MegaMeet 2008

MegaSquirt

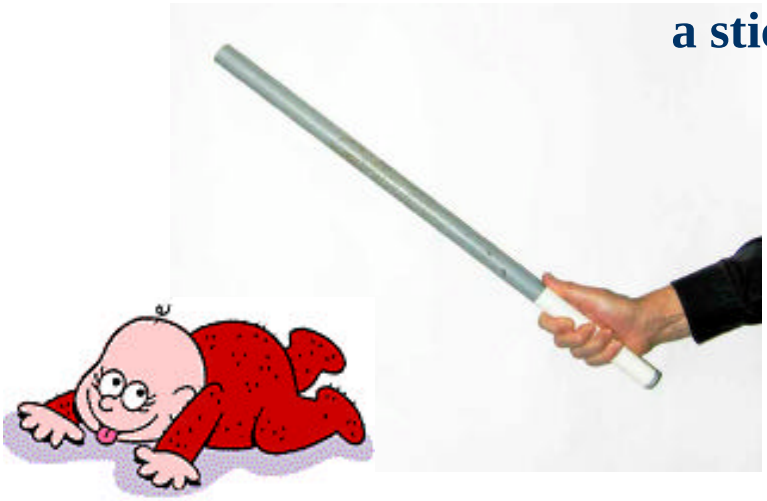
Noise – it's your fault…

Bowling & Grippo

Understanding Noise

Understanding Noise

If you strike a child with a stick, the child will cry…



Who should we blame?

MegaSquirt
www.megasquirt.info

Understanding Noise

- The Automotive Environment is perhaps the most hostile environment:
  - Temperature Extremes (-50 C to 150 C)
  - Vibration
  - Electrical Noise – Spikes/Undervoltage/Overvoltage
- By far the most challenging is Electrical Noise.
- All Automotive Electronics are Affected by Noise:
  - Electronics have protective circuits for noise and out-of-range voltages.
  - Reaction of a particular device depends on many factors
  - No two installations are alike, even for same vehicle types
  - Use should protect their electronics (baby) from noise (stick) the best way possible.
  - Simple solutions go a long way…..

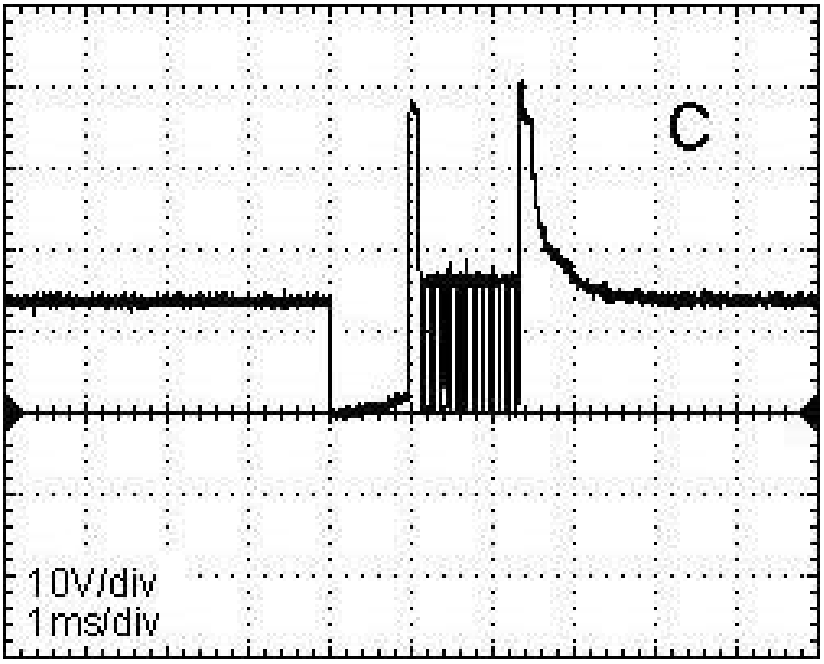
MegaSquirt
www.megasquirt.info

Understanding Noise

- Sources of Vehicle Electrical Noise – Radiated Noise
  - Ignition – primary currents and secondary voltages
  - Injectors
  - Electric motors (starter, wiper, heater)
- Sources of Electrical Supply Noise
  - Charging (alternator)
  - Electric motors (starter, etc)
  - Resistance/Inductance in wiring
- Noise Can Occur When:
  - Starting (radiated and voltage-drop, a.k.a. “IR Drop”)
  - Running (injector/ignition/solenoids)
  - Activating Accessories (heater, headlights, wiper)

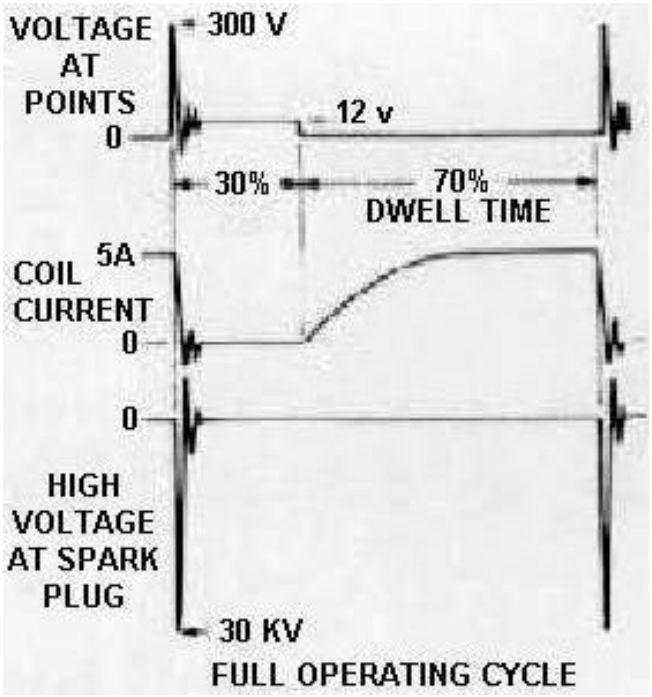
MegaSquirt
www.megasquirt.info

Radiated Noise Source



MegaSquirt
www.megasquirt.info

Radiated Noise Source



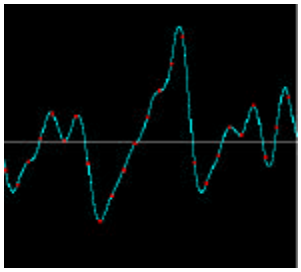
MegaSquirt
www.megasquirt.info

Radiated Noise Source

MegaSquirt
www.megasquirt.info

Detecting Radiated Noise

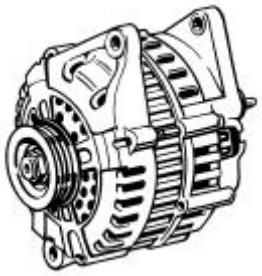
Simple Transistor AM Radio
Makes an Excellent Noise Sniffer!



Listen for the buzz…

MEGASQUIRT
www.megasquirt.info

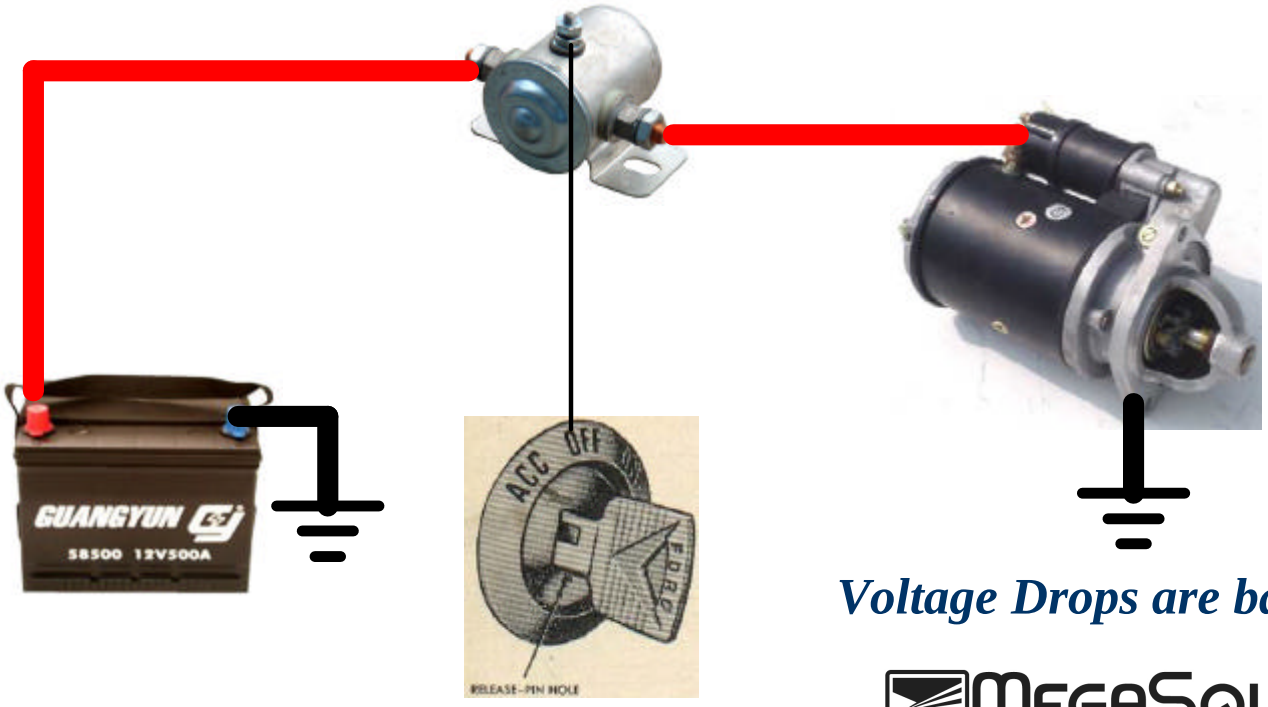
High-Current Noise Sources



MegaSquirt
www.megasquirt.info

High-Current Noise Sources

Resistance in wiring can cause <u>Voltage Drops</u>



Voltage Drops are bad…

MEGASQUIRT
www.megasquirt.info

Finding Noise Sources

Voltage Drop = Current x Resistance

- The voltage drop across a wire is equal to the resistance of the wire multiplied by the current flowing thru the wire – a.k.a. “IR Drop”
- High current sources include:
  - Starter
  - Charging System
  - Headlights
  - Horn
  - Heater/Wipers
- Use a voltmeter to determine the voltage drop…

Remember this rule!

MEGASQUIRT
www.megasquirt.info

Finding Noise Sources

Total Voltage = Sum of Voltage Drops

- The sum of all of the voltage drops equals the battery (potential) voltage.
- Very useful relationship in determining where a voltage offset is occurring.
- The use of these two rules together is POWERFUL!

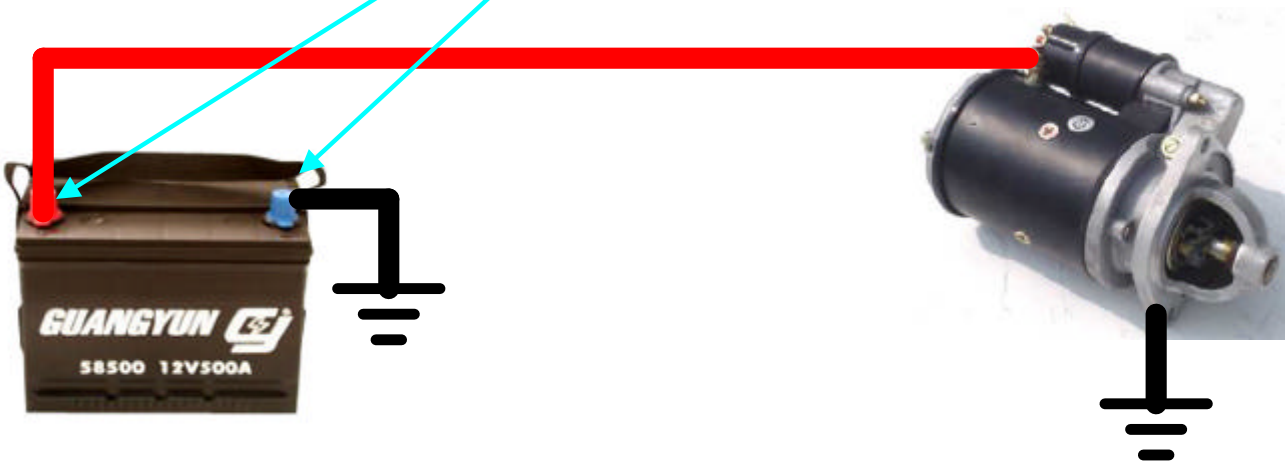
Remember this rule!

MEGASQUIRT
www.megasquirt.info

Finding Noise Sources

Step 1 - Determine battery voltage during cranking

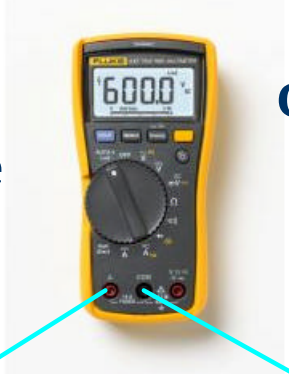
Call this Vtotal



MEGASQUIRT
www.megasquirt.info

Finding Noise Sources

Step 2 – Measure wire voltage drop while cranking



Call this Vwire

MegaSquirt
www.megasquirt.info

Finding Noise Sources

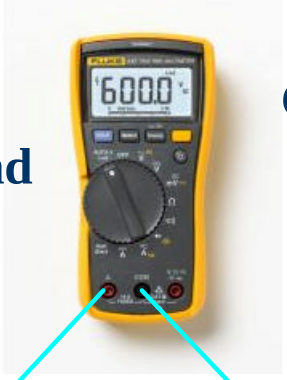
Step 3 – Measure starter voltage drop while cranking

Call this Vstarter

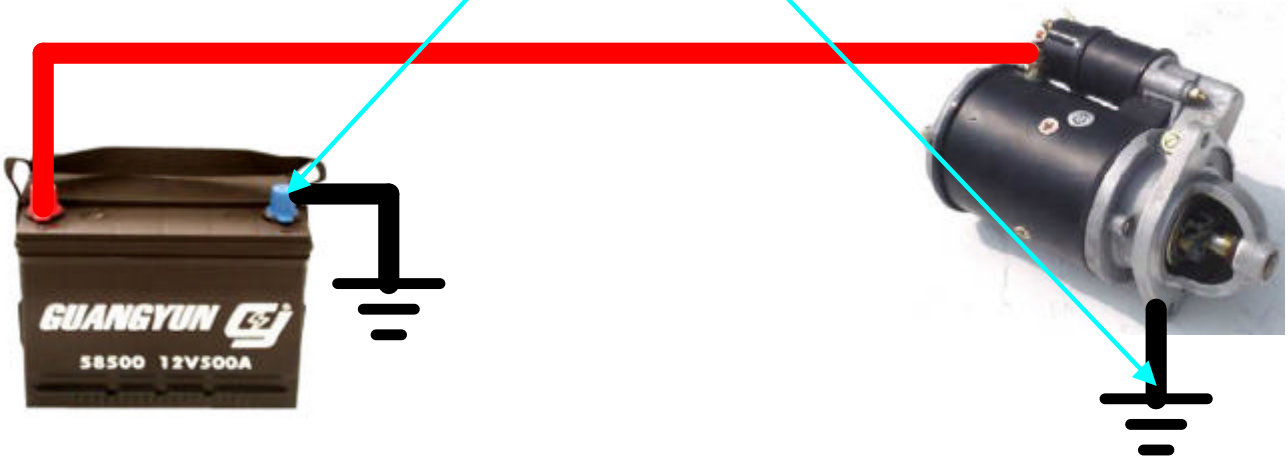
MegaSquirt
www.megasquirt.info

Finding Noise Sources

Step 4 – Measure ground voltage drop while cranking



Call this Vgnd



MegaSquirt
www.megasquirt.info

Finding Noise Sources

Example Analysis: **Vtotal = 10.0 volts**

Vwire = 1.5 volts

Vstarter = 8.0 volts

Vgnd = 0.5 volts

Vwire + Vstarter + Vgnd ~= Vtotal

Vwire and Vgnd should be as low as possible!

MegaSquirt
www.megasquirt.info

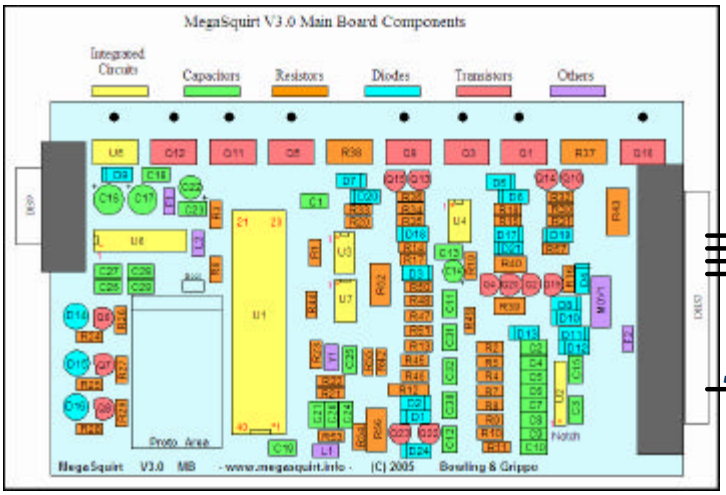
MegaSquirt Hardware Wiring

- In some cases the source of the noise cannot be eliminated - *or even located…*
- The V3 MegaSquirt has built-in noise-protection circuitry – however there are some instances where more noise resistance is required
- Simple changes in wiring strategy can go a long way:
  - Sensor ground returns separate from high-power grounds
  - Multiple ground wires from MS to engine block
  - Tach input leads physically separated from high-current wires

MEGASQUIRT
www.megasquirt.info

MegaSquirt Hardware Wiring

Run Sensors on Separate Ground Return Path to MS:



Main MS Ground Bus

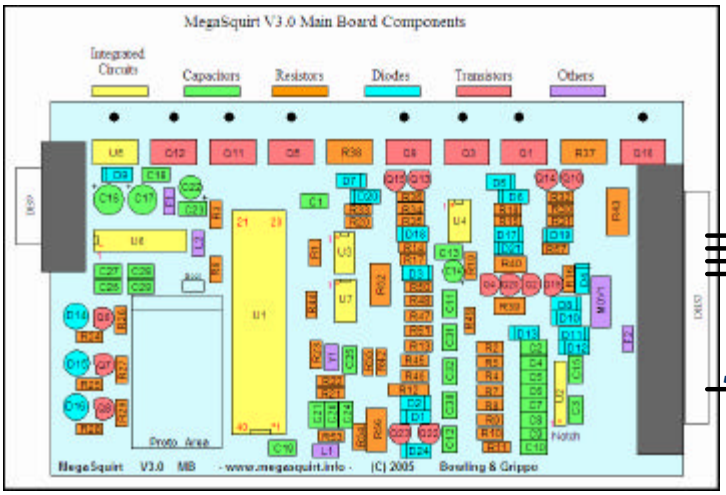
Sensor Ground Bus

High currents on sensor returns will cause voltage drops, resulting in noise and inaccuracies…….

MEGASQUIRT
www.megasquirt.info

MegaSquirt Hardware Wiring

Run Multiple Engine Grounds Back to MegaSquirt:



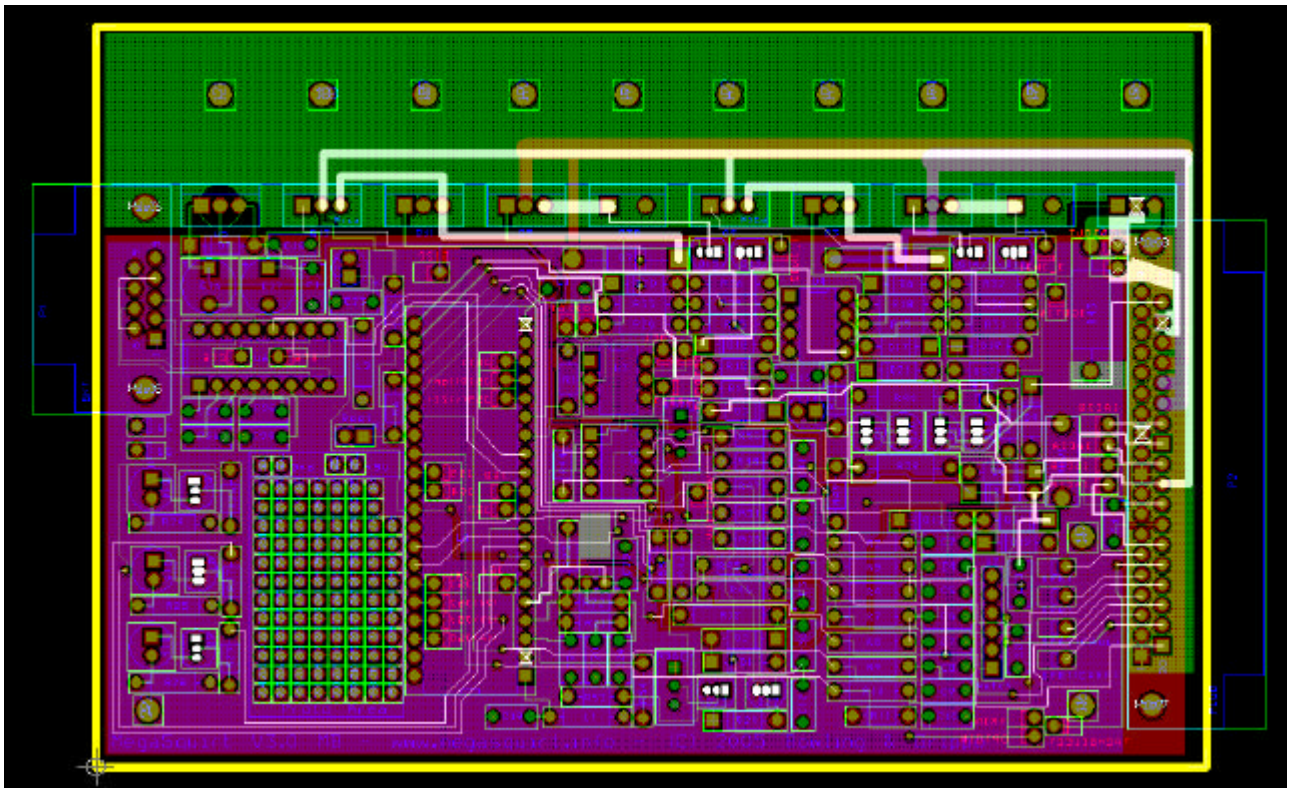
Main MS Ground Bus

Sensor Ground Bus

Each wire acts as a series resistor/inductor.
Multiple wires act like resistors/inductors in parallel….

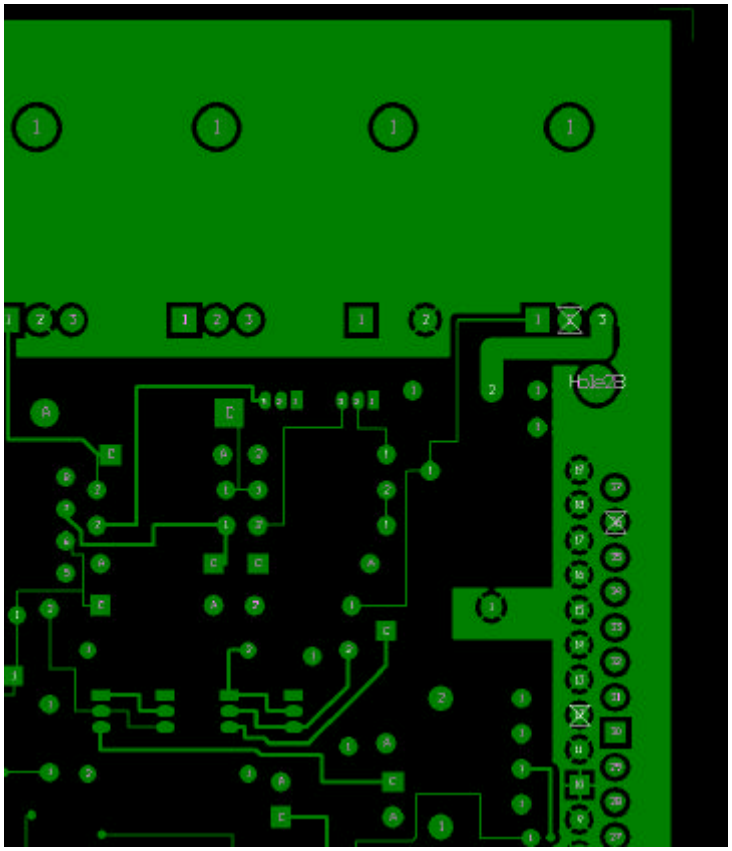
MEGASQUIRT
www.megasquirt.info

MegaSquirt Hardware Wiring



MEGASQUIRT
www.megasquirt.info

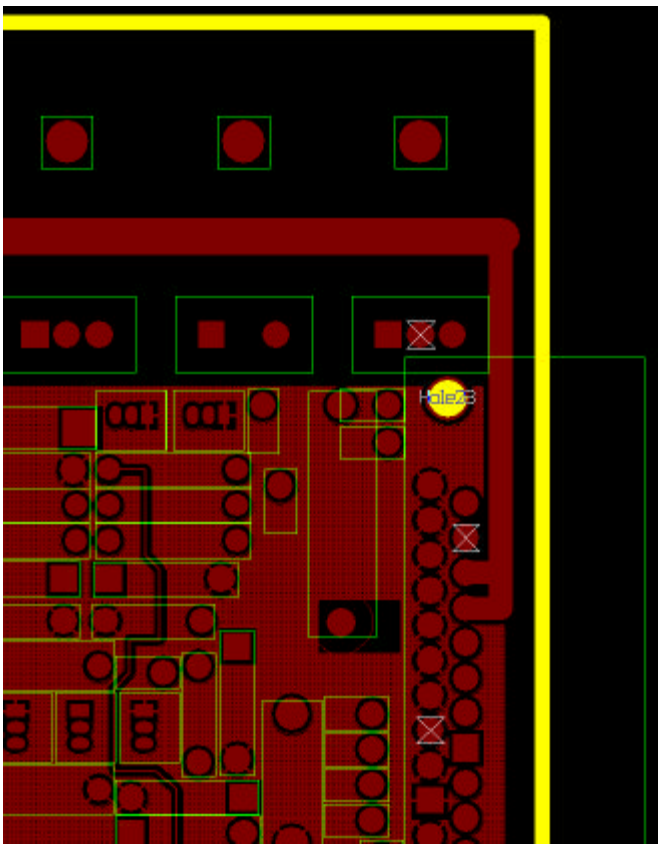
MegaSquirt Hardware Wiring



High-Current Ground Plane

MEGASQUIRT
www.megasquirt.info

MegaSquirt Hardware Wiring



5-V
Ground Plane

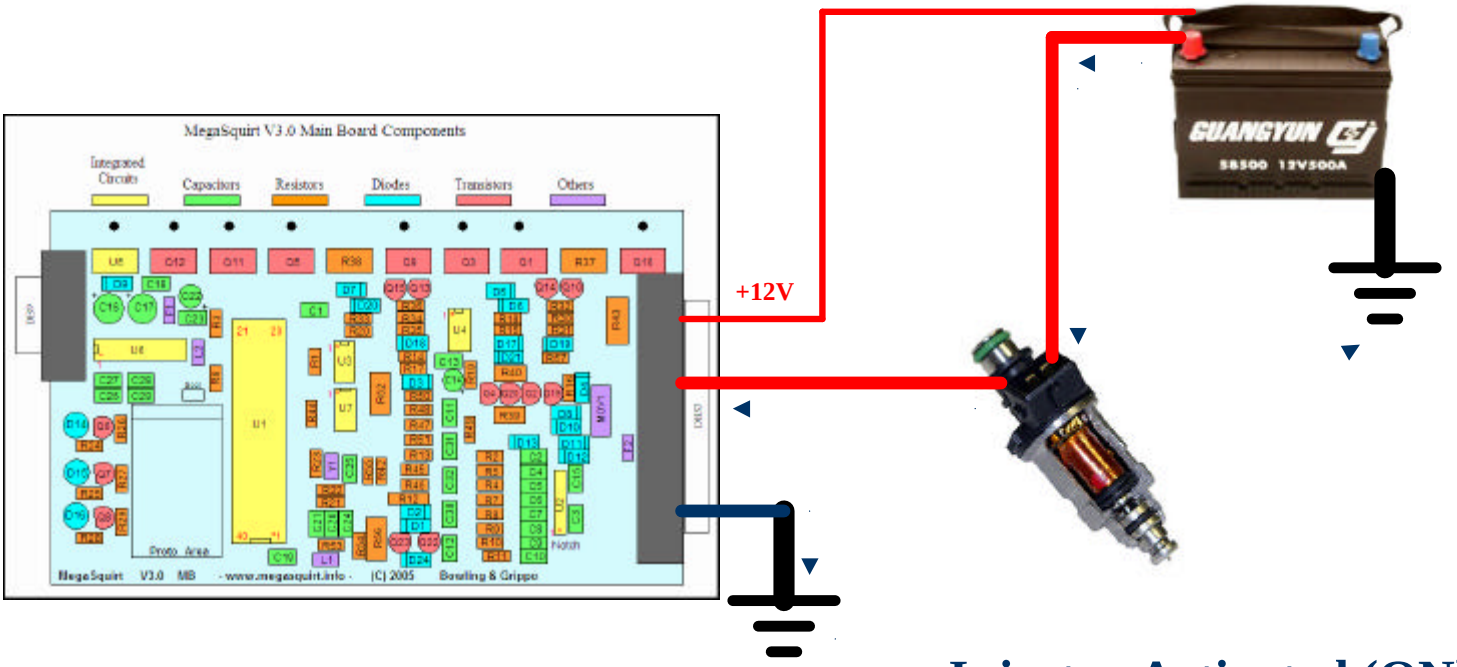
MEGASQUIRT
www.megasquirt.info

MegaSquirt Low-Z Injector PWM

- When multiple low-impedance injector are used on MegaSquirt, the PWM switchmode current limiting can introduce noise on the +12V battery rail.
- Voltage transients from PWM caused by “IR” voltage drops in vehicle +12 volt supply wiring
- Solutions include:
  - Improving vehicle wiring for +12V source to injectors and MS board to reduce resistance
  - Board modification to provide separate return for flyback currents
  - External shunt and storage capacitance on +12V vehicle supply.

MegaSquirt
www.megasquirt.info

MegaSquirt Low-Z Injector PWM

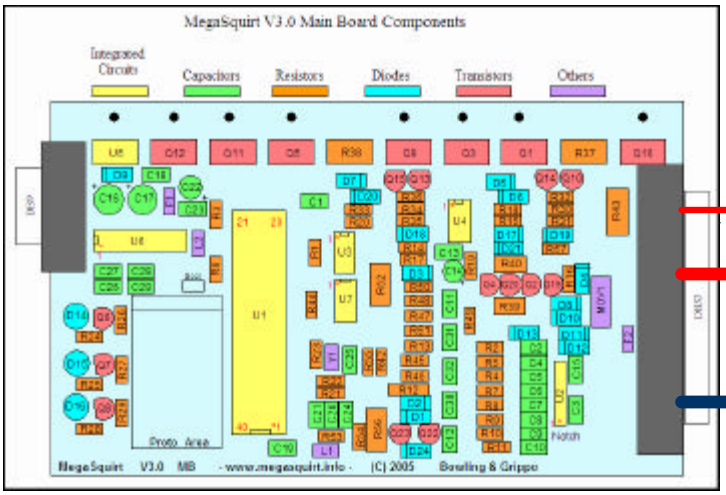


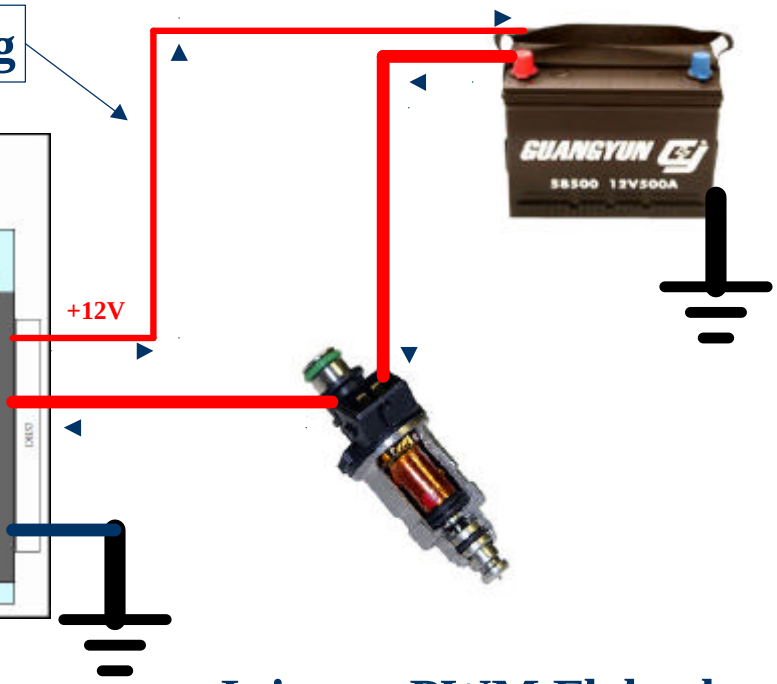
Injector Activated (ON)

MEGASQUIRT
www.megasquirt.info

MegaSquirt Low-Z Injector PWM

Vehicle +12V Wiring



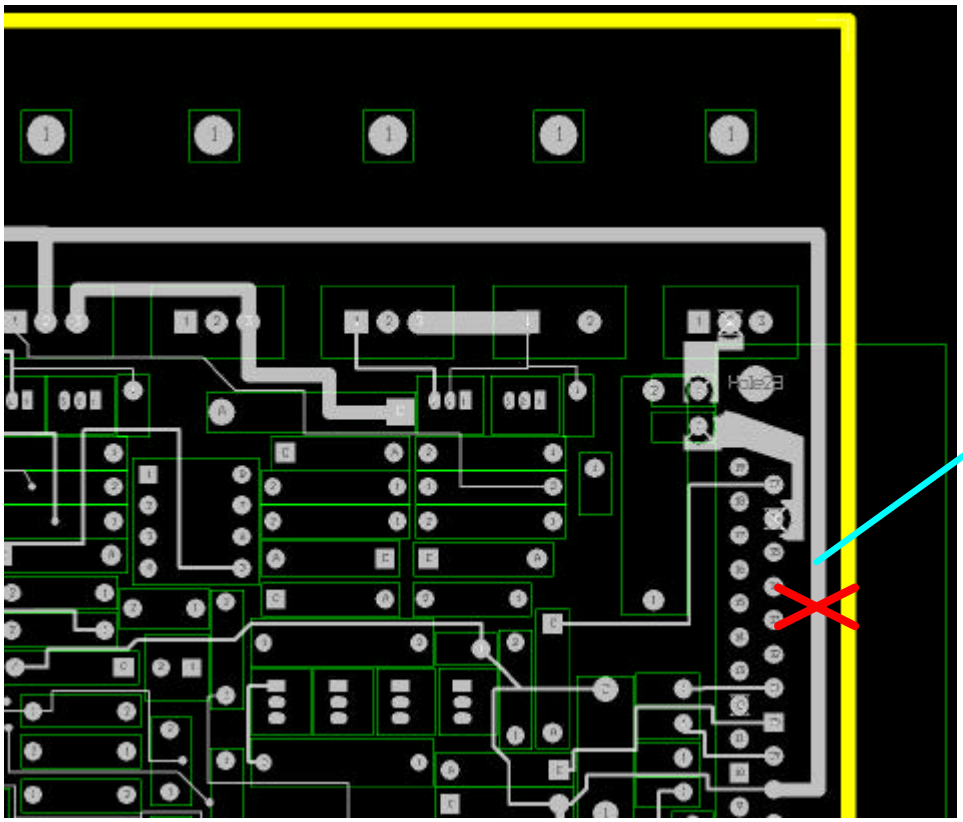


Resistance in vehicle wiring will cause voltage drop……

Injector PWM Flyback

MEGASQUIRT
www.megasquirt.info

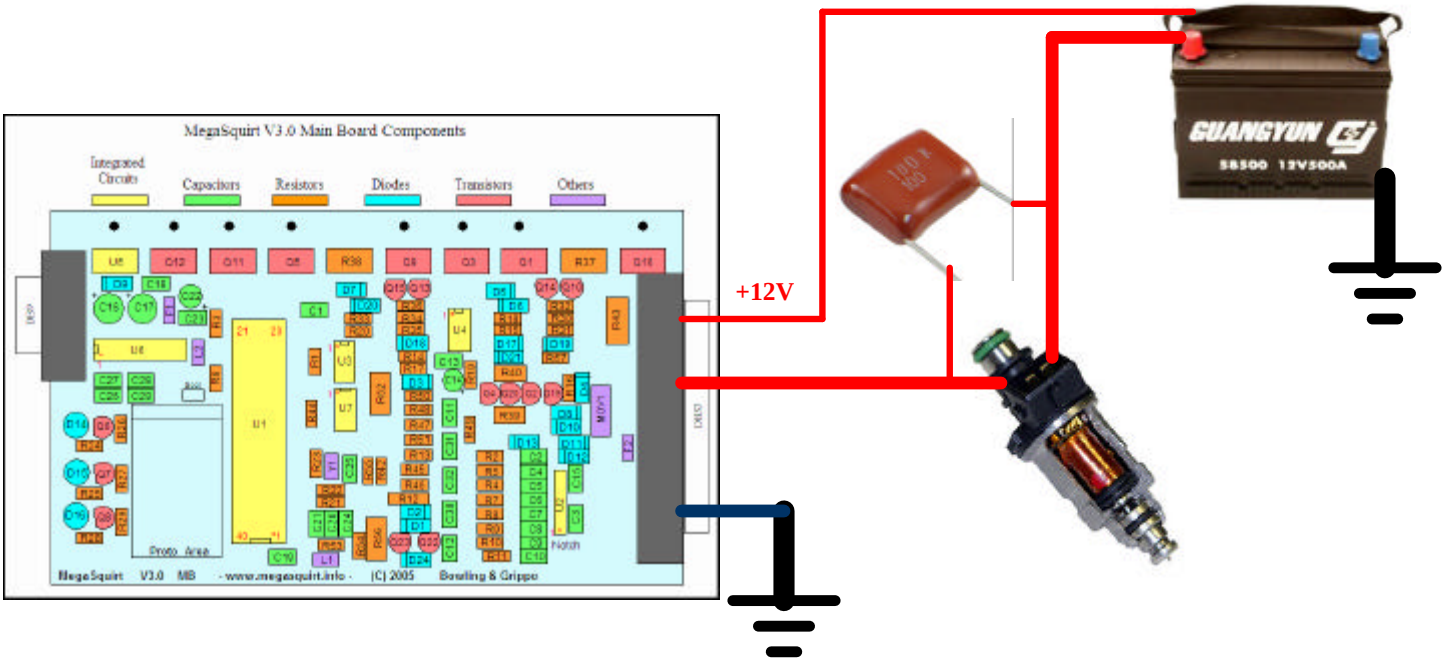
MegaSquirt Low-Z Injector PWM



Cut this trace (+12V) and bring it out separate, return directly back to injector +12V

MegaSquirt
www.megasquirt.info

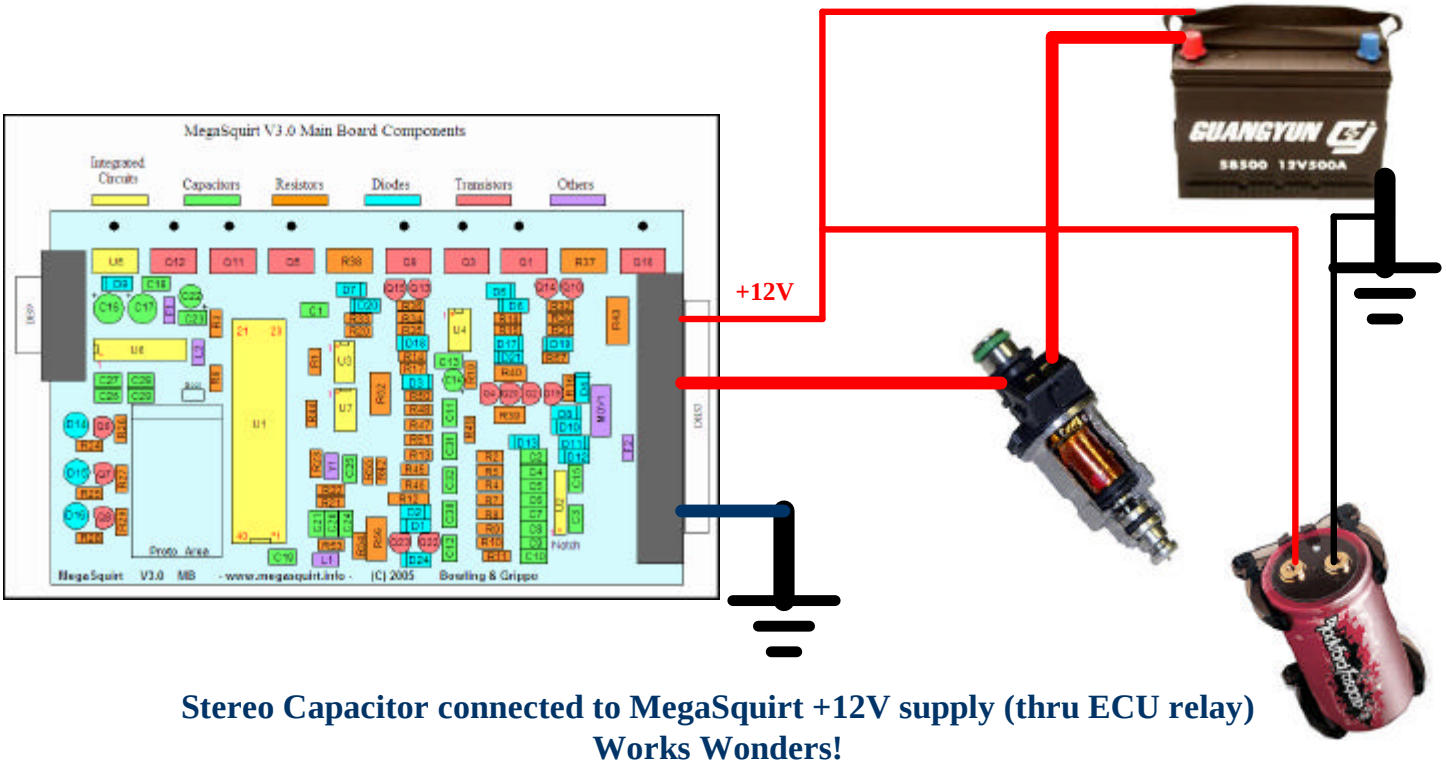
MegaSquirt Low-Z Injector PWM



Connect capacitor and resistor in series with injector bank (snubber)
Starting values are 0.1uf and 100 ohm, adjust…

MEGASQUIRT
www.megasquirt.info

MegaSquirt Low-Z Injector PWM



Stereo Capacitor connected to MegaSquirt +12V supply (thru ECU relay)
Works Wonders!

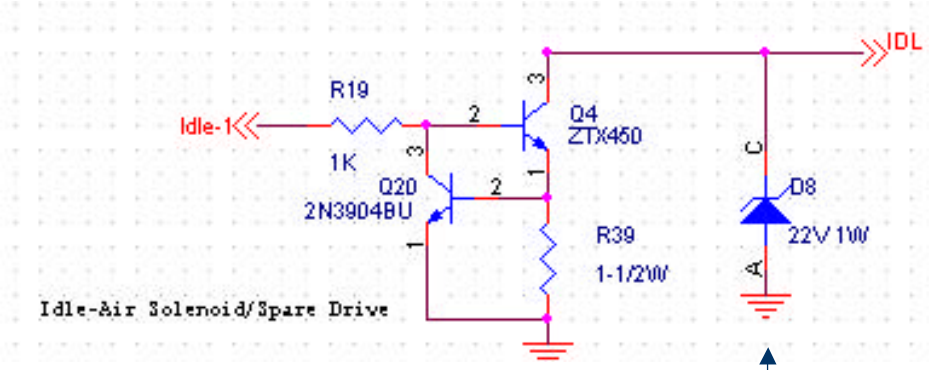
MEGASQUIRT
www.megasquirt.info

MegaSquirt Fast Idle PWM

- The fast idle driver transistor was originally designed for on-off operation. However, the use of the output for PWM idle valve operation is quite popular!
- The driver transistor grounds are not optimal on the V3 board for PWM use, but there are a few user-changes that can improve this.
- The transistor overcurrent circuit can cause issues with PWM idle valve use due to activation during flyback.

MegaSquirt
www.megasquirt.info

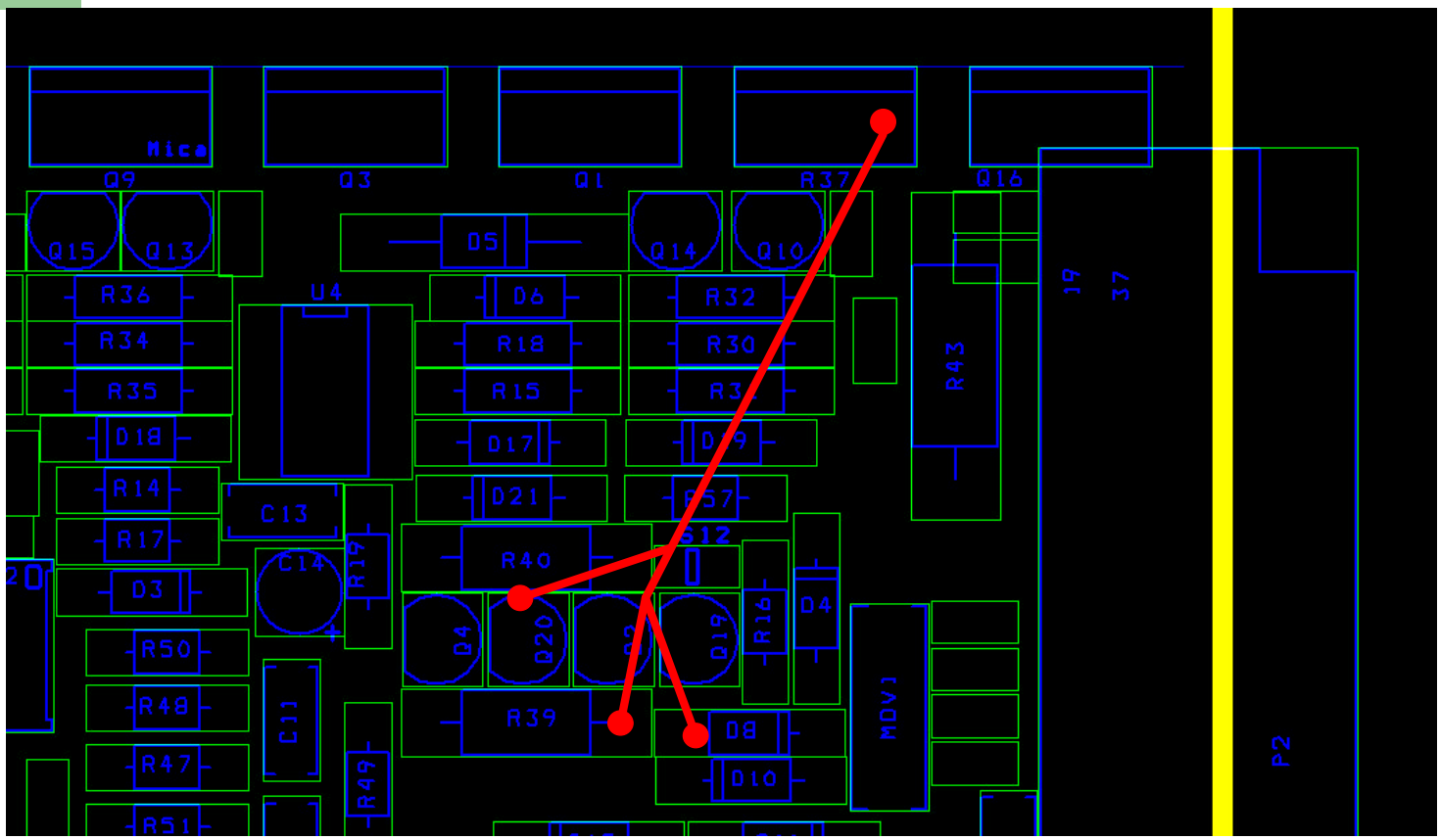
MegaSquirt Fast Idle PWM



These grounds should go to the High-Power Groundplane….

MegaSquirt
www.megasquirt.info

MegaSquirt Fast Idle PWM



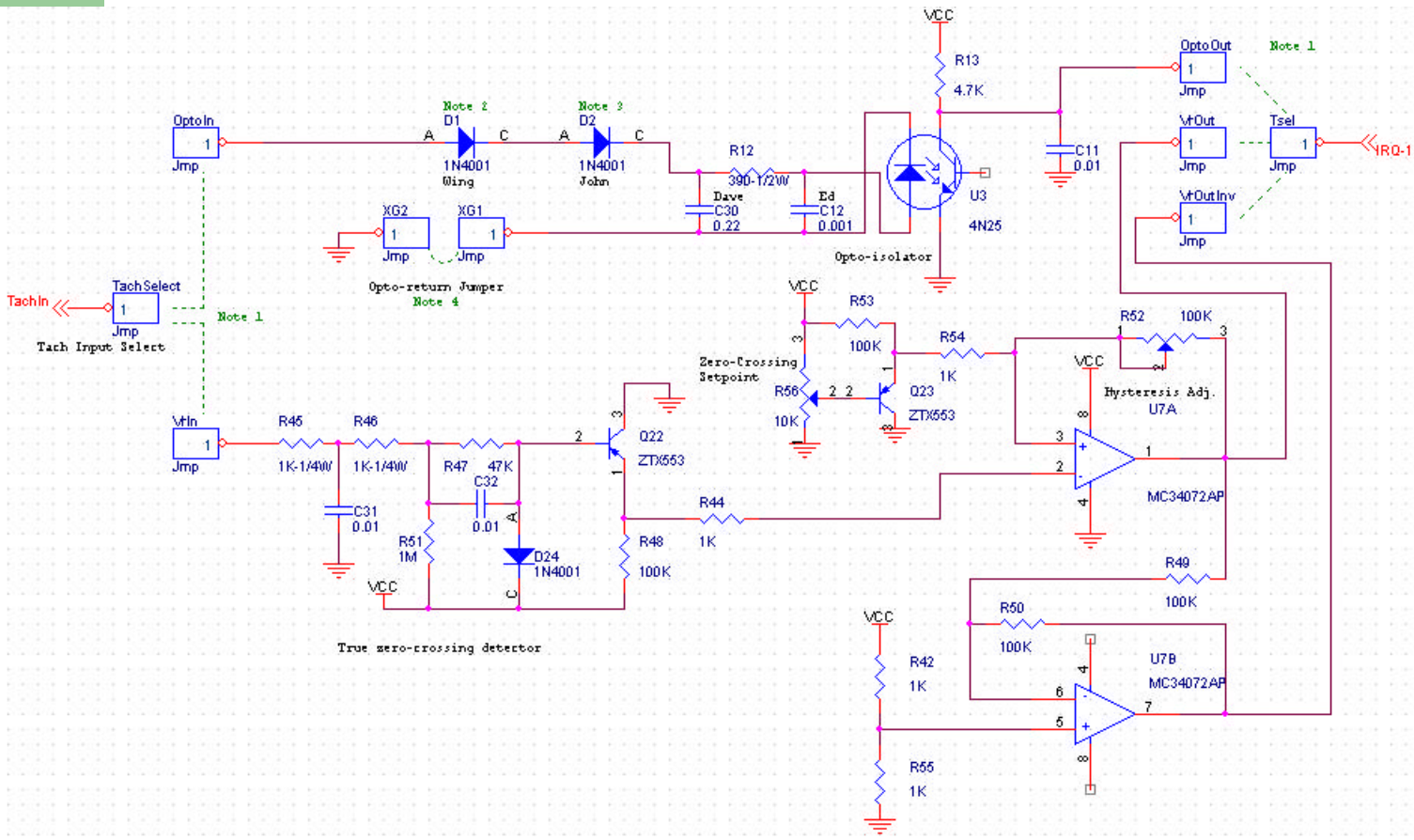
MegaSquirt
www.megasquirt.info

MegaSquirt VR Circuit

- There are hundreds of different VR sensor configurations, each generating outputs of wildly different voltages/currents.
- The V3 VR circuit was designed with some adjustability for different sensor signals.
- However, there are some situations where the signal needs to be “pruned” a bit:
  - Voltage amplitude
  - Current
  - Irregular signals
- Here is a background on the VR circuit operation:

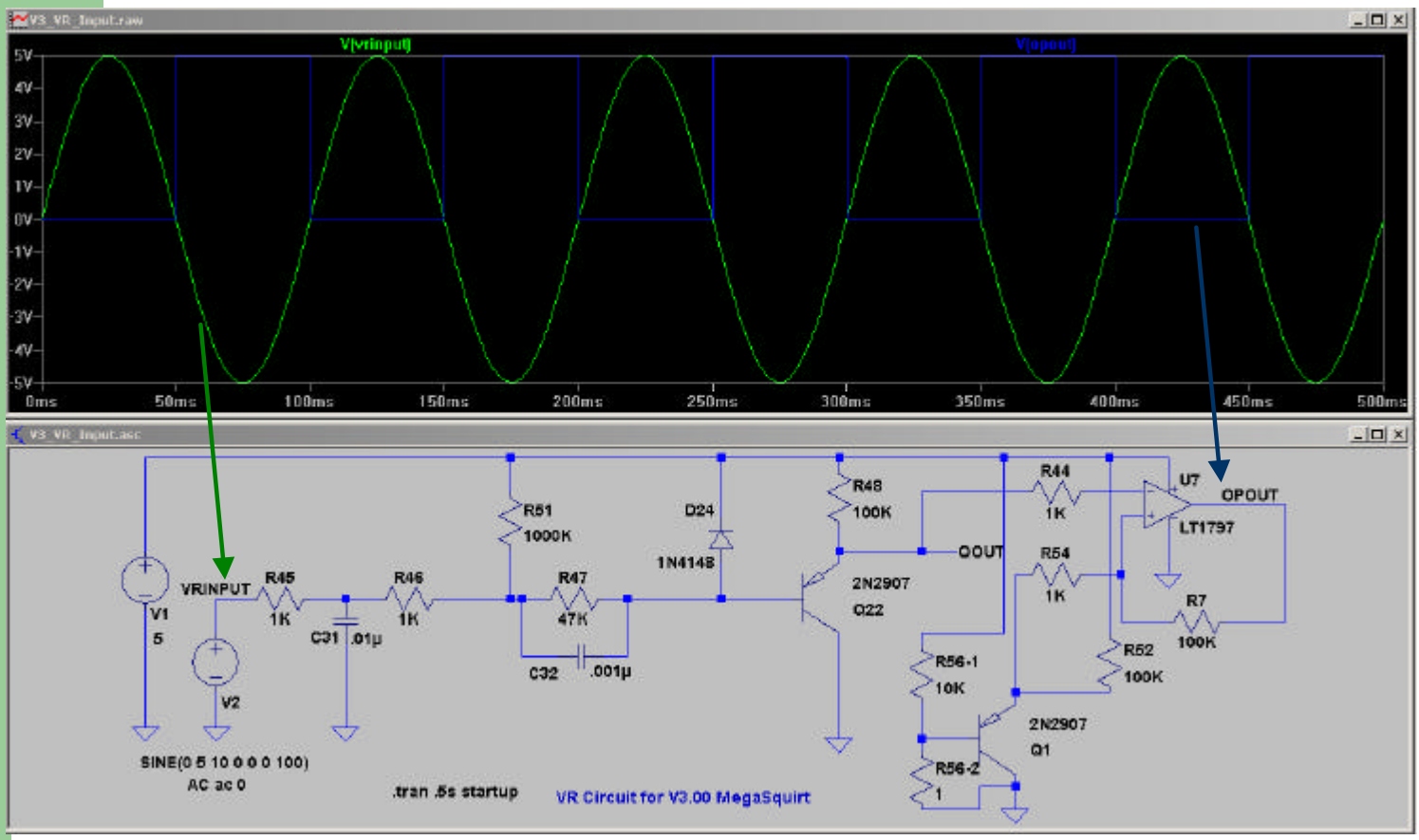
MegaSquirt
www.megasquirt.info

MegaSquirt VR Circuit



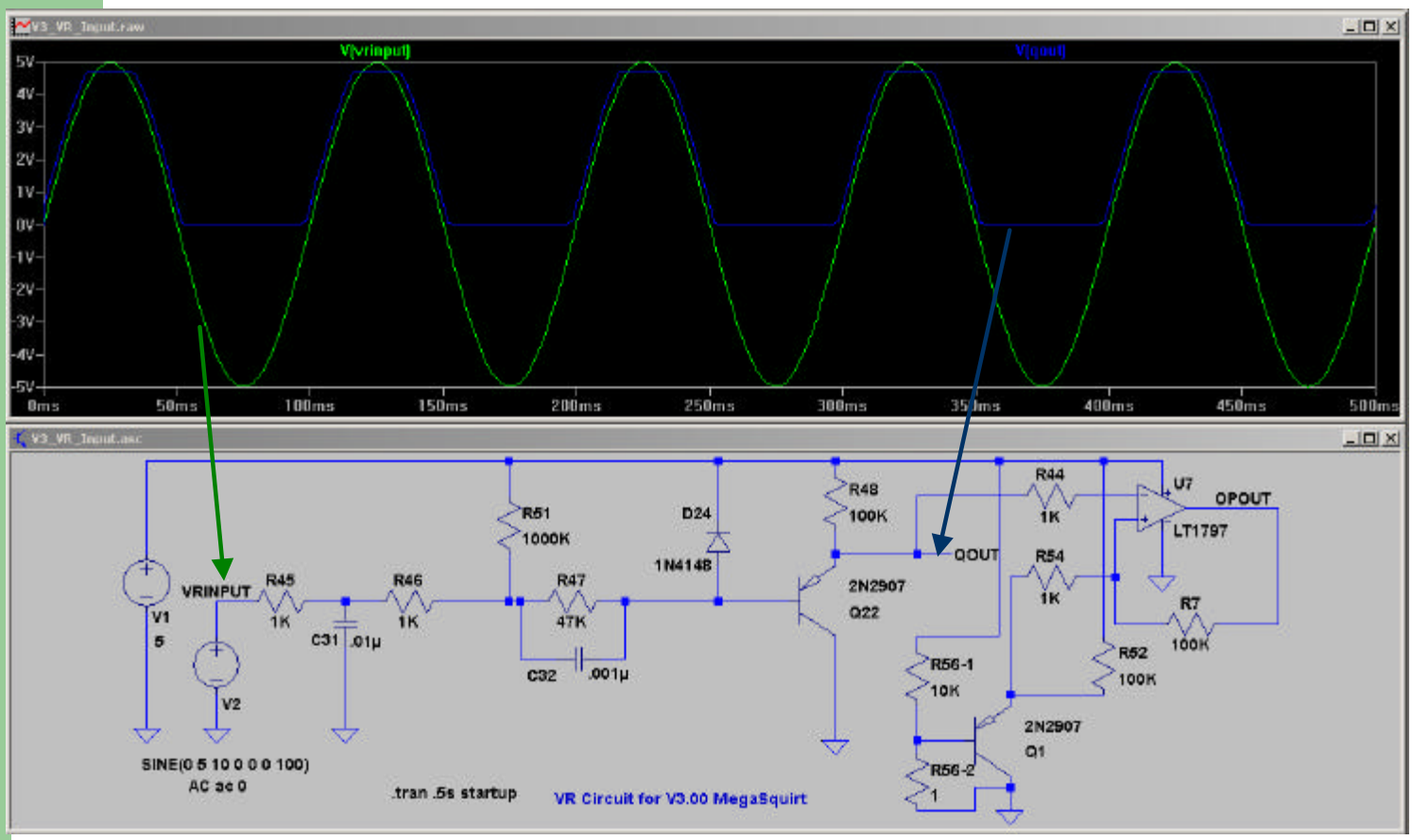
MegaSquirt
www.megasquirt.info

MegaSquirt VR Circuit



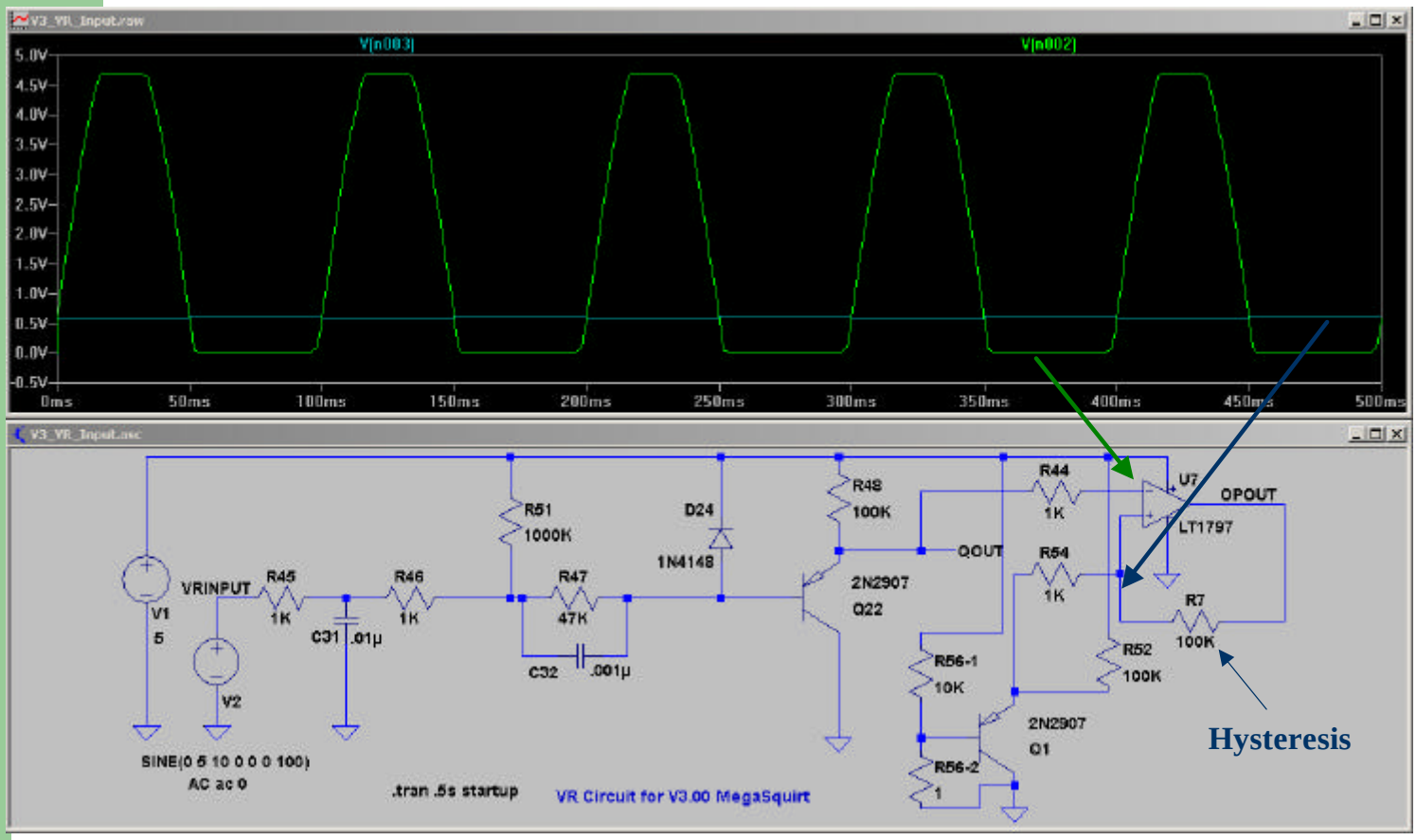
MEGASQUIRT
www.megasquirt.info

MegaSquirt VR Circuit



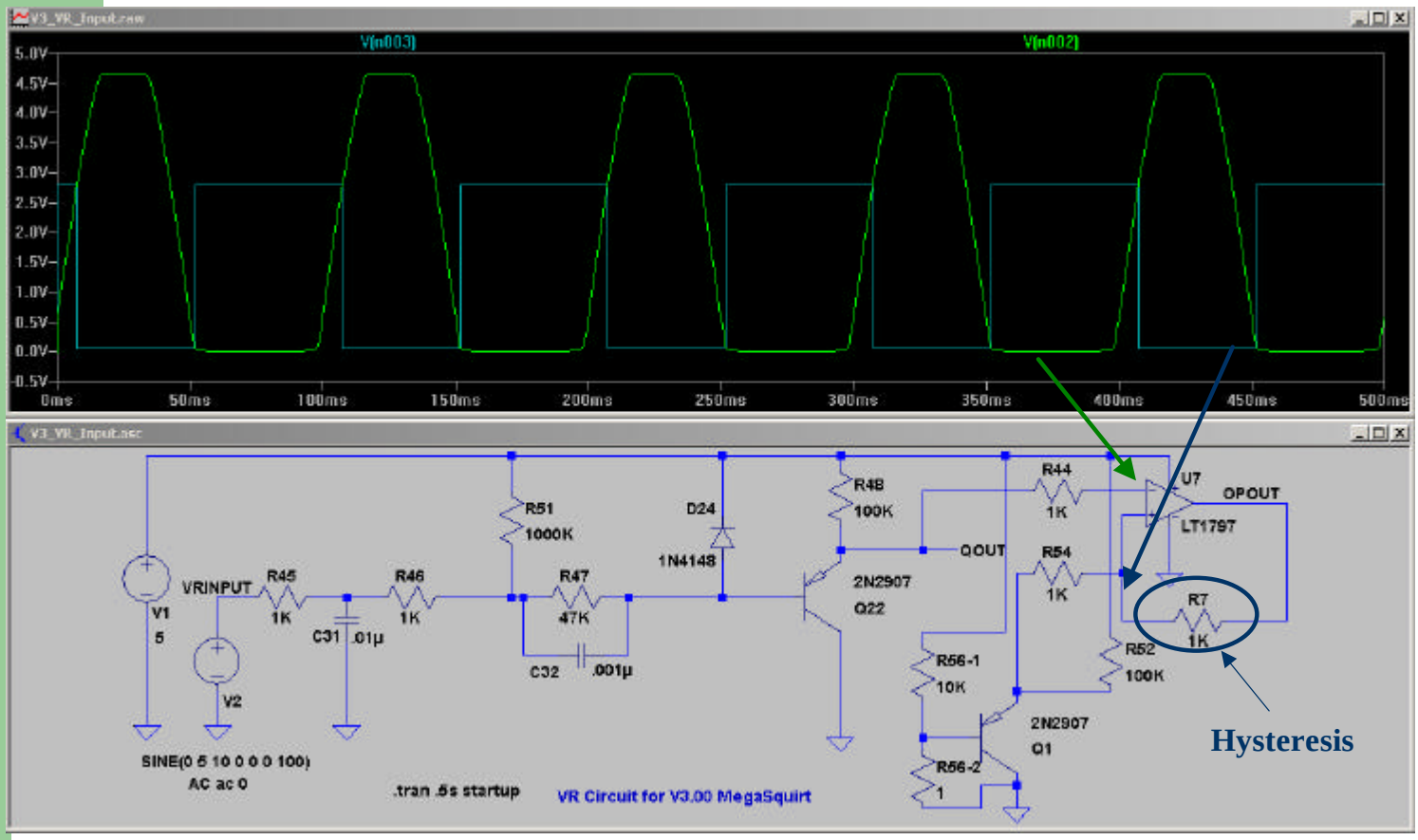
MegaSquirt
www.megasquirt.info

MegaSquirt VR Circuit



MegaSquirt
www.megasquirt.info

MegaSquirt VR Circuit



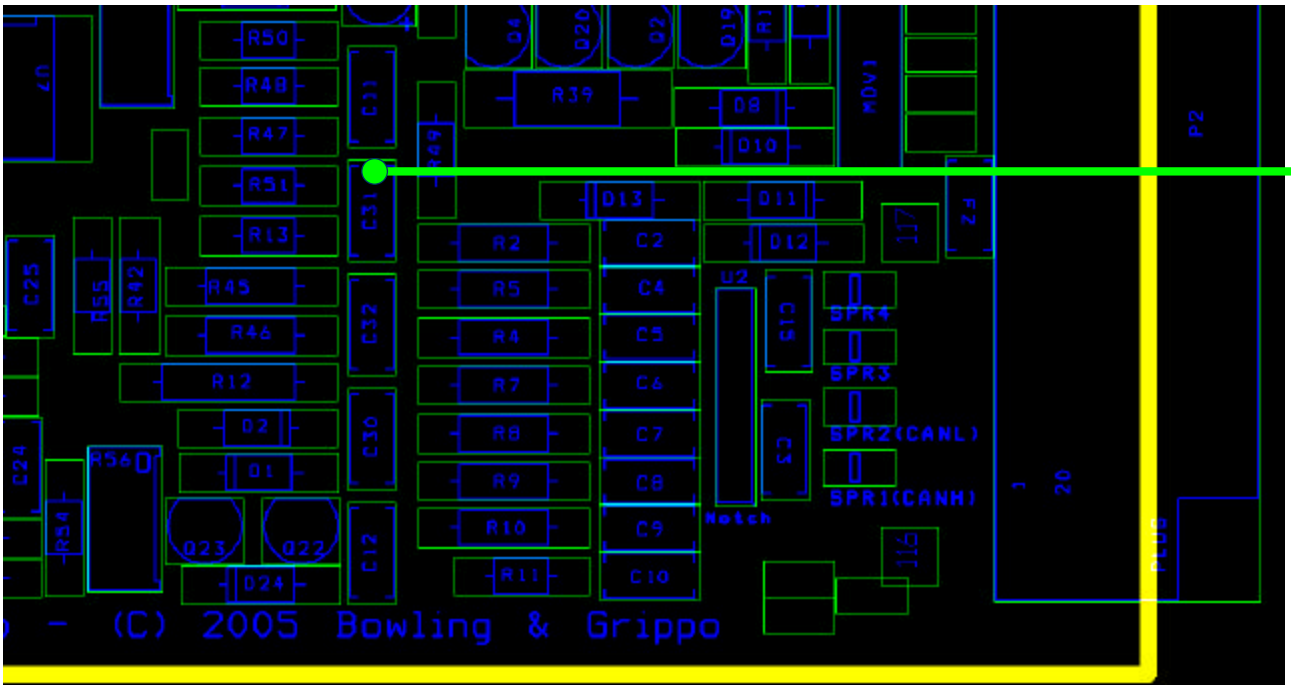
MegaSquirt
www.megasquirt.info

MegaSquirt VR Circuit

- Here are some proven VR circuit tweaks:
  - Increase series resistance R45 from 1K to up to 10K
  - Increase capacitance C31 up to 0.1 (Note - this will cause a phase shift for high toothcount wheels at high RPM)
  - Resets from VR can be cured by supplying separate VR return ground back directly back to C31 (next slide…)
  - Provide hysteresis capacitor (later slide)

MEGASQUIRT
www.megasquirt.info

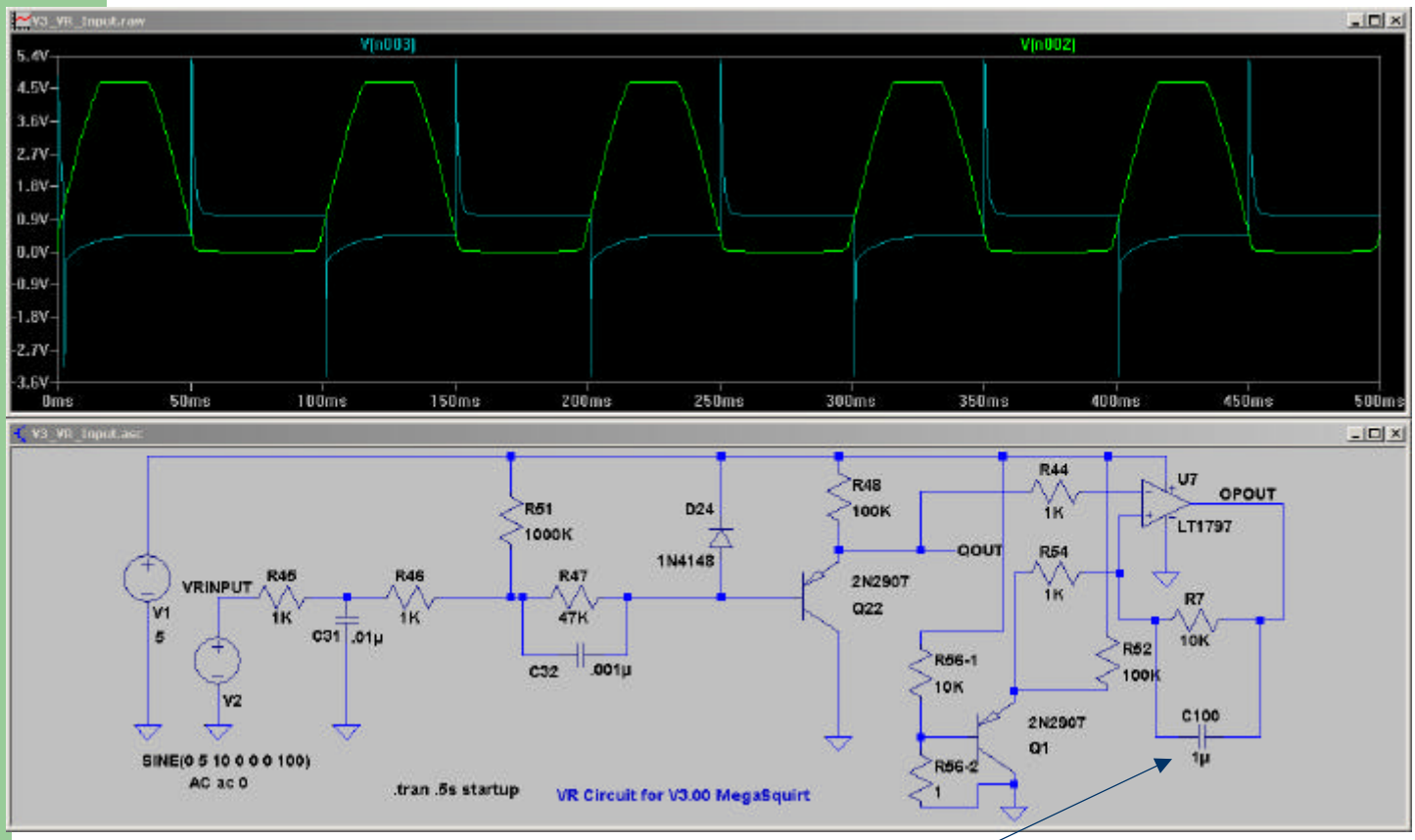
MegaSquirt VR Circuit



Bring VR return signal back to C1 or Q22 ground to localize ground circulation currents for VR circuit.

MegaSquirt
www.megasquirt.info

MegaSquirt VR Circuit



Hysteresis Capacitor

MegaSquirt
www.megasquirt.info