Using the DIYPNP N76 Kit to MegaSquirt a '96 Rav4

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As part of a project to turbocharge my '96 Rav4, I installed a DIYPNP engine management system based on the Microsquirt v1.1 board. I didn't have to change any wiring at all, the MS unit plugged into the existing harness and the only change under the hood was to disconnect the vacuum hose running to the stock MAP sensor and run a hose to the MAP sensor built into the MegaSquirt unit.

So, it's about a close to "Plug N Play" as you can get.

My goal was to install a low-boost turbo setup on my stock 3sfe engine, with MS managing fuel and timing.

For this project, I used DIYPNP MegaSquirt unit from DIYAutotune. This particular version of MS comes with connectors that plug into the stock Toyota harness -- you just unplug the stock ECU and plug in the MegaSquirt.

The key to making it work on the RAV4 was figuring out the ignition system. My '96 model has a distributor with a cam angle sensor built in and a crank angle sensor mounted on the crankshaft. In the end, I ignored the cam sensor and just used the signal from the crank sensor. Once I figured out the right settings, the car fired on the first try.

Crank Wheel trigger

The crank trigger wheel on my '96 Rav4 has space for 36 teeth, but there is a block at one point that takes up the space of 3 teeth. The crank angle VR sensor sees that block as one tooth followed by two missing teeth. So, MegaSquirt sees 34 teeth and two missing.

Here's a drawing of the trigger wheel. If your Toyota has this same setup, you should be able to use an MS2 or PNP kit to control ignition, whether your car has a distributor or not.

Here's a link with info on the missing tooth decoder that will give you a good idea of what's possible: www.msextra.com/doc/ms2extra/MS2-Extra_Miss_Tooth.htm. Also, here's a link to the Ignition Manual, which discusses all the various possibilities: www.msextra.com/doc/ms2extra/MS2-Extra_Ignition.htm

NE Pick up Coil

NE Signal Timing Rotor
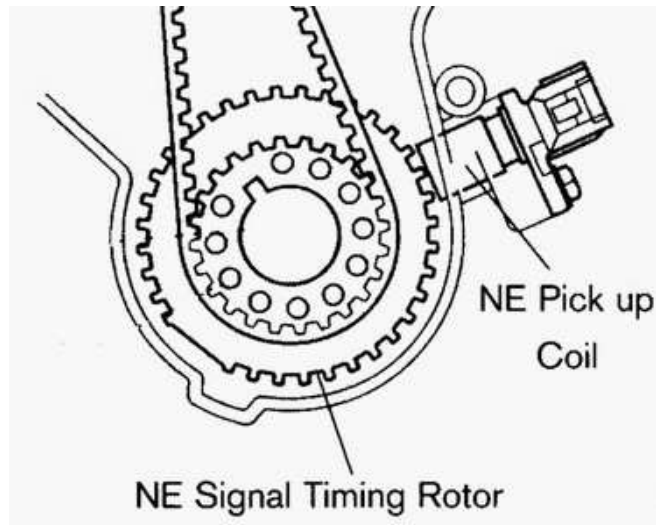
My basic ignition settings in MS are:
Toothed Wheel
Ignition Input Capture = Rising Edge
Spark Output = Going High (Inverted)
Number of coils = Single Coil
Trigger Teeth = 36
Missing Teeth = 2
Tooth #1 Angle (deg BTDC) = 95
Wheel speed = Crank Wheel.

DIY PNP Kit

The DIYPNP kit I used is short for "do it yourself, plug n play" -- Well, some assembly is required for the version I purchased. The kit consists of a MicroSquirt board, an expansion board that includes space for a lot of interesting functions, and the connector board that allows you to plug into your car's harness.

MicroSquirt is a scaled down version of the larger MegaSquirt and comes pre-assembled on a credit-card sized board. When mounted on the expansion board in the PNP kit, you've got all the functionality you could ever want, including boost control, knock control and lots of user selectable input/output options.

The picture below is my assembled unit. It took about two hours of hands-on work to get to this stage. The orange wires connect the expansion board to the harness connector. On the edge of the expansion board you have a series of output holes that are clearly labeled: Ignition, injectors, coolant sensor, throttle position, etc. You just have to wire those to the appropriate pins on the connector board.

It helped that I had a complete schematic for my Rav4 that I downloaded from the Toyota Information Center. Included was a page showing the terminals of the ECM and which pins do what. That made the wiring straight-forward.

Anyone can do this with patience and a willingness to learn, even if you've never soldered anything before. But, it's not for the faint of heart. I understand you can get these kits pre-assembled if you want to pay the extra $$$. Even then the cost would be less than a third of most engine management systems.
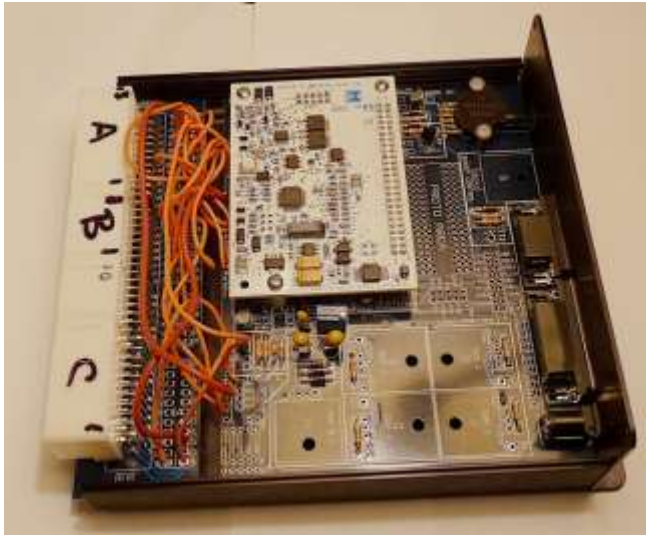
The DIYPNP kits are a product offered by www.diyautotune.com. The kit that has the right harness plugs for the Rav4 is the *DIYPNP Nippon Denso 76pin Unassembled Kit* [DIYPNPN76-K].

The software you need is MS2-Extra. Complete documentation, running to hundreds of pages, can be found here: http://www.msextra.com/doc/ms2extra/index.html.

1996 RAV4
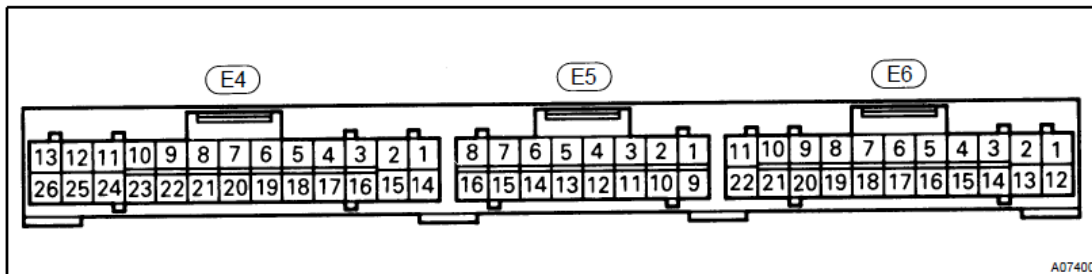
ECU	MegaSquirt	Notes
+B (E6-12)	12v	Switched 12 v
VC (E5-1)	Vref	5 volt reference for sensors
VTA (E5 11)	TPS signal	Throttle Position
THA (E5-3)	IAT	Intake Air Sensor
THW (E5-4)	CLT	Coolant Sensor
#10 (E4-12)	INJ 1	Injectors 1-2 paired
#20 (E4-11)	Inj 2	
#30 (E4-25)	Inj 3	Injectors 3-4 paired
#40 (E4-24)	Inj 4	
IGT (E4-20)	Igt	Ignition out
NE+ (E4-4)	VR-	VR sensor signal in
NE – (E4-17)	VR +	VR sensor in (Backward of what seems right. I had to swap them to make it work)
FC (E6-14)	Fuel	Fuel Pump Control
ISCC (E4-9)	IAC Close	Idle air control closed
ISCO (E4-10)	IAC Open	Idle air control open
OX1 (E5-6	O2 sensor	
OX2 (E5-5)	O2 sensor	second 02 sensor is optional
KNK (E5-10)	Knock	Rav4 has a knock sensor. Optional.
Grounds:		
E4-14	Main ground	
E5-9	Sensor Ground	
E4-13	Injector ground	

Idle Air Control Valve

The '96 Rav4 has a three-wire Idle Air Control (IAC) valve that opens and closes to bypass air around the throttle and control the idle. To make it work with the DIYPNP kit, you need to add the circuit pictured below. This was the most complex wiring task of the entire project. All the components below were sourced at my local Radio Shack and looked to be fairly standard components they keep on hand. They also may be purchased online through Electronic Supply houses.

The PNK kit includes a couple open areas on the board for building add-on circuits like this. I understand some of the kit suppliers offer this circuit pre-mounted on a add-on board for use with the standard MegaSquirt.

By tracking engine temp and other sensors, the MS kit provides an IAC output. You run a wire from that output port to the control circuit. It splits that signal into an Open and Close signal that the Toyota IAC understands. Make sure you get the open and close order correct. I wired it up backwards the first time around and the car would NOT idle. On the '96 Rav4 harness, the pins are marked ISC**C** (valve closed) and ISC**O** (valve open).

"This circuit uses a pair of TIP120s to drive the opening and closing coils of a 3 wire idle air control valve. Some cars that use the N76 board (particularly Toyota and Subaru products) use versions of the 3 wire IAC valve. This circuit takes the IAC signal and splits it into two opposite signals. The IAC_Open output is grounded when the input is grounded, and the IAC_Close output is grounded when the input is not grounded." –Source, DIY AutoTune.

Idle Software Setup

The MS-Extra software includes several strategies for controlling Idle. The one that works for my Rav4 was **PWM Closed Loop**. (PWM stands for pulse width modulation). In very basic terms it uses the open and close signals to "modulate" or move the valve back and forth to maintain idle.

Rather than go into detail on the setup, here are some screen shots. My car idled fine on these settings throughout warmup and during stop-n-go driving.

You can find an in-depth discussion on idle setup here:
http://www.msextra.com/doc/ms3/tmp/2Idle_Control.html

Closed Loop Idle Valve Settings

Setting	Value
Idle Open Duty(%)	99
Idle Open Steps(steps)	253
Idle Valve Closed Duty(%)	20
Idle Valve Closed Steps(steps)	51
Idle Activation RPM adder(rpm)	300
Idle Activation TPS threshold(%)	0.4
Dashpot adder(%)	4
Dashpot adder(steps)	9

NOTE: Close delay of 0 means do not close

Close delay(sec)	2

Burn   Close

Closed Loop Idle PID Settings

Setting	Value
Min Duty for PID(%)	5
Min Steps for PID(steps)	13
RPM with valve closed(rpm)	500
RPM with valve open(rpm)	1600
PID delay(sec)	2
Crank to run taper(s)	5
PID ramp to target time(sec)	4
PID Control Interval(ms)	75
Proportional Gain(%)	30.0
Integral Gain(%)	140.0
Derivative Gain(%)	0.0

PID lockout detection

Setting	Value
PID lockout rpmDOT threshold(rpm/sec)	50
PID lockout max decel load(%)	25.0

Burn   Close

Closed loop idle target rpms

Closed loop idle target rpms

Burn   Close
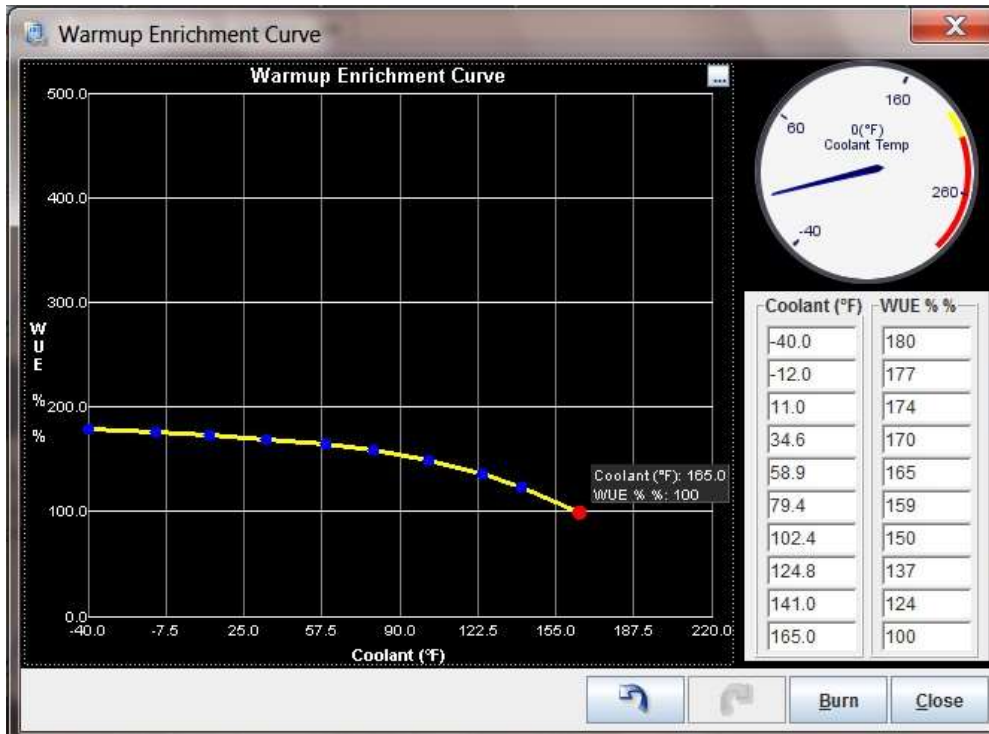
Other Software Settings

Here are some various screenshots from my setup, including engine constants and ignition. My Rav4 uses injectors rated at 250cc per minute and the 3sfe is 2000 cc:

Standard Injection

Calculate Required Fuel

Required Fuel...	13.4
	(ms) 13.40

Control Algorithm	Speed Density
Squirts Per Engine Cycle	2
Injector Staging	Alternating
Engine Stroke	Four-stroke
Number of Cylinders	4
Injector Port Type	Port Injection
Number of Injectors	4
Engine Type	Even fire

Burn   Close

Injector Characteristics

Help

Injector Characteristics

Bank 1

Injector Open Time(ms)	1.000
Battery Voltage Correction(ms/V)	0.200
PWM Current Limit(%)	100
PWM Time Threshold(ms)	25.5
Injector PWM Period(us)	66

Bank 2

Specific bank 2 setting	Off
Injector2 Open Time(ms)	1.000
Battery Voltage Corr.(ms/V)	0.200
PWM Current Limit(%)	50
PWM Time Threshold(ms)	1.0
Injector PWM Period(us)	66

Burn   Close

Ignition Options

Help

Ignition Options

General Ignition

Spark mode(dizzy, EDIS,wheel)	Toothed wheel
Trigger Angle/Offset(deg)	0.00
Angle between main and return(deg)	50.0
Oddfire small angle	90
GM HEI/DIS options	Off
Use cam signal if available*	Off
Oddfire phasing	Alternate
Skip Pulses	3
Ignition Input Capture	Rising Edge
Spark Output	Going High (Inverted)
Number of coils	Single coil
Spark A output pin (D14 preferred)	D14

Burn   Close

Trigger Wheel Settings

Help

Trigger Wheel Settings

Trigger wheel arrangement	Single wheel with missing tooth
Trigger Wheel Teeth(teeth)	36
Missing Teeth(teeth)	2
Tooth #1 Angle(deg BTDC)	95.0
Wheel speed	Crank wheel
Second trigger active on	Rising edge
and every rotation of.	Cam

(see F1 help)

Red settings require an MS-II reboot!

Burn   Close