Double Relay Explained. . . In Color!

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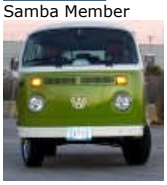
Author **Message**

Amskeptic
Samba Member

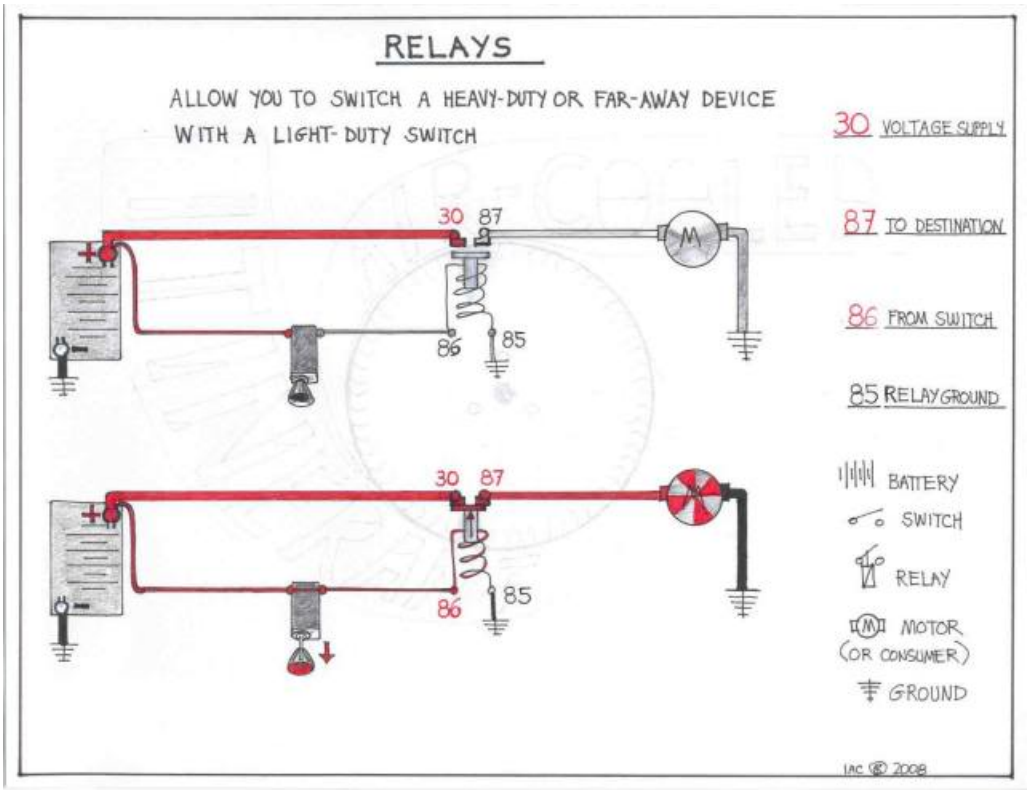


Joined: October 18, 2002
Posts: 5993
Location: All Across The Country
offline

Posted: Mon Dec 22, 2008 10:23 pm Post subject: Double Relay Explained. . . In Color! quote

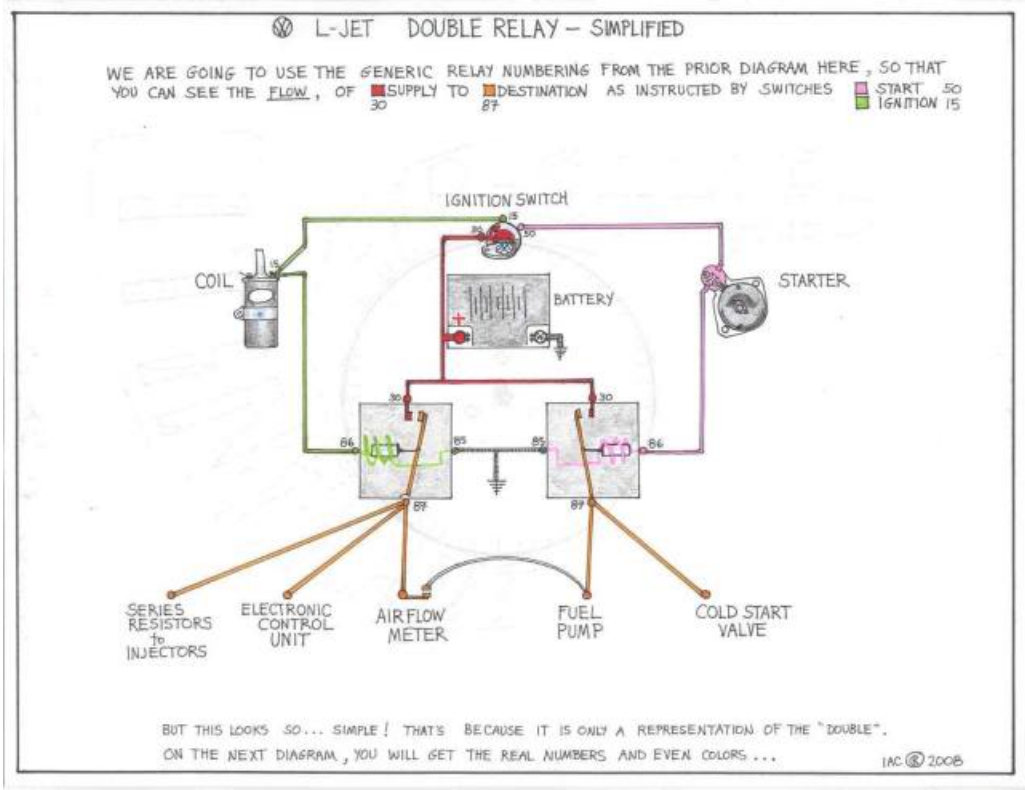
Relays allow you to switch heavy duty or far away devices with light duty switches.
In the case of the rear-engined VW, we get to instruct the starter to turn over the engine with a very light wire telling the starter relay to hook up the heavy duty battery cable with the equally heavy duty starter motor wire.

The convention with generic German car relay numbering is that the power supply wire is designated #30, the destination wire is #87, the instruction wire is #86, and the ground wire is #85.

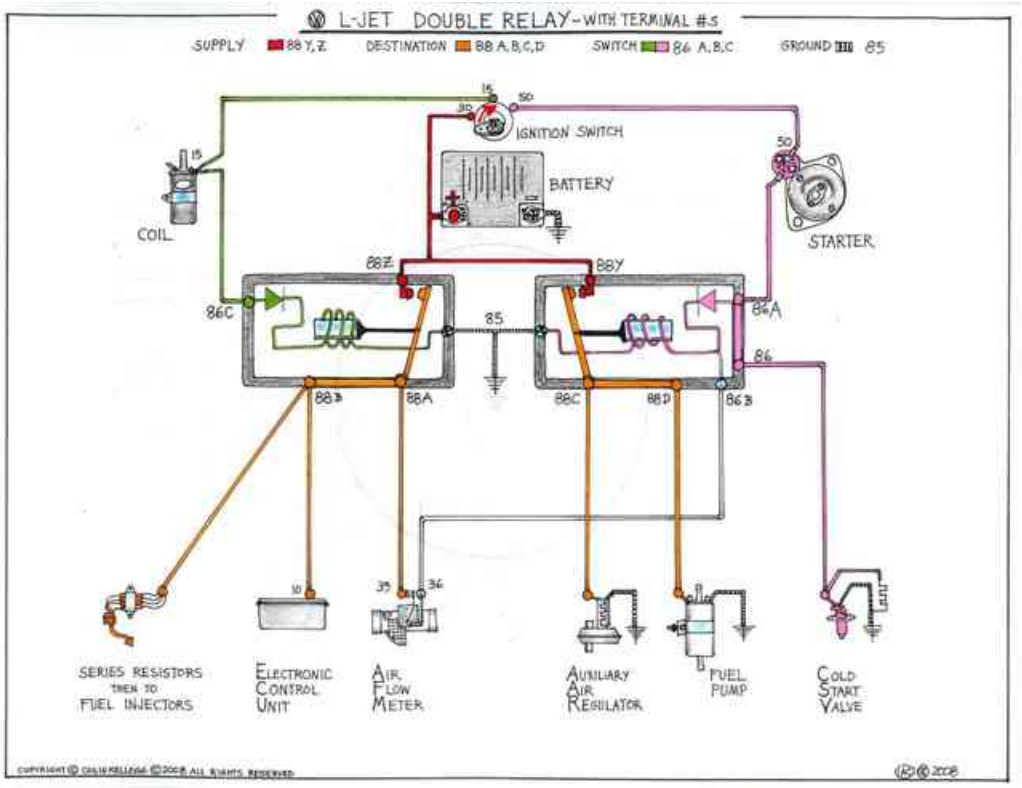


In German car wiring diagrams, #30 is used not only on relays, but any time a wire is "hot". If your battery is hooked up and charged, expect full voltage at any #30 terminal you happen across. #15 is found wherever you get battery voltage when the ignition key is turned to the "on" position, that would include the #15 terminal on your ignition coil. #50 is used for any wire that receives voltage when the key is at "start."

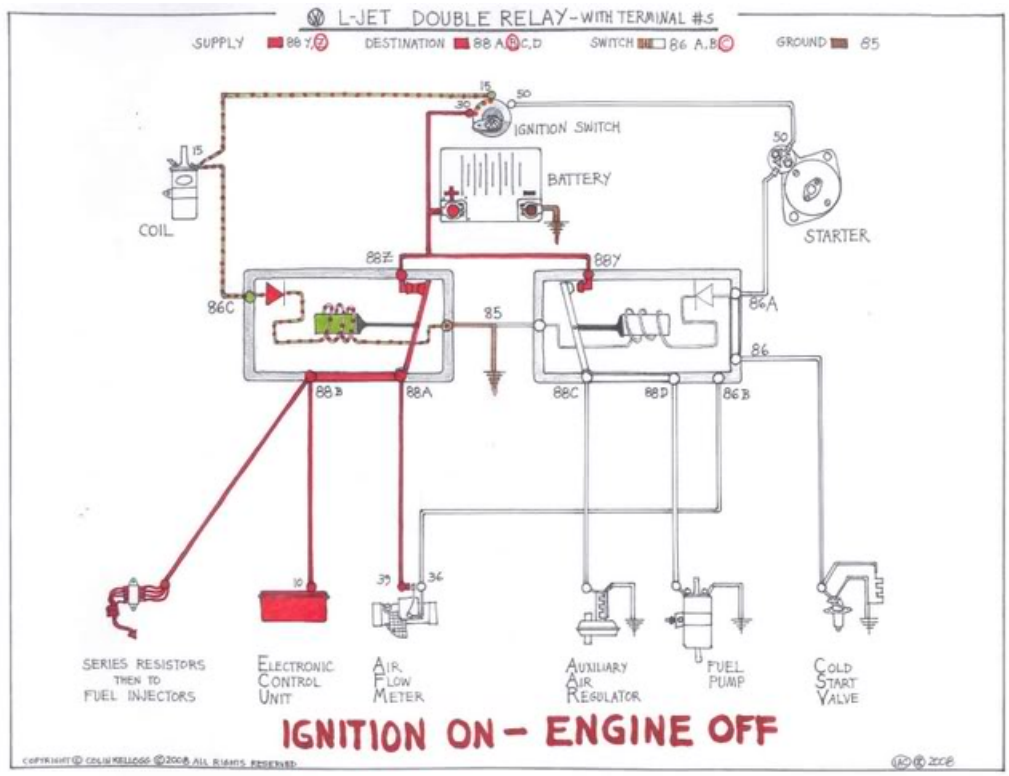
So here is our generic, simplified double relay diagram with conventional numbering just for us. All the double relay does is two things:
1) Supply voltage to the fuel injection system when the ignition is on.
2) Supply voltage to the fuel pump under two specific instructions,
a) when starting,
b) when the engine has informed the relay that it is now running under its own power.



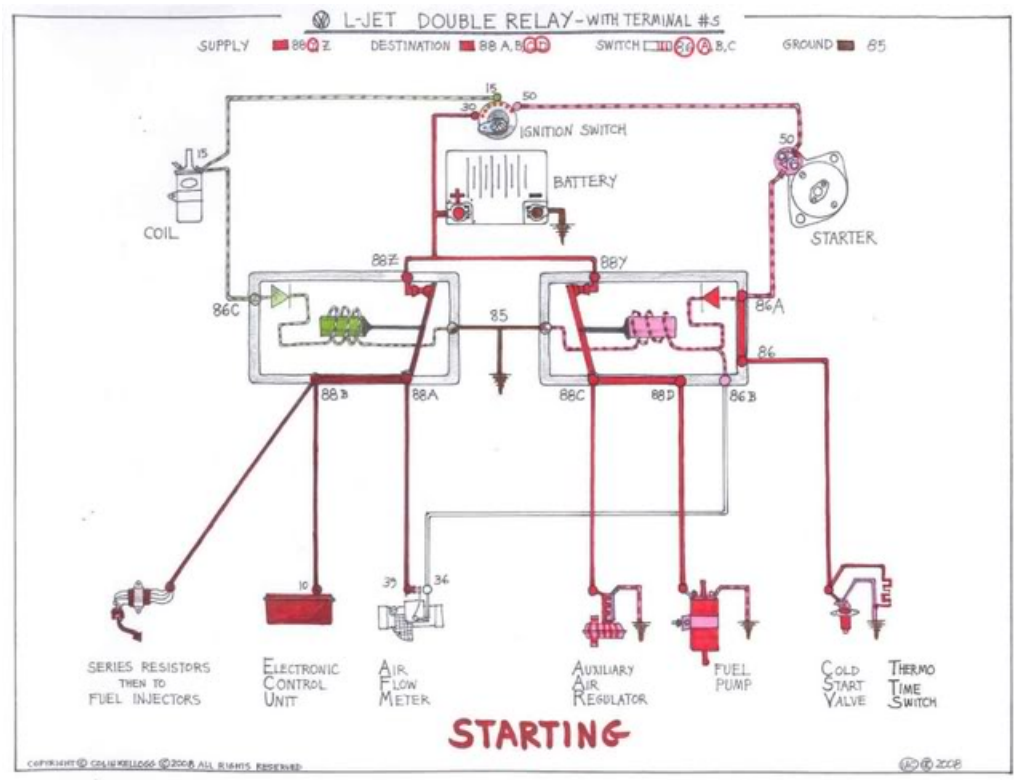
Alas, it cannot be so simple. You will also see only little adherence to the German electrical system numbering conventions at the double relay itself. But if you compare the colors used in the above generic diagram to the colors below in the actual current path diagram of your Volkswagen L-Jetronic fuel injection system, you will see the simple functions of the double relay. The ignition circuit is colored in green and it instructs the *power* relay to provide voltage to the injectors, via the voltage dropping "series resistors", and the Electronic Control Unit. The starting circuit is colored in pink. It runs the *fuel pump* relay which supplies voltage to the fuel pump, and the Auxiliary Air Regulator.



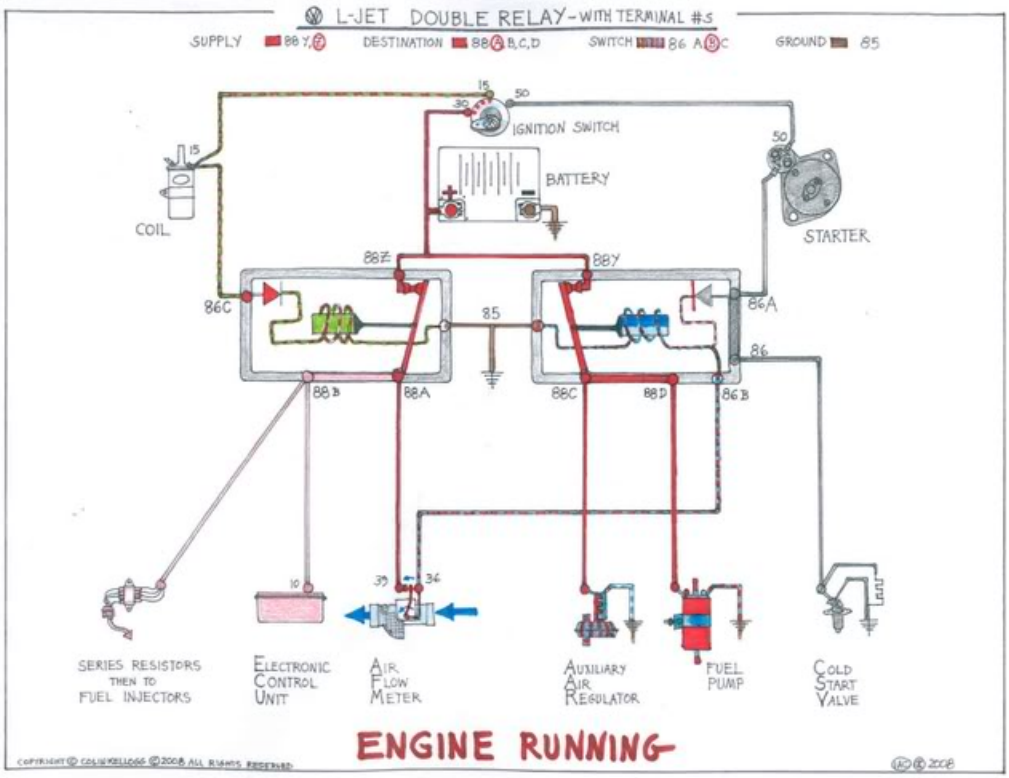
Let's run you through the sequence: First, we turn on the ignition. Power relay gets energized and the ECU and series resistors have voltage. The engine is not turning though, so we certainly don't need a fuel pump just yet. Ignition On - Engine Off:



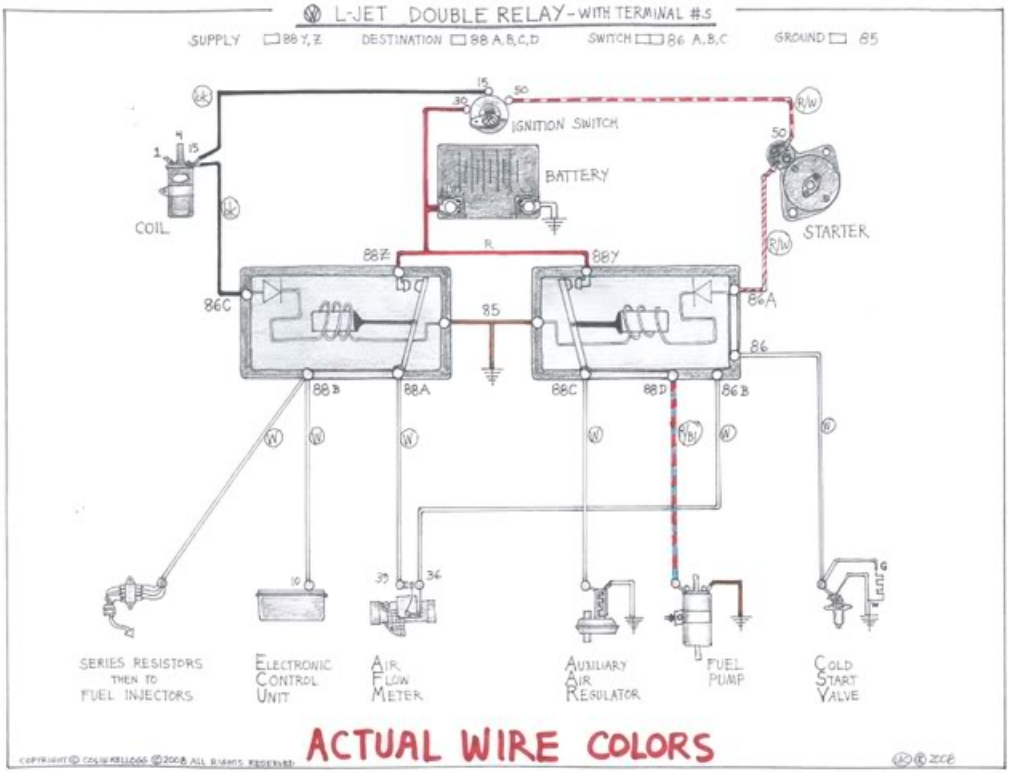
But, as soon as we turn the ignition key to "start" we need fuel pump and we need some cold starting assistance. (the ignition side is energized as above, but I have darkened the display to keep you focused on the starting side) With the ignition key at #50, voltage is supplied to the starter which is now turning over the engine. Voltage also continues to the double relay where the fuel pump relay is energized and connects supply voltage to the fuel pump and the Auxiliary Air Regulator (it only needs voltage to energize a timed heater). You will note (!) that there is another circuit that is energized OUTSIDE of the double relay function, the 86a > 86 terminals are "bussed" and voltage goes down to the cold start valve quite independently of anything going on inside the double relay. The cold start valve is limited to operating only when the starter #50 circuit is energized, and it shuts off when the Thermo Time Switch cuts the ground path. Like the Auxiliary Air Regulator, the Thermo Time Switch only needs voltage to energize an even faster timed heater than the AAR's.
Starting:



When the engine starts, we release the ignition key. The starter circuit drops out. The CSV and TTS are cut off as well. And inside the double relay, the fuel pump relay is going to want to drop out as well. . . . but, it doesn't. Thanks to the Air Flow Meter, which has determined that the engine is running all by itself, the power relay voltage that has been supplied to terminal #88a to the AFM all of this time, now gets to return to the fuel pump relay through 86b, illustrated with a shocking blue/red striped wire. There is a diode inside the relay that prevents the AFM voltage from running out to try to engage the starter and cold start valve, so all that happens is that the fuel pump and AAR are allowed to continue to run only so long as the AFM is reading air flow. If you stall the engine, well, consult "Ignition On - Engine Off" diagram.
Engine Running:

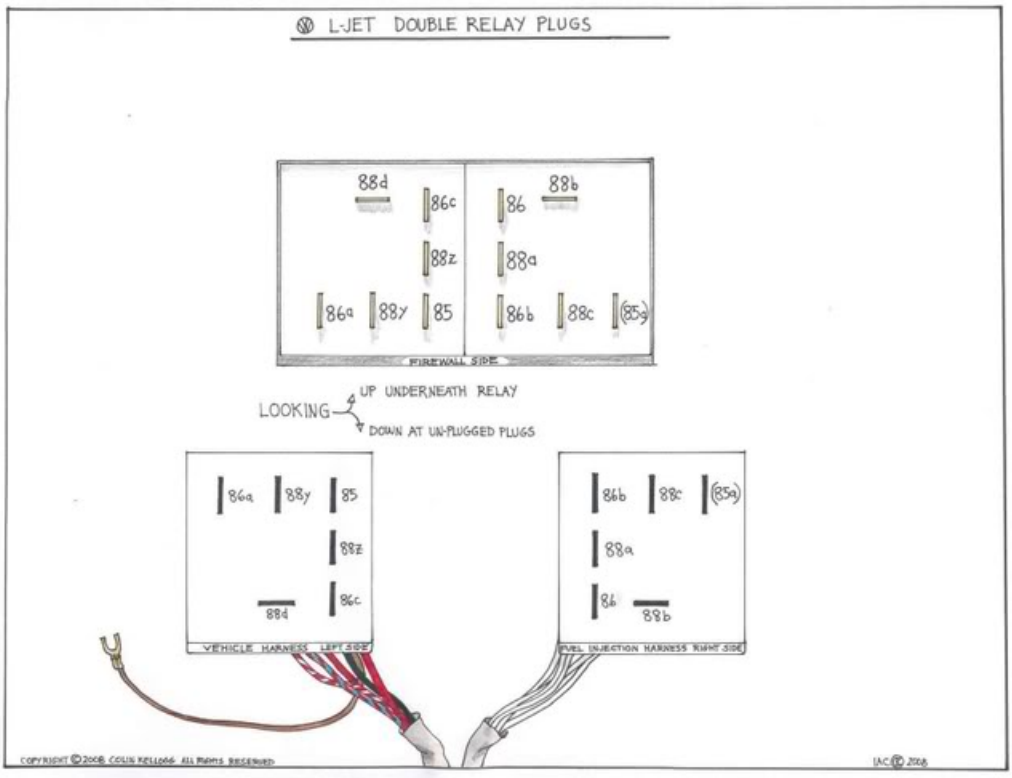


Actual wire colors and locations are unfortunately not nearly so beautiful as depicted. This might be a good thing. All wiring in the L-Jet fuel injection system is white. Vehicle wiring is color-coded.
Actual Wire Colors:



Now this is disappointing. After that nice elegant distribution of terminals in a logical way in all of the above

diagrams, I have to show you the actual layout. It looks willy-nilly, but it is what VW/Bosch had to do to separate the vehicle harness from the fuel injection harness, and still get all the tracks and bus bars laid out inside the double relay. The view of the relay underside is as if you laid it on its firewall "back" side. The plugs are oriented as if you just pulled them off and stared down at them. The left plug is the vehicle harness, you can see multi-colored wires. The right plug is all white wires leading into their harness. People get confused trying to read the terminal designations on the relay and then transposing the correct terminal number onto the correct plug "slot", so here I have labelled both the double relay terminals and the plug terminals.



Note that with the correct wiring colors on the preceding diagram, you can catch that blue/red wire on the left and know instantly that it is the fuel pump supply wire coming from relay terminal #88d. From here on out, you will know that if your car refuses to start readily when cold, you can double check the red/white wire from the starter solenoid #50 terminal to make sure it is sending voltage to the double relay #86a where it buses right back out from #86 to fire up the CSV Cold Start Valve.
Enjoy. This is not terribly complicated stuff, just annoying when wires and terminals get all bunched up and you can't read designations. More to come. . .
Colin
(if your specific bus has slightly different terminal designations, do not panic. For example, the late '78-'79 buses grounded the relays internally instead of the outside wire trapped under the bracket screw. '76 buses had an electrically-controlled EGR that borrowed off the double relay. The entire series resistor pack was deleted when they discovered that they get the same voltage drop within the wires to the injectors, roll with it)

_____
now huckstering my art . . .
www.zazzle.com/73vw1800
www.itinerant-air-cooled.com

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regis101
Samba Member

Joined: July 28, 2005
Posts: 1327
Location: Livermore, Ca
offline

Posted: Mon Dec 22, 2008 10:56 pm Post subject: quote

Very Nice.
I'm looking at the schematic(s) in the Bentley. Our 78 Cali uses the 11 pin relay. I see 12 pins on the drawings. The difference being 85 and 85a which are grounds. No big.

The 79 Cali uses a 13 pin. Pretty much the same except for power taken to the injectors for cylinders 1 & 2 and 3 &

4.

(roll with it) quote, unquote

Thanks,

_____
Peace, Regis
78 campr
http://vwcamperfamily.ning.com/

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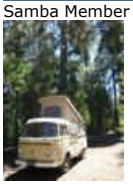
evanwilliams4u
Samba Member



Joined: December 16, 2008
Posts: 88
Location: California

offline

Posted: Mon Dec 22, 2008 11:12 pm Post subject: quote

Nice drawings. It's a real talent to be able to bring life into wiring schematics, and helpful too!

_____
1978 Stock Westfalia Deluxe

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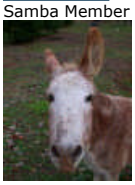
Wildthings
Samba Member



Joined: March 13, 2005
Posts: 9215

offline

Posted: Tue Dec 23, 2008 12:46 am Post subject: quote

In the second drawing labeled L-jet Double Relay Simplified the cold start valve is wired wrong. It is not fed power off the relay at terminal 88d , but gets its power from the trigger circuit (#50) for the relay at terminal 86, as shown in the more detailed drawings.

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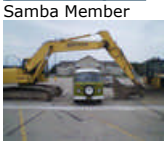
greenbus pilot
Samba Member



Joined: March 14, 2008
Posts: 788
Location: Wisconsin: Rustbelt, USA baby!!

offline

Posted: Tue Dec 23, 2008 12:48 am Post subject: quote

Wow Colin, very nice! At last, an easy to read explanation all laid out in color.
So, when is your book gonna be out?

_____
Why the hell should I have to press 1 for English?

No warning shots will be fired.....

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asafk
Samba Member

Joined: April 15, 2008
Posts: 62

offline

Posted: Tue Dec 23, 2008 1:28 am Post subject: quote

Looking at the wiring diagram of the '78 L-jet, I see a resistor in line with 86b. I don't see it in the very helpful drawing you've made. what do I miss? (I usually miss something...)

Asaf.

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Amskeptic
Samba Member

Posted: Tue Dec 23, 2008 1:31 am Post subject: quote

Wildthings wrote:

> In the second drawing labeled L-jet Double Relay Simplified the cold start valve is wired wrong. It is not fed

> power off the relay at terminal 88d , but gets its power from the trigger circuit (#50) for the relay at terminal 86, as shown in the more detailed drawings.

Ya rope em slowly, Wildthings. That picture was just to get the conceptual flow established, that is why I used INCORRECT terminal numbering as well. . .
Colin

Joined: October 18, 2002
Posts: 5993
Location: All Across The Country
offline

now huckstering my art . . .
www.zazzle.com/73vw1800
www.itinerant-air-cooled.com

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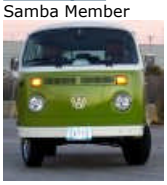
Amskeptic
Samba Member



Posted: Tue Dec 23, 2008 1:41 am Post subject: quote

> **asafk wrote:**
> Looking at the wiring diagram of the '78 L-jet, I see a resistor in line with 86b. I don't see it in the very helpful drawing you've made. what do I miss? (I usually miss something...)
> Asaf.

Joined: October 18, 2002
Posts: 5993
Location: All Across The Country
offline

As I mentioned to Wildthings, I am most interested in people getting the concept down, and seeing how the factory answered the question, "how do we get the fuel pump to run during start and run only after the engine has proved that it is running?"

I didn't think that was the place to chase down the arcana of resistance to not only limit the current through the AFM 36/39 contacts to help them last longer but also setting the threshold for the diode as per this thrilling aside:

> **Quote:**
> Diodes are components that allow current to flow in only one direction. They have a positive side (leg) and a negative side. When the voltage on the positive leg is higher than on the negative leg then current flows through the diode (the resistance is very low). When the voltage is lower on the positive leg than on the negative leg then the current does not flow (the resistance is very high). The negative leg of a diode is the one with the line closest to it. It is called the cathode. The postive end is called the anode.
> Usually when current is flowing through a diode, the voltage on the positive leg is **0.65 volts higher than on the negative** (the resisted) leg.

now huckstering my art . . .
www.zazzle.com/73vw1800
www.itinerant-air-cooled.com

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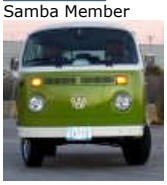
Amskeptic
Samba Member



Posted: Tue Dec 23, 2008 1:46 am Post subject: quote

> **greenbus pilot wrote:**
> Wow Colin, very nice! At last, an easy to read explanation all laid out in color.
> So, when is your book gonna be out?

Joined: October 18, 2002
Posts: 5993
Location: All Across The Country
offline

Man, I am in the thick of it. I wonder if it will have a market if we continue to suffer this economy. Jobless and bored? Read this book about that classic car you don't want to sell with EZ On The Eye Illustrations. I dunno. Still working on it. Want it done!
Colin

now huckstering my art . . .
www.zazzle.com/73vw1800
www.itinerant-air-cooled.com

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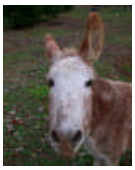
Wildthings
Samba Member

Posted: Tue Dec 23, 2008 2:25 am Post subject: quote

Seems like posting a conceptual drawing that is incorrect is kind of like roping a fence post. Causes that conceptual



flow to come to a stop pretty quick.

Joined: March 13, 2005
Posts: 9215

offline

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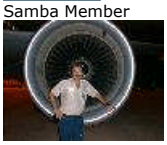
aeromech
Samba Member



Posted: Tue Dec 23, 2008 8:15 am Post subject: quote

Amskeptic, thanks for the great posting. i could have used that a couple months ago.

Joined: January 24, 2006
Posts: 2001

offline

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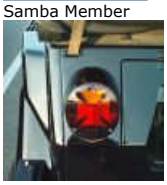
dan macmillan
Samba Member



Posted: Tue Dec 23, 2008 9:00 am Post subject: quote

Quote:

> Wildthings
>
> In the second drawing labeled L-jet Double Relay Simplified the cold start valve is wired wrong. It is not fed power off the relay at terminal 88d , but gets its power from the trigger circuit (#50) for the relay at terminal 86, as shown in the more detailed drawings.

Joined: October 19, 2003
Posts: 1766
Location: Northern Ontario, Canada

offline

Wildthings wrote:

> Seems like posting a conceptual drawing that is incorrect is kind of like roping a fence post. Causes that conceptual flow to come to a stop pretty quick.

Give the guy a break. He has taken what many consider to be a mystery and broken it down so anyone can understand it.
It is an over simplified version of the actual circuits used to illustrate the CONCEPT of how it works. Yes it is wired wrong BUT it will accomplish the same thing as the correctly wired diagram other than the fact that the CSV will recieve power at all times with the key on. The TTS will shut down the CSV as it warms up. [Moving the CSV circuit to term 50 of the starter and adding a diode in between term 50 and term 84 {of the double relay simplified drawing} would make it electrically correct. However. that is not necessary as the next diagram clears it up and his description makes it easy for people to follow.] The terminal designations are that of a standard relay. Keep in mind that the concept drawing uses easily obtainable, low cost, standard bosch relays. Using his description and diagrams one could easily build their own double relay for under $20.00

Amskeptic, you have done an excellent Job of describing the operation of the double relay. I am sure it will help many people understand it.

_____
Licensed Automotive Service Technician
Licensed Truck and Coach Technician
Licensed Heavy Duty Equipment Technician
CFC/HCFC/HFC A/C handling and installation license
Alignment specialist
66 Modified Manx, 68 Kyote, 74 Thing, 74 Beetle, 76 Transporter, 75 self made Double Cab, 65 Meyers Manx, 78 Westy
Current projects: 69 Ghia
Built for others: 69 Manx Clone

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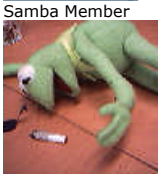
theizzardking
Samba Member



Joined: June 13, 2008
Posts: 2107
Location: seattle

offline

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Posted: Tue Dec 23, 2008 9:26 am Post subject: quote

very nice! but i'm just thinking to my self actual wire colors is kind of a relitive term as i wonder how many of my wires are og! hahaha! still very well written and clear graphics good job!

_____

"Democracy is two wolves and a lamb voting on what to have for lunch.
Liberty is a well-armed lamb contesting the vote." - Benjamin Franklin
'71 westie "the wanderer"
Fe(OH)3-xOx/2 hater.....

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busdaddy
Samba Member

Joined: February 12, 2004
Posts: 11300
Location: Surrey B.C. Canada, Land of the giant flying moose!

offline

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Posted: Tue Dec 23, 2008 9:53 am Post subject: quote

Great post Colin, trying to explain electrics to some people is like describing color to a blind man and this really helps.

_____

Rust NEVER sleeps and stock never goes out of style.

Wanted, 68-73 westy OG plaid curtains, singles OK.

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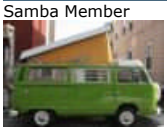
WhirledTraveller
Samba Member



Joined: January 09, 2008
Posts: 657
Location: Cambridge, MA

offline

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Posted: Tue Dec 23, 2008 9:54 am Post subject: quote

Thank you Colin!

Reading this post has suddenly resulted in an ah-ha moment for me. You know one of those moments where your brain suddenly connects totally separate facts into a revelation. I think I may have found the source of several of my troubles.

My '77 Bus fuel pump runs continuously with the ignition on. I've always known this and never really thought much about it.

Seperately, I've been having other issues... idle is poor until warmed up, and there's a hesitation when accelerating if I try to drive away right away, but then after a long highway drive it will sometimes die randomly at stops. Recently I took a long road trip and my MPG dropped each leg - 1st tank 17.5 mpg, 2nd tank 15.5 mpg, 3rd tank 14.5 mpg. Outside Temperature was dropping each leg also, and pulling into home with 11 degrees F outside the bus would occasionally die randomly at idle, then start right back up again. Exhaust smells rich at idle. I've replaced the Temp Sensor II, no change.

So now - looking at your diagrams - It occurs to me that if the fuel pump is always running due to incorrect starter wiring then the cold start valve may also be energized through the thermo-time switch. The TTS should shut the cold start valve off after 8 seconds BUT it's not intended for continuous use. It might let some current through, particularly if the temperature in the engine compartment is very low I'd imagine it would cycle on and off as the TTS turns on, heats, shuts off, cools, turns on etc, randomly killing my engine with extra fuel.

_____

1977 Green Westy Pop-Top

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Lionhart94010
Samba Member

Joined: January 04, 2005
Posts: 527
Location: SF Bay Aria / Silicon Valley

offline

Posted: Tue Dec 23, 2008 10:54 am Post subject: quote

Very nice explanation :0) thanks for the effort /contribution!

Noting to add, but want to follow this thread…

_____

71 T2 Westy SO-72/6(Miami) (Stock 1584cc with 2027cc MS FI Motor in the works)
71 T2 Crew Cab (1904cc motor in the works)
72 Karmann Ghia GT ;0) (2074cc)

Mercedes ML, Daily driver (Gets worse mileage than my 71 Camper)
Other family owned VW's over the years: 59 Bug, 64 Bug, 68 Euro Bug 1500s, 69 Bug, 71 Bug, 72 Super Beetle, 73 Square Back & 67 Westy, 67 Deluxe, Other 71 DC, 2001 Golf GLS.

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busman78
Samba Member

Posted: Tue Dec 23, 2008 1:25 pm Post subject: quote

Joined: August 17, 2004
Posts: 2728
Location: ALbuquerque, NM
offline

I am not a FI type of guy but I do applaud Colin's drawings, not everybody out in the VW world is a 100% know-it-all and thank god not as arrogant as dan.

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onion456
Samba Member

Posted: Tue Dec 23, 2008 1:42 pm Post subject: quote

Joined: September 09, 2006
Posts: 526
Location: Houston, TX
offline

allow me to be off topic by being more on topic- colin i think your drawings are outstanding- these and also i saw one about double-clutching- exceptional work. as an electronics kinda guy, i often do explanitory drawings or write-ups, and i understand the work that goes into it. yours are top notch.

'76 Sage Green Westy 2.0 FI
'76 Creamsicle 7-passenger 2.0 CS FI

> **aliennetwork wrote:**
>
> > **RIOMX wrote:**
> >
> > Out of all replies on any thread, about 4/10 are from morons who bitch or insult, rather than help out.
>
> You could have said 2/5.

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germansupplyscott
Samba Member

Posted: Tue Dec 23, 2008 2:22 pm Post subject: quote

Joined: May 26, 2004
Posts: 4660
Location: toronto
offline

please people, don't let the thread get out of control.

wildthings, dan, this has nothing to do with your vehicles or your expertise.

it's about some cool drawings that colin posted. i think they're cool, yes. if the drawing of the relay has the wrong number of terminals or a wire in the wrong spot i'm sure colin will fix it.

scott lyons
http://www.germansupply.com

VW Bus-Centric Online Parts Source

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onion456
Samba Member

Posted: Tue Dec 23, 2008 2:41 pm Post subject: quote

Joined: September 09, 2006
Posts: 526
Location: Houston, TX
offline

i see the 'simpified' drawing to show how a generic relay, when energized, will supply power to the various devices. his drawing shows that terminal 87 of the generic relay to be the heavy duty terminal. (as referenced by the preceeding drawing, explaining a generic relay)

it was probably unnecessary to number the terminals at all, since it is just a simplified drawing, like a block diagram. the more detailed drawings below show the correct terminal numbers, as those are not a generic relay, but the VW dual relay we know and love/hate.

makes sense to me

on the other hand lol, regarding the CSV and TTS, i was under the assumption that the TTS controls ground for the CSV; that the TTS is a temperature controlled switch that interrupts the ground circuit for the CSV. if the TTS is

open, theres no ground connection and the CSV cant fire. this is not really shown in the drawing, it looks like they are sharing a ground connection. i dont know that its really necessary to fix the drawing, as the focus of the drawing was the dual relay and not the components, but if you were inclined to fix it, its just a small detail.

_____
'76 Sage Green Westy 2.0 FI
'76 Creamsicle 7-passenger 2.0 CS FI

aliennetwork wrote:

> **RIOMX wrote:**
>
> > Out of all replies on any thread, about 4/10 are from morons who bitch or insult, rather than help out.
>
> You could have said 2/5.

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