15000 RPM and above.

## **About closed loop speed control.**

Closed loop means that the actual speed of the router is measured, and the power to the router is adjusted to keep the speed constant. This is quite rare in commercial routers as it requires more complex electronics inside the router, and possibly computing power. However the Hitachi router M12VC is one router known to have this type of internal speed controller. Simple closed loop controllers can suffer from instability especially at low speed where the motor is naturally much less stable, so simple closed loop controllers generally are generally still limited to about 8000 to 10000 RPM as a minimum speed.

## **About PID speed control.**

PID stands for Proportional Integral Derivative. These are three separate mathematical systems for closed loop speed control working together in a highly tuned way to maximise the strengths of the three systems and give the desired result of accurate speed control, good power at low speeds and high stability. In the past PID was an expensive option usually reserved for large industrial motors where the complexity and cost of a proper PID system would be justified.

Router motors are designed for higher RPM use and 25000 to 30000 RPM is typical. To run a router motor at 5000 RPM is difficult as the router motor is inherently less stable and less powerful at these lower speeds, so it is critical to have a properly tuned PID system. The Super-PID uses a high speed microcontroller chip to constantly monitor the router speed hundreds of times a second and do the PID math in real time and almost instantly control the power to the router. The result is that the router can be run even at speeds as low as 5000 RPM and still have excellent cutting power and good stability. Furthermore the PID algorithm in the Super-PID has been carefully optimised specifically for routers, and optimised for the specific types of pulsating loads introduced by router cutting bits of 1 to 4 flutes.

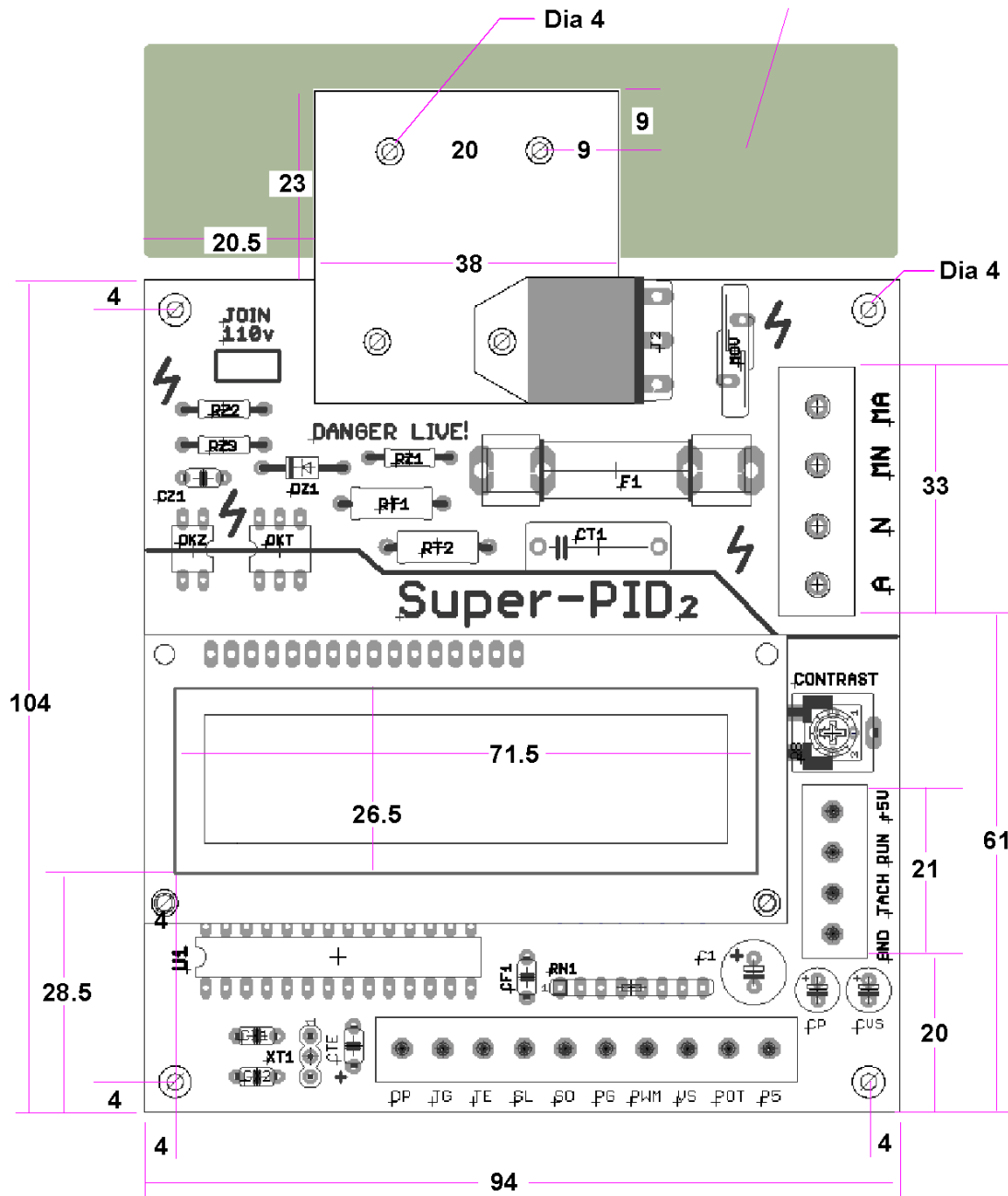
(continued) The result is that the Super-PID gives excellent cutting power at all speeds from 5000 to 30000 RPM and will rival or exceed the performance of many VFD spindles in that RPM range. A Super-PID and a large 3.5 hp router like a PC7518 work together to make an extremely powerful spindle for CNC use.

## Dimensions diagram

### Super-PID v2 PCB Dimensions

All dimensions in mm,  
and are approximate; +/- 0.2mm

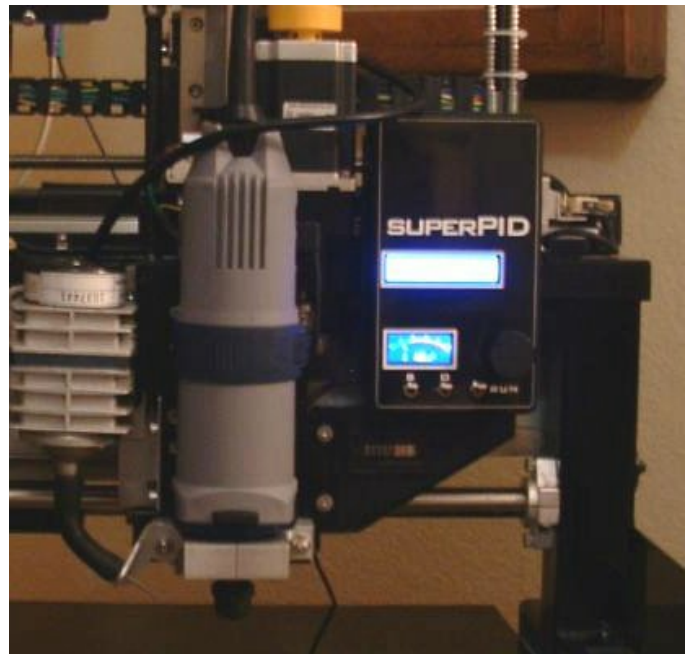
Recommended Heatsink;  
94 x 25 x 6 mm Aluminium

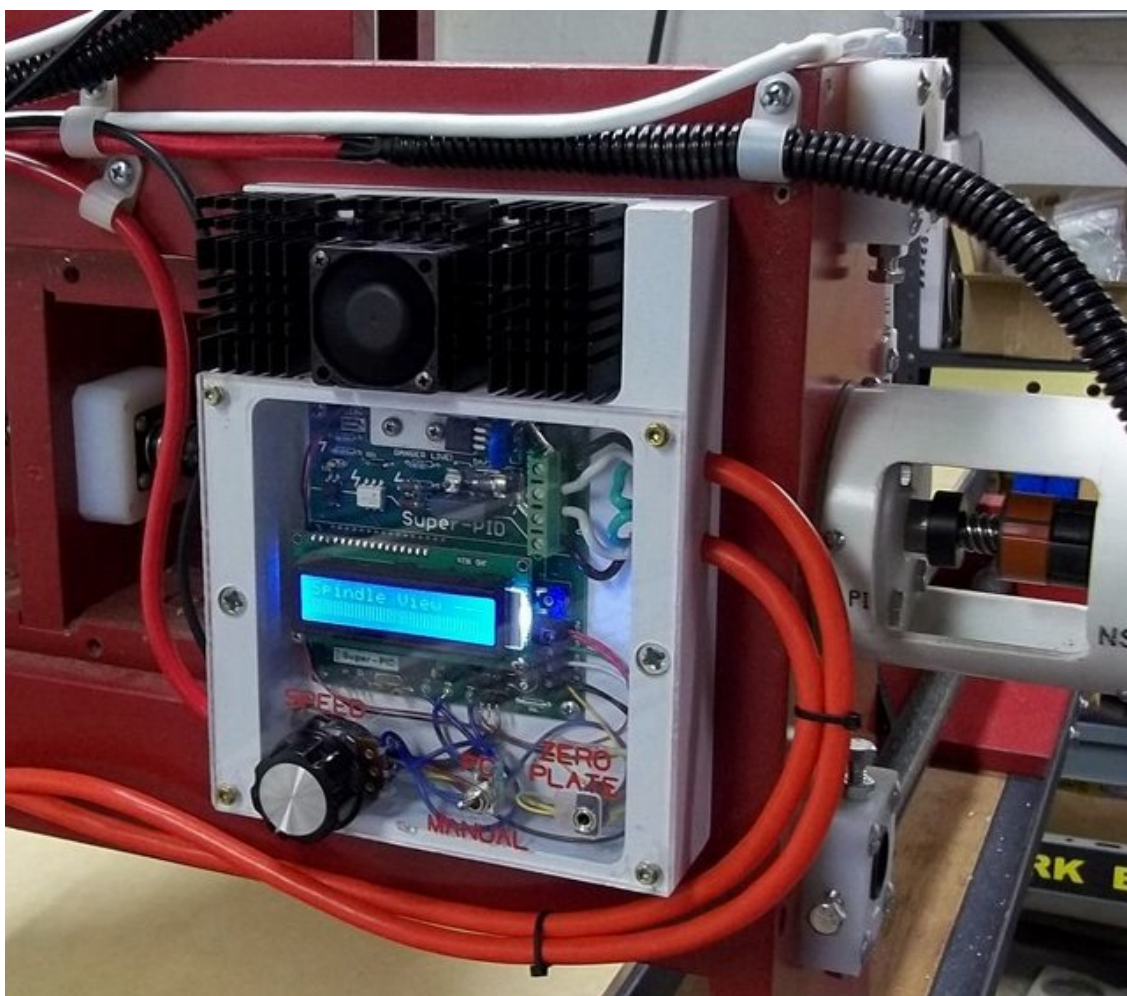


## User's box enclosures



Above is a clear enclosure carved out of solid perspex, and an exotic hardwood enclosure with clear perspex front. Below is a white plastic electronics enclosure to match a white machine and a black enclosure that matches a black machine.





Above shows a neat custom shaped enclosure with external heatsink.

**Safety Note!** If your heatsink can be touched it is necessary to make sure the heatsink is electrically insulated from the heatsink tag on the Super-PID. This means using an insulating gasket and non conductive screws. Generally the best option is to enclose the entire heatsink so it can never be touched (as seen in the examples on the previous page).

# Super-PID links and resources

<http://www.SuperPID.com>

Official home site for the Super-PID product. The latest instructions can be downloaded from here.

[http://www.cnczone.com/forums/diy-cnc\\_router\\_table\\_machines/112658-super-pid\\_new\\_low-cost\\_router\\_speed\\_controller.html](http://www.cnczone.com/forums/diy-cnc_router_table_machines/112658-super-pid_new_low-cost_router_speed_controller.html)

This is a long and informative thread on the CNC Zone forum. It covers the early development of the Super-PID and has discussions between the designer of the SuperPID and the Super-PID users. There are a lot of photos and details of user installations, router modifications and tech support. Highly recommended reading.

[http://groups.yahoo.com/group/mach1mach2cnc/post?postID=nzdpBiPqs0r0JjBX1fa24Y4lhTmXzX1AddeAPY8GCBsWx9q2R1ZINW6clgL3GiHRMO4UI-sn538wld5YSK7-TH\\_sCkSoVw](http://groups.yahoo.com/group/mach1mach2cnc/post?postID=nzdpBiPqs0r0JjBX1fa24Y4lhTmXzX1AddeAPY8GCBsWx9q2R1ZINW6clgL3GiHRMO4UI-sn538wld5YSK7-TH_sCkSoVw)

Super-PID discussion on the Mach3 PC software forum.

[http://www.youtube.com/watch?v=NIHa6\\_MpN7A](http://www.youtube.com/watch?v=NIHa6_MpN7A)

Video of Super-PID cutting acrylic with a 5mm endmill at 8000 RPM.

[http://www.youtube.com/watch?v=oBJ4Ebo-\\_HU](http://www.youtube.com/watch?v=oBJ4Ebo-_HU)

Video of Super-PID drilling acrylic with a 1/8" drill bit at 5000 RPM.

<http://www.youtube.com/watch?v=h1s9f72dKPc>

Video of a Super-PID and a cheap 850W router easily cutting aluminium at 7000 RPM with a 5mm end mill and giving a good finish.