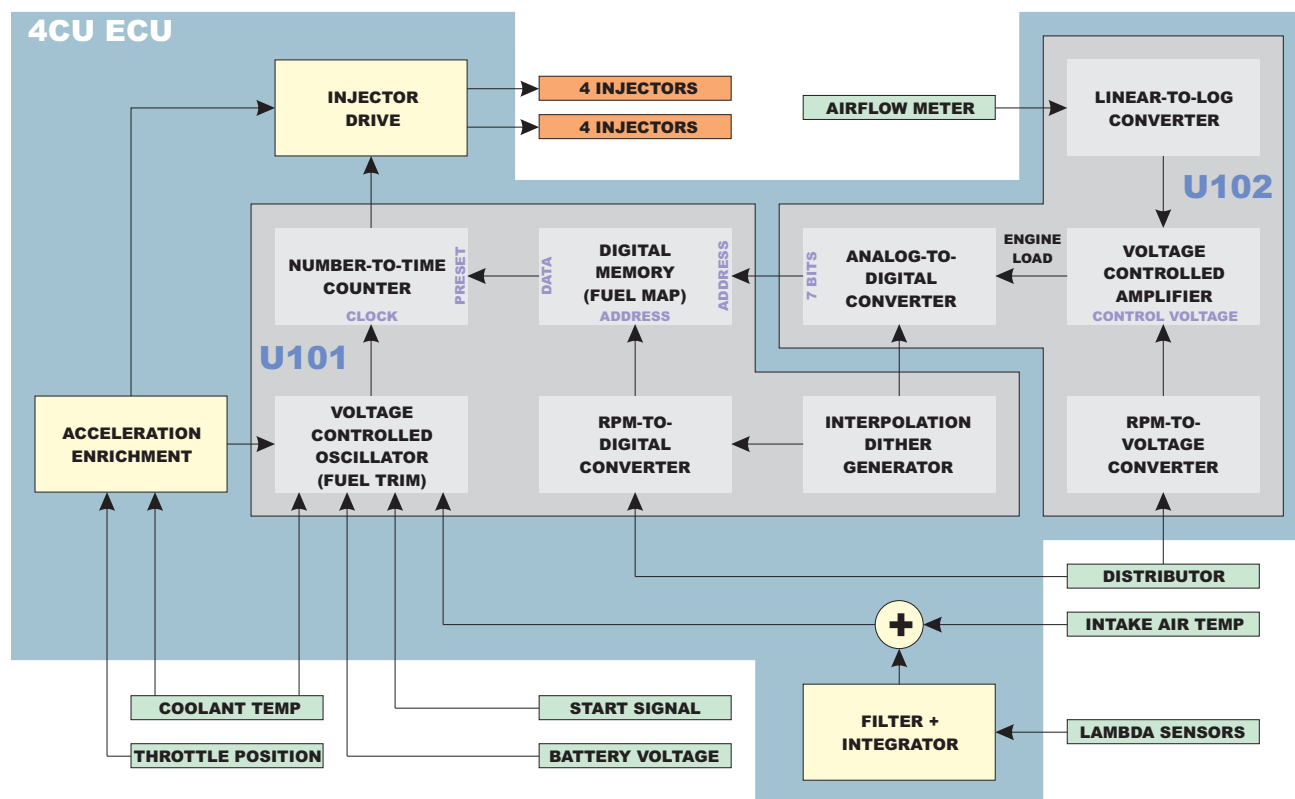


Lucas 4CU Fuel Injection

Gene Thompson

The Lucas 4CU and 6CU “P-Digital” ECUs were the first EFI controllers introduced into volume production that made extensive use of digital technology. They evolved from Bosch L-Jetronic and D-Jetronic designs, acquiring increased accuracy and the ability to independently control two banks of injectors as required on Rover V8 and Jaguar V12 engines.



This block diagram shows my best guess about what goes on inside the 4CU ECU. It's based on a diagram released by Lucas describing the Jaguar 6CU ECU. The Jag uses a manifold absolute pressure (MAP) sensor instead of an air flow meter. It would be extremely difficult to use an air flow meter in the XJS due to the tight fit and unusual layout of the V12. There is also less intake restriction without the flap type air flow meter. Unfortunately, engine wear, performance mods or even dirty air filters throw off the calibration of a MAP sensor equipped system. It can be tough to persuade an old XJS to pass its emissions test.

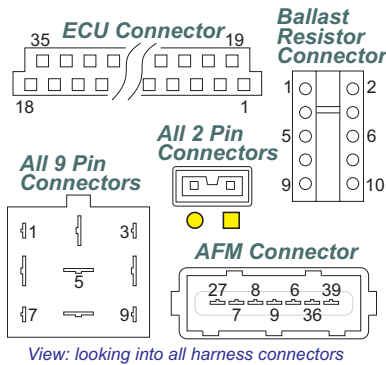
The circuitry surrounding the 4CU controller is very similar to that in a typical L-Jetronic installation. However, there are two lambda sensors, some differences in the air flow meter signal and a throttle potentiometer instead of a throttle switch. Operation is also similar to L-Jetronic – the ECU does *not* control the ignition timing, idle speed, radiator fans or even the cold start injector.

But, cleverly, it *isn't* L-Jetronic, and since some of its most common problems never show up on L-Jet systems, it has an unmatched ability to confound and annoy your local Bosch-trained mechanic. Even so, it is very helpful to have a good understanding of L-Jet, along with some complete and accurate schematics, an oscilloscope and the right attitude. The schematics are presented here. For the rest, you're on your own. The following commentary is based mostly on the U.S. specification Triumph TR8 – your system may vary.

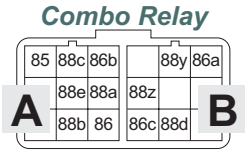
1980/1981 Triumph TR8 Fuel Injection System

Late '81 without combo relay excluded

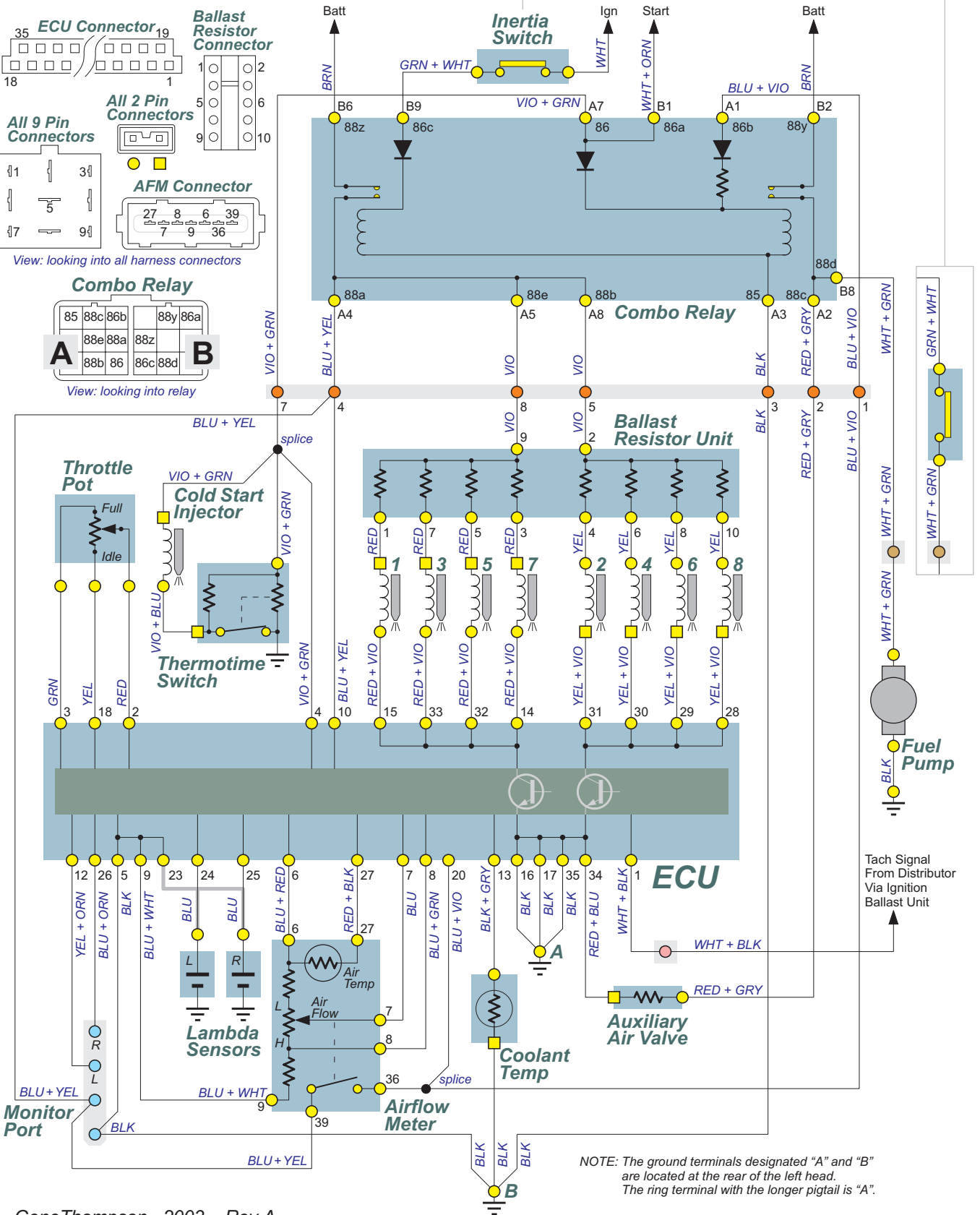
NOTE: On earlier systems, the inertia switch is placed between the combo relay and the fuel pump. The white "Ign" wire is connected directly to 86c on the combo relay.



View: looking into all harness connectors



View: looking into relay



NOTE: The ground terminals designated "A" and "B" are located at the rear of the left head. The ring terminal with the longer pigtail is "A".

Repair

First of all: don't get absolutely fixated on the EFI system as the cause of a drivability problem. The EFI *always* reacts to its environment – faults elsewhere will make it misbehave. If you can't find anything wrong with the EFI, maybe there isn't. Many “fuel injection problems” turn out to be a rusty fuel tank, bad ignition (don't hack up the ballast resistor!), bad cam or an unwise modification made by the previous owner.

The 4CU ECU has quite a reputation for unreliability, but things aren't nearly as hopeless as advertised. The ECU has a couple of... ahem... minor design defects that result in circuit board solder joint problems. ***I suspect that this has caused more 4CU ECUs to be replaced than anything else.*** Even if the car is running fine, it would be a good idea to remove the ECU and have the at-risk components resoldered.

Thermal cycling will eventually cause the three large power transistors in the ECU to develop bad solder joints. If the 5V regulator transistor comes adrift, the car will drop dead. If one of the injector driver transistors has a problem, one bank of injectors will stop injecting and the car will stumble badly or die. It often will restart then die again. It's easy to fix. Resolder the transistors with fresh high quality electronic solder and a good soldering iron with a grounded tip – don't kill the patient trying to save it! If you don't know much about soldering, have someone else do the work. The circuit board pads can be detached by too much heat and the resulting joints will soon go bad.

The lambda sensor and throttle pot circuits use large boxed film capacitors. They are not held down properly and vibration fractures their solder joints. Surging and stumbling result. Resolder all the joints on the large rectangular green or yellow capacitors and any other joint that is suspicious. The eventual failure rate must be close to 100%. Do it now, because you ***will*** have to do it eventually.

It can be mighty hard to pin down the source of an obscure problem, but here are the usual suspects:

- **Won't run at all, or suddenly quits.** It's often an ignition problem. Before tearing into the EFI, make sure the ignition is working properly. The Lucas distributor is a real dog and the ignition ballast resistor unit is weird and confusing. When an aftermarket distributor or ignition unit is installed, the wiring often gets screwed up. I'm constantly amazed at the amount of trouble the ignition system causes.

The stock ignition setup uses three resistors in various combinations to accomplish what most cars do with one. The resistance of each is less than normal, so if care isn't taken when installing aftermarket equipment, the coil may overheat and die when you're out in the middle of nowhere. When it cools down, it starts working again. It may take your new distributor with it, too.

The ECU needs to get a proper signal back from the coil. Even if a non-ballasted coil is used, the tach and ECU should get their signals from the extra resistors inside the ballast unit. You can substitute good quality discrete resistors if you just can't stand looking at the stock unit. The resistors reduce the amount of electrical noise radiated into the wiring harness by the coil. See the ballast schematic on page 13 of this document.

Check for 12V where it is required. Relays can wear out or fill with rust. The TR8 ignition switch often starts to come apart when it gets old. Squeeze it back together if the car intermittently dies. The inertia switch on earlier models carries the full fuel pump current. It turns out that it wasn't a very good idea.

The entire EFI system is grounded through two ring terminals bolted to the rear of the left head. Check!

- **Surges at idle.** If it runs OK when dead cold, but becomes unstable after a moment, resolder the large capacitors inside the ECU. The lambda circuit may be acting up once the lambda sensors come on line.

Make sure the throttle pot is adjusted correctly and isn't worn out.

If the the timing is retarded or the mixture is too lean for any reason, it may surge at idle.

- **Surges while cruising on level ground.** Also called “trailer hitching” because it feels like you're towing a trailer and the hitch ball is too small. Your throttle potentiometer may be worn out. If it's a TR8 or older SD1, good luck. The pot is No Longer Available. The almost exact replacement from an XJS is also NLA. Sometimes you can do delicate surgery on the pot and shift the wiper's contact path, but it's fussy work and often doesn't last. Some ingenuity and a home-made mount may make the throttle pot from a '90 Corvette fit - or not.
- **Too rich, too lean.** Manifold air leaks make it run lean. *All* the air entering the engine must be accounted for. If the crankcase ventilation system has been modified, it might be admitting too much fresh air. The brake vacuum servo might be leaking. Check all the rubber hoses attached to the intake.

If the air flow meter has gotten damp under its plastic cover, it might be corroded and may make the mixture very rich or lean. Rust in the fuel can clog the injectors, making things too lean.

Lambda sensors *do* wear out. Bad fuel can foul the sensors, too. MTBE is evil in sooooo many ways. If the car has been sitting for months or years, replace the fuel and run it for a couple of hours. If you have disconnected a lambda sensor, do not ground the wire. It will make the engine run rich.

If the coolant sensor goes bad, it usually runs extremely rich. An intermittent sensor isn't unusual.

If a spark plug is fouled, the ECU gets fooled and will make that bank of cylinders run rich. A bad spark plug wire will do the same thing.

An intermittent wire to any of the sensors can cause a very rich or lean condition.

- **Hot start problems.** Use a pressure gauge to verify that the system retains pressure when not running. Check for a good spark (that damn Lucas ignition, again). If the flap in the air flow meter sticks when it is heat-soaked, the system will be too lean to start. The condition is badly aggravated if the starter cranks slowly when hot. Floor the throttle while cranking to allow enough air to flow through the AFM to break the flap loose – it works for me. Get a starter heat shield or a gear reduction starter to speed things up.

Operation

All parts referred to in the following discussion are shown in the included schematics.

The ECU operates in "open loop" mode - ignoring the lambda sensors - until the engine coolant sensor reaches about 30° C. The lambda sensor circuit modifies the air/fuel ratio by changing the intake air temperature signal, causing the ECU to think that the incoming air is more or less dense than it actually is.

Unlike many other FI systems, the stock US 4CU stays in closed loop mode even at wide open throttle.

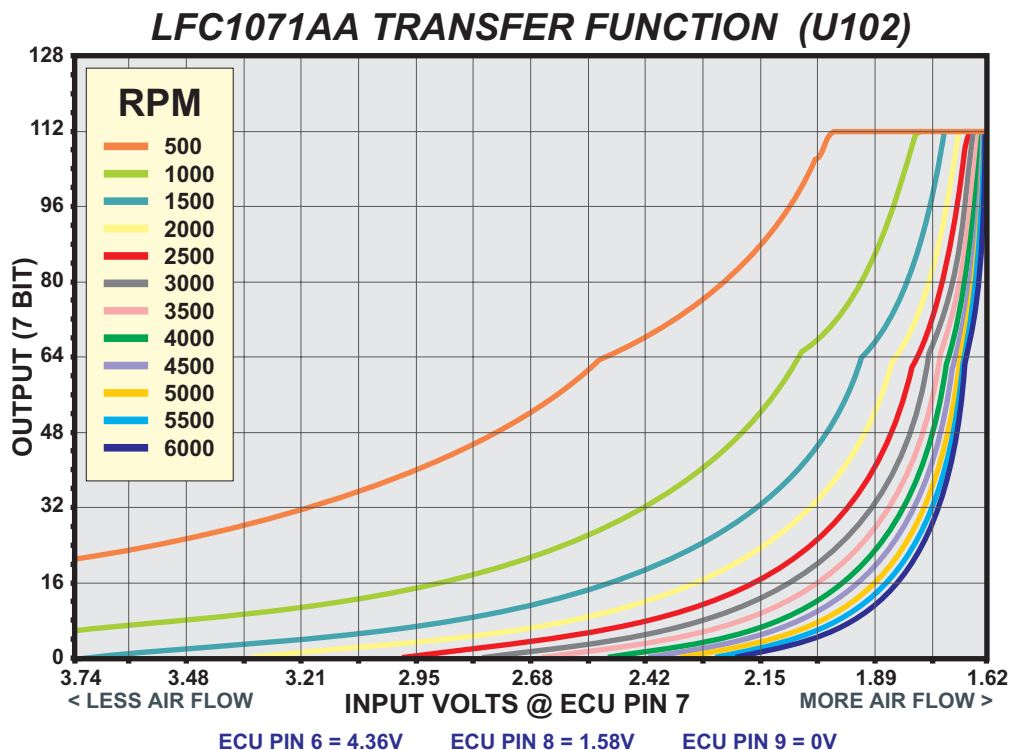
- Many non-US SD1s and Range Rovers (until '89) use a version of the the 4CU ECU with the lambda circuit components removed from the circuit board. Additionally, they use a circuit to enrich the mixture at throttle openings greater than 75%. The US 4CU includes all the required components except one - R901. Putting a 220K resistor in for R901 should give extra enrichment at full throttle. If D803 is added, the ECU will switch to open loop operation at full throttle as well.

The enrichment signal developed on the lambda board is labeled "lambda out" on the schematic. In closed loop mode it is pulled toward Vcc by R909, R910 and R911 and pulled toward ground by the open collector output of U901C through R908. The lambda sensors contribute their opinion through R825 or R828. In open loop mode, the enrichment signal is pulled closer to Vcc by R907 and R908 in parallel with R909, R910 and R911. Judicious adjustment of the resistors can tailor the response as needed.

The accelerator pump circuit is largely separate from the main control logic. It reads several signals, does some digital and analog stuff and controls the injector drivers in parallel with the main control circuit. Replacing missing components D903 and R912 should result in more aggressive accelerator pump action. I don't know what the best value for R912 is. The throttle position sensor also provides an enrichment signal to U101 through the part of the circuit connected to "Pad A".

The ECU can be forced to operate open loop by grounding pin 19 of the wiring harness connector. In a Jaguar XJS, this is used to put the system in open loop mode when the automatic transmission is in Park because the V12 lambda sensors cool down while idling and stop working properly. Although the contact is missing from the TR8 connector, position 20 does have an unused contact attached to a blue/purple wire. After cutting that wire at its little three wire splice "stub" just inside the firewall grommet, a little careful work with a paper clip will release the contact inside the connector and allow it to be moved to position 19. You can add a switch that will put the ECU into and out of closed loop mode for tune ups, etc.

The following graph shows what the analog-to-digital converter chip does. It reads the air flow meter and tachometer signals and derives a 7 bit number that represents engine load, acting as a "virtual vacuum gauge". Coasting downhill with a closed throttle outputs a low load number (high RPM with little air flow), while wide open acceleration causes higher air flow at a lower RPM and outputs a high load number. I don't know why it only goes to 112 instead of 127 – one of these days I'll re-run the test.

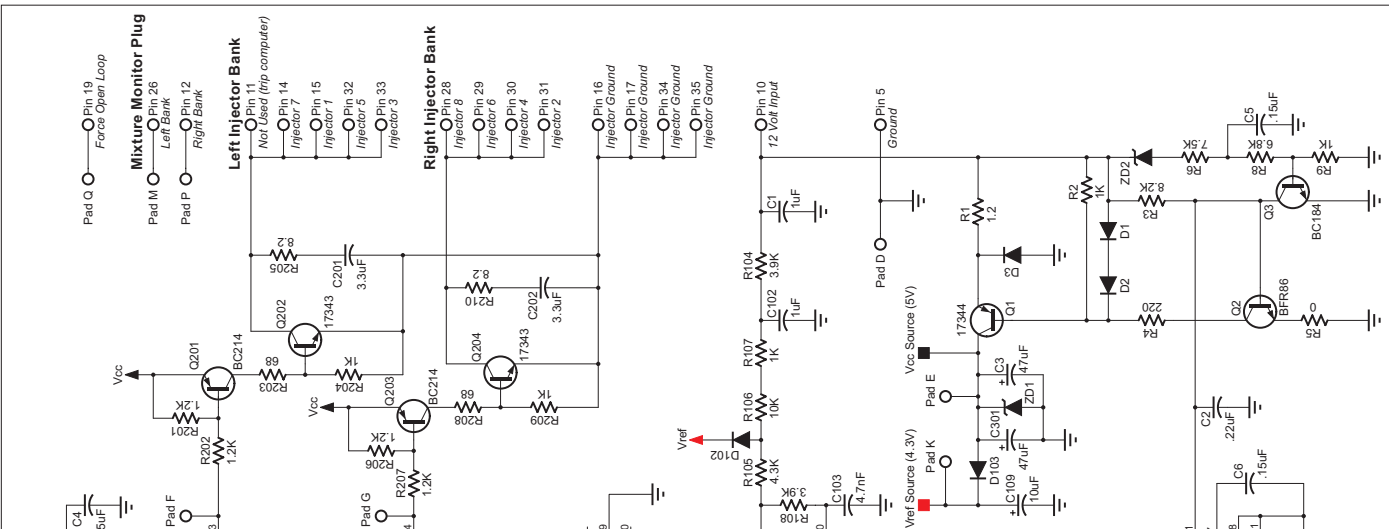
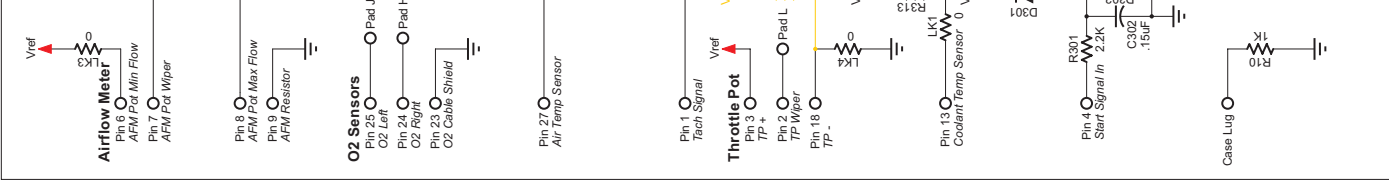


I haven't tried any of this modification stuff myself. In the USA, the EPA says mods are for off-road use only. Neither Lucas nor Rover have provided any information to me. There are numerous versions of the 4CU that have different component values. I do not warranty any of this propaganda; use it at your own risk. I have been called an idiot, now and then. Remember: British and American fuse ratings are very different.

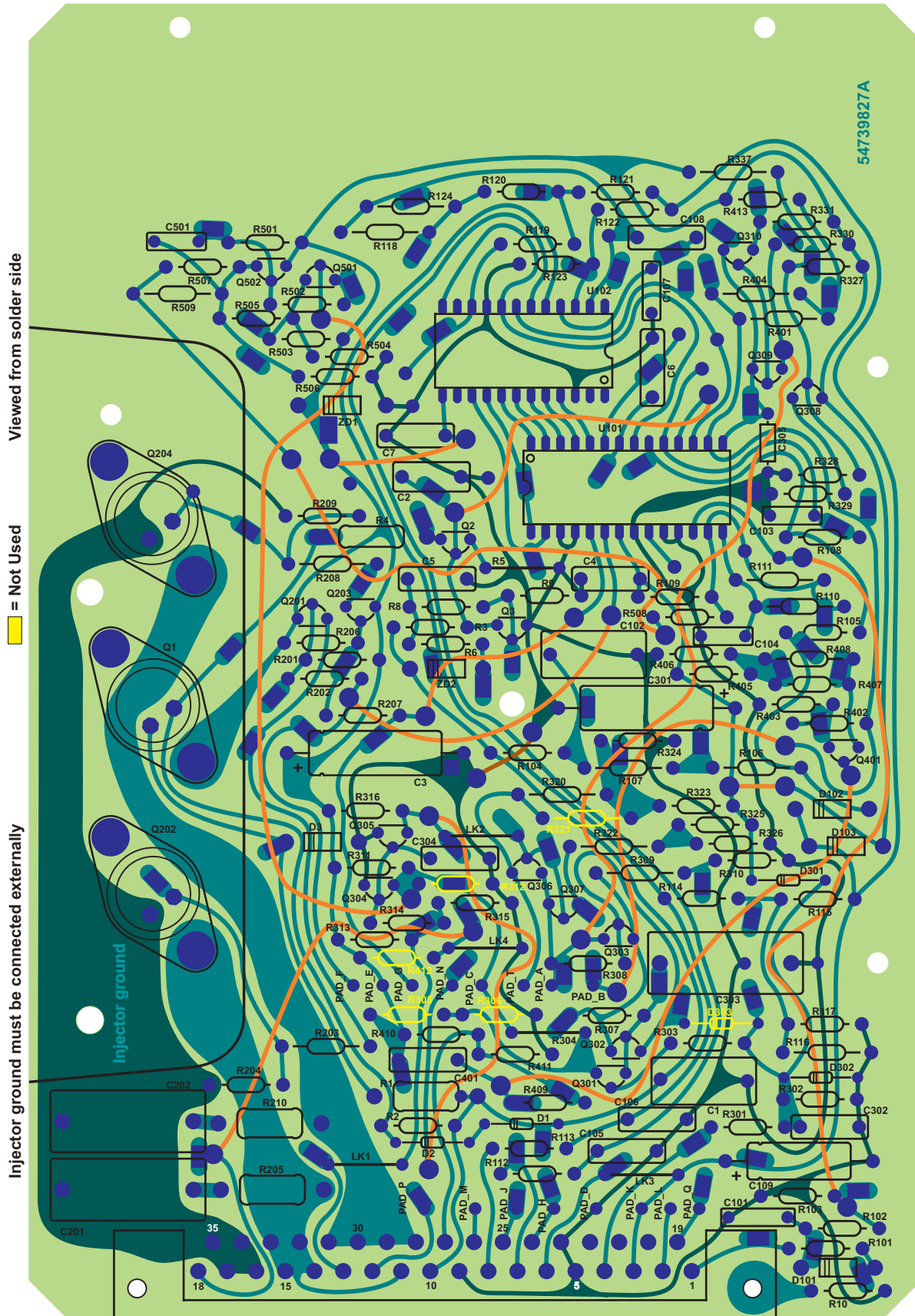
U.S. TR8/SD1 Logic Board

Lucas™ Model 4CU
 Fuel Injection ECU
 1981 Triumph TR8
 Page 1 of 2 - Logic Board
 Gene Thompson 1998 Rev C
 NOTE: Resistor values may vary

= NOT USED



U.S. TR8/SD1 Logic Board – Solder Side



Gene Thompson 2000 (rev B)

#83617A

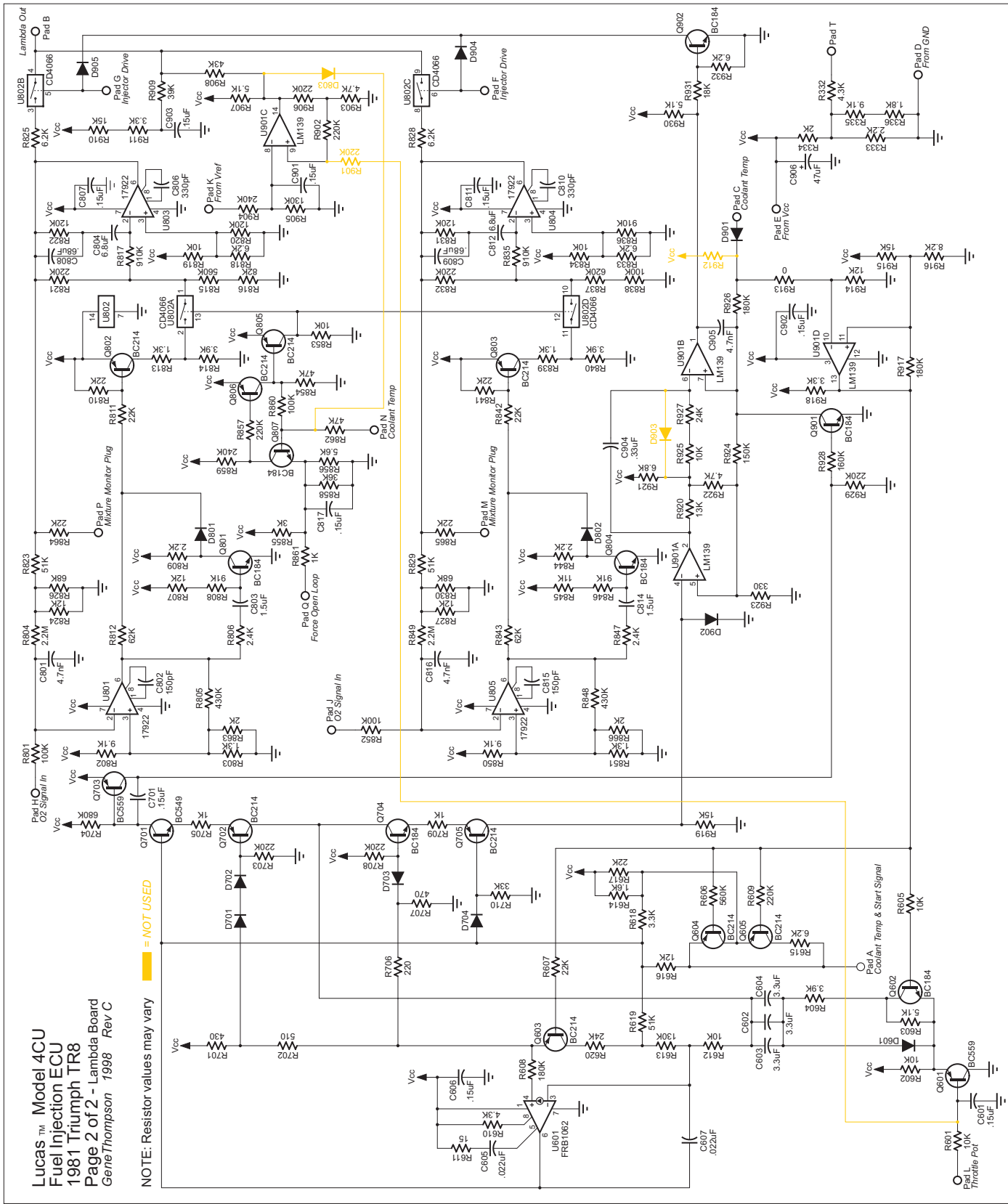
1981 TRIUMPH TR8 FUEL INJECTION ECU - LOGIC BOARD - 4CU

U.S. TR8/SD1 Lambda Board

Lucas™ Model 4CU
 Fuel Injection ECU
 1981 Triumph TR8
 Page 2 of 2 - Lambda Board
 Gene Thompson 1998 Rev C

NOTE: Resistor values may vary

 = NOT USED



U.S. TR8/SD1 Lambda Board - Solder Side



Viewed from solder side

■ = Not Used

54739835A

Gene Thompson 2000 (rev B)

1981 TRIUMPH TR8 FUEL INJECTION ECU - LAMBDA BOARD - 4CU #83617A

U.K. SD1/Range Rover Logic Board

Range Rover component values courtesy of:
Andy Perry
(c/o Chris Barnes)

Lucas™ Model 4CU
Fuel Injection ECU
Range Rover
Page 1 of 2 - Logic Board
Gene Thompson 2003 Rev A (unused parts not shown)
NOTE: Resistor values may vary

Airflow Meter
Pin 6 O AFM Pot Top
Pin 7 O AFM Pot Wiper

O2 Sensors
Pin 8 O AFM Pot Bottom
Pin 9 O AFM Resistor
Pin 24 O O2 Left
Pin 24 O O2 Right
Pin 23 O O2 Coarse Shield

Pin 27 O Air Temp Sensor

Pin 1 O Throttle Pot
Pin 3 O TP +
Pin 2 O TP Wiper
Pin 18 O TP -

Pin 13 O Coolant Temp Sensor

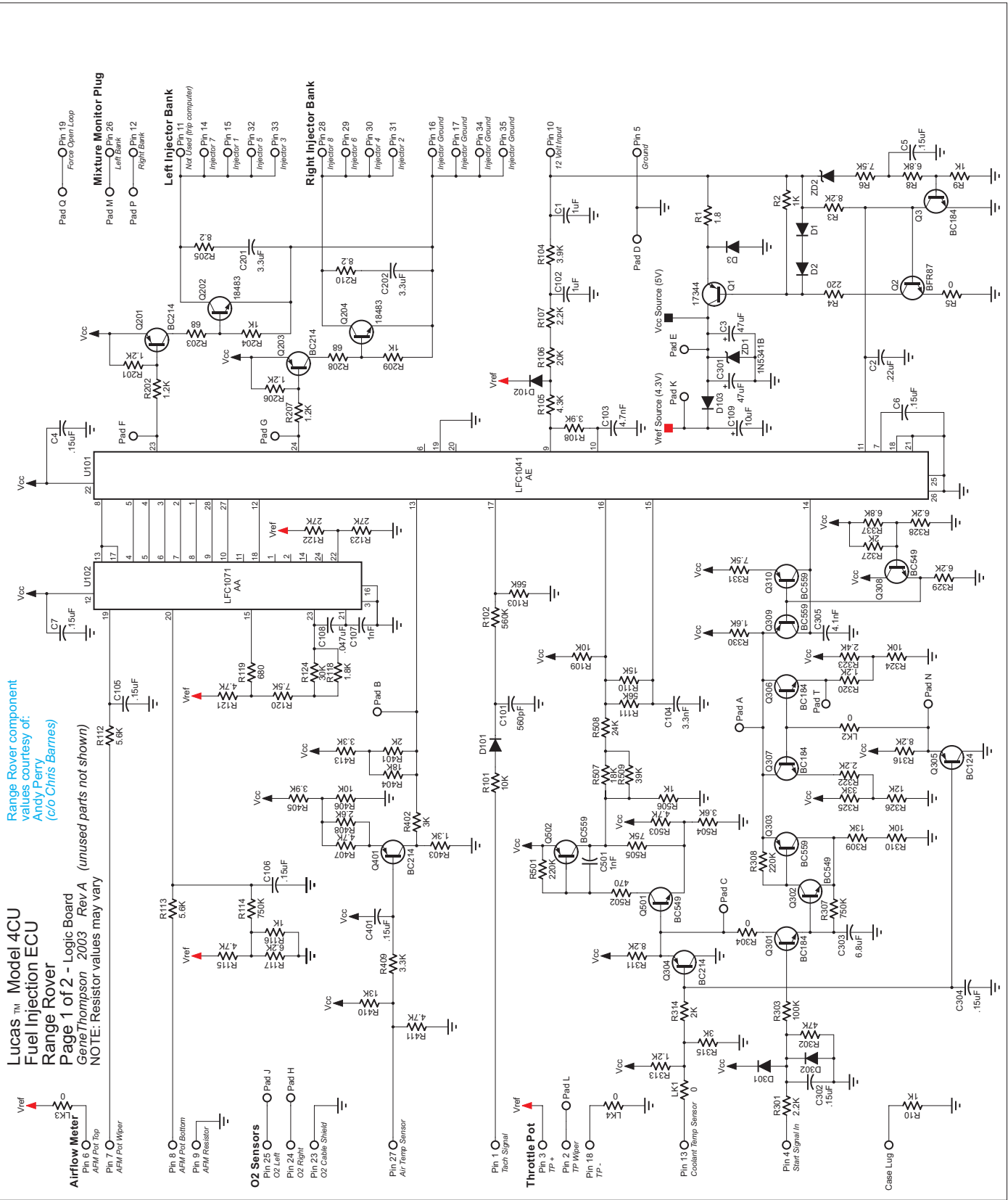
Pin 4 O Start Signal In

Case Lug O

Pad Q O Pin 19 Force Open Loop
Pad M O Pin 26 Left Bank
Pad P O Pin 12 Right Bank

Left Injector Bank
Not Used (rip computer)
Pin 11 Injector 7
Pin 14 Injector 7
Pin 15 Injector 1
Pin 32 Injector 5
Pin 33 Injector 3

Right Injector Bank
Pin 28 Injector 8
Pin 29 Injector 6
Pin 30 Injector 4
Pin 31 Injector 2

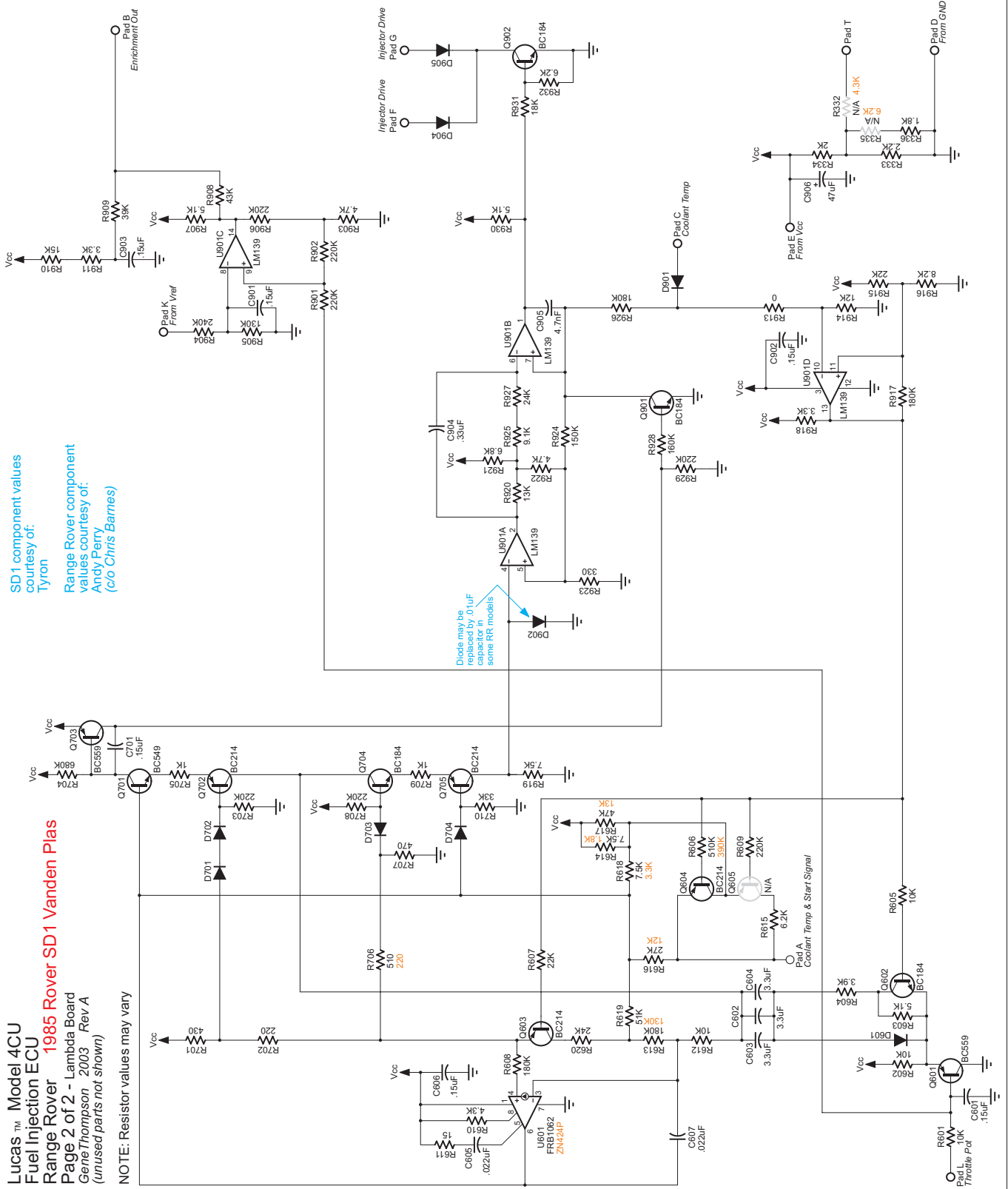


U.K. SD1/Range Rover Lambda Board

Lucas™ Model 4CU
 Fuel Injection ECU
 Range Rover 1985 Rover SD1 Vanden Plas
 Page 2 of 2 - Lambda Board
 Gene Thompson, 2003, Rev A
 (unused parts not shown)

NOTE: Resistor values may vary

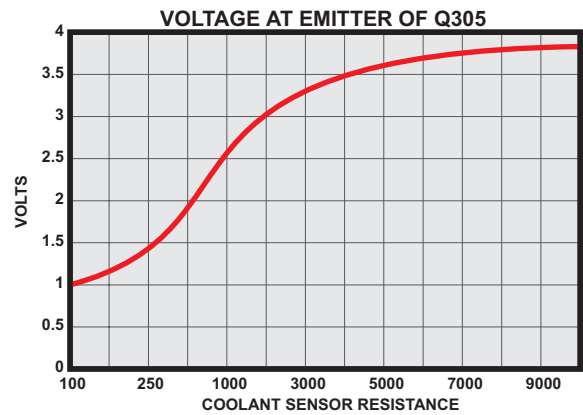
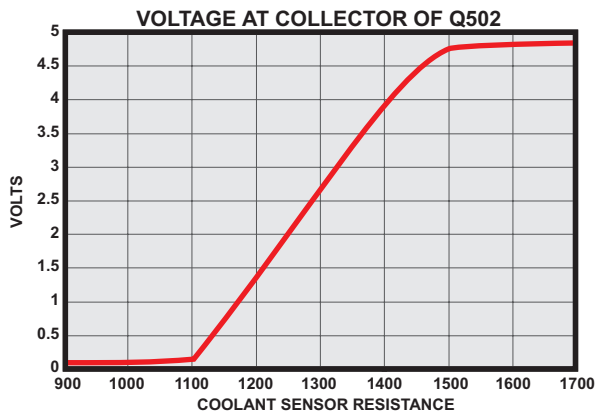
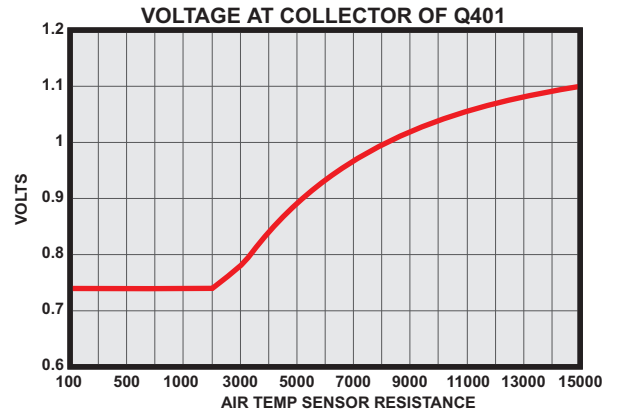
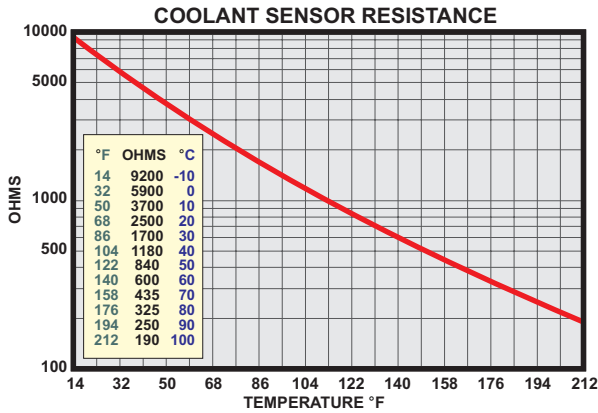
SD1 component values
 courtesy of:
 Tyron
 Range Rover component
 values courtesy of:
 Andy Perry,
 (c/o Chris Barnes)



U.K. SD1/Range Rover Lambda Board - Solder Side



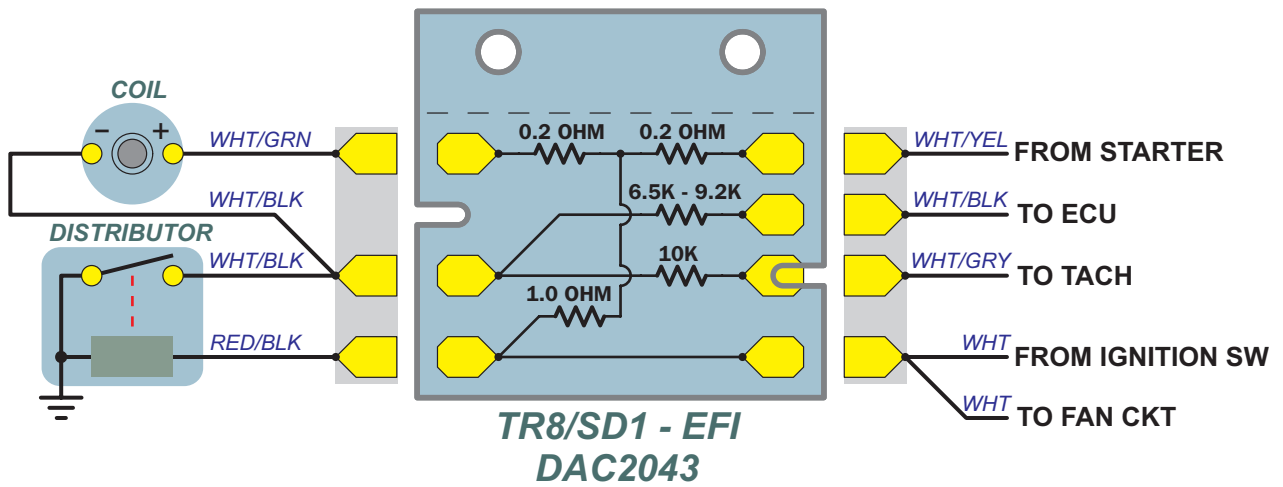
Miscellaneous Data



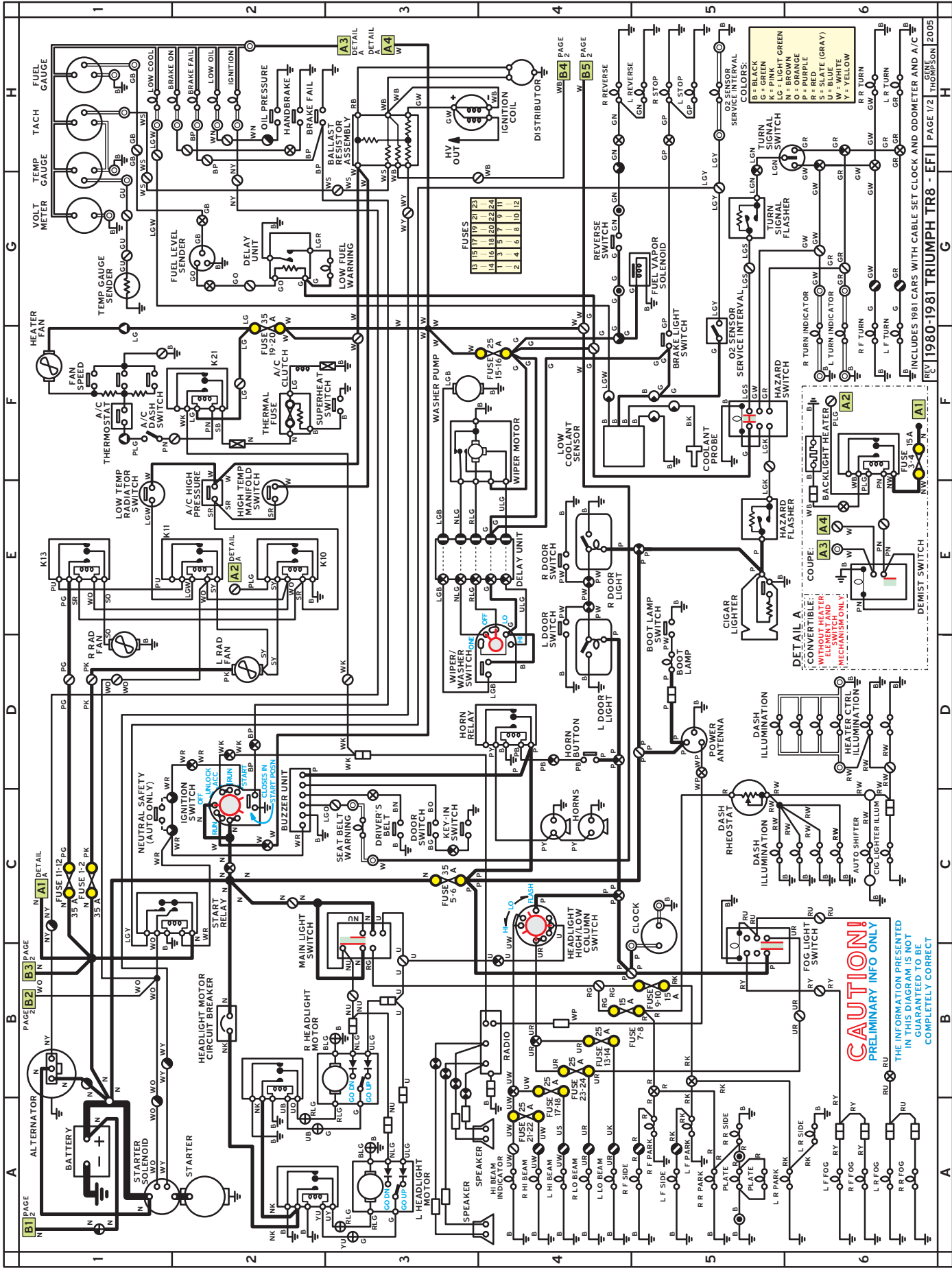
TR8 Ignition Ballast

FORWARD ↑

TOP VIEW - AS INSTALLED



A final note about resistor values in the ECU: The color bands on resistors can be tricky. Depending on the light and the manufacturer, brown looks like red; red looks like orange; violet looks like black or blue. When in doubt, pull one end and check with an ohmmeter.

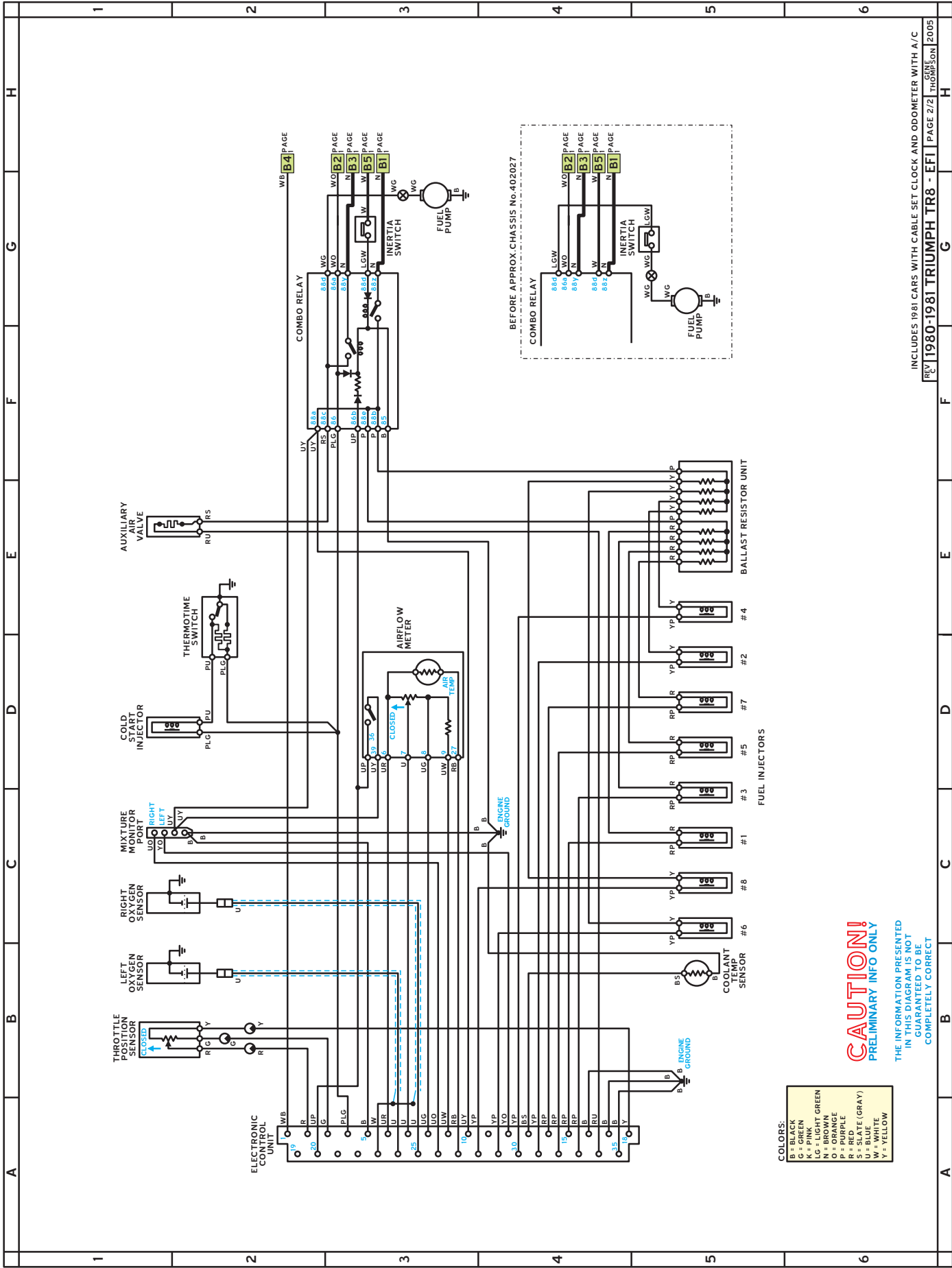


COLORS:
 B = BLACK
 G = GREEN
 LG = LIGHT GREEN
 N = BROWN
 O = ORANGE
 R = RED
 U = BLUE
 Y = YELLOW

CAUTION!
 THE INFORMATION PRESENTED
 IN THIS DIAGRAM IS NOT
 GUARANTEED TO BE
 COMPLETELY CORRECT

INCLUDES 1981 CARS WITH CABLE SET CLOCK AND ODOMETER AND A/C

© 1980-1981 TRIUMPH TR8 - EFI PAGE 1/2 THOMPSON 2005



COLORS:
 B = BLACK
 G = GREEN
 K = PINK
 L = LIGHT GREEN
 N = BROWN
 O = ORANGE
 P = PURPLE
 R = REDDIE (GRAY)
 U = BLUE
 W = WHITE
 Y = YELLOW

CAUTION!
 PRELIMINARY INFO ONLY
 THE INFORMATION PRESENTED
 IN THIS DIAGRAM IS NOT
 GUARANTEED TO BE
 COMPLETELY CORRECT