

Rossmann Repair Training Guide

Created by Louis Rossmann - Open-sourced to the internet (that's us!)

<https://www.youtube.com/user/rossmanngroup/>

You can read more about our company here & inquire about service. <https://www.rossmanngroup.com>

We have a paid forum to provide support to component level technicians <https://www.rossmanngroup.com/boards>

We offer training at our store <https://www.rossmanngroup.com/logic-board-repair-training-class/>

The biggest problem in this business

- Engineers know how to repair logic boards.
- Engineers do not want to fix logic boards.
- Regular people want to fix logic boards.
- Regular people are not engineers.



You do NOT need to be an engineer!

- You need not know how a resistor resists.
- You need not know how an inductor creates inductance.
- You need not know how to create a circuit to repair common faults.
- We are not going to spend four years turning you into an expert on physics, chemistry, and electricity.
- We will be skipping over a lot to get to the point.

Electricity is based on theft and burden

- You're lazy, you don't want to get up.
- Imagine if I stole your wallet.
- You'd probably chase me around the room.
- To get you to get up off your ass, I motivate you by causing a pain point.

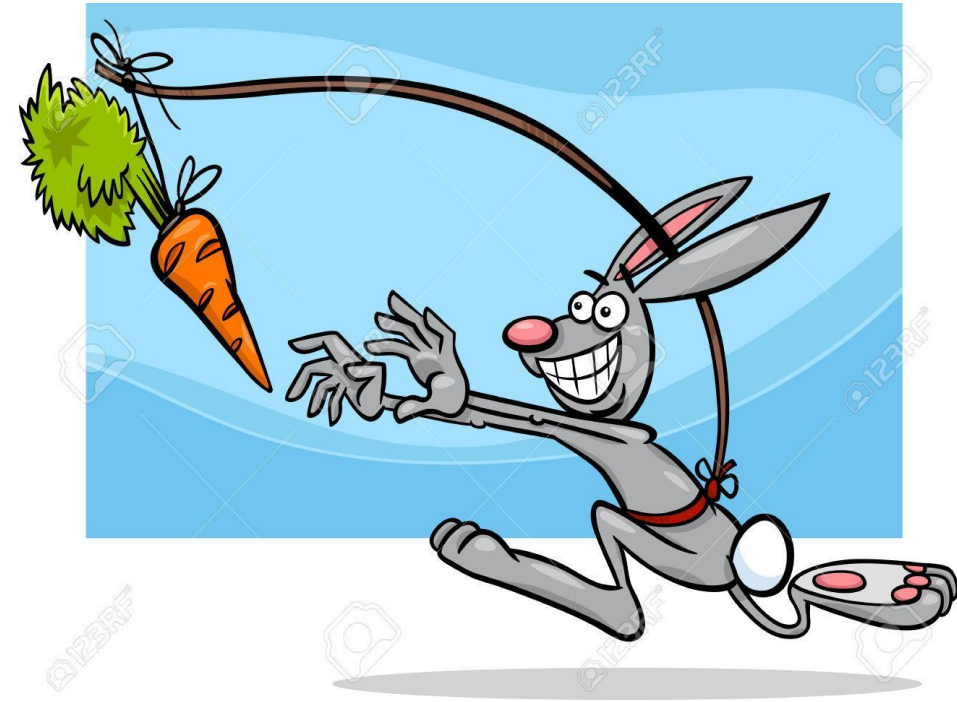
Electricity works the same way

- Stealing an electron from an atom gives it a positive charge.
- Giving an atom an extra electron gives it a negative charge.
- The more electrons you steal, the higher the charge.
- The higher the charge, the higher the voltage.

To get electricity to do anything, we manipulate it

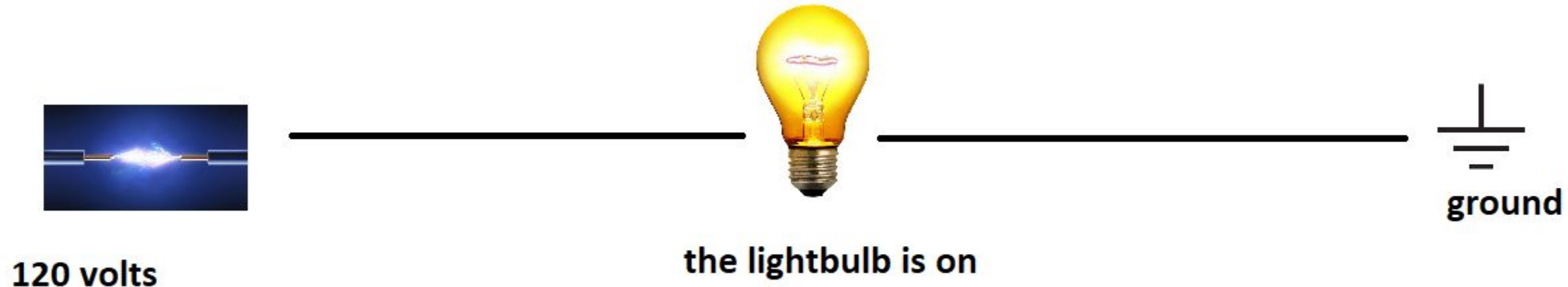
- What will you do to get your wallet back?
- What will the atoms do to get their electrons back?
- What will Jessa do to not fix 100 iPad minis with BGA problems within a no-fix-no-pay business model?
- What will atoms do to toss out unwelcome, uninvited electrons?

This is what we are doing to electricity



- We show it a path to what it wants, and tell it if you walk through this path, you'll get what you want.
- We rarely give it what it wants (if we DID, our STUFF would turn off!)

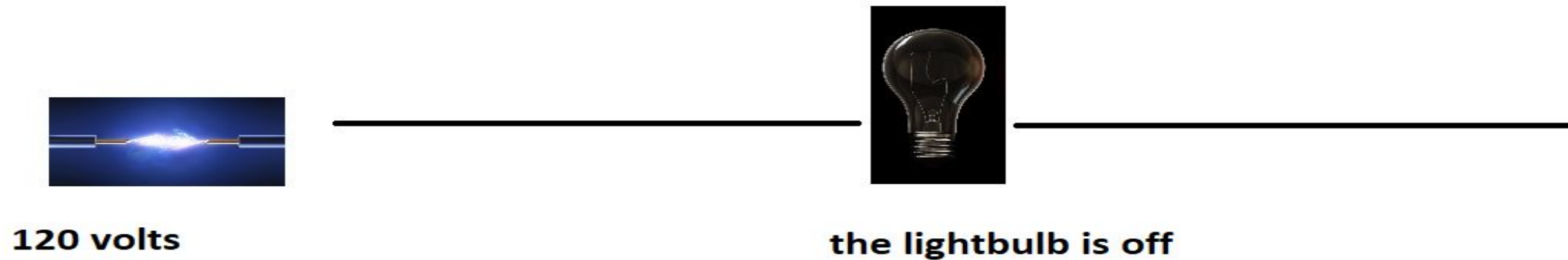
Just as the elephant walks to get the peanut, Electricity goes through anything to get to ground



- The 120 volts wants to go back to being 0 volts - it doesn't like being 120 volts.
- The electrons wish to flow back to the 120 volts, but in order to do so, they must go through the light bulb!
- The light bulb turns on as electrons flow through it.

QUICK QUESTION: HOW MANY VOLTS ARE AT EACH POINT IN THIS CIRCUIT? Answered at next page.

If 120v is applied to the lightbulb but there is no “path to ground”, it won’t light



Just as the elephant has no motivation to get up off his ass without the peanut being dangled, a p won’t cause electrons to flow without a complete circuit. Just because we apply 120v to the light bulb does not mean it will turn on if we do not complete the circuit by adding a ground on the other end.

How do we measure this?

- **Voltage** - think of this like a person's strength.
- **Current** - think of this like stuff that's actually moved using one's strength.
- **Resistance** - think of this like the weight of what we are moving.
A one thousand pound bag is more difficult to move than a ten pound bag..

Ohm's law helps you figure this out

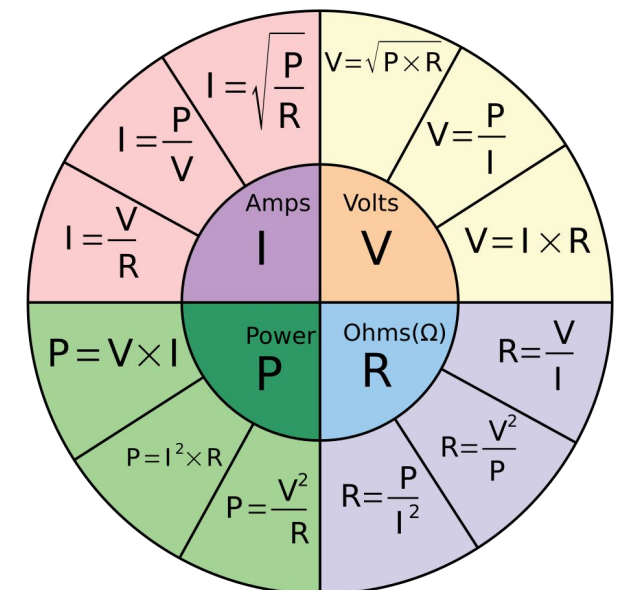
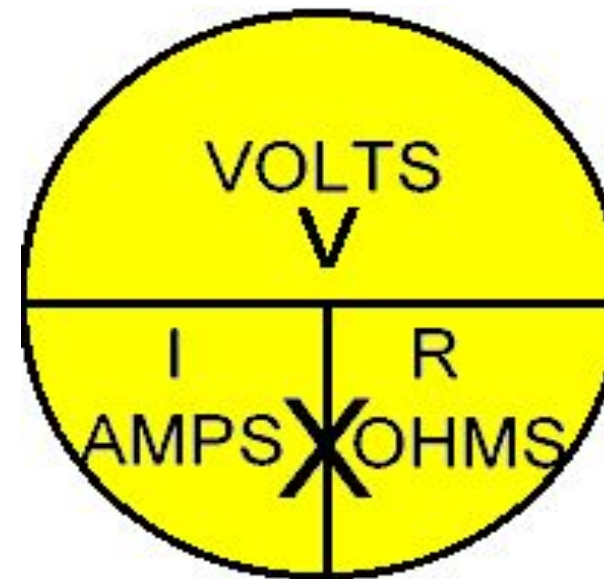
- Use an ohm's law calculator online.
- Or an app on your phone.

Your 4th grade teacher told you “you won't be carrying around a calculator everywhere for the rest of your life”

- They **LIED!!!**

How does this work?

- POWER is equal to voltage times current. 2 volts at 10 amps = 20 watts.
- Current sent through a circuit is equal to voltage divided by resistance.
- Resistance in a circuit is equal to voltage divided by amperage.
- This is called **OHM'S LAW**.



TO KEEP IT SIMPLE:

Try not to just not remember it like a sheep would, try to understand it like a good student would! If you understand, you do not need to remember.

Just learn that in a Fraction:

A / B

B is the denominator and A is the numerator, When A is higher than B, a value higher than 1 will be the result of the fraction, and when A is less than B, a value lower than 1 will be the result.

Example :

$A=50 \ B=10 \ \rightarrow A/B= 5$

$A=50 \ B=70 \ \rightarrow A/B \sim 0.77$

$5 > 0.7$

Remember the formula in the previous slide:

$$P = V^2 / R$$

- More resistance = less power. (DUH!)
- Less resistance = more power. (DUH!)
- Higher voltage = more power. (DUH!)
- Lower voltage = less power. (DUH!)

Remember the formula in the previous slide:

$$V = R \times I$$

This is simple... higher are the terms in the product higher will be the result



120 volts



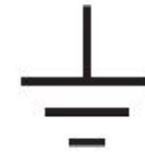
120 volts



the lightbulb is on



120 volts



ground



0 volts



0 volts

Example from a speaker amplifier, the Rotel RB-1090

Lower resistance = more power! The same amplifier can put out almost twice as much power when a lower impedance speaker is attached.

Specifications

Continuous Power Output

(20-20 kHz, < 0.03%):

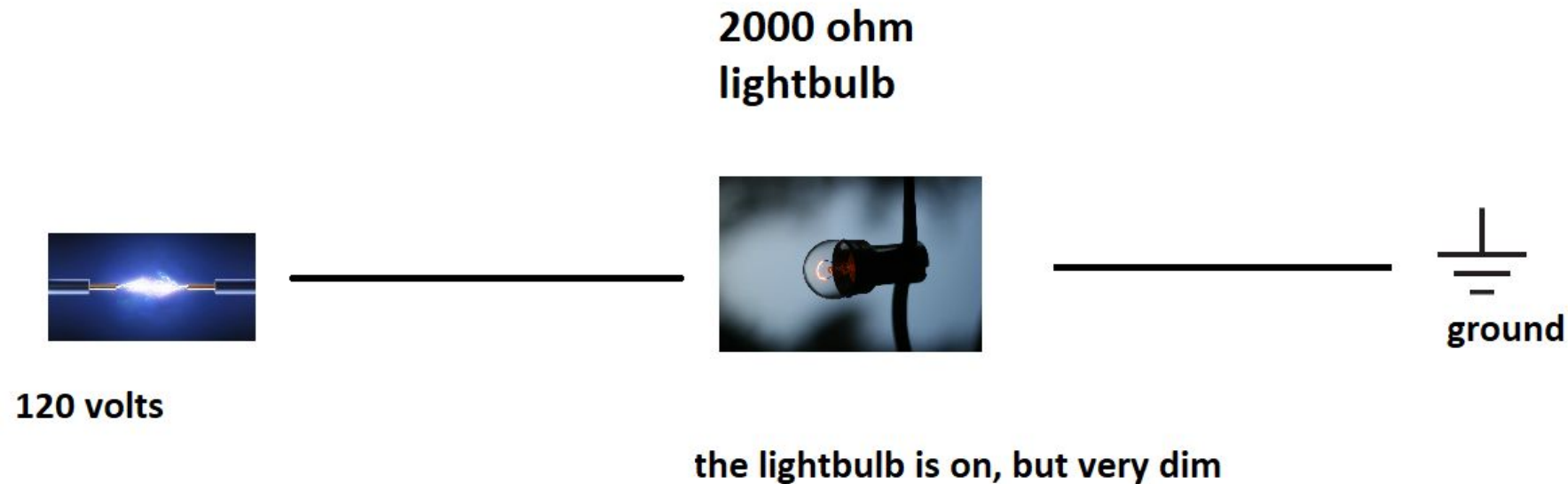
380 watts/ch into 8 ohms

700 watts/ch into 4 ohms

You do not SET current!

- You can increase voltage to increase current.
- You can decrease voltage to decrease current.
- You can increase resistance to decrease current.
- You can decrease resistance to increase current.

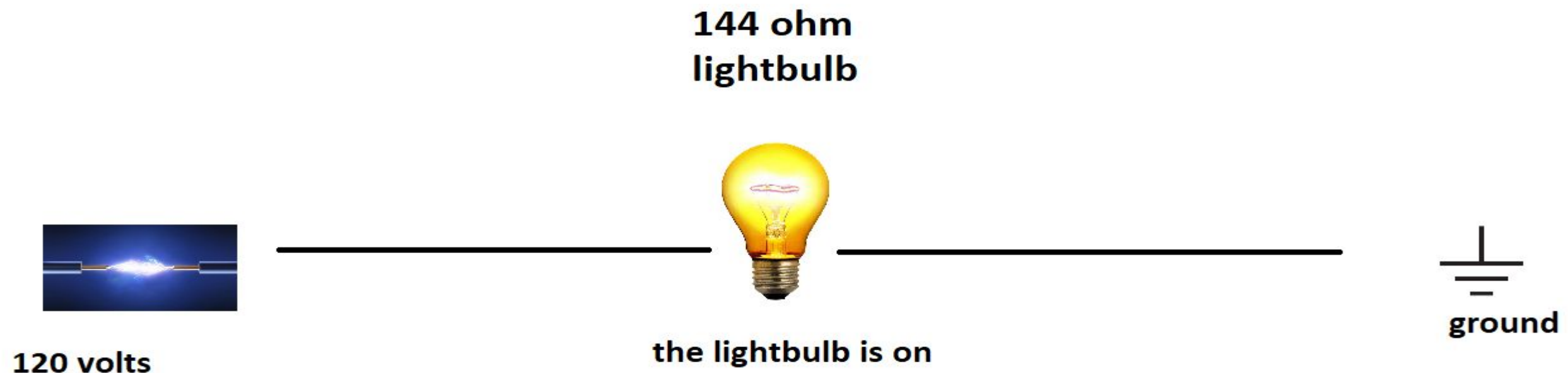
Let's check out a real world example



- Voltage is 120v. Resistance is 2000 ohms.
- $120\text{v} / 2000 \text{ ohms} = 0.06 \text{ amps}$.
- $120\text{v} * 0.06 \text{ amps} = 7.2 \text{ watts}$
- $7.2 \text{ watts} = \text{dim light bulb}$.

Now you do it!

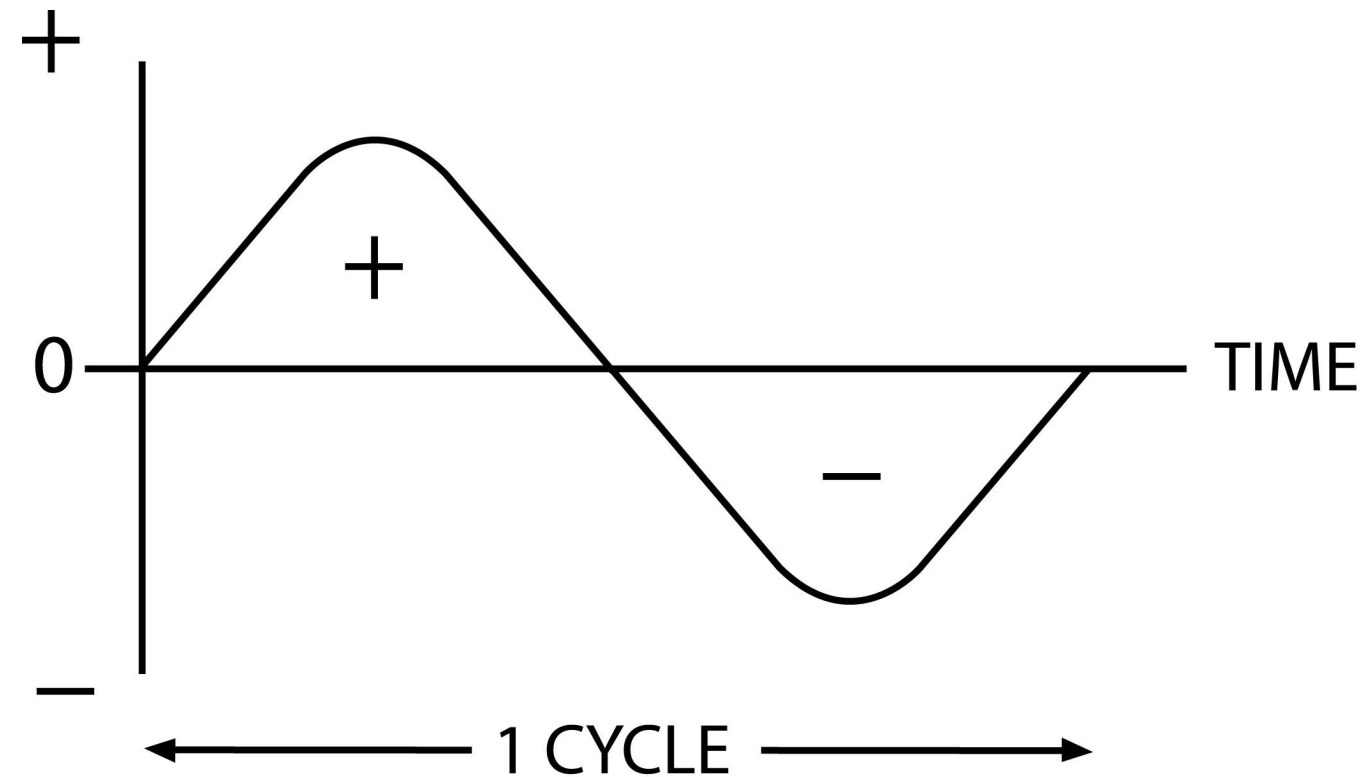
- How many amps is this bulb using?
- How many watts is this light bulb?
- Why is it brighter than the previous light bulb?



Answers!

- The bulb is using 0.83333 amps, using the equation of 120 volts divided by 144 ohms of resistance. $120/144 = 0.83333$
- The bulb is a 100 watt bulb using 120 volts multiplied by 0.83333 amps of current. $120 * 0.83333 = 100$.
- This bulb is brighter because less resistance allows more current to flow.
- More current flow = more electrons = more power = more light!

AC is Alternating Current



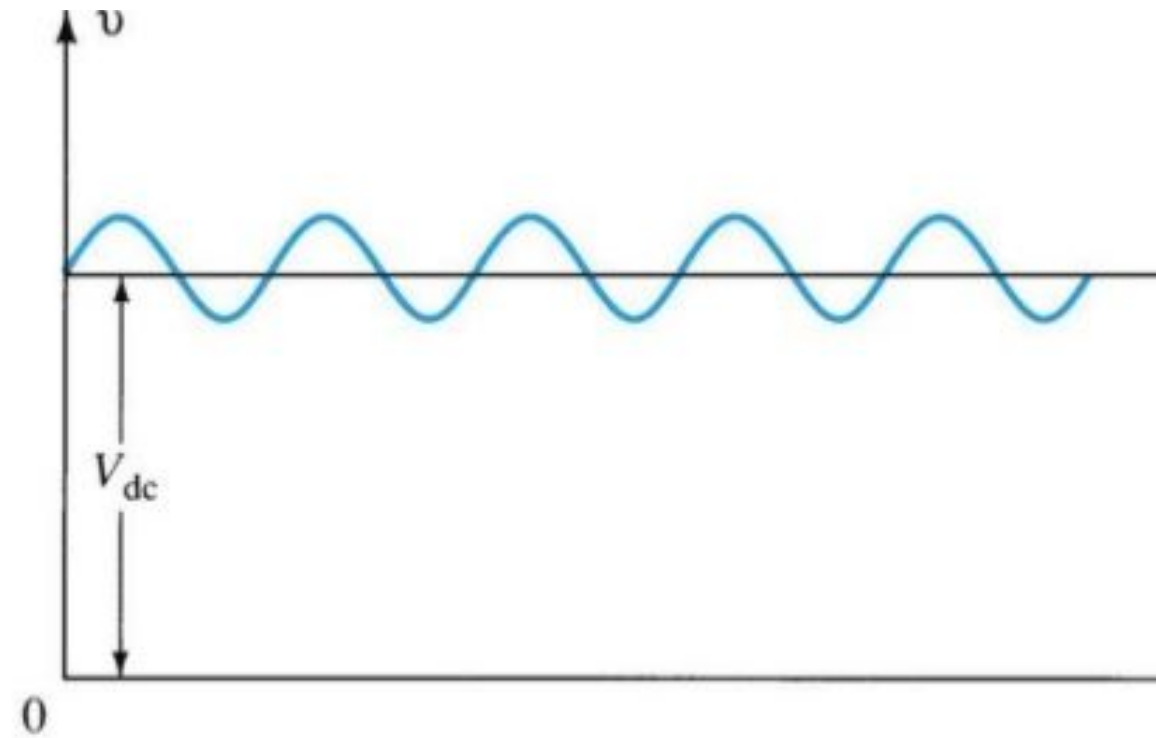
It alternates between positive and negative. So, it's called alternating.. get it? Up down up down.

DC is Direct Current



DC doesn't move back and forth, it is a straight line.
Direct - straight - get it?

This is also DC but a crappy one



The more straight the line the better

*(We use capacitors to make it as straight as possible)

Laptops use DC

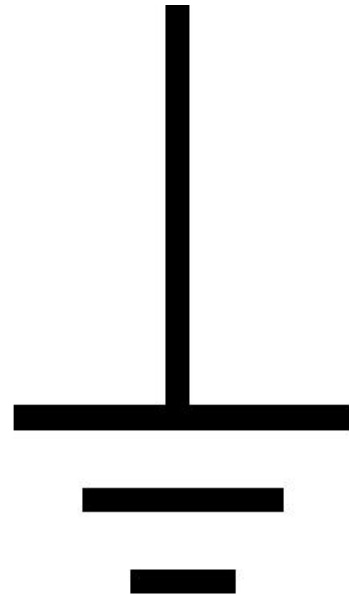
- Computer processors are based on transistors and binary code - 1s and 0s. On and off.
- In order for you to have a 0 or a 1, you need a valid reference. So, we do not want alternating current for our power source.

Getting a computer processor to work using AC would be like trying to play Jenga on a roller coaster. We do not use AC for powering most parts of laptop and cellphone circuits. We want flat, steady voltage.

Think of ground as a black hole

- Whether a voltage is 1000v or -1000v, when it gets to ground it becomes nothing.
- Ground is a reference by which we measure other voltages.
- For our purposes troubleshooting laptop & cell phone circuits, ground is always 0v.
- For our purposes troubleshooting laptop & cell phone circuits, ground is the absence of voltage.
- Electricity does not enjoy existing – it wants to return to 0v, so it will always seek ground.

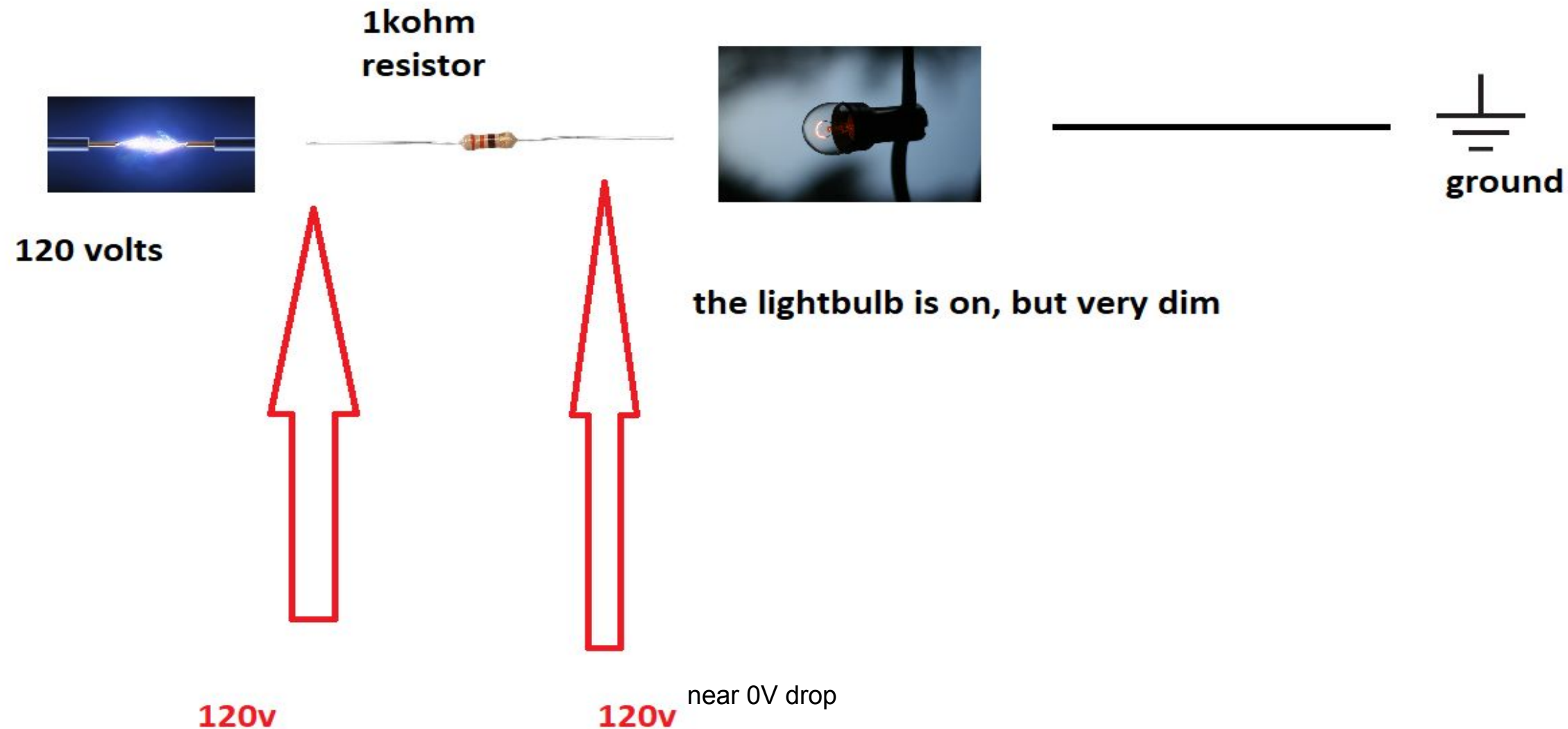
This is the symbol for ground



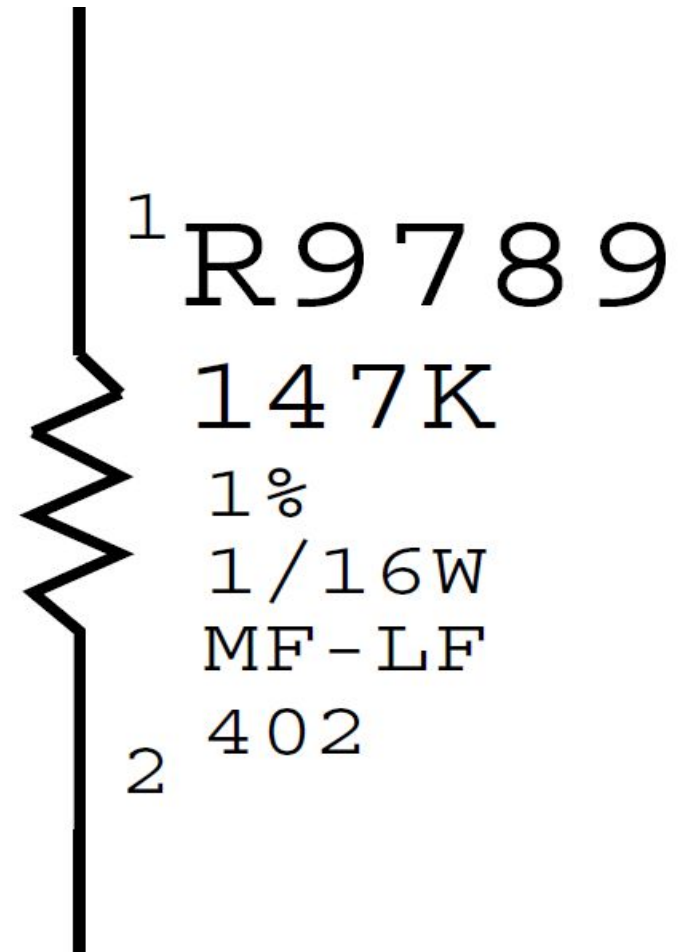
Resistors resist the flow of current

- You will have the same amount of current on each side of an individual resistor.
- You will have less voltage on the other side of a resistor.
- Resistance is measured in ohms.
- Higher resistance = less current flow through the circuit.
- Higher resistance = less power. Lower resistance = more power.
DUH!!

You typically have the same or near identical voltage on both sides of a resistor, but less current flows (Note from Paul, this slide is 100% wrong and needs to be corrected, pay no attention to this slide)

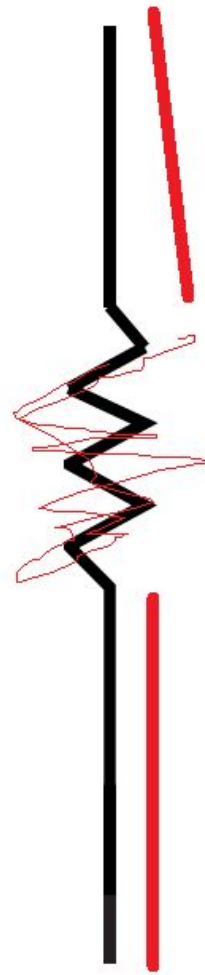


This is the symbol for a resistor



How resistors often fail

I resist and pass power properly.



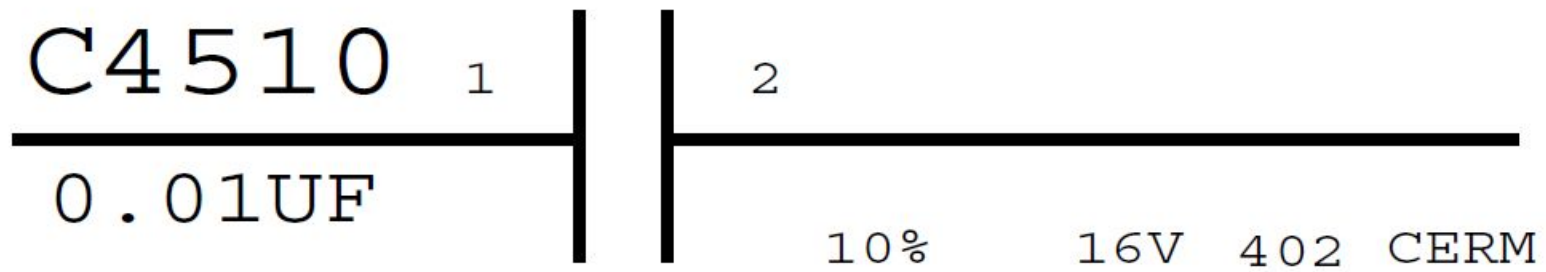
I DON'T!!!!



and
nothing
comes
through

Capacitors consist of two charged plates with an insulator sitting between them

- Capacitors can be used as a “battery”, retaining electrical charge.
- Capacitors are used to smooth out a signal.
- Capacitors pass AC, and block DC.
- When capacitors “short” they begin passing DC as well as AC, you get a short to ground - which is how many logic boards fail.



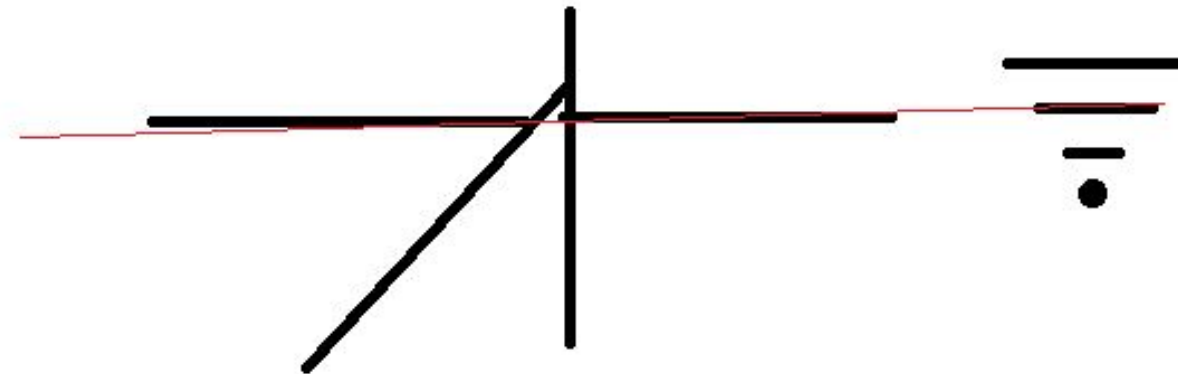
Hi, I'm a
capacitor

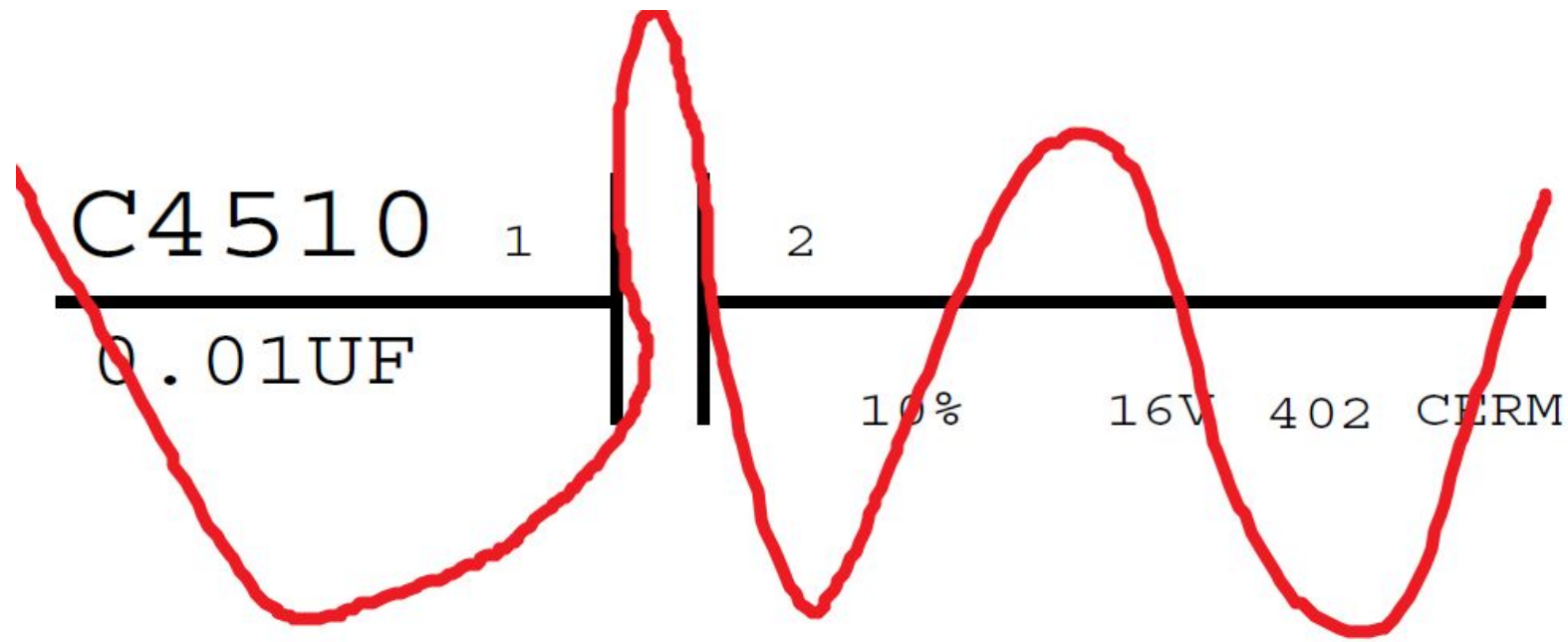
How capacitors often fail

I'm a capacitor, I only capacitate.
Watch me laugh at DC as it tries
to pass through me.

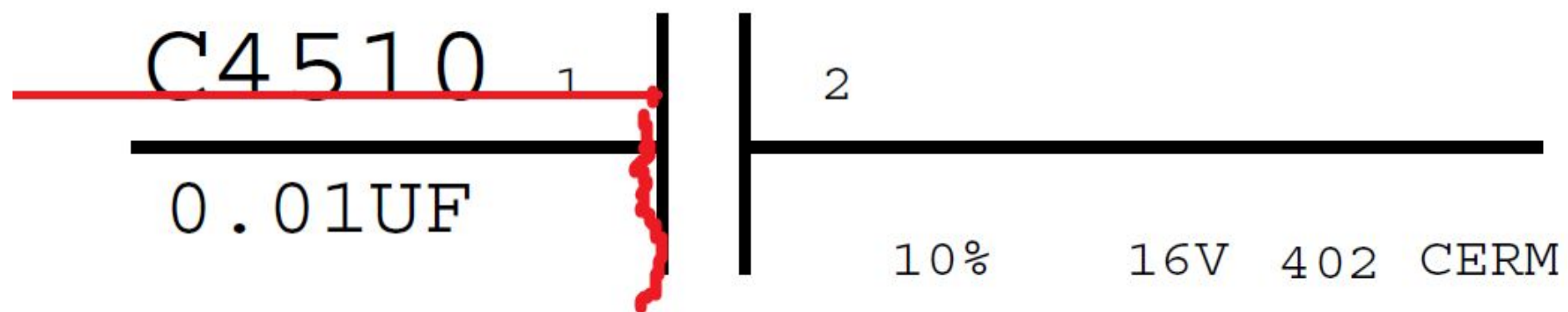


I'm a fucked capacitor,
watch DC pass through me
with ease.





I'm a capacitor
letting AC
through



I'm a capacitor
blocking DC

Cool things we can do with a capacitor

- Knowing ground is where electricity will always go given a path.
- Knowing capacitors can only pass AC(waving), not DC(flat).
- We can take a waving current and make it flat by putting a capacitor to ground on a power line.
- We MANIPULATE the electricity by only sending the part we don't want away. This is all about manipulation.

Knowing that we LOVE using Capacitors to smooth out signals!

- Capacitors to ground on a line help to smooth out that line.
- Capacitors can fail in a manner in which they turn into a wire.
- This can produce a.... short to ground.



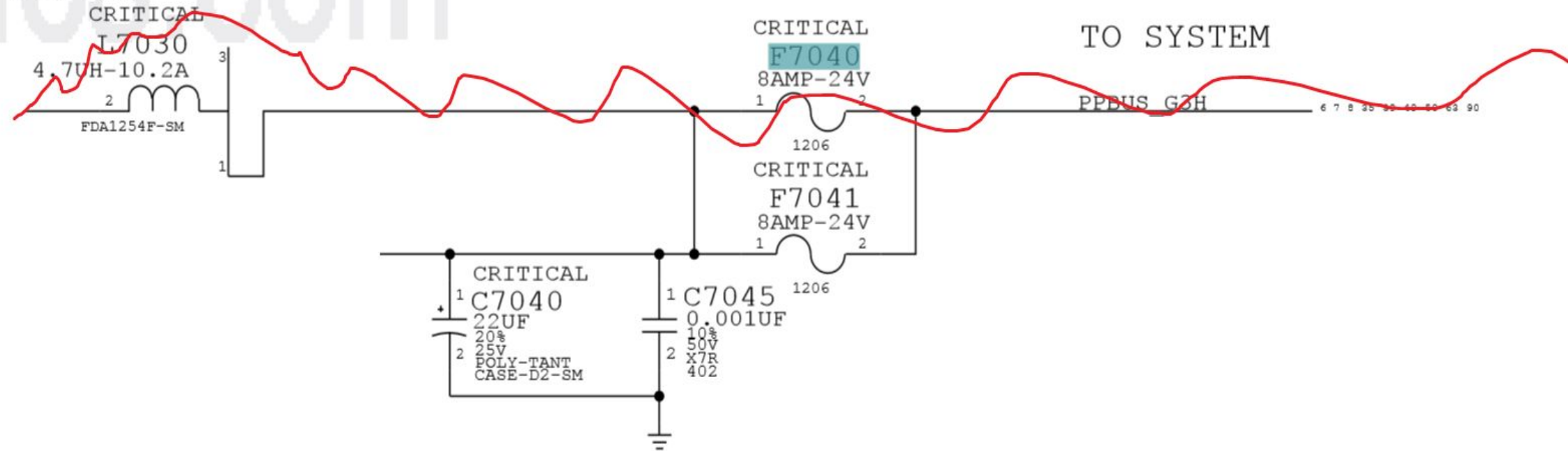
What is a short circuit?

- A short circuit is when a signal or voltage is stopped before it makes it to its final destination, short referring to its trip being “**Shorter**” than it should have been.
- A short can be caused by poor soldering that bridges two points together, or a failed component that is tying two signals/power lines together that should not be tied together.
- A “short to ground” is when a pathway to ground exists that should not.

Example of a working circuit

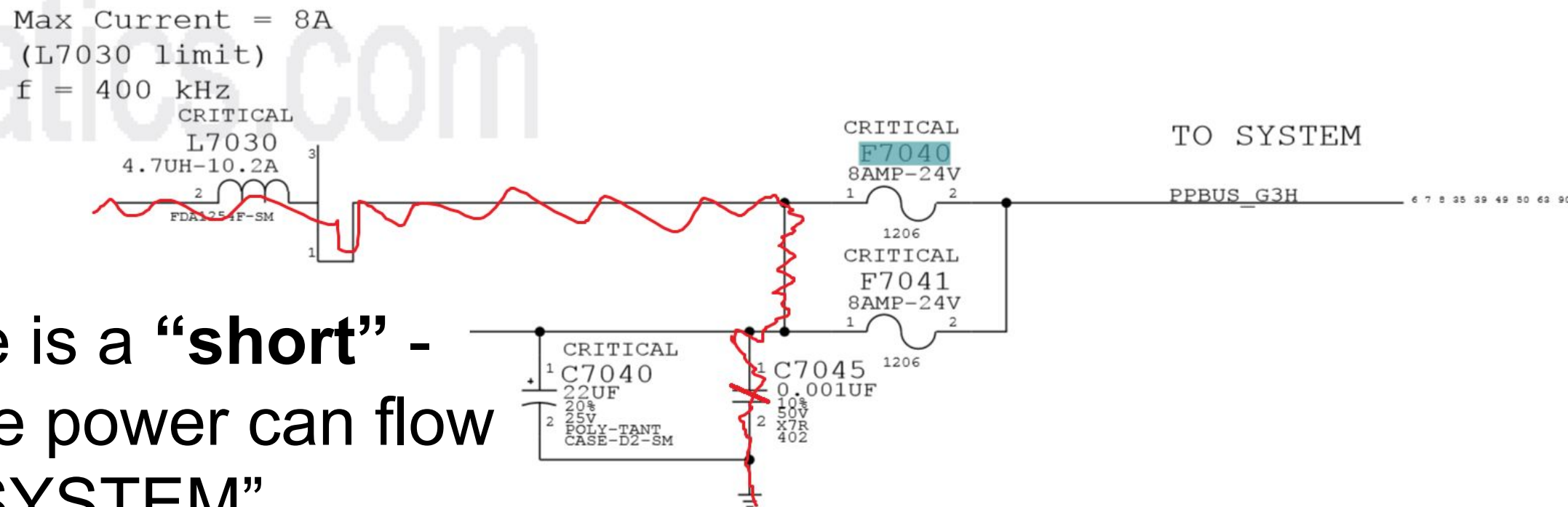
- Red line signifies path of electricity, going to system, happy :)

Max Current = 8A
(L7030 limit)
 $f = 400 \text{ kHz}$



Example of a short to ground.

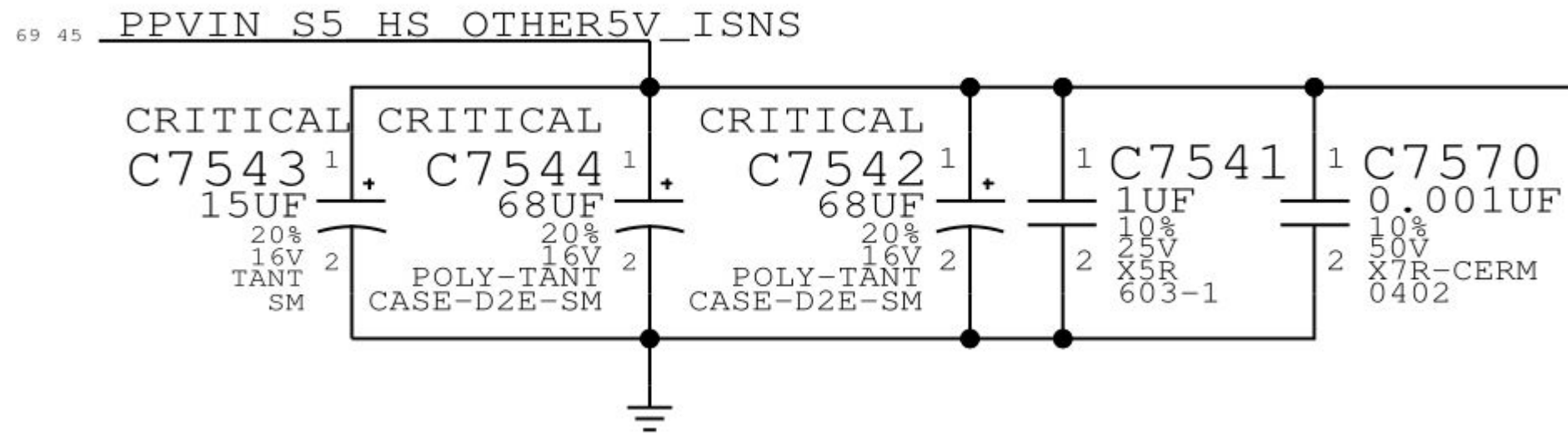
- Red line signifies path of electricity.
- C7045 went bad and is acting as a wire.
- Circuit ends



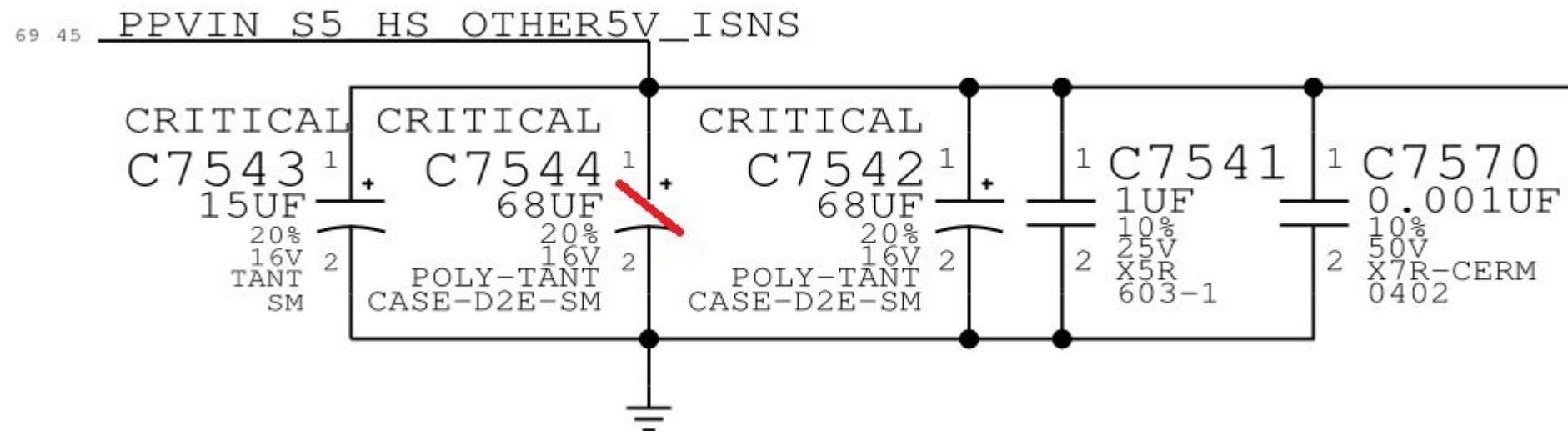
- There is a “**short**” -
before power can flow
“TO SYSTEM”

Finding a short

We have five happy caps on this line. The line works great!

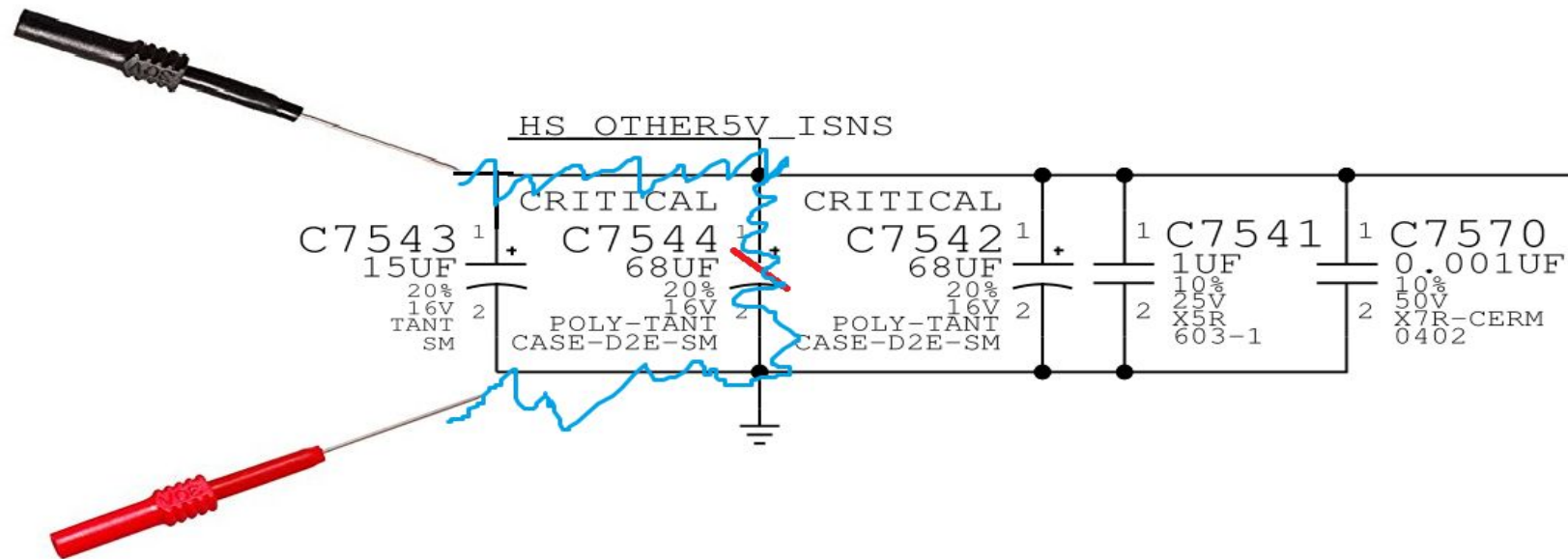


Until one day, water is spilled, and a cap explodes. C7544 is now sending all the voltage to ground!



Measure each cap, right?

- Many will turn their multimeter to capacitance or resistance mode and “measure each cap. Let’s
- assume C7543, C7542, C7541, and C7570 are working and in perfect condition.
- We take the multimeter and place black probe on pin 1 of C7543 and red probe on pin 2 of C7543.
- This WILL NOT WORK!!! Can you guess why?
- The meter says 0 ohms of resistance. Why? C7544 is the culprit, not C7543. What is going on here?



- The meter measures resistance by sending out a voltage and measuring what comes back on the other end.
- Since all of these capacitors are on the same line, you will get the “same” measurement reading any cap.
- C7544 is providing the line a path to ground.
- Since C7543, C7542, C7541, C7570 all share a line with the bad C7544, they will all measure the same if they are
- still soldered onto the board.
- WHAT NOW???

Go back to the light bulb example: do brighter bulbs make more heat?

- The lower the resistance in a circuit, the more power it will use.
- More power usage = more heat.
- More heat = hotter.
- If the capacitor passing lots of energy is hotter, we might now have a method to figure out WHICH is the bad one!

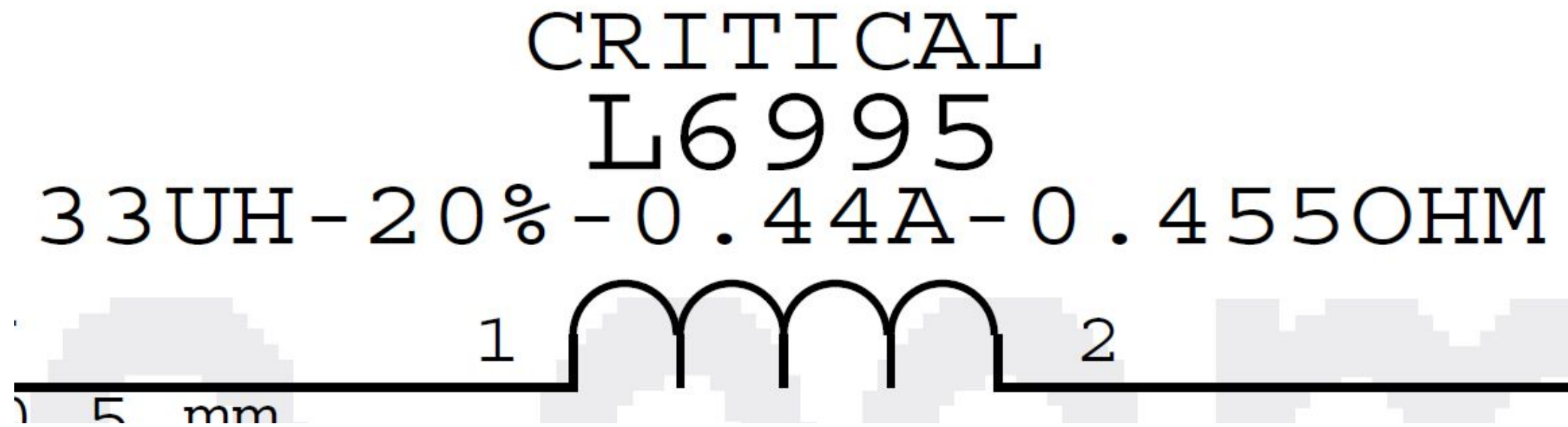
We can use heat for short detection.

- Whichever component is warmer is likely the component that is short circuited.
- We can use freeze spray to help us detect the shorted component - wherever it evaporates first is warmest.
- We can also put alcohol on the board which is cheaper, and evaporates quickly.
- Note a perfect short circuit will pass a lot of current but will cause no voltage drop across the short and will not get hot
- An open circuit component will pass no current but will have a voltage drop across it but will not get hot
- A partial short as a result of for example a capacitor failing and passing some dc current will get hotter than normal because it will have a current flowing and a voltage drop across it resulting in a power loss in the component and the component will get hotter than normal.

What is an inductor?

- An inductor resists quick changes in current.
- Alternating current has changes as it waves back and forth.
- An inductor is handy in helping turn AC into DC.
- An inductor is useful in keeping high frequency noise out of a line.
- An inductor cannot send current out quickly if a sudden demand for current comes up. So, what will it send if quickly shorted to ground but....VOLTAGE! More on this later.

This is the symbol for an inductor



What is a transistor?

TO KEEP IT SIMPLE:

- A **transistor** is a ***transforming resistor***.

A transistor is a resistor whose value can change.

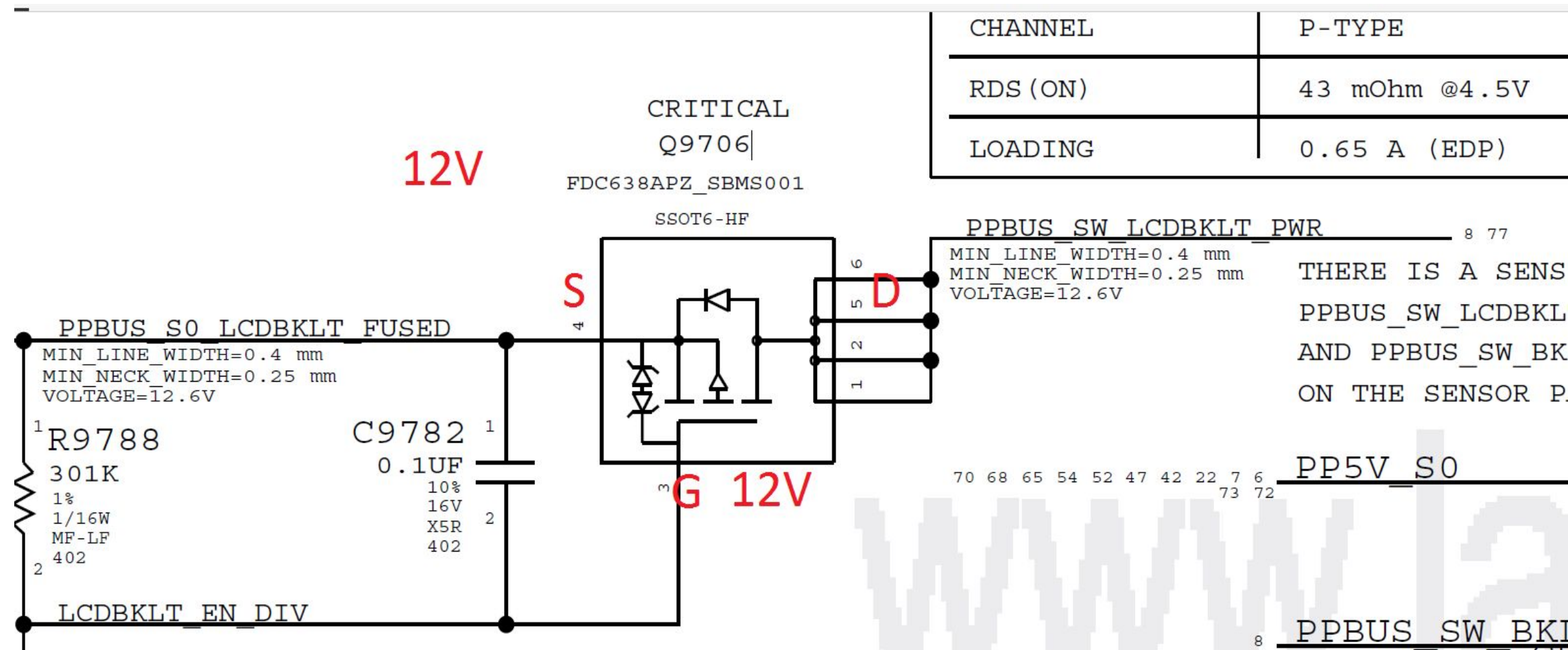
If you're an electronics engineering major, yes, they are not linear devices, kindly STFU. We know.

- MOSFETs have three tabs – source, drain, and gate. Power flows from source to drain dependent on the voltage at the gate.
- 99.9% of the time, we are looking at MOSFETs, not other type of transistors in laptop & cell phone circuitry.

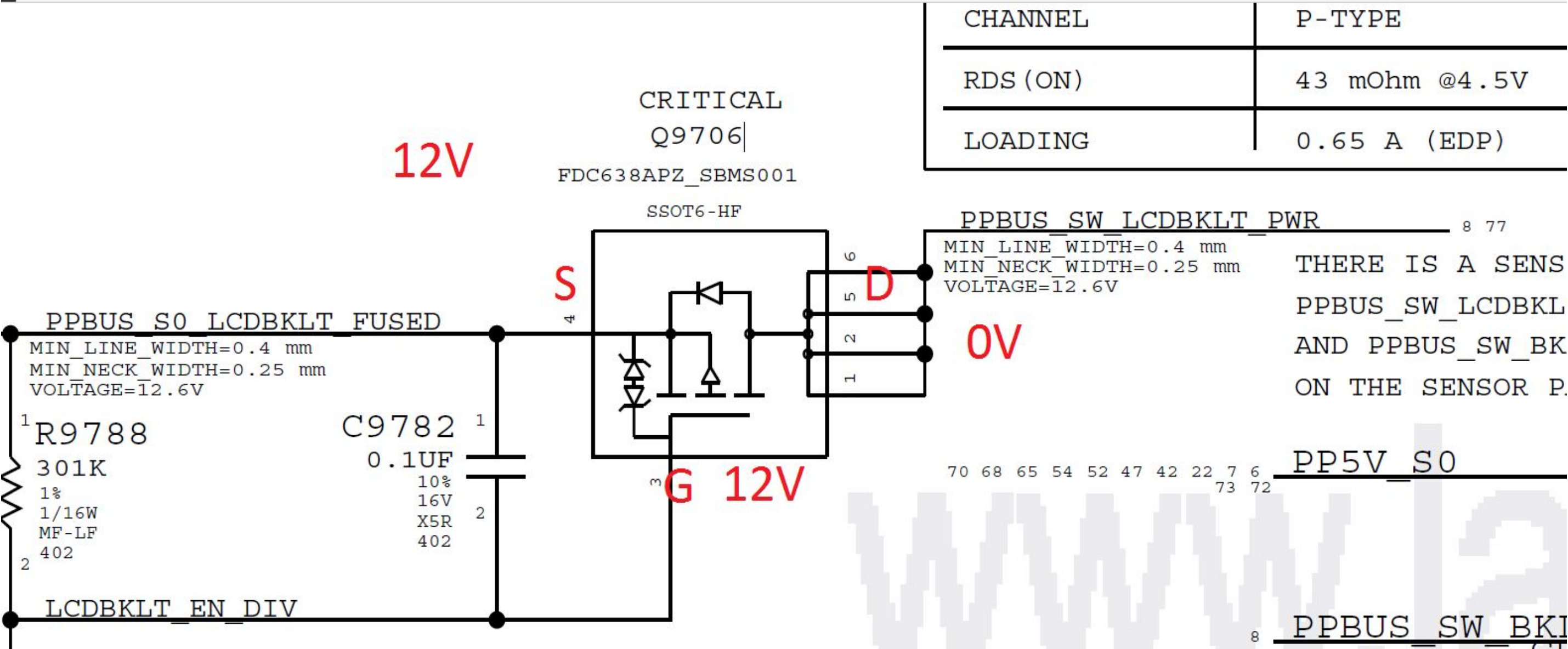
Types of transistors we care about

- **P channel MOSFET** lets power through when voltage on gate is **LOWER** than source.
- **N channel MOSFET** lets power through when voltage on gate is **HIGHER** or equal to source.

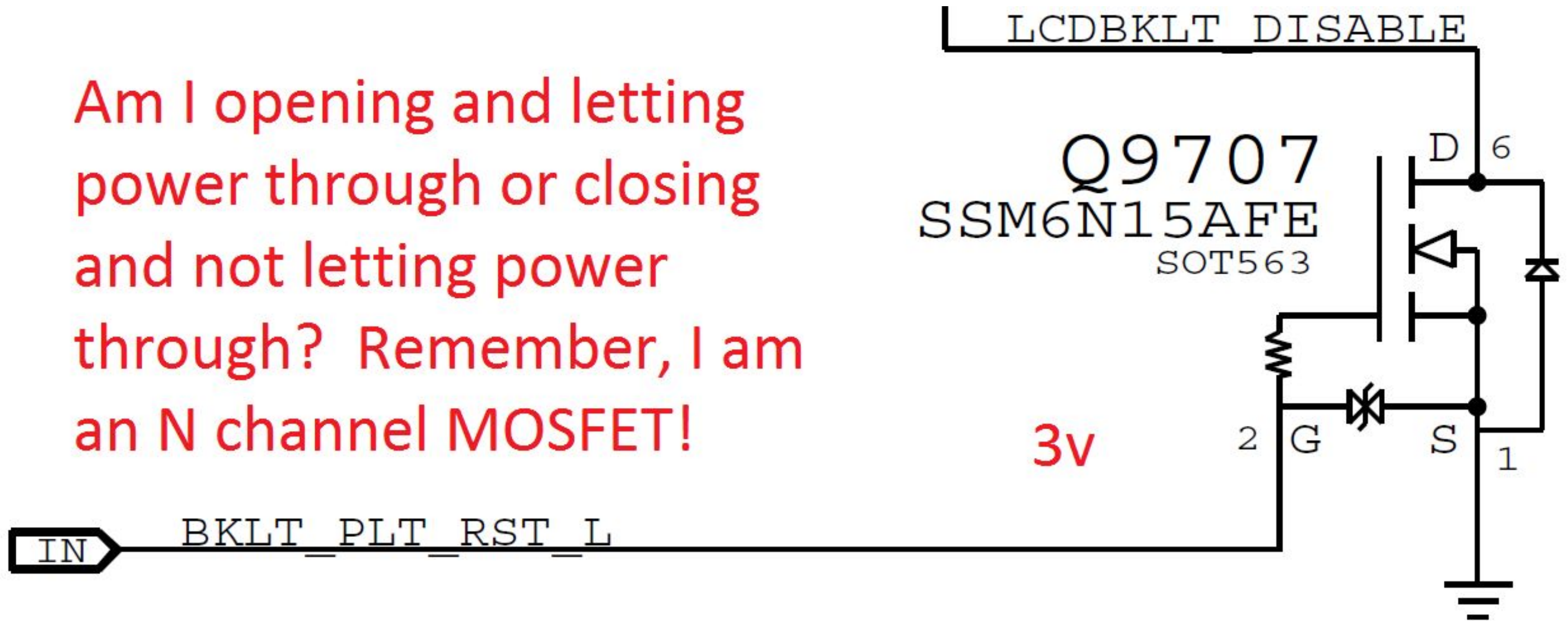
What voltage is present on the drain when 12v is on the source and the gate of this MOSFET?



0 volts! A **P type MOSFET** opens when voltage on the gate is lower than what is present on the source. Schematic claims 4.5v, but there is always 5v there in the real world (SCHEMATICS ARE NOT ALWAYS RIGHT)

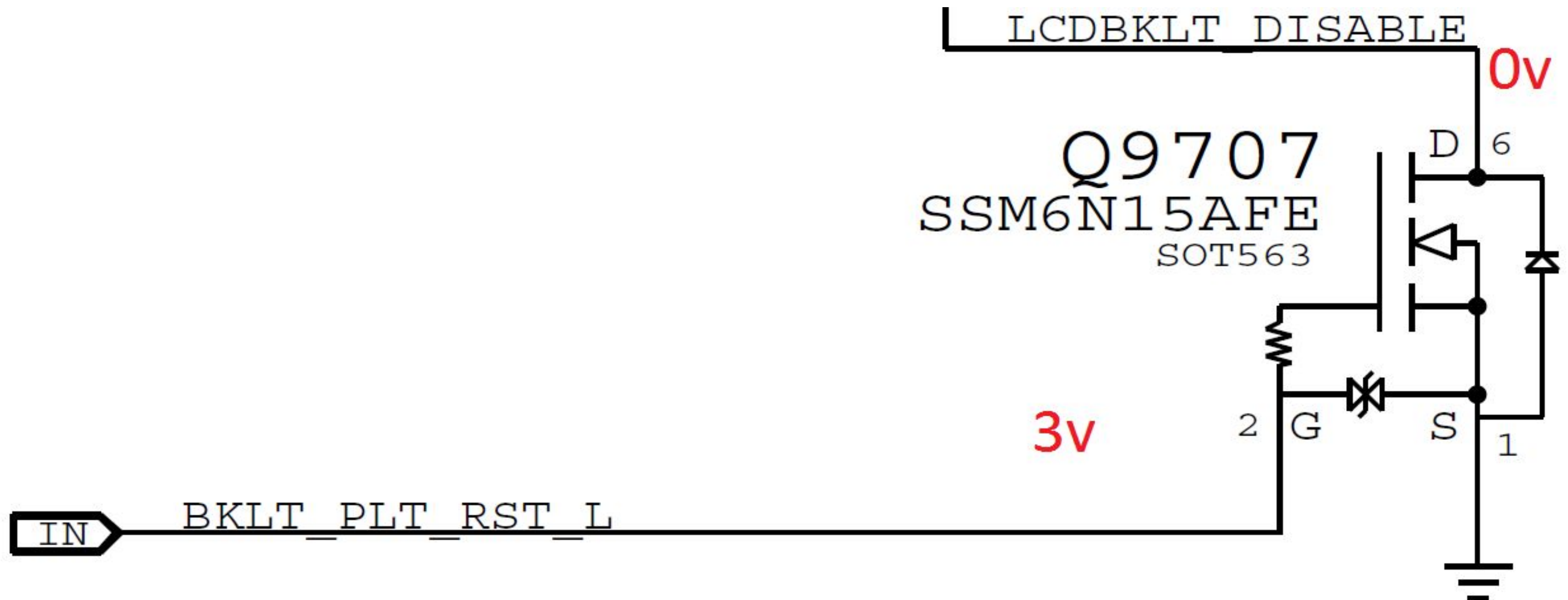


Am I opening and letting power through or closing and not letting power through? Remember, I am an N channel MOSFET!



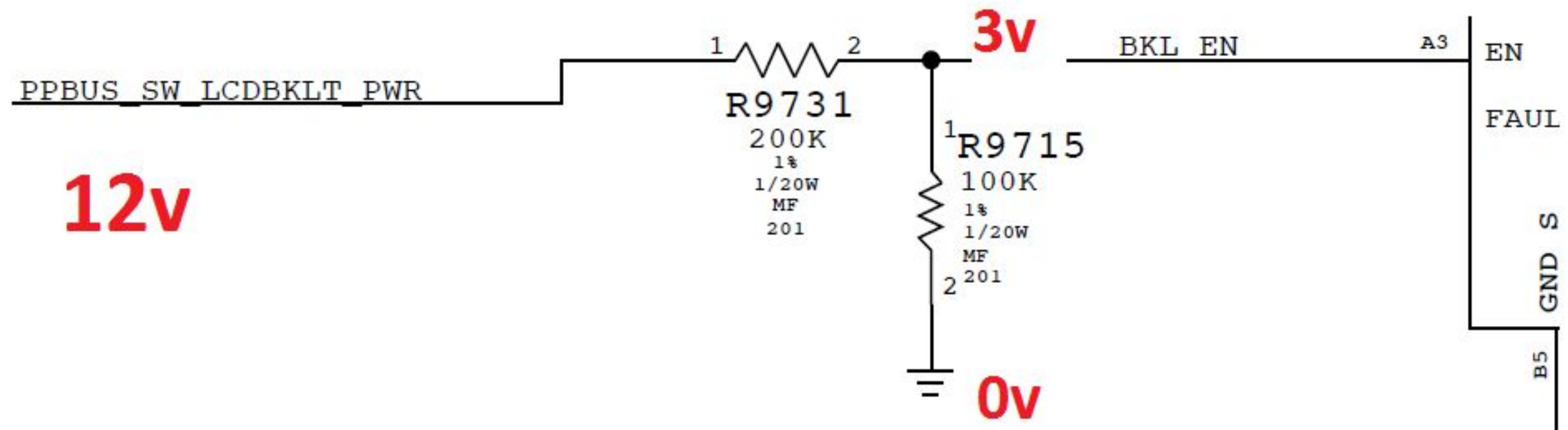
HINT!!!! Ground = zero volts!!

It lets power through! N channel MOSFETs let power through when the gate voltage is higher than the source. Ground is 0 volts. If there is 3 volts on the gate then it will open. This will then send whatever is on the drain to ground, which will cause 0v to be on the drain.



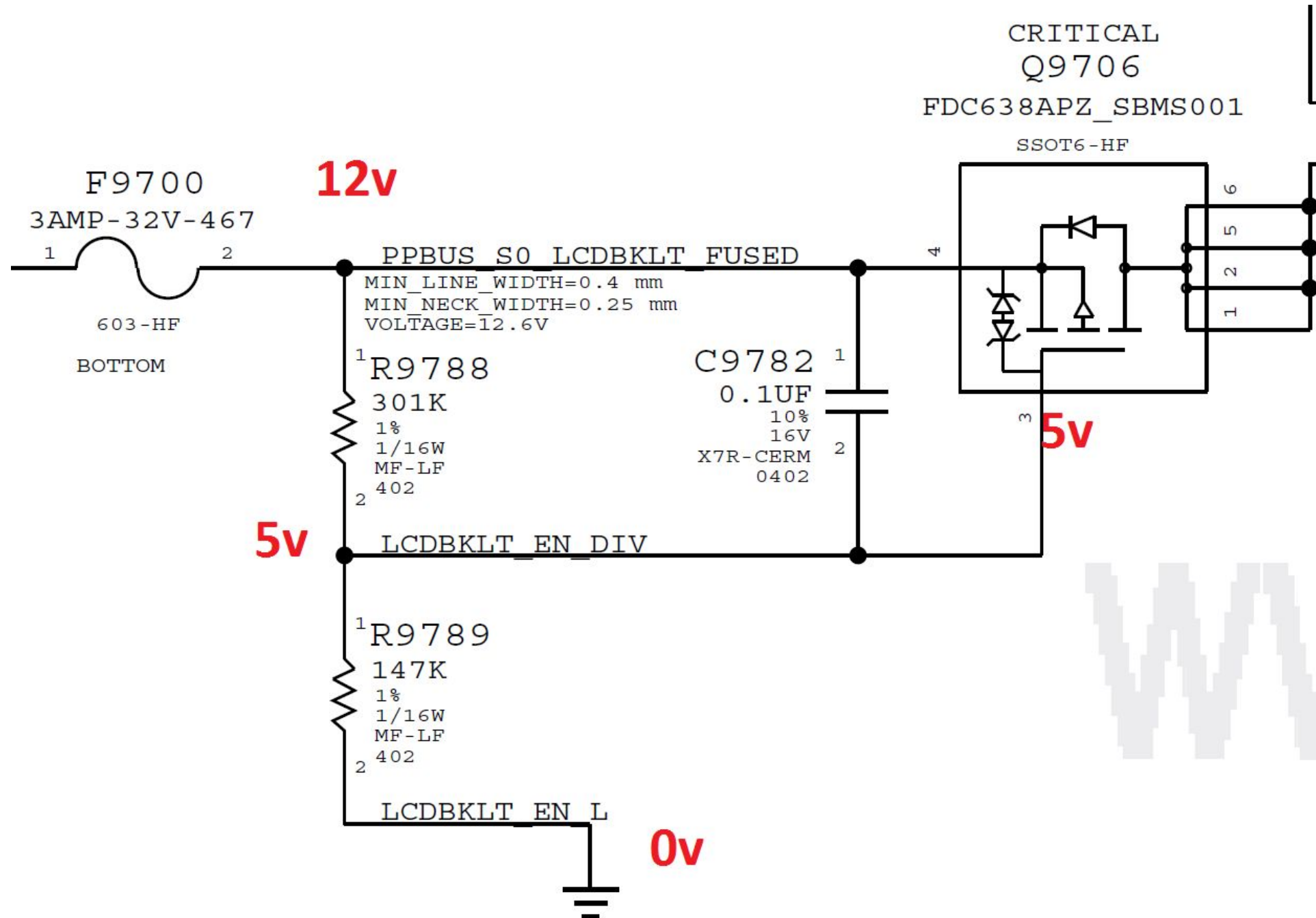
What is a voltage divider?

- A voltage divider steps down a higher voltage to a lower voltage.
- A voltage divider is a series of resistors between a higher voltage and ground.
- A voltage divider is inefficient, but cheap - used for things that do not have high current requirements.



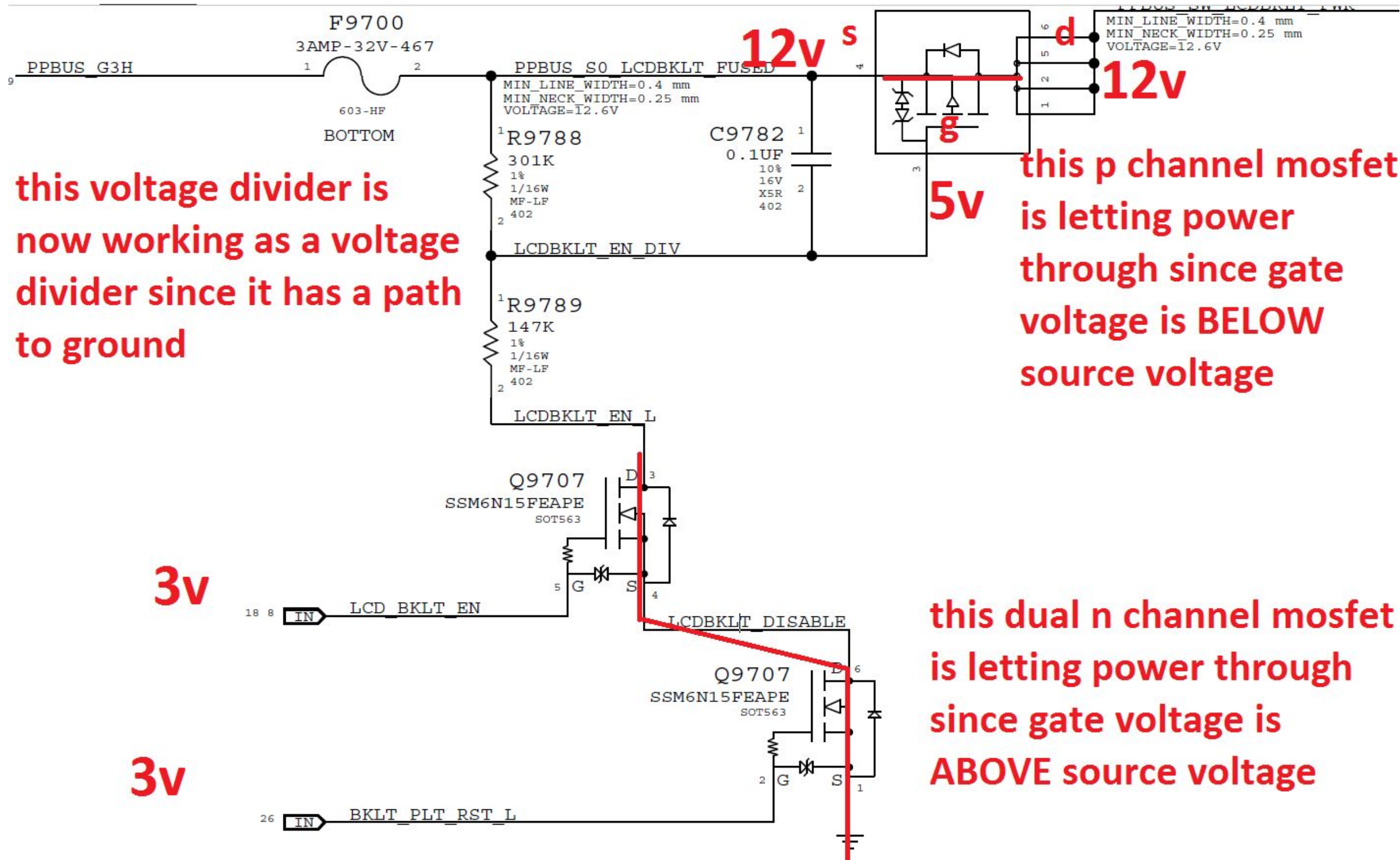
Here we have a resistor between a high voltage source and the intended destination, then another resistor between the intended destination and ground. It is turning 12v into 4v.

Reminder: what is a voltage divider?



What if we used a transistor to control the voltage dividers path to ground?

- We could then control whether the voltage divider works.
- By being able to control that voltage divider, we can then control backlight being on or off based on signals from other parts of the machine.



What is a pullup resistor?

- A pullup resistor keeps a signal high. When it is not being shorted to ground, it will be 3.42v.
- A pullup resistor “isolates” the data line from the main power supply.
- You can have as many data lines as the power line is capable of providing amperage for on a given data line.

What happens when creating a data line without a resistor to limit current. Remember, the chips are shorting the signal to GROUND down to ZERO VOLTS to make this work.



THAT IS WHY WE USE
PULLUP RESISTORS!!!

What is a Diode?

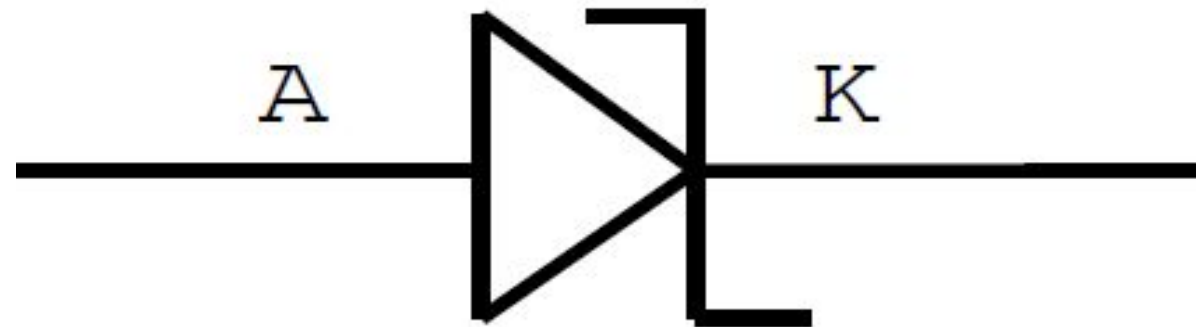
- A diode only allows current to pass in one direction.
- Often used in boost circuits, where voltage at the end is higher than voltage at the beginning.

This is the symbol for a zener diode

CRITICAL

D9701

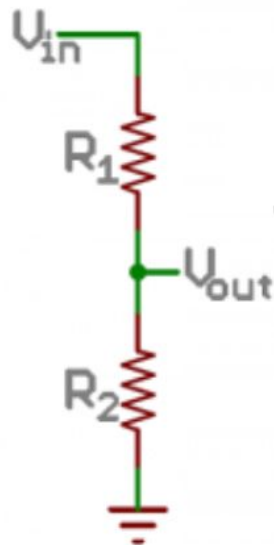
SOD-123



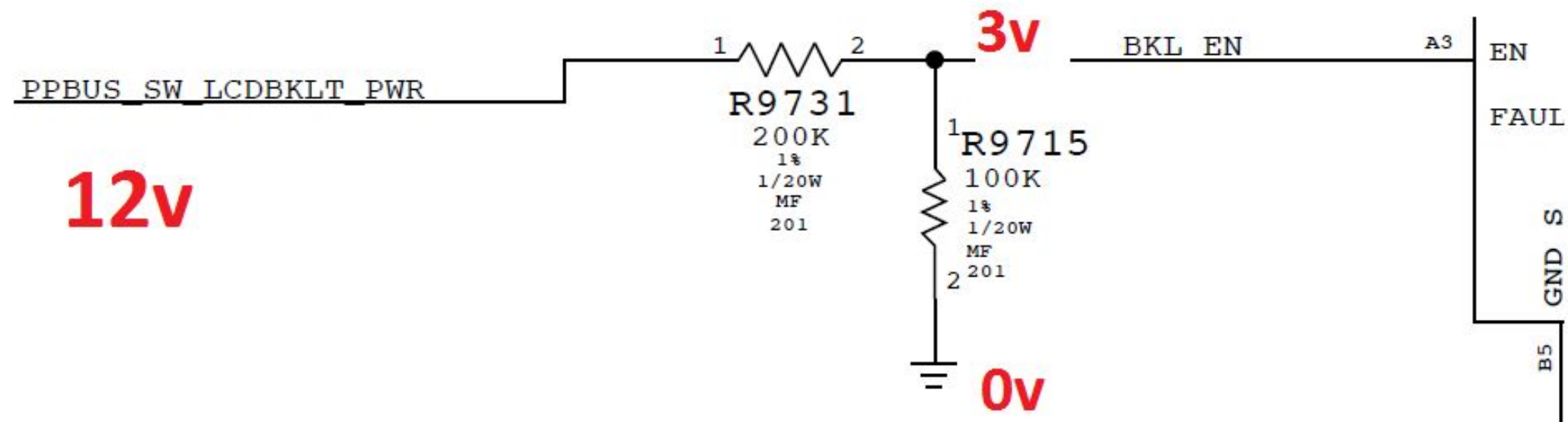
RB160M-60G

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$$V_{out} = V_{in} \cdot \frac{R_2}{R_1 + R_2}$$



Here we have a resistor between a high voltage source and the intended destination, then another resistor between the intended destination and ground. It is turning 12v into 3v.

- Resistance of resistors will set the voltage.
- Allows the enable pin of this backlight IC to get 3v whenever PPBUS_SW_LCDBKLT_PWR is on.
- If you sent 12v to the enable pin of backlight IC, it would die. Good thing we have a voltage divider. :)

NOW ONTO THE FUN!!!!

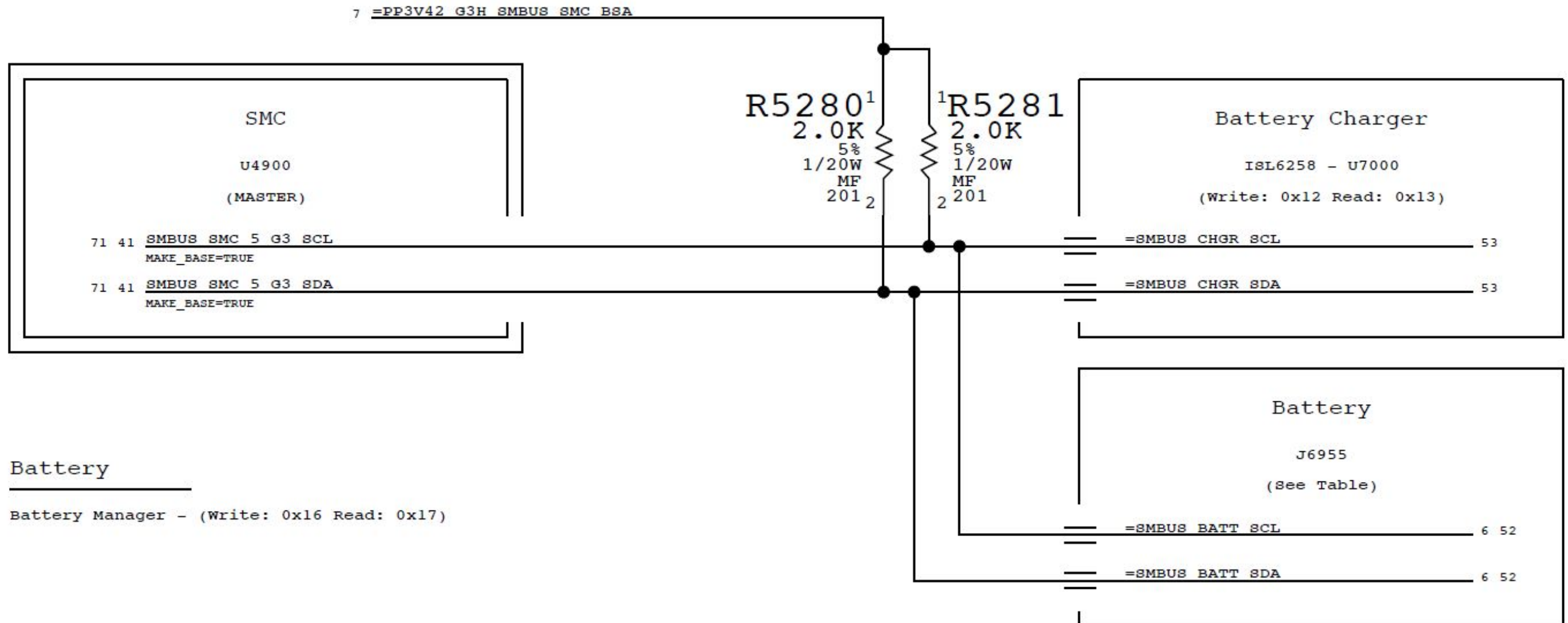
- Now that you have basic knowledge of what electricity is, we can go on to basic circuits.
- **Get food first!**

What is a data line?

- A data line is a line that carries data
- Data lines are used to transmit information between sensors and the SMC, between the SMC & the battery, between SMC and the battery charger chip, between the charger and the SMC.
- Chips “create” data by shorting an existing voltage to ground. Think of it like “drawing.”
- Morse code/Telegraph, where a series of pulses created by closing a circuit translates to something else

Here is the battery, battery controller IC, and SMC speaking to one another.

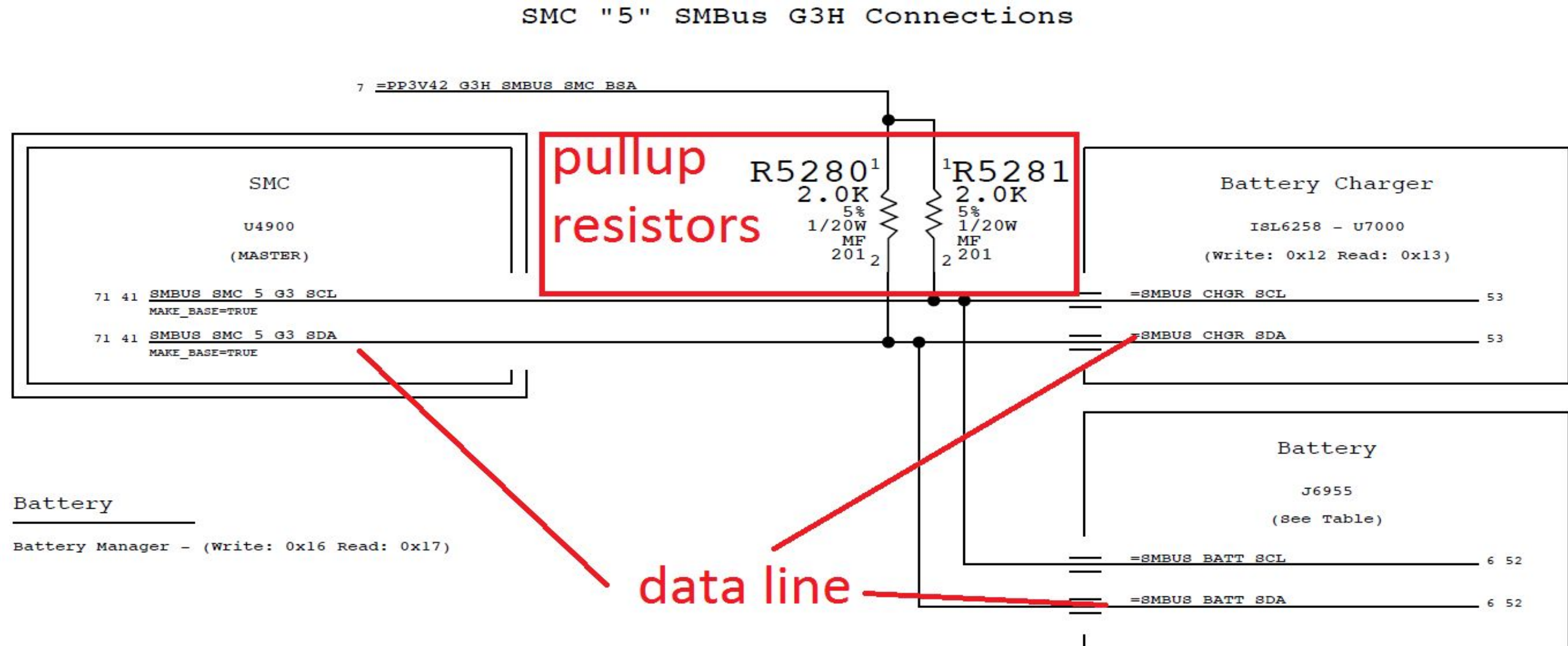
SMC "5" SMBus G3H Connections



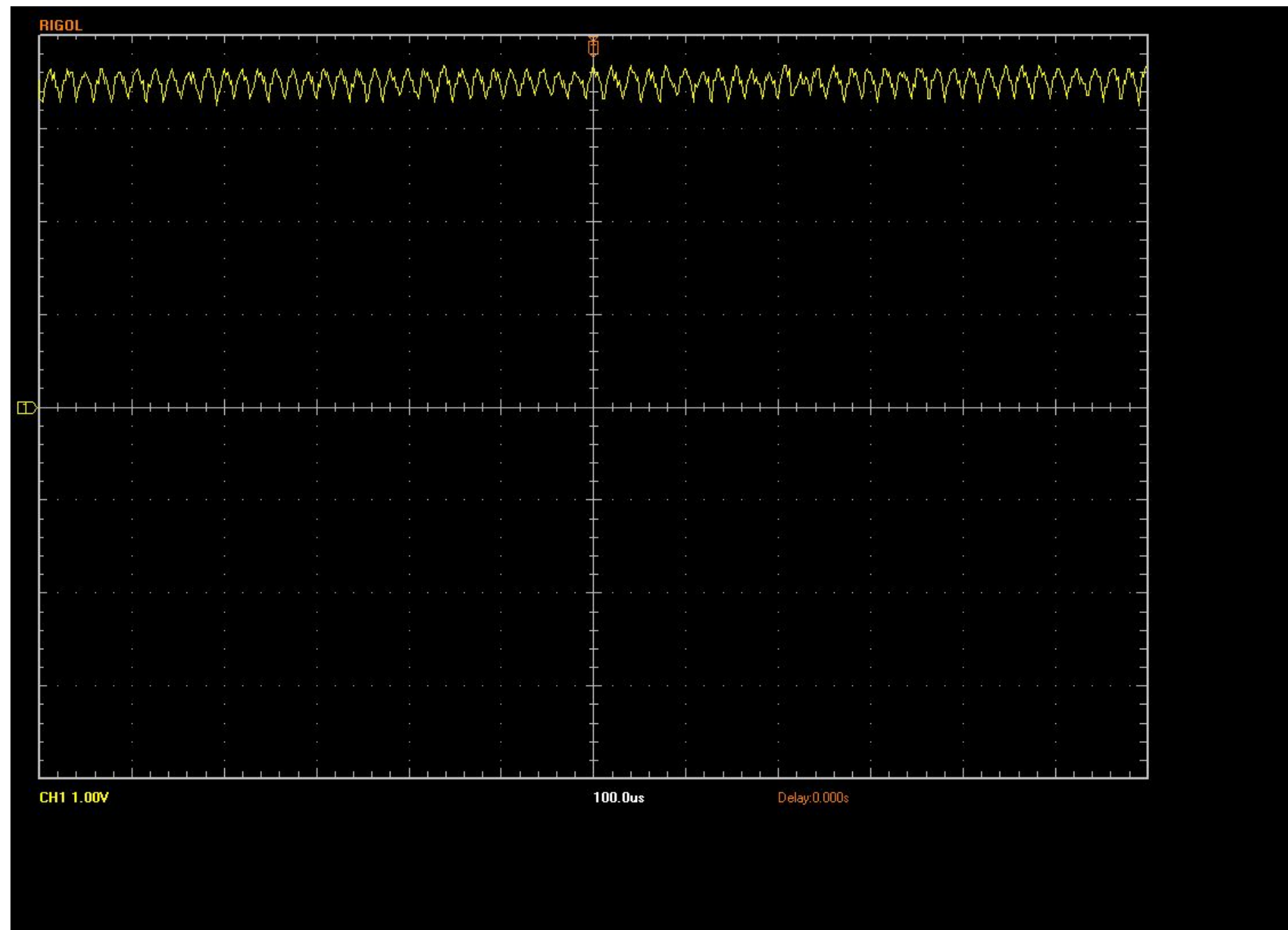
Creating a data line

- The chip is creating data by shorting a voltage to ground to make a waveform that represents data.
- Without voltage present, it will always be 0v, which will be no data.
- We need voltage to be present so the chip has something to create a waveform from!
- What will happen when we short a main power rail to ground?

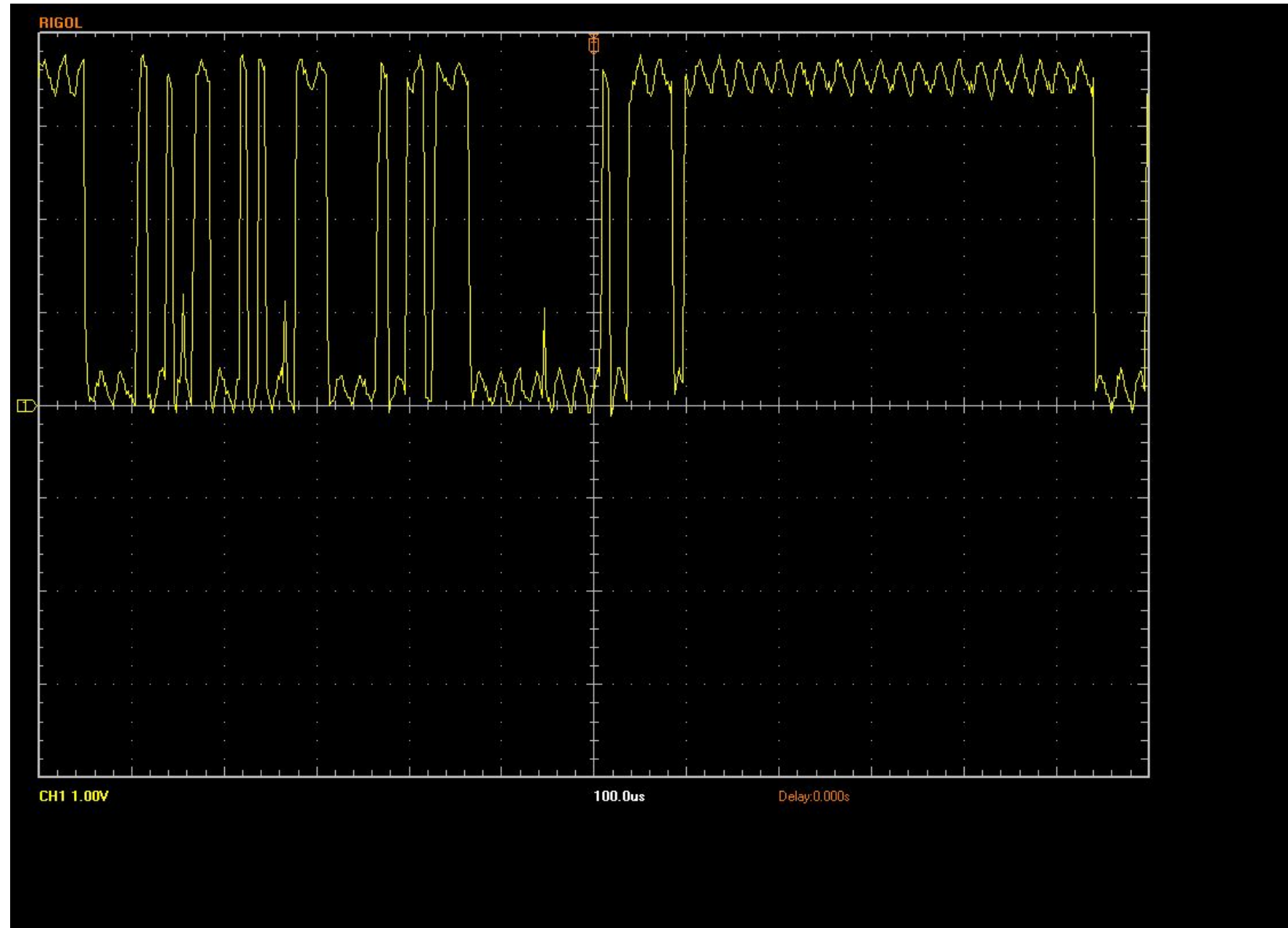
A resistor is placed between a DC voltage line and the data line to create the data line



Here is the 3.42v side of the pullup resistor. Look, plain flat 3.42v of DC.



This is the DATA side of the data line. Note how the chip is creating data by making voids in the 3.42v of different width and height. This means something

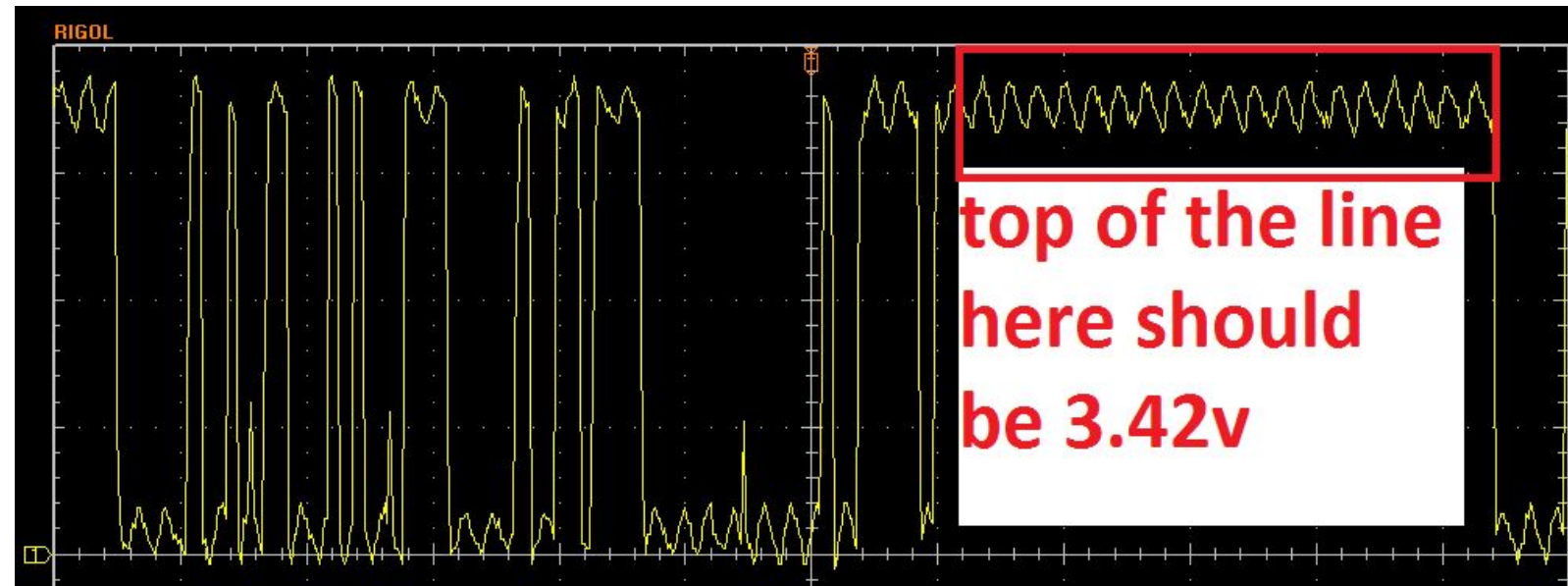


DON'T ASK ME!!!!

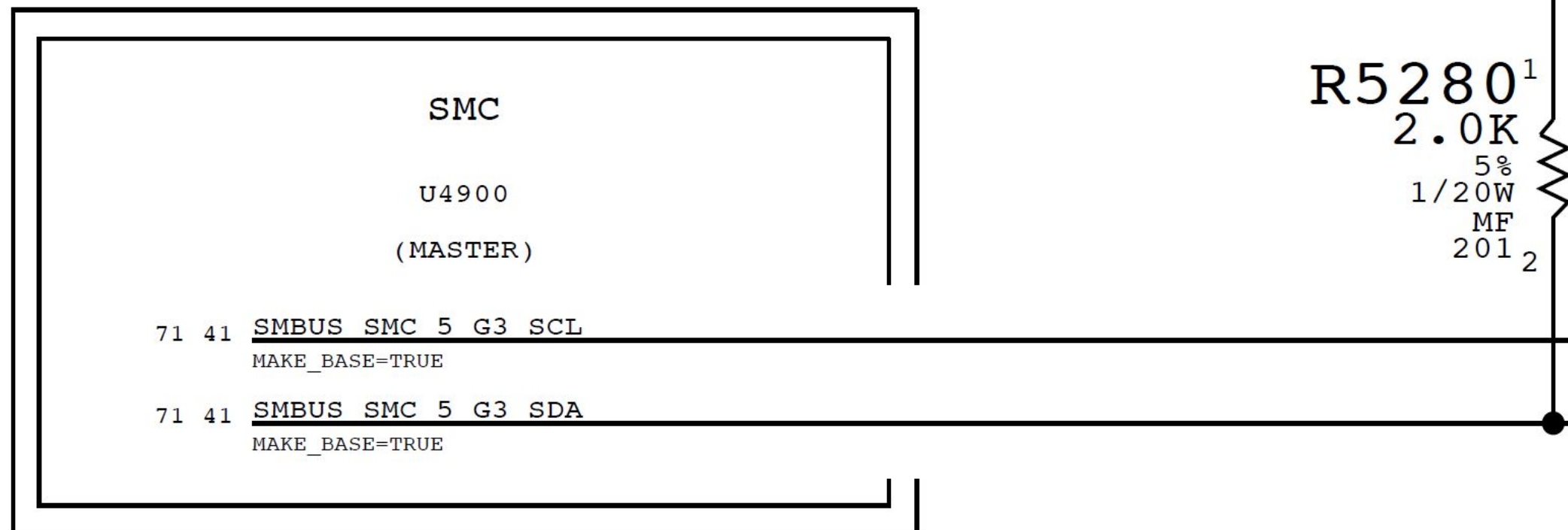
- What the pulses mean.
- What the width of the pulses mean.
- What the height of the pulses mean.
- Because FUCK IF I KNOW!!!!
- Ask an APPLE ENGINEER!!!!
- And good luck with that....
- Some of these signals can be found in IC data sheets, if the're documented there's usually enough information to infer what is supposed to be happening in optimal circumstances -k

What are we interested in when checking data lines?

- Is there pulsing?
- Does it look similar to what you see on a working board?
****MOST IMPORTANT****
- Does the TOP voltage on the data side equal the voltage present on the data line?



3.42v 7 =PP3V42 G3H SMBUS SMC BSA



When troubleshooting a data line running on a 3.42v power line...

- If it is stuck at the top voltage of the power rail all the time - say 3.42v, something is not speaking.
- If it is stuck too low – it tops out at 2.6v, or 2v, instead of 3.42v, then some component on the line is pulling it down. Maybe crap in a connector or a bad chip.

What is a power rail?

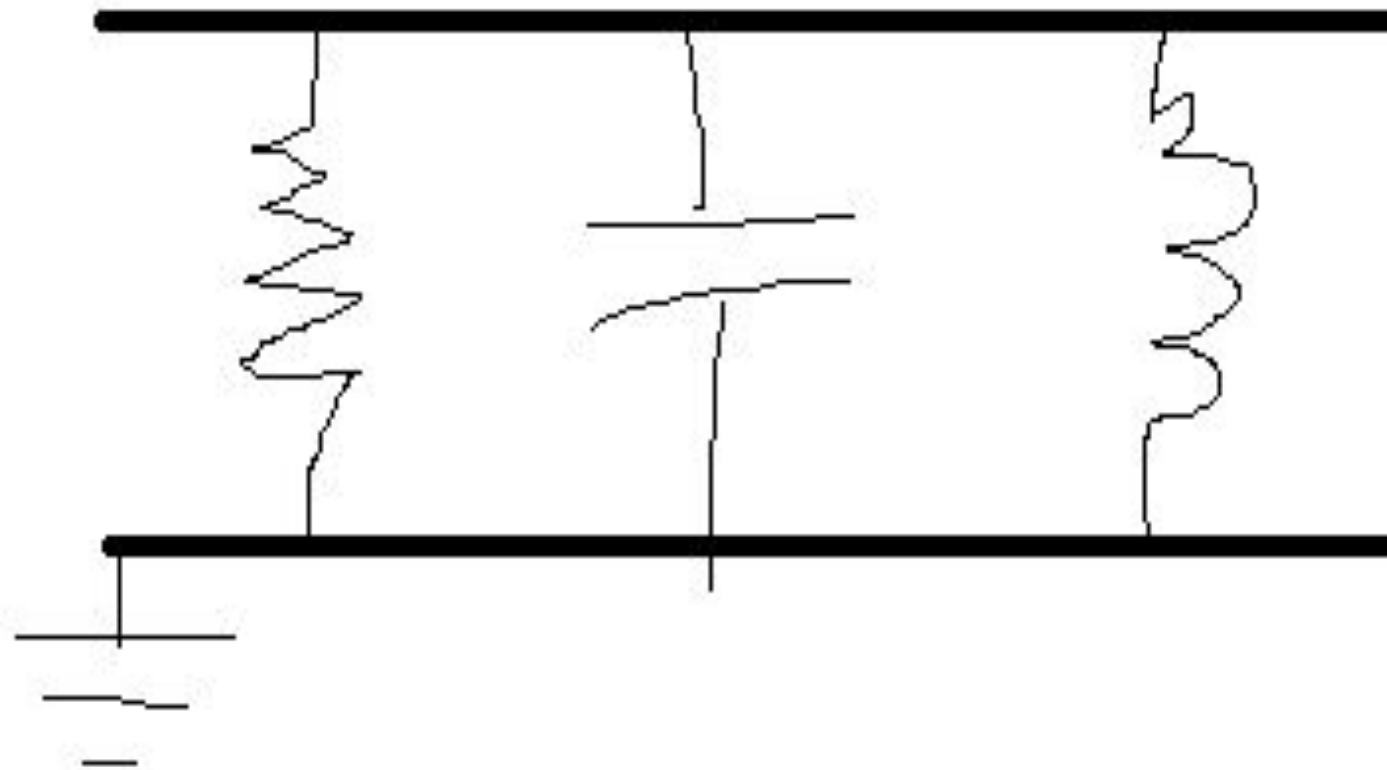
- A power rail is just a power line upon which you can attach components.
- PP5V is a 5V power line, with five volts on it.
- PP3V3 is a 3.3v power line, with 3.3 volts on it.

Here a resistor, capacitor, and inductor
are attached to a 5 volt power rail.

PP5V_S5

5 VOLTS

GROUND



If a power rail is ****MISSING****

- Is it not being created?
- Is it being shorted to ground?
- Is an enable pin on the integrated circuit responsible for it not receiving power?
- ``
- WHO KNOWS!?! It could be any of the above, and your job is to figure it out.

How circuits fail

- A circuit can fail if it is not being told to turn on.
- A circuit can fail if there is a short circuit to ground - something is pulling all the power to ground when it should not.
- A circuit can fail when a line goes “open” and does not conduct power – power simply stops at a point and does not make its way through the circuit.
- Many people go nuts checking for shorts and opens before seeing if the circuit is even being told to turn on. Do not be one of those people.

Checking for shorts to ground

- Diode mode on multimeter is VERY HANDY for this.
- Diode mode is much faster than resistance mode.
- Put red probe on ground, black probe on power rail you believe is not working how it should.
- See number. Low number = low voltage drop to ground.

Finding a short to ground on the line.

- Ground is a black hole for electricity - electricity will try to give all of itself to ground given a low resistance path to it.
- More energy = more heat.
- A component shorted to ground will try to pass infinite energy, making it very hot.
- On a 5 volt power line, if you inject 5v from an external source, and attach the ground of the external source to the ground of the board, the component shorting to ground will get very hot.
- This will allow you to find the component that is shorted.
- Do NOT use your genitalia to find the hot spot on the board, regardless of what the internet tells you.

Other benefits of diode mode troubleshooting

- All circuits attach to ground in some way or another.
- By comparing the way a malfunctioning circuit attaches to ground to how a working circuit attaches to ground, we can narrow down the point of failure.
- Before you repair a circuit, measure diode mode to ground on it and compare to a working board.
- Write down the numbers in a spreadsheet, along with the issue.
- Make a database of numbers and attach them to issue types.

For example, on backlight circuit output on LP8550 based boards....

- 0.565-0.595 = bad switch via from inductor to LED driver.
- 0.465-0.511 = bad feedback via from backlight output to LED driver
- 0.200-0.300 = bad LED driver
- 0.000-0.070 = bad LCD connector, or totally destroyed LED driver.

These numbers do not come from thin air!

- I measured the circuit each time I had a problem.
- When I figured out the problem, I put the number next to the issue in my brain.
- The next time I had a problem, I would make a diode mode measurement. Without wasting brain power
- Troubleshooting / diagnosing / chasing problems, I just checked what was wrong the last time I had that number.

You can use this to make your own “ANSWER KEY” when you are lost!

- If you have a known working board and your dead board, this is an amazing way to compare and contrast back and forth.
- You can check every pin of an IC for power management.
- You can check sensor data lines for SMC communication.
- You can check PCI express data lines for CPU/GPU communication.

The possibilities are endless - build your own answer key using diode mode measurements so you do not have to reinvent the wheel every time a board has a problem.

What are power STATES?

- Computer is off - S5
- Computer is hibernating - S4
- Computer is sleeping - S3.
- Computer is on and working, S0.
- Different power will be present during different states. You need CPU vcore during S0 while it is on, but you do not want it when it is off – S5.
- PP5V_S3 and PP5V_S0 are created by the exact same circuit, but PP5V_S0 is only meant to be present when the laptop is on, opened up, and being used.

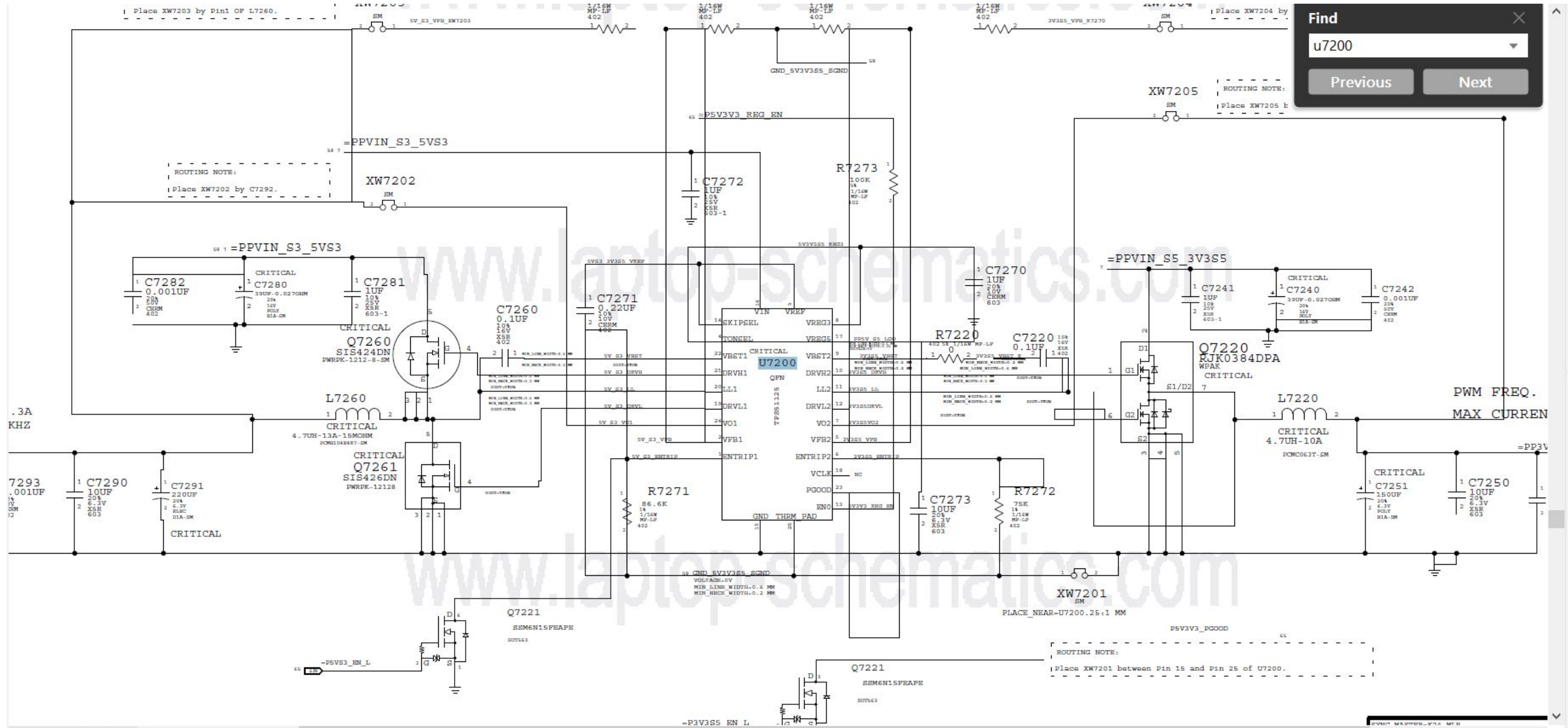
When troubleshooting power rails, is the rail ABOVE the rail you are troubleshooting working?

- Let's say PP5V_S5 is missing – a 5 volt power line.
- Many people would start troubleshooting PP5V_S5.
- Schematic shows that the chip that CREATES 5 volts is powered by a 12 volt power line called PPBUS_G3H.
- If 12v is not present on the board, would we get PP5V_S5? NO!!!
- Would you rather start replacing things on PP5V_S5 circuit, or check if it is getting 12v to turn into 5v first? CHECK 12V FIRST!!

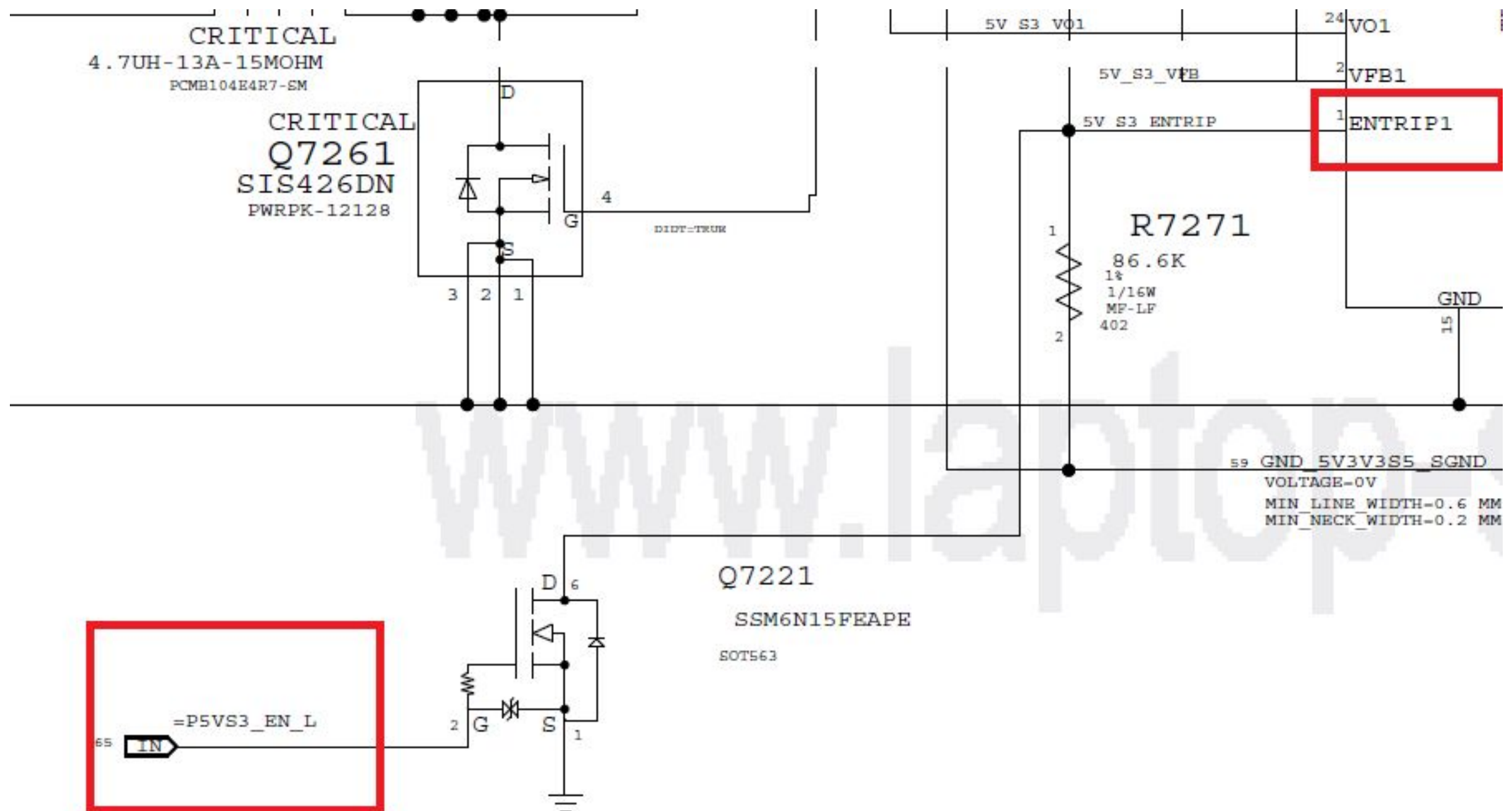
When troubleshooting power rails, is it even being told to turn on?

- Most power ICs and circuits have enable or entrip pins.
- Without voltage at these pins, it will not turn on.
- What is easier to do – check ONE enable signal, or measure 50 resistors/capacitors?
- Check if it is being told to turn on BEFORE YOU DRIVE YOURSELF NUTS!

How many people get sick looking at this?



Let's make this simple. First; is it being told to turn on?



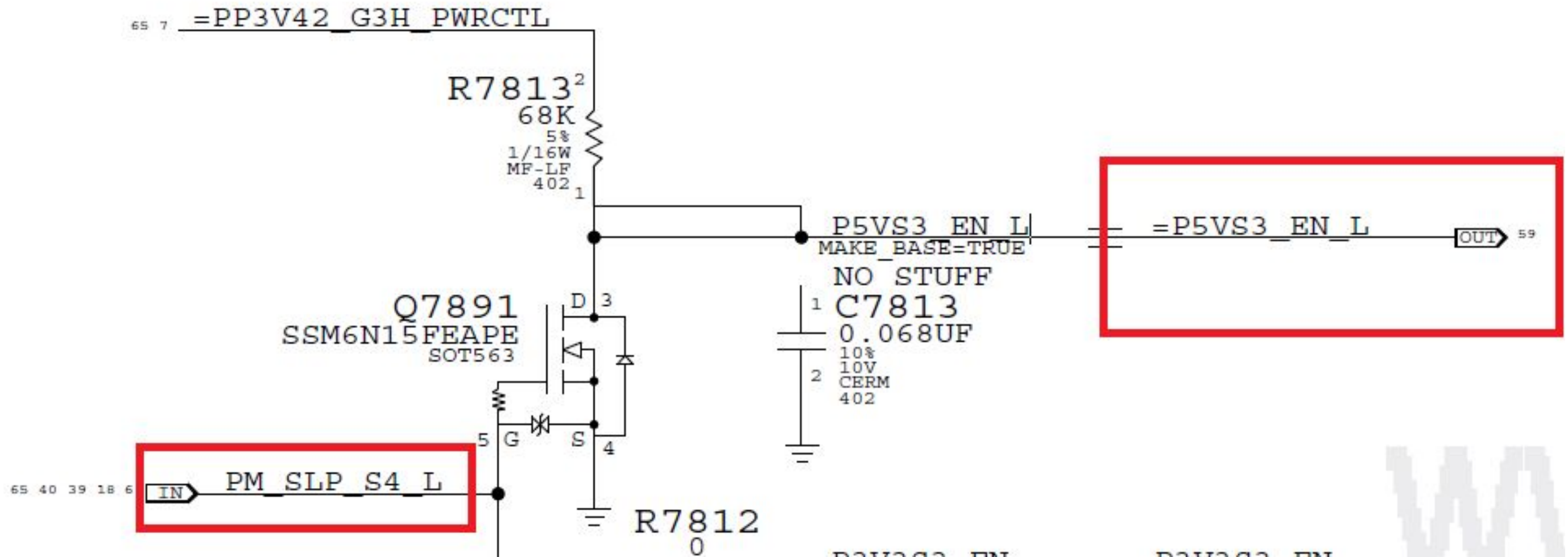
See how we ignore all the shit on that page that is boring to get to what is relevant?

P5VS3_EN_L tells Q7221 to short the ENTRIP pin to ground. According to the datasheet for TPS51125, the chip will NOT create a 5 volt power rail while its entrip pin is shorted to ground! We need to get rid of this terrible P5VS3_EN_L signal.

Let's follow further down.

P5VS3_EN_L is shorted to ground if
PM_SLP_S4_L is high

S3 Rail Enables



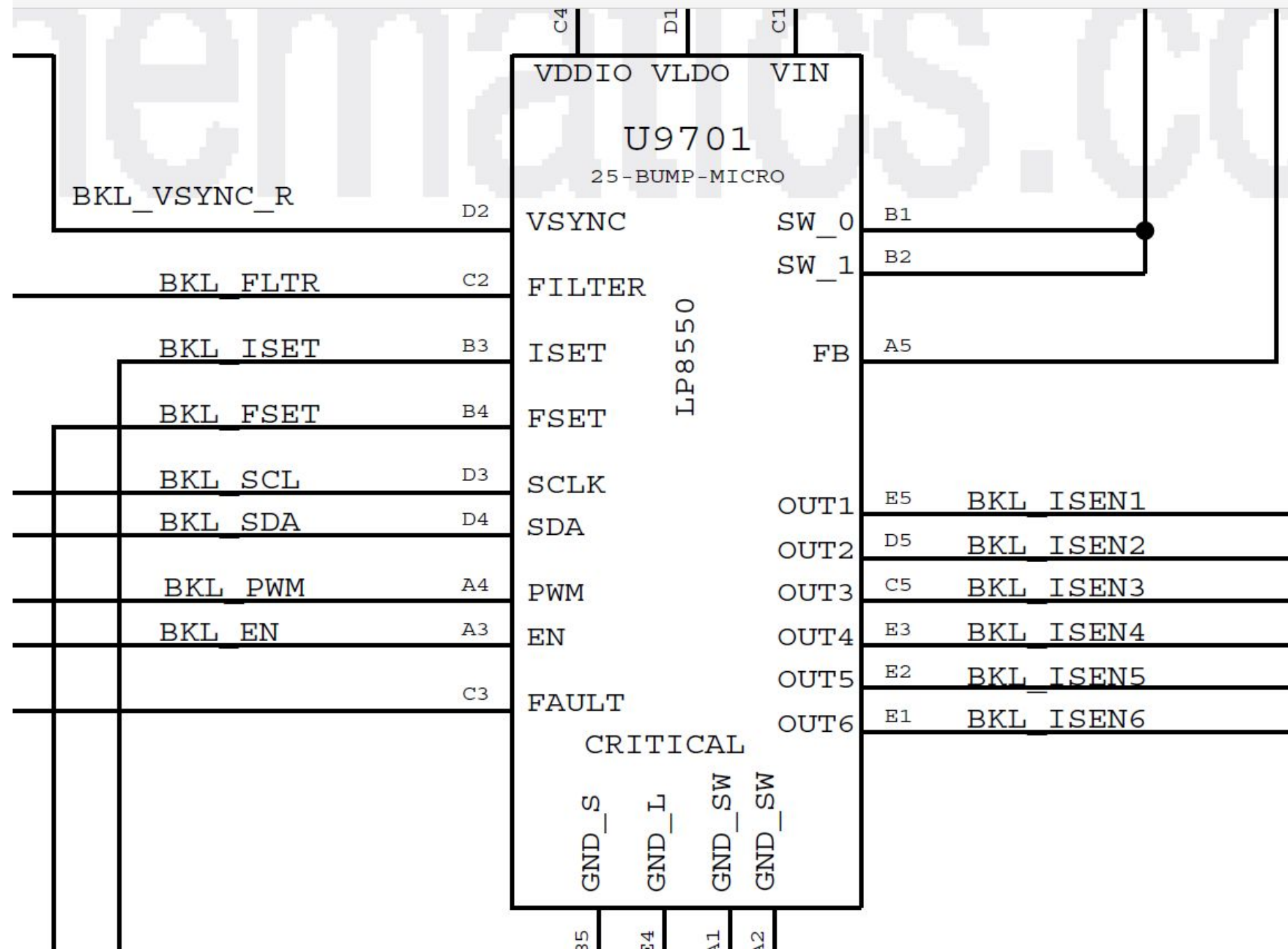
PM_SLP_S4_L is where this ends

- If PM_SLP_S4_L exists, check upstream. Is the chip bad? Is the enable signal getting fucked up somewhere else in the line?
- If PM_SLP_S4_L does not exist; STOP TROUBLESHOOTING TPS51125 CIRCUIT! You cannot blame a chip for not creating voltage when it is not being told to.
- Make sure you are troubleshooting the correct problem.
- We talk of chasing a rabbit down a hole all the way to hell. The problem is often that we running down the wrong hole; one within which a rabbit does not even reside.

What is an integrated circuit?

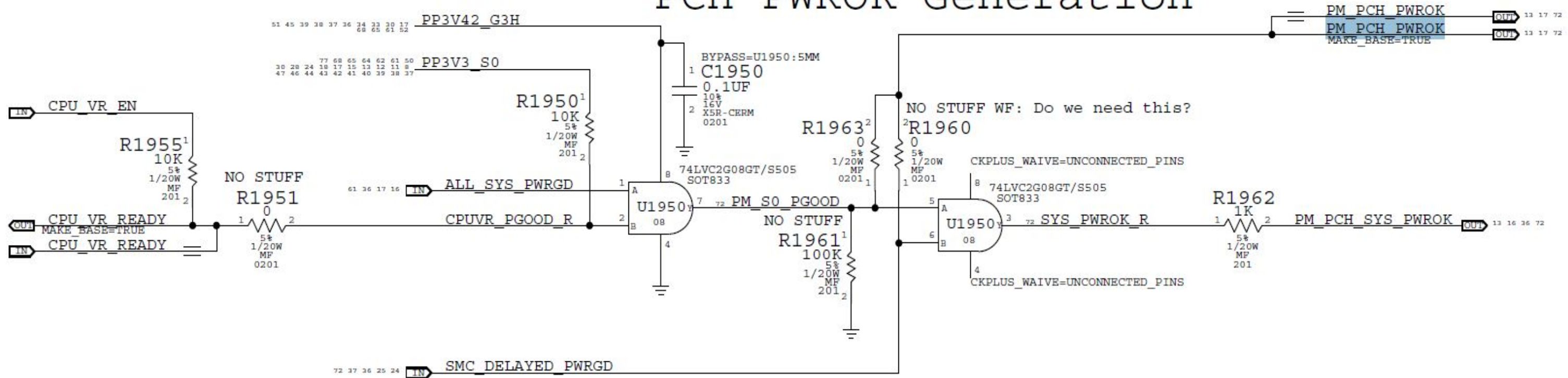
- Commonly known as a “chip”
- Integrated circuits are combinations of the above components inside of a single package.
- This single package has a specific function. Make my backlight. Make my CPU power. Whatever it is meant to do.
- Integrated circuits allow us to have smaller devices with less visible components.

Here is an integrated circuit



WTF is this?

PCH PWROK Generation



A few basic things to take note of

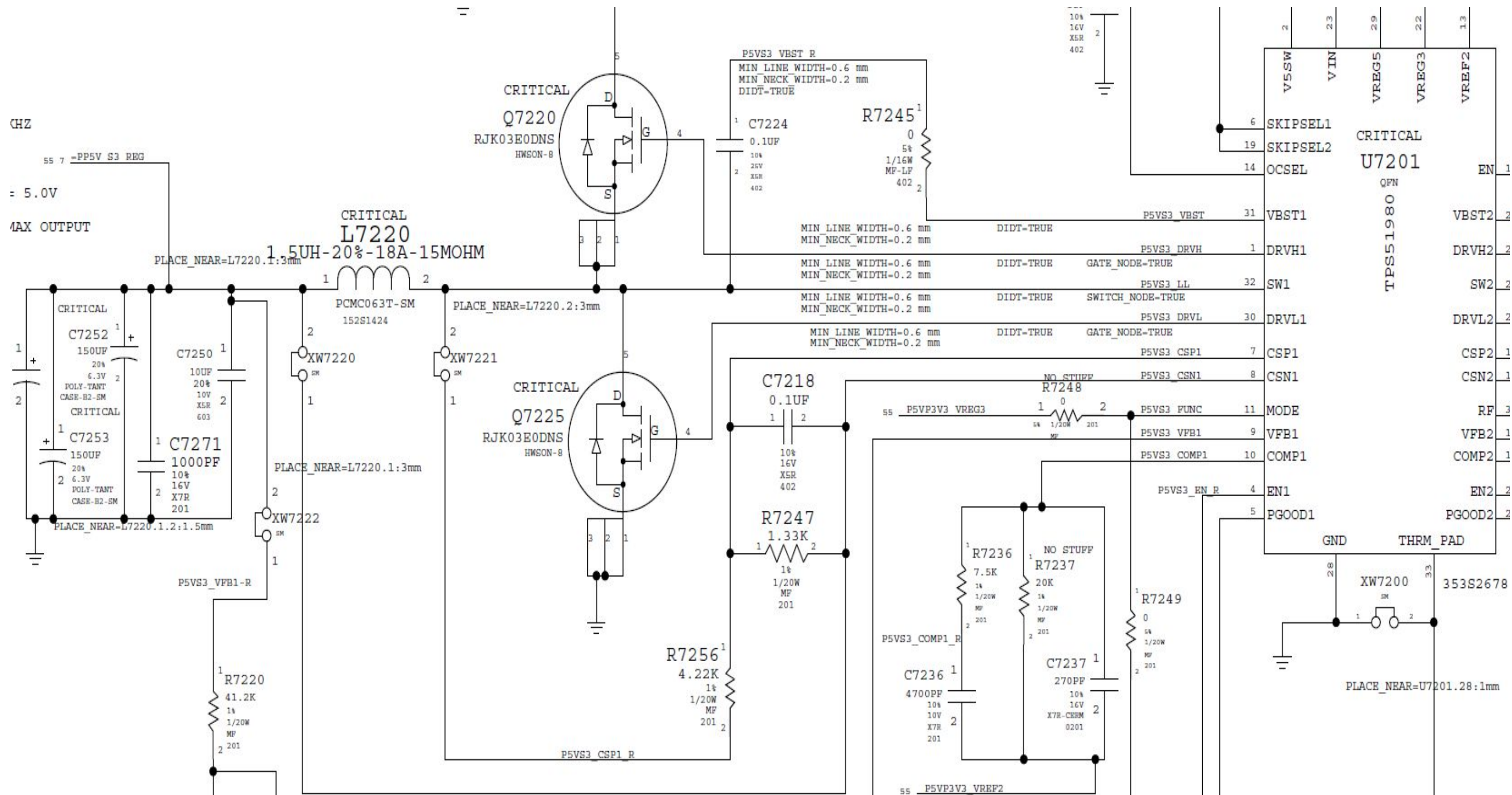
- Integrated circuits need power to run. This pin is called VCC, VDD, VEE, VSS, or VIN.
- If it says “PP5V” on a VCC, VDD, VEE, VSS, or VIN pad, **YOU WANT 5 VOLTS TO BE THERE!!!**
- **EN** is usually for “**ENABLE**”
- If you do not have voltage at an “ENABLE” pin, **DO NOT REPLACE THE IC**. It's not being told to turn on. On rare occasion enable pin is shorted to ground inside of a messed up chip, but as a general rule, make sure it is being told to turn on.

What is a logic gate?

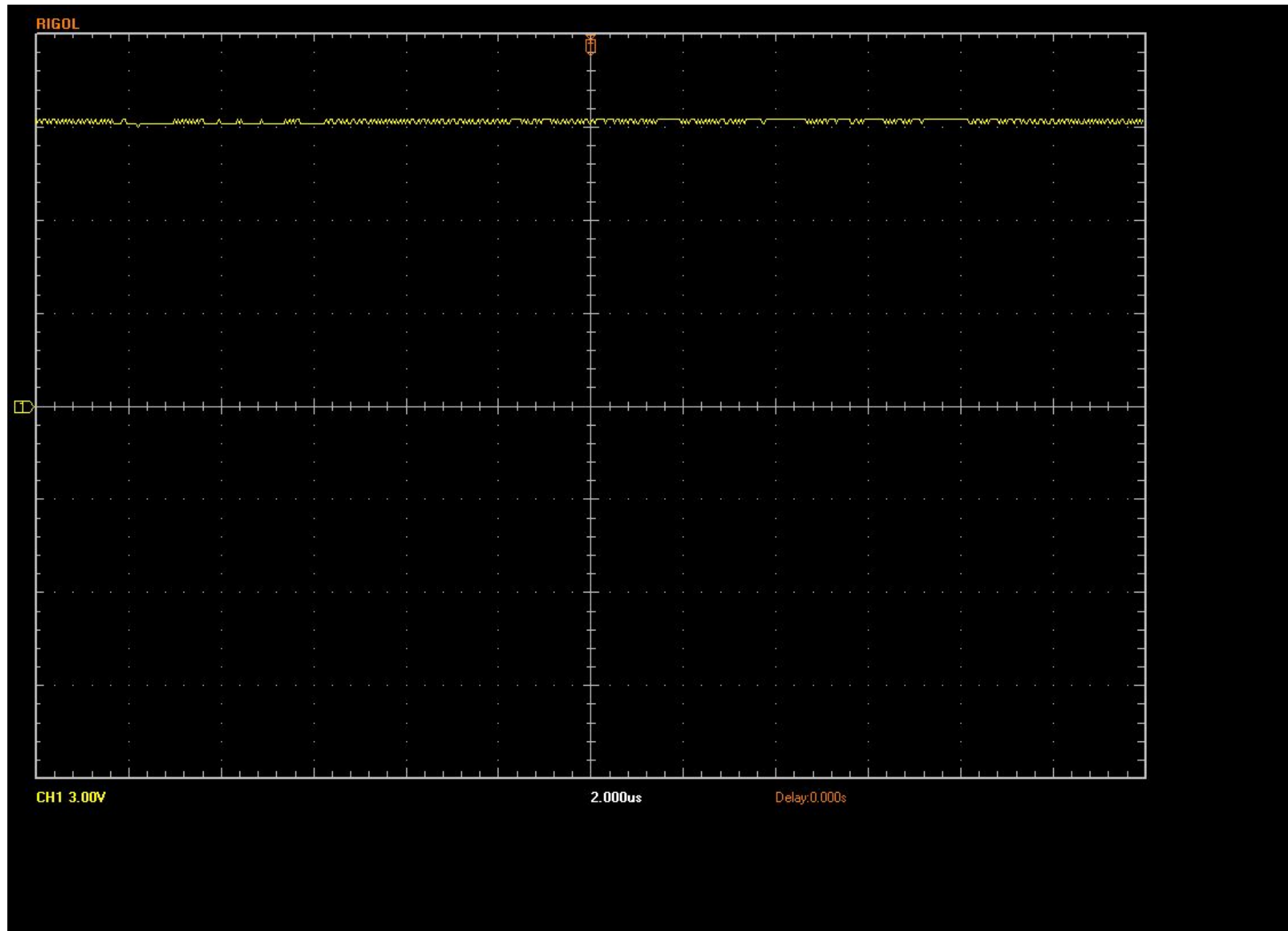
- A logic gate has a set output for a set input.
- A logic gate is often used to only let power through if specific input signals are present.
- For example, if circuit A and B tell me they are ok, then tell circuit C to turn on.
- If circuit A is ok but circuit B is fucked, do not turn circuit C on.
- Different logic gates work in different ways. Look at datasheet for a specific logic gate to see how it works. OR compare with working system.

What is a buck converter?

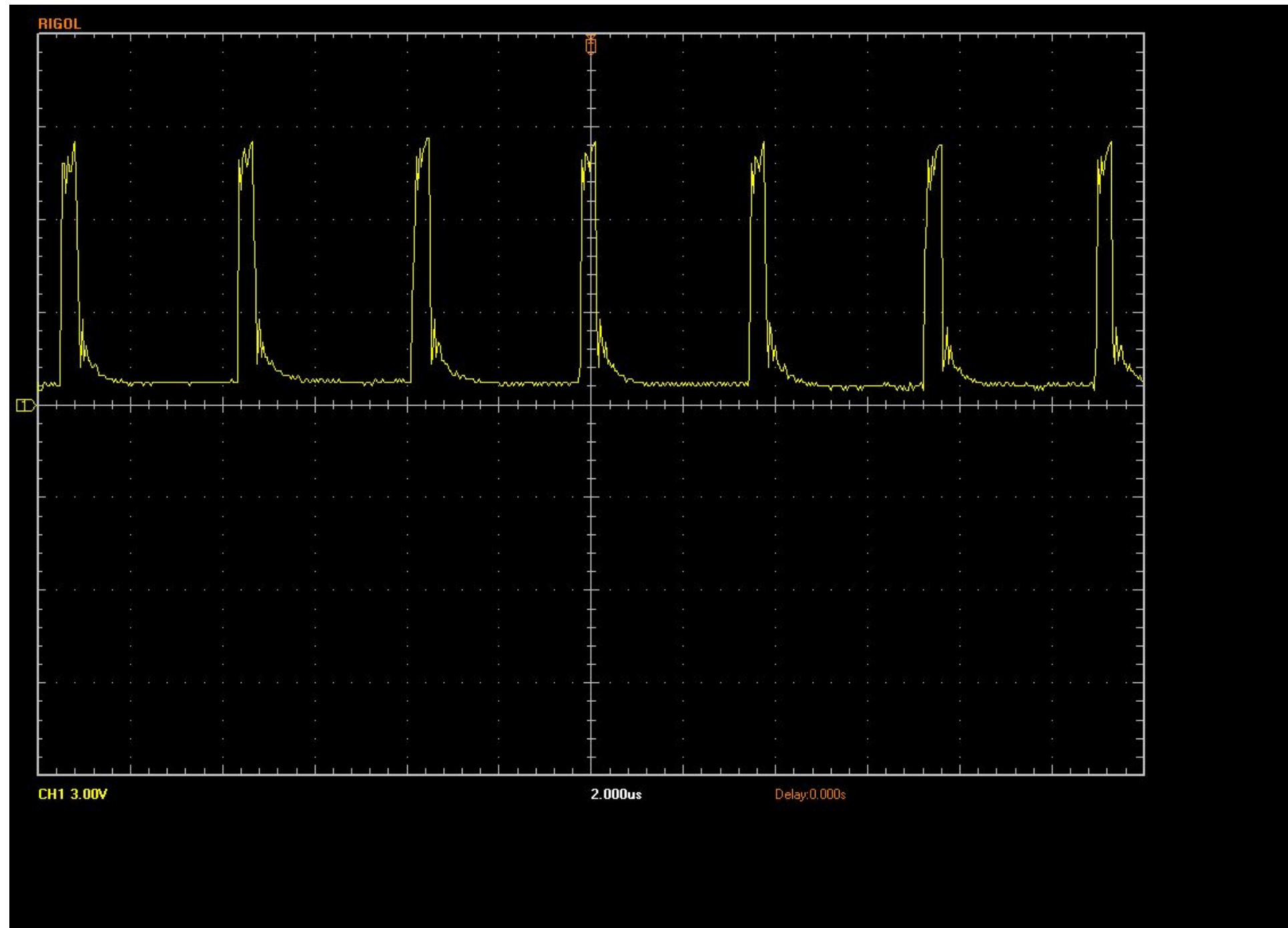
- A buck converter takes a higher voltage and turns it into a lower voltage.
- Voltage dividers do the same thing, but are VERY inefficient since it is “always on”
- A buck converter is a linear voltage regulator.



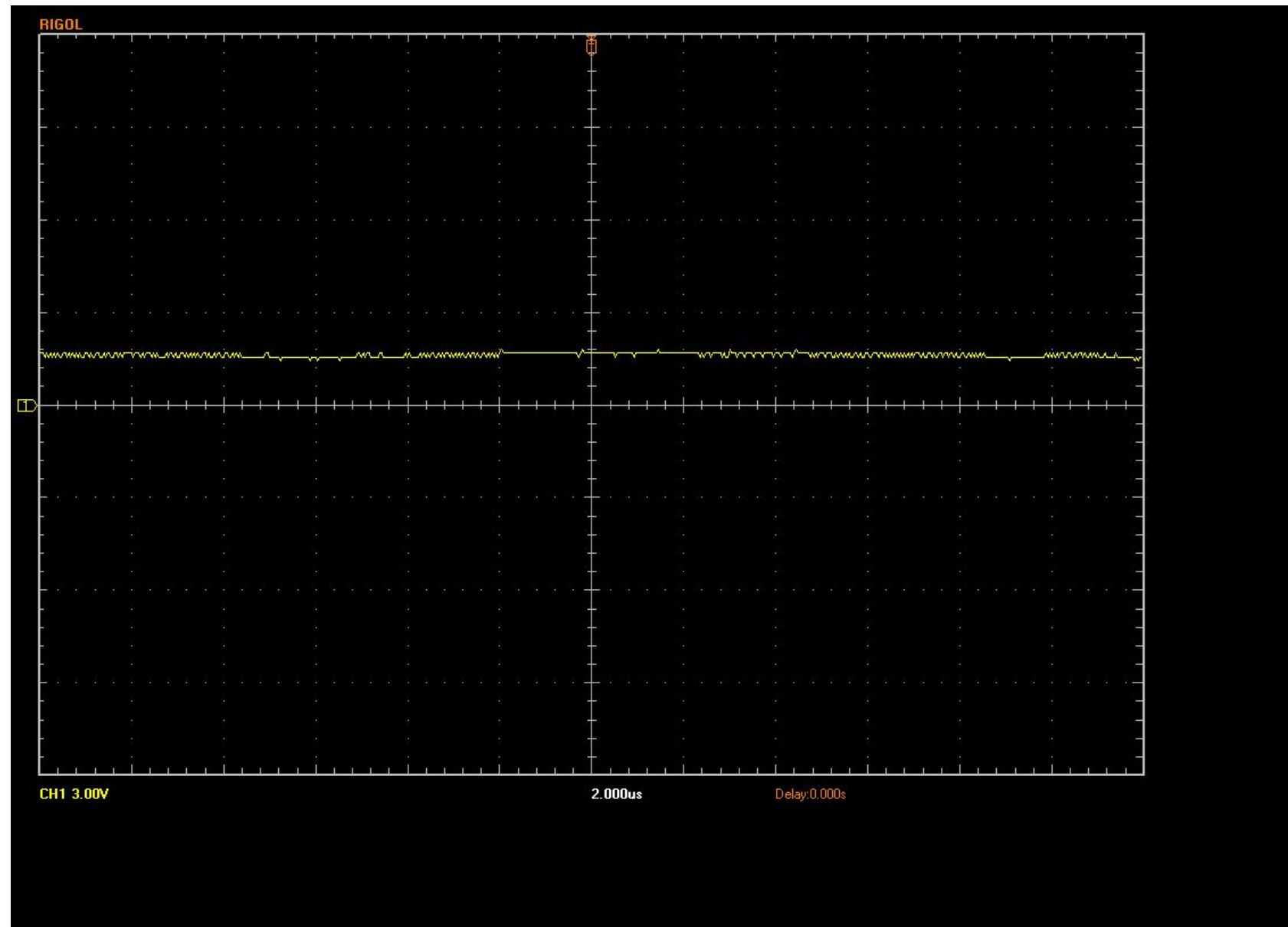
We start with a high voltage, like 8 volts

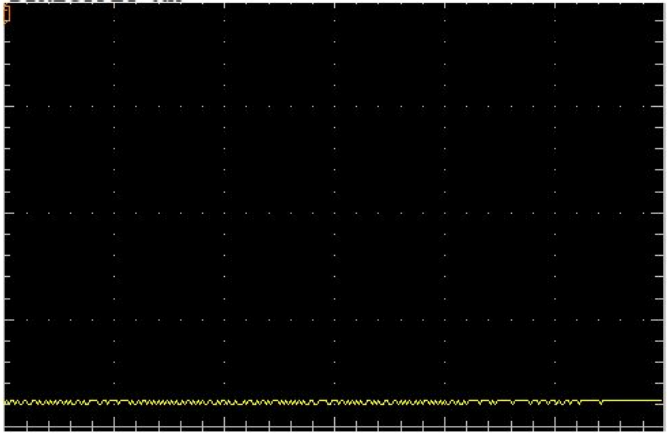
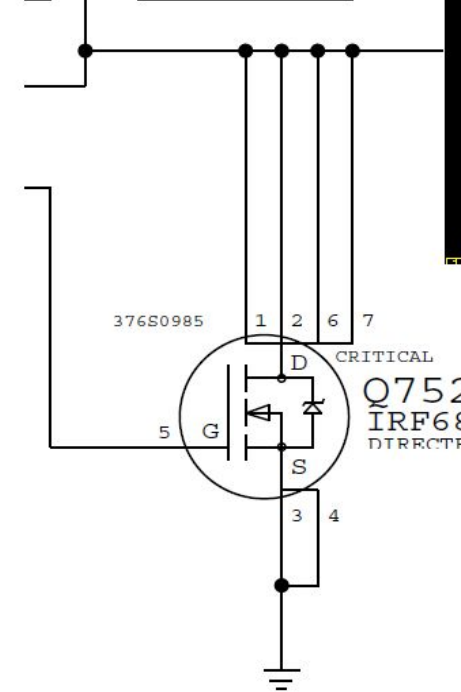
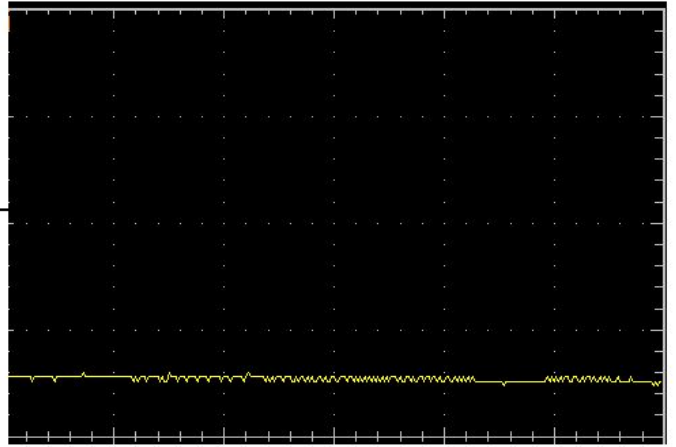
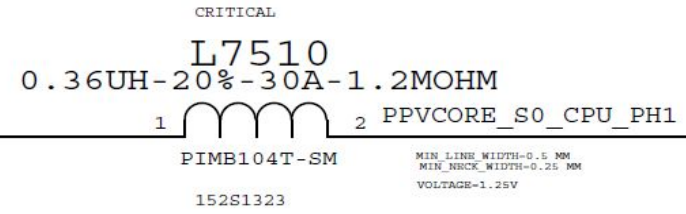
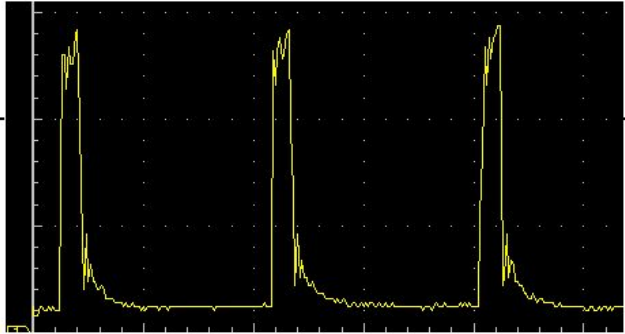
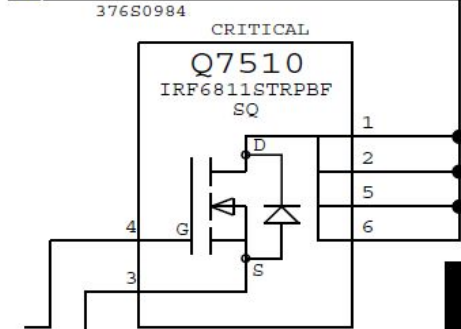
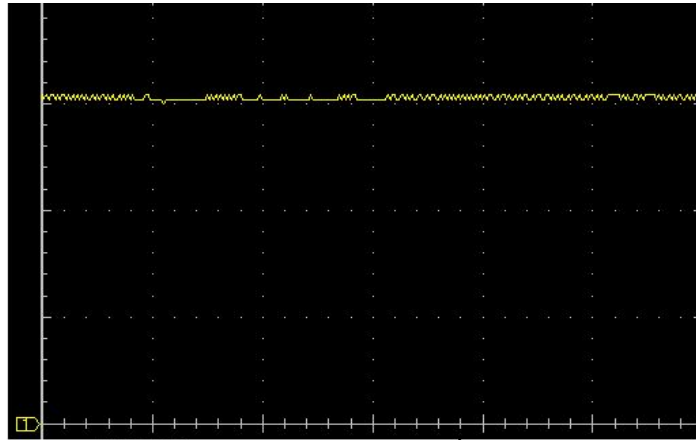


Buck converter “switches” it on and off. 8 volts, 0 volts. 8 volts, 0 volts.
This sucks. Would you want to drive in this car???



Output is “averaged” to 0.8 volts by an inductor and a capacitor into a nice flat line. Ahh, much nicer ride, says the CPU.





What is a DC to DC boost circuit?

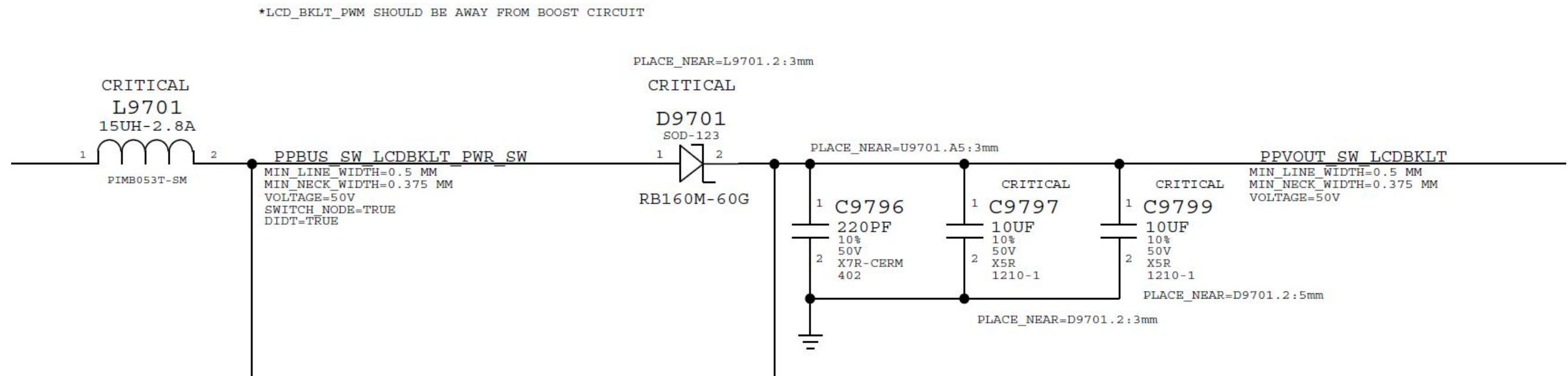
A laptop LCD backlight runs off of about 39 volts in an A1286 Macbook Pro. Its BATTERY is a 12.6 volt battery. Does this mean we carry around flashlights? NO!!! We boost it.

- A DC to DC boost circuit boosts a lower DC voltage into a higher DC voltage.
- Think of it like stopping short in a car.
- For that split second when the brakes are slammed, you are moving forward faster than the speed of the car. Good thing we have seatbelts!

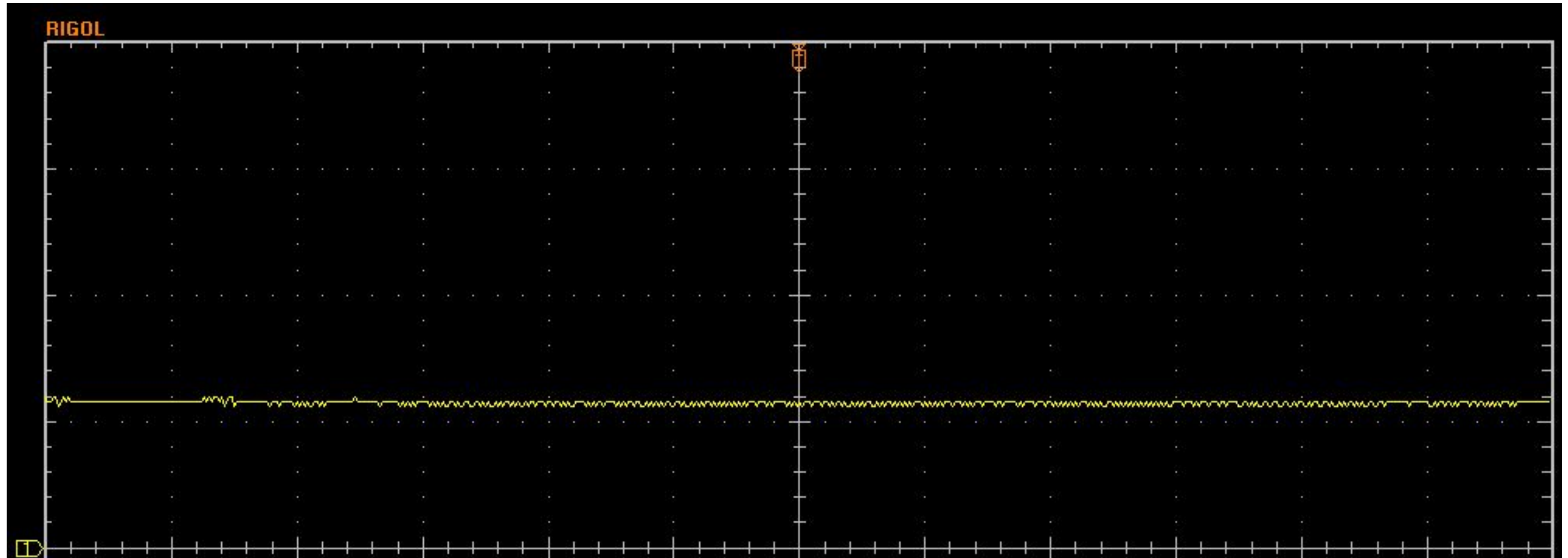
Same concept is applied in electronics.

DC to DC boost circuit contains four main elements

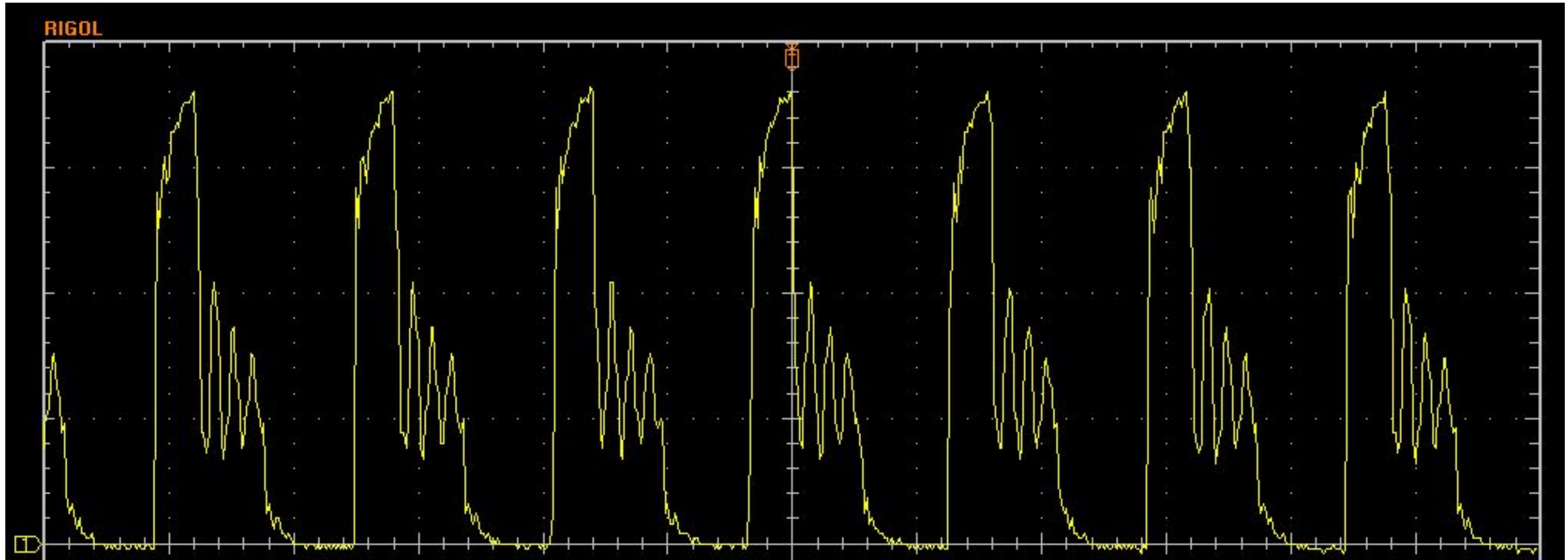
- **Inductor** - this is what is energized by the driver, and then shorted to ground to create the higher voltage.
- **Diode** - this keeps the boosted voltage from flowing back through the circuit.
- **Capacitor** - this stores the boosted voltage, and also smoothes it into a straight line.
- **LED driver** - this is what does the switching to switch the inductor's output to ground.



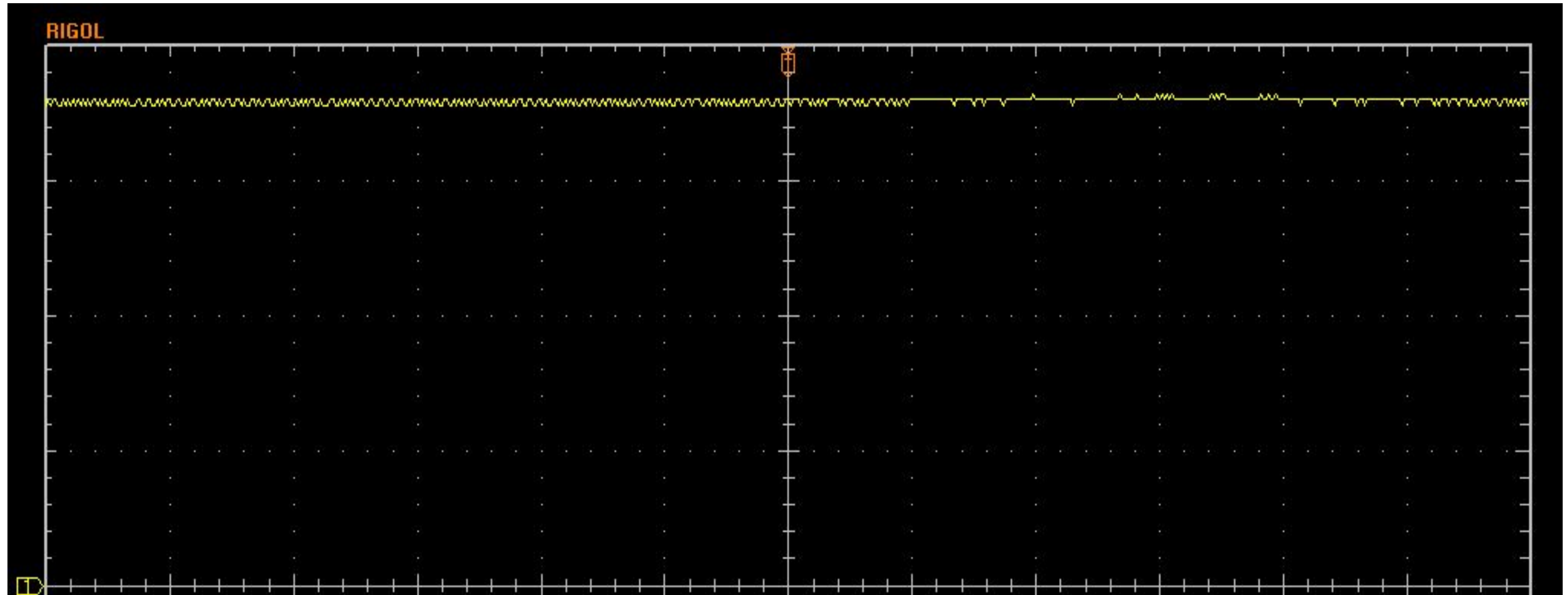
Unboosted 8 volts. BEFORE INDUCTOR!!!



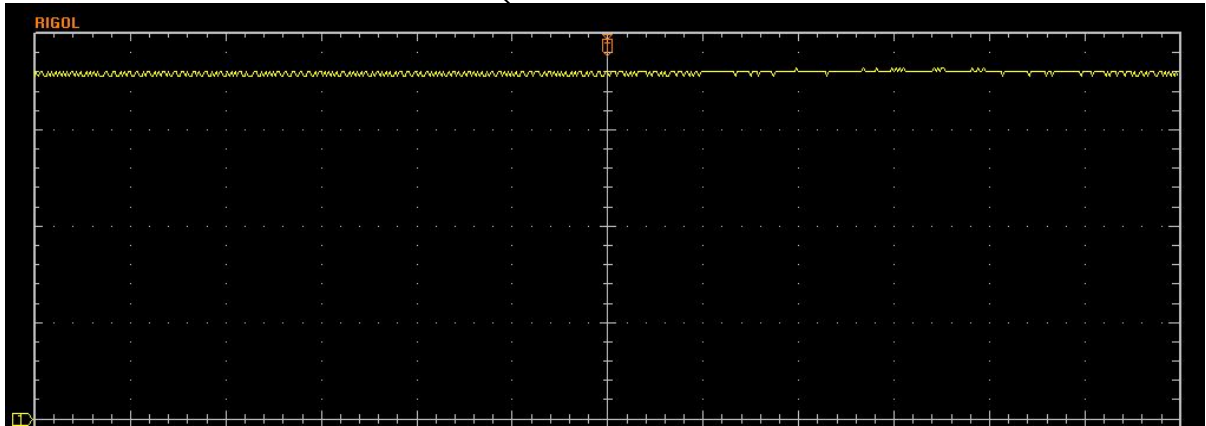
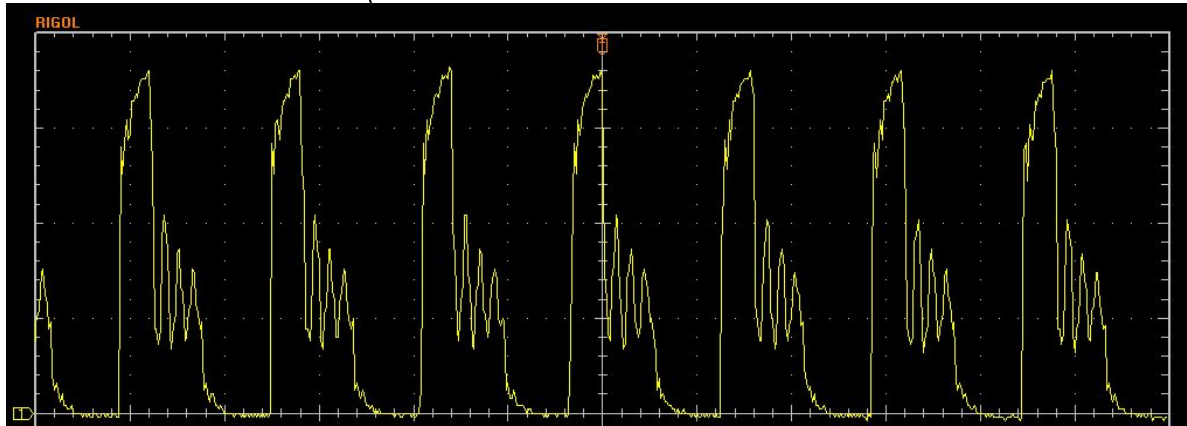
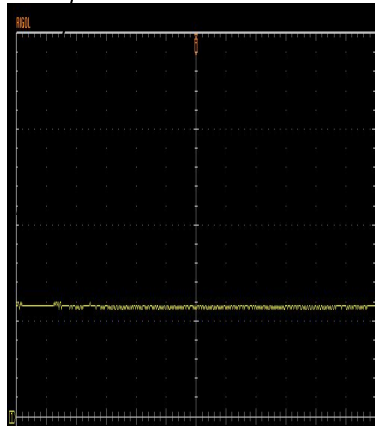
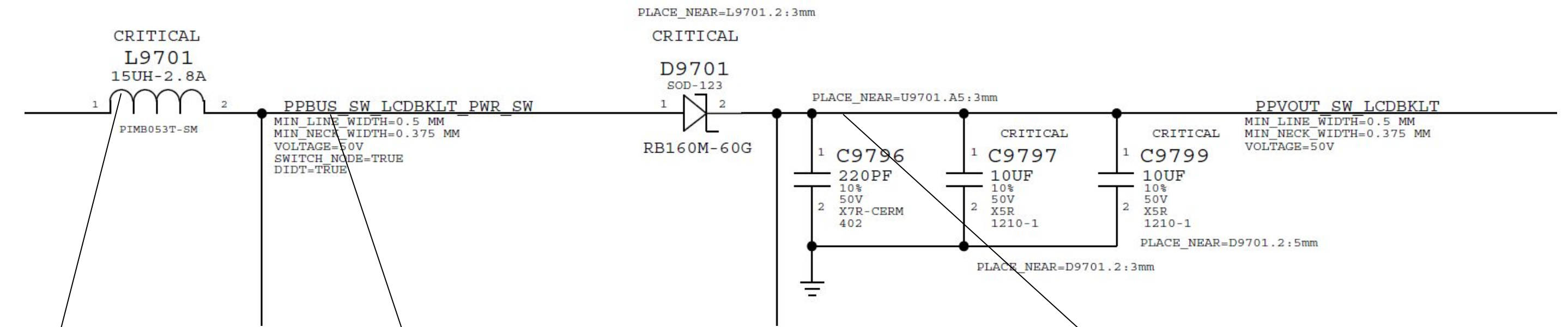
Voltage after inductor when switching to ground



Voltage after diode & smoothing capacitors



*LCD_BKLT_PWM SHOULD BE AWAY FROM BOOST CIRCUIT

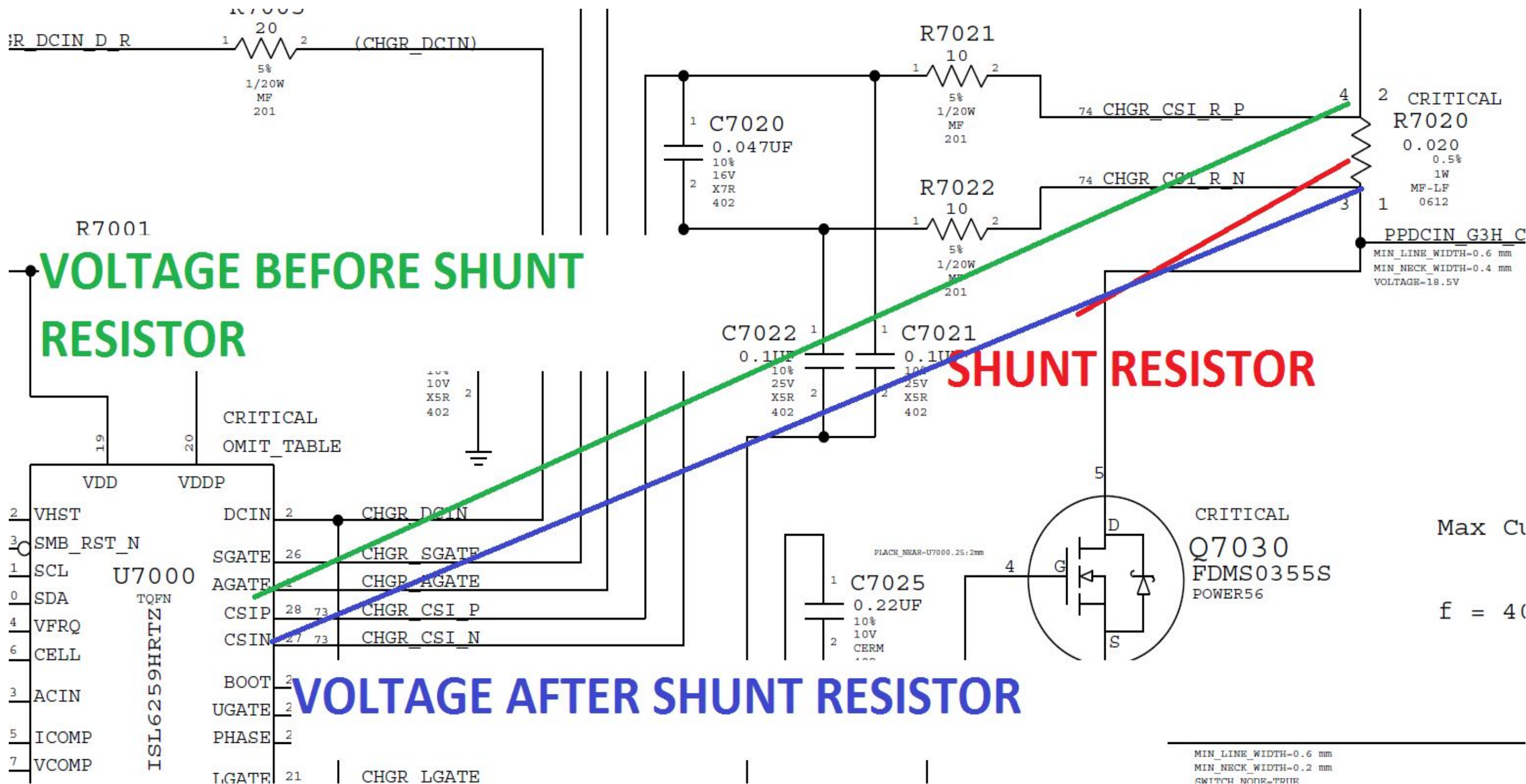


What is current sensing?

- Current sensing is to sense how much amperage a circuit is using.
- Knowing how much power a circuit is using is important for safety concerns – turn it off if it is using too much!
- Also useful for data. Laptops tell you how much time is remaining on battery, and this changes based on what you are doing.
- How does it KNOW?

If a circuit is using too much current, current sensing turns it off.

- To tell current being used, you must be “in” the circuit.
- Outside the circuit, U7000 can't measure current – only voltage.
- We solve this problem by putting a shunt resistor in the circuit.
- The resistor will have a very tiny voltage drop across it – barely noticeable.
- This voltage drop is **DEPENDENT** on the power the circuit is drawing.
- U7000 measures the difference in voltage before and after the resistor. This allows the buck regulator controller chip to know the amperage of the circuit - without being inside the circuit!



Max C_t

f = 40

MIN_LINE_WIDTH=0.6 mm
MIN_NECK_WIDTH=0.2 mm
SWITCH NODE=TRUE

Common faults

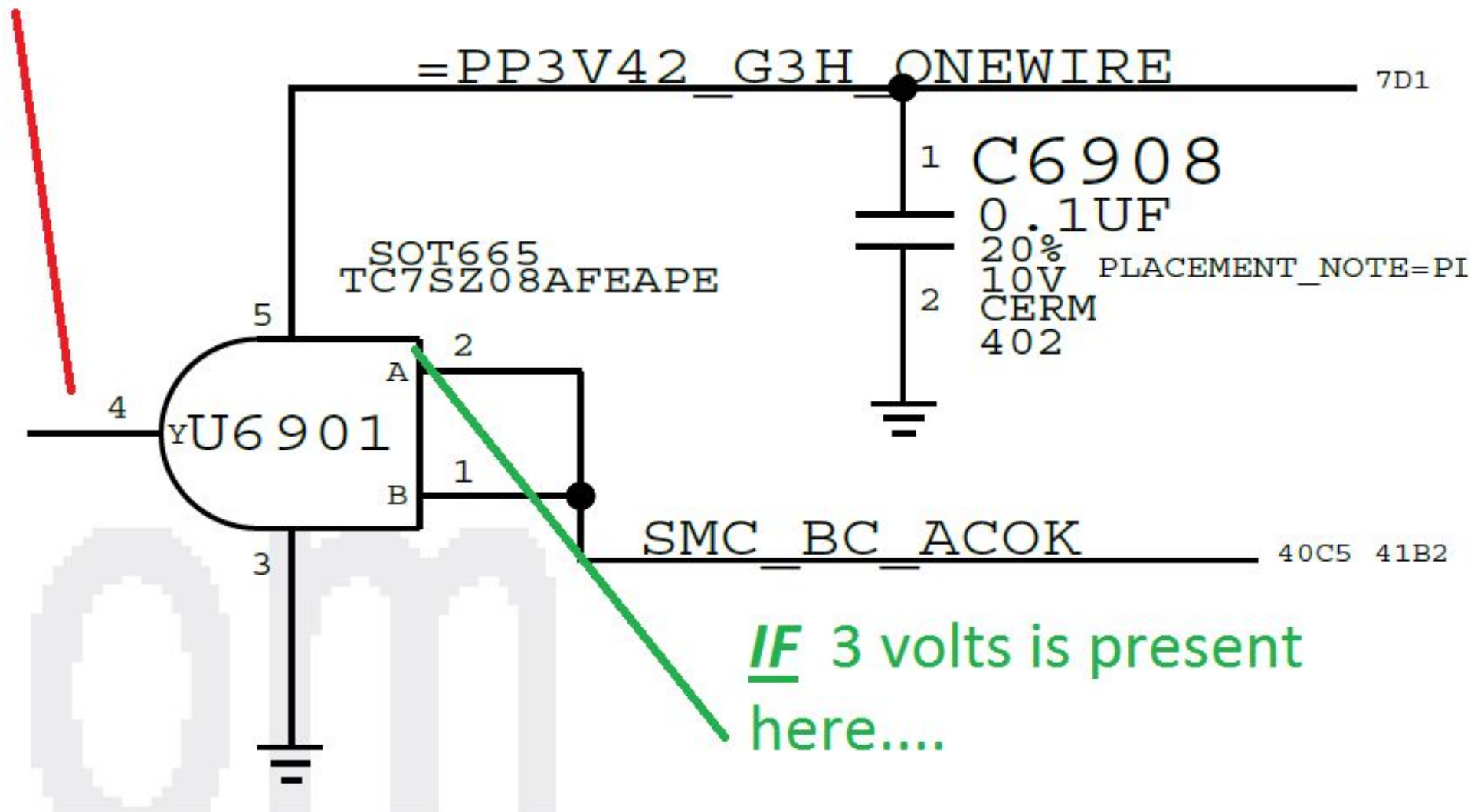
- Resistor between shunt resistor and buck controller IC die.
- Traces between shunt resistor and resistor, and resistor and buck controller IC die.
- This can cause not charging the battery, not turning on, no green light, quarter fan spin.
- Can also keep battery from charging. If it thinks charger is drawing too much it will turn off charging, if it thinks battery is exploding it will turn off charging.

What is the onewire circuit?

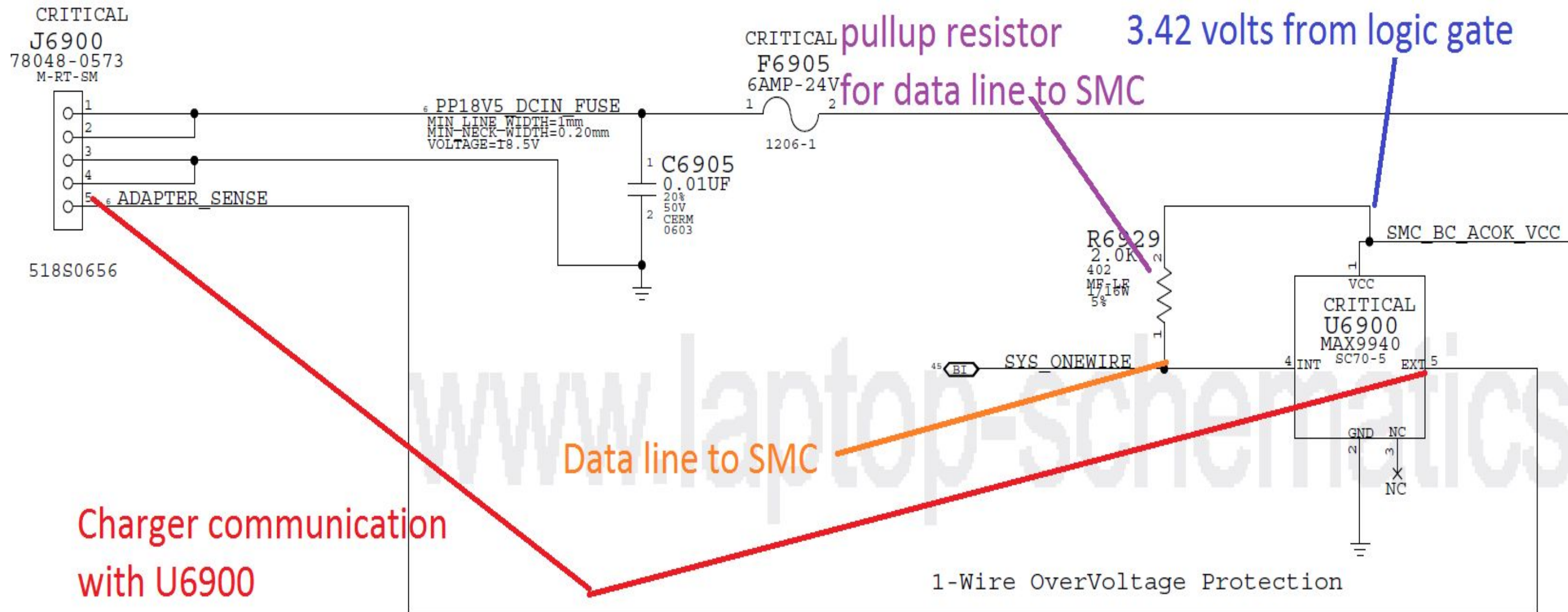
- Allows communication between the magsafe charger and the SMC.
- Only allows communication if certain conditions are met.
- Constantly dies for silly reasons.

QUICK REFRESHER: Remember what a logic gate is?

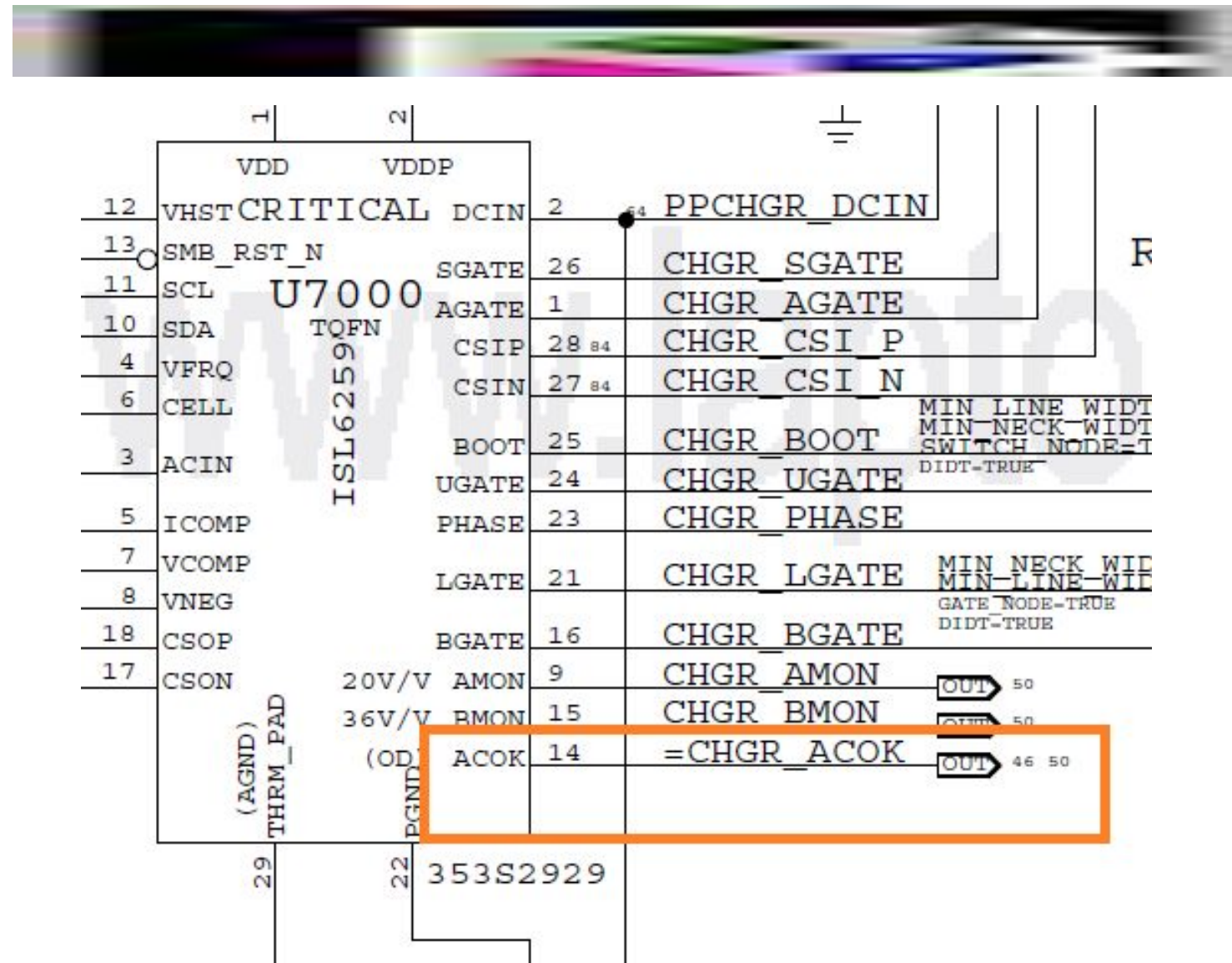
THEN the 3.42v from pin 5 will be passed through pin 4.



The 3.42v that comes out of the LAST chip powers this chip that sends charger data to the SMC.



SMC_BC_ACOK can be brought low by the U7000 - which controls creating the main 12.6v rail of the machine from the charger power. This can stop the onewire circuit from allowing the charger voltage through to the machine.

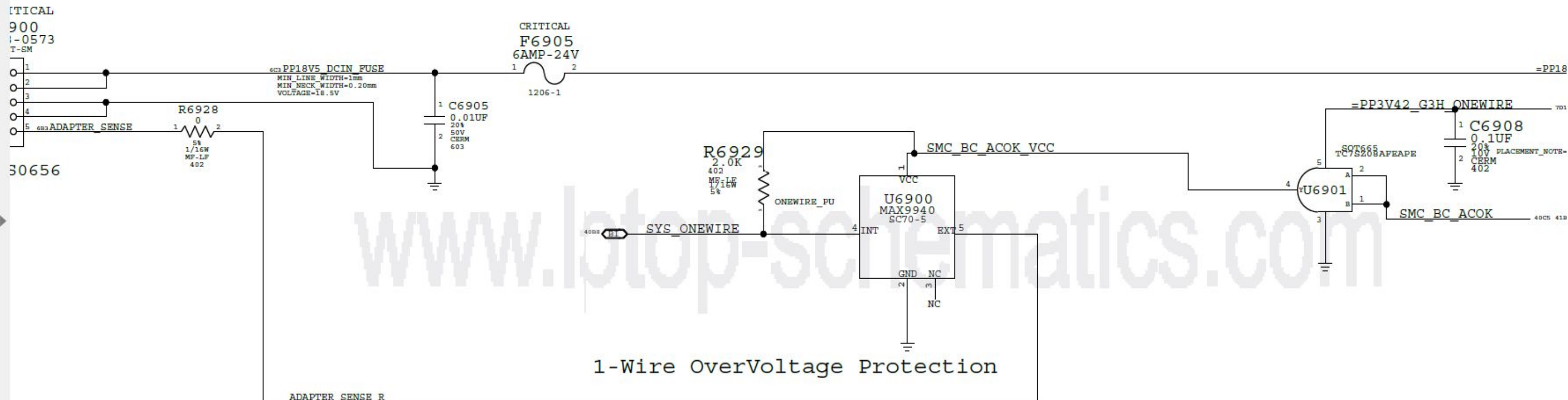


So the way this works...

- If PP3V42_G3H voltage rail is present
- And SMC_BC_ACOK is present from the charging IC that creates PPBUS_G3H
- The onewire circuit allows the adapter to communicate with the SMC.
- If the PP3V42_G3H voltage rail is NOT present, or the circuitry for PPBUS_G3H is fucked in any way, charger will NOT be able to communicate with the machine.
- PP3V42_G3H must come on before every other voltage so that onewire can work so that PPBUS_G3H can come on.

U6901 is a logic gate that will let PP3V42_G3H(3.42v) through to U6900 ONLY if SMC_BC_ACOK is present. U690 allows communication between the chargers *adapter sense* line and SYS_ONEWIRE which goes to the SMC. This is how the SMC talks to the charger. The SMC tells the charger things like “TURN ON!”, “TURN ON BUT LIMIT POWER!”, or “DON'T TURN ON!” Without this data line being present, the charger will NOT TURN ON!!

Power Jack



PP3V42_G3H needs to turn on first.

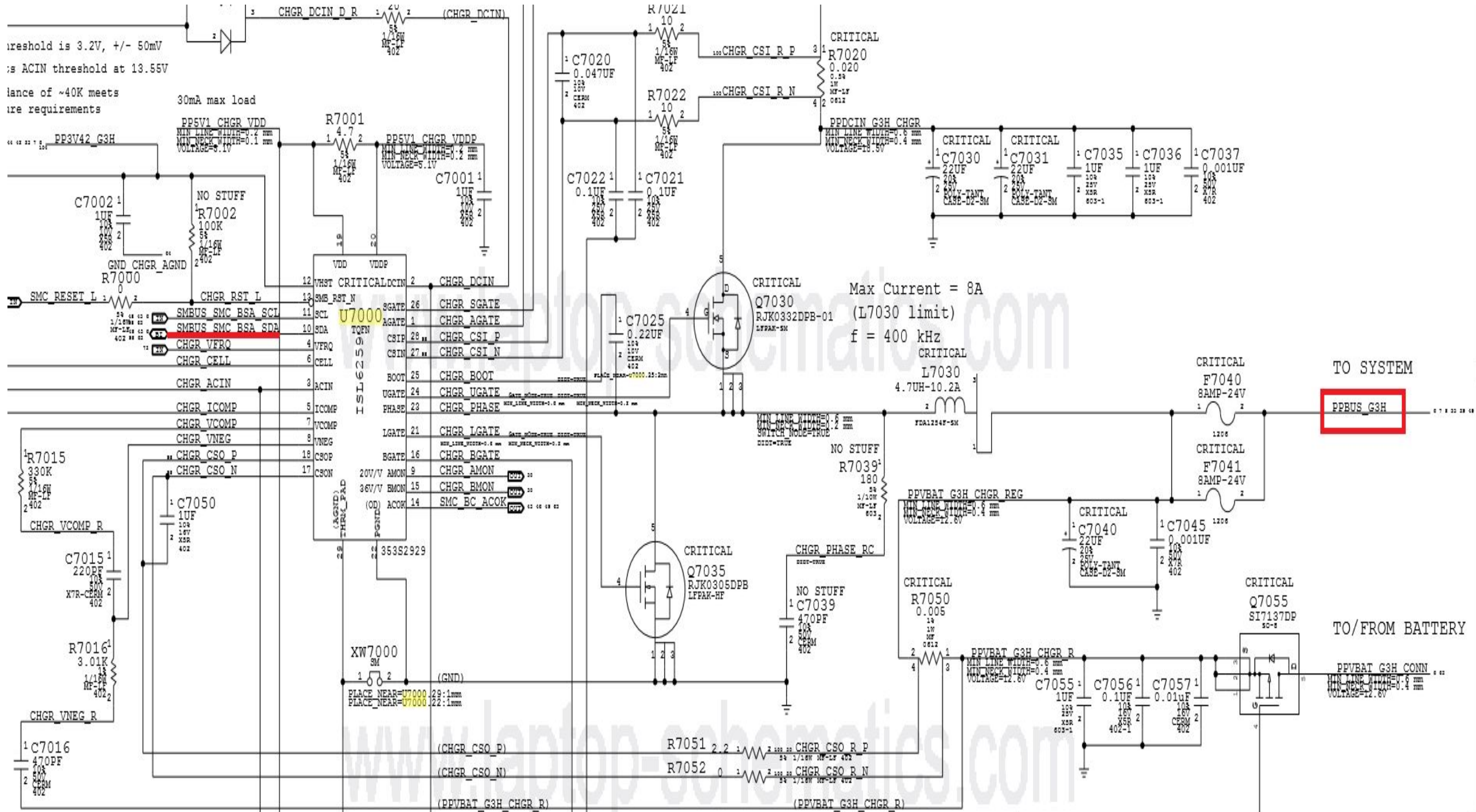
- You need PP3V42_G3H to work for the onewire circuit to work.
- You need the onewire circuit for your charger to turn on.
- You need the charger to turn on to get PPBUS_G3H voltage.
- You need PPBUS_G3H to get every other rail in the system; every other power rail is created from PPBUS_G3H's 12.6v
- Therefore; YOU NEED PP3V42_G3H TO WORK
****BEFORE**ANYTHING**ELSE** !!!!!!!**
- Do not troubleshoot anything before checking that PP3V42_G3H works.

If you have a green or orange light on your charger; PP3V42_G3H works.

Is the SMC on? How do we tell?

- The SMC turning on is required for the onewire circuit to work.
- The SMC communicates with the ISL6259/ISL9239 to set the final PPBUS_G3H voltages on 2011-2021 Macbooks.
- On Macbook Airs and old Macbook Pro 17" PPBUS_G3H is 8.5v when
- the SMC is able to communicate with the ISL, 8.16v when the SMC
- cannot.
- On Macbook Pros PPBUS_G3H is 12.56v when the SMC is able to communicate with the ISL, 12.23v when the SMC cannot.
- On 13" MBP's with ISL9239 (A1708, A1989) it is not uncommon for PPBUS_G3H to be 13.00V

How SMC communicates with ISL6259



What turns the SMC off?

- SMC_RESET_L being low – will keep SMC in reset mode.
- SMC being bad.
- SMC having corrosion on it.
- SMC_LID signal being low (Sleep sensor activated/corroded)

Let's move onto PPBUS_G3H

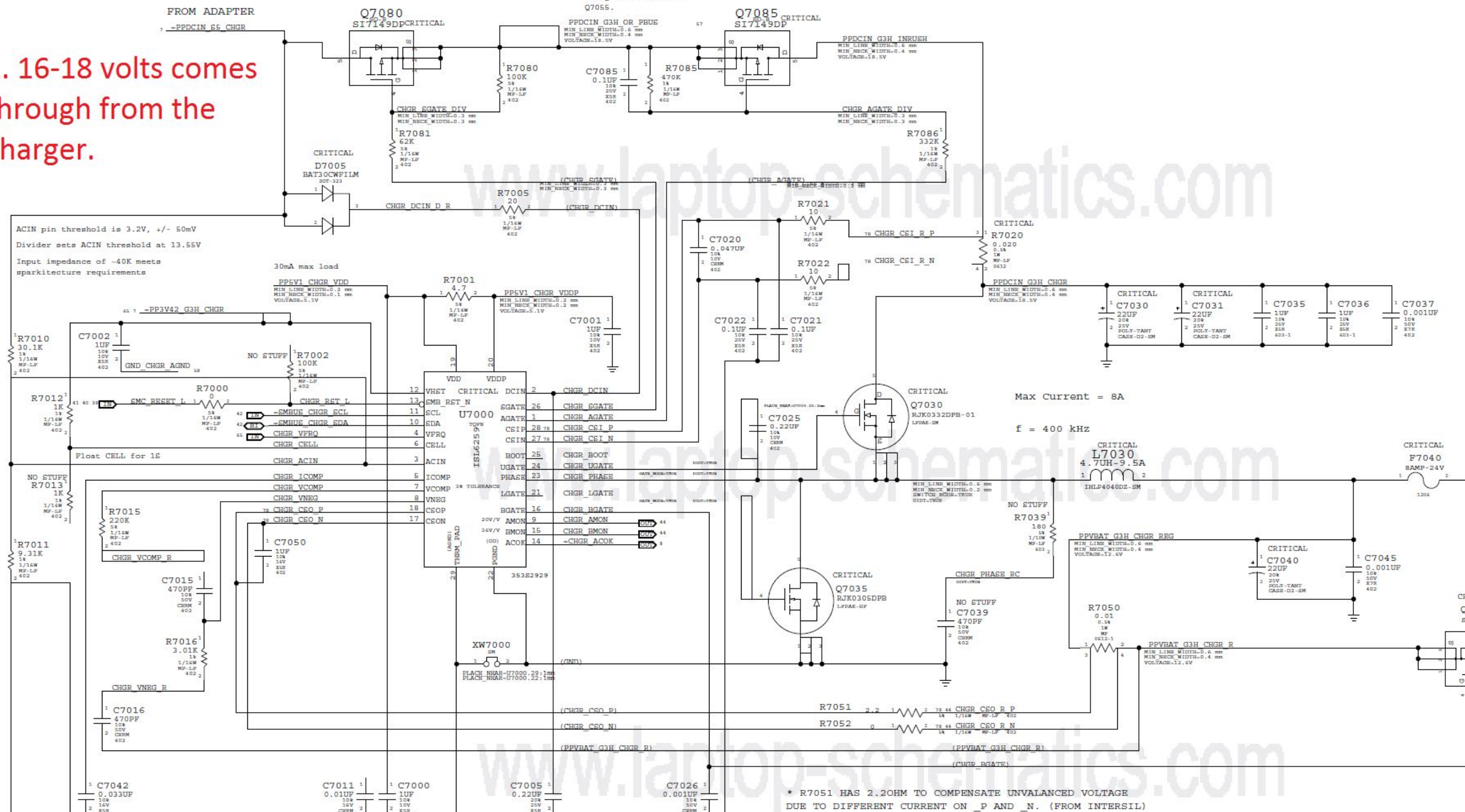
- The onewire circuit allows the charger to talk to the SMC. The first thing that will occur after this is creation of PPBUS_G3H.
- PPBUS_G3H is a 12.6 volt power rail that all other lines in the system are created from.

Reverse-Current Protection

Inrush Limiter

1. 16-18 volts comes through from the charger.

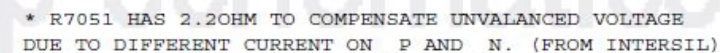
This node is powered through body diodes:
 * DCIN through Q7080.
 * PBUS through Q7085, Charger TOP FETs and Q7055.



Inrush Limiter

Q7085
SI7149DP CRITICAL

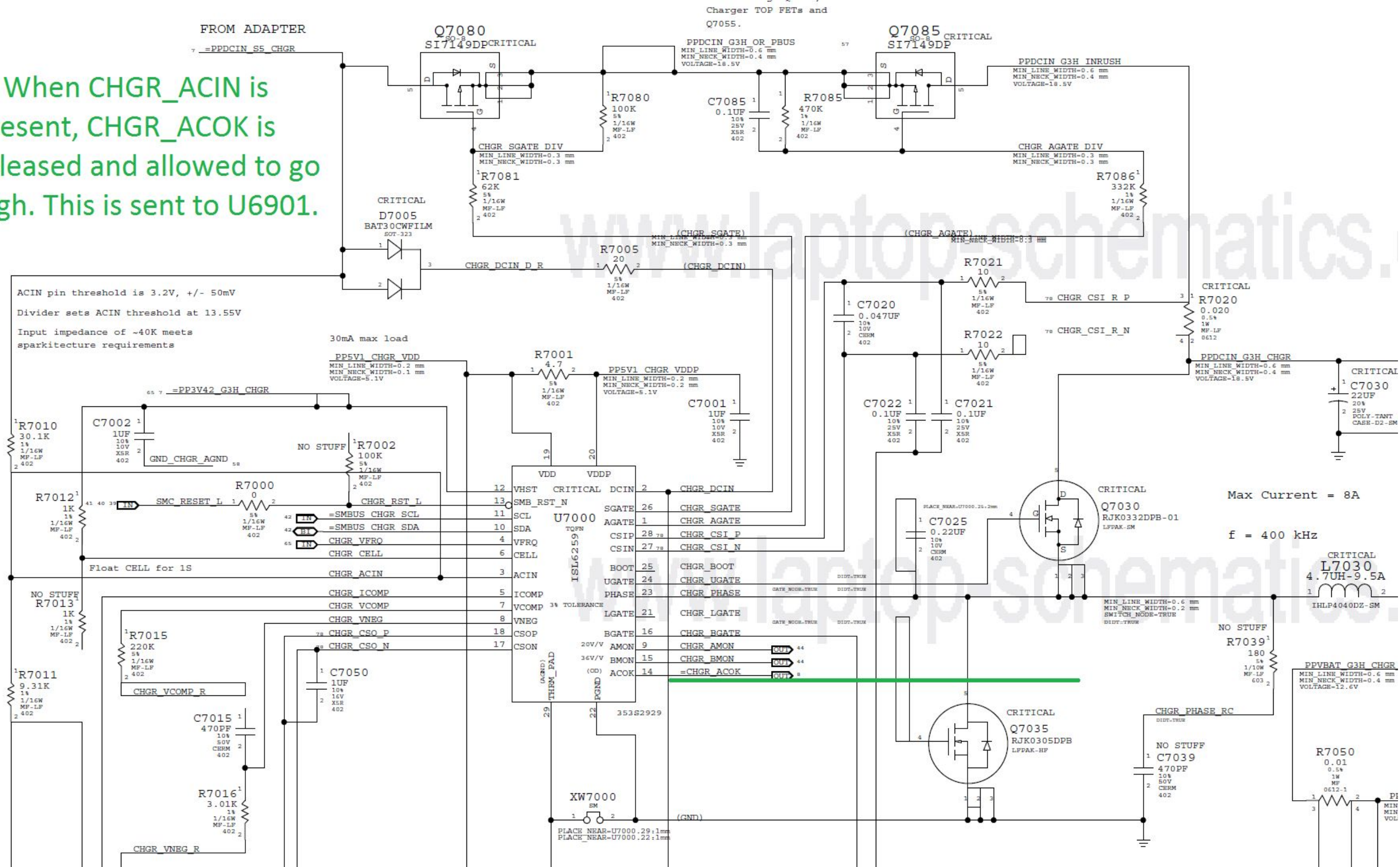
30mA max load



C

B

3. When CHGR_ACIN is present, CHGR_ACOK is released and allowed to go high. This is sent to U6901.



4

3

2

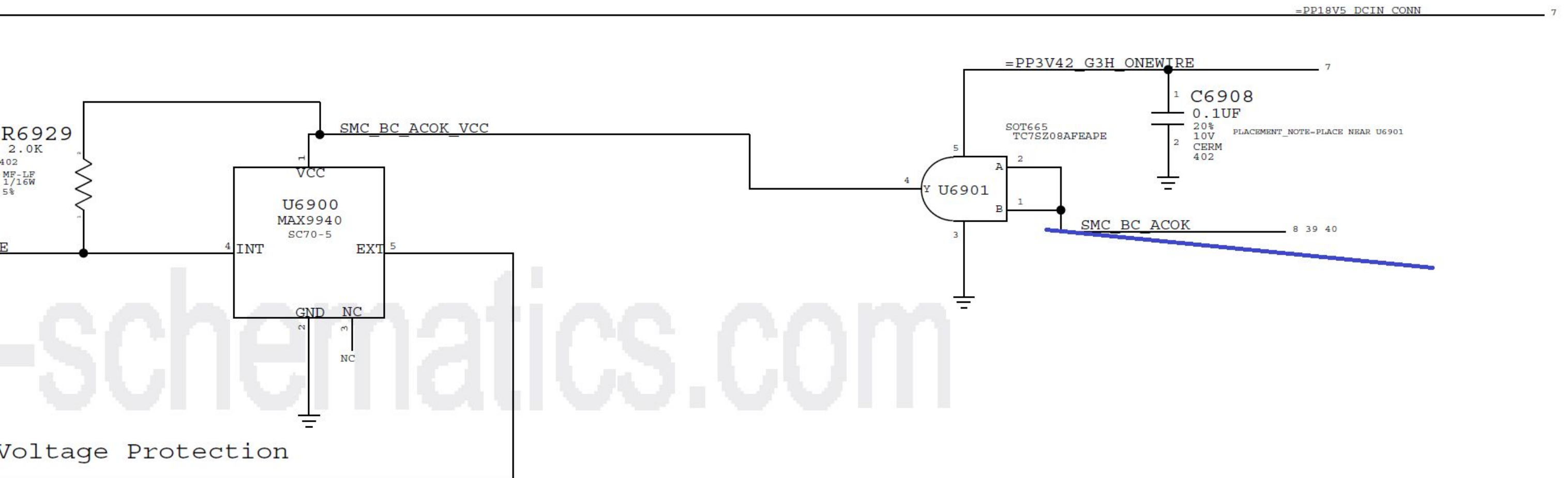
Find

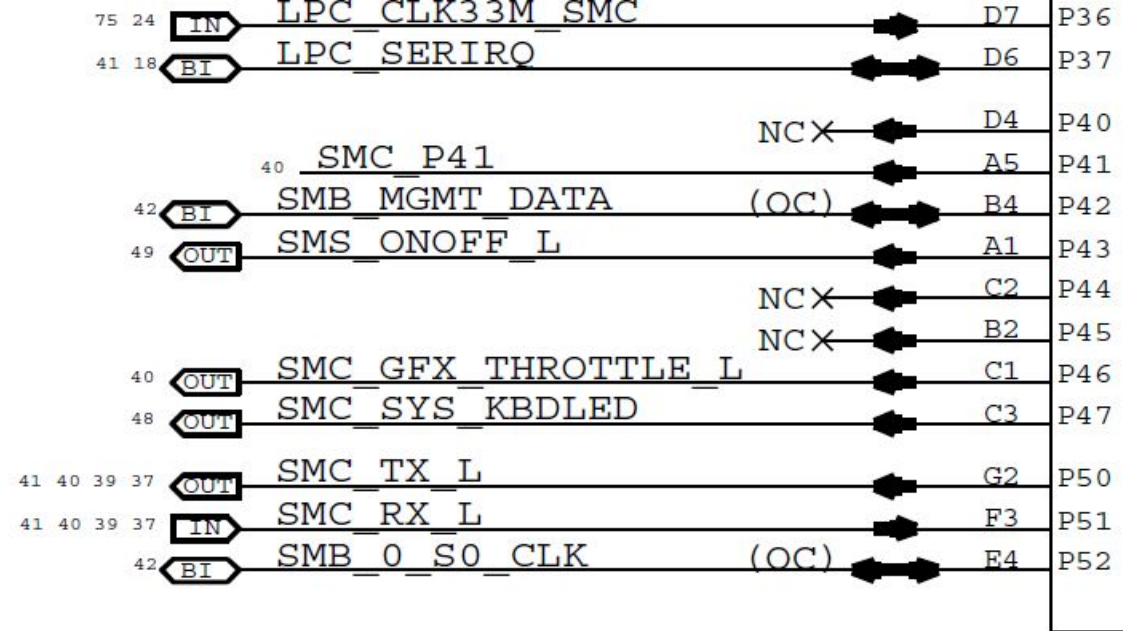
u6901

Previous

Next

4. SMC_BC_ACOK enters U6901 logic gate. This tells U6901 to allow PP3V42_G3H on pin 5, a 3.42v power rail, to be sent to U6900.

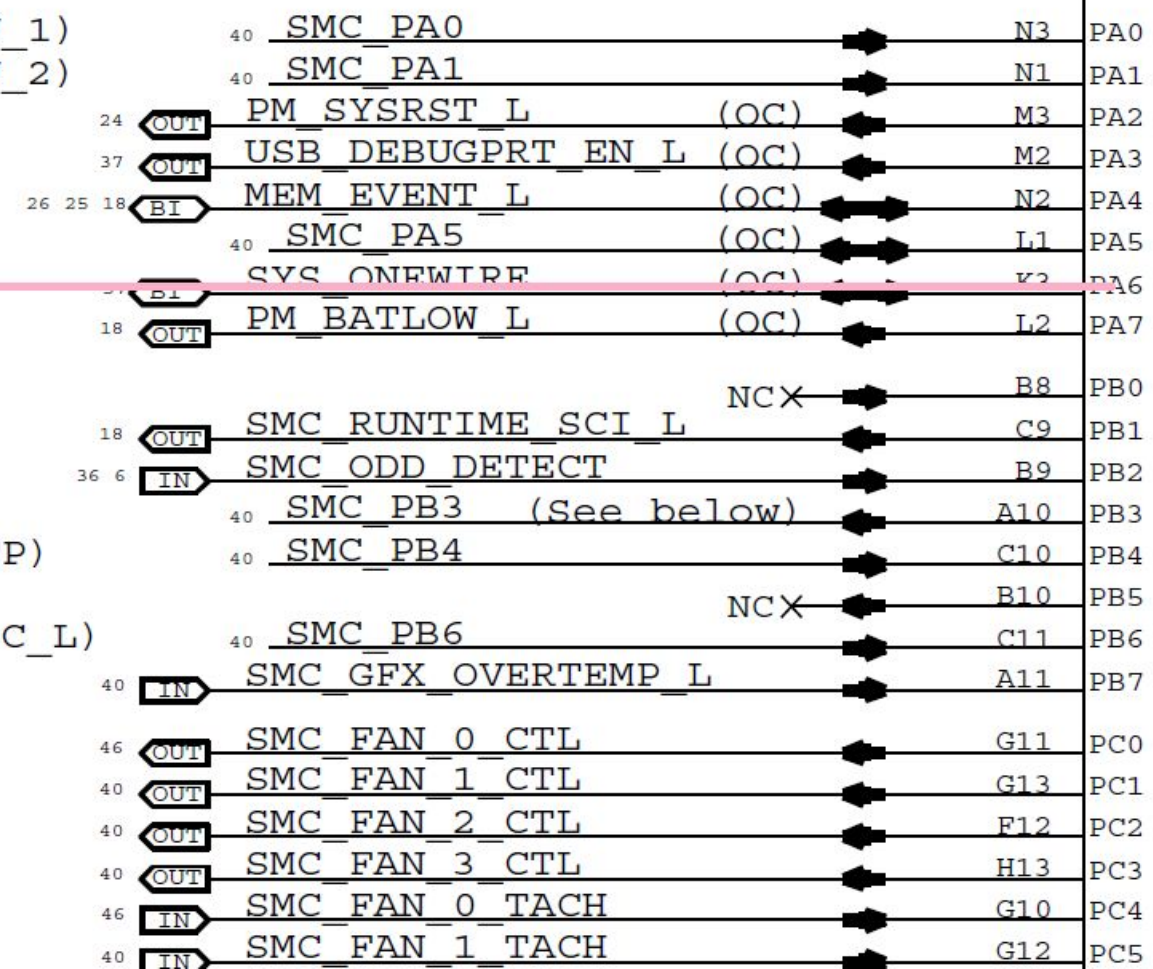




7. SMC speaks to charger on SYS_ONEWIRE and if all is good, tells charger it's time to turn on.

B

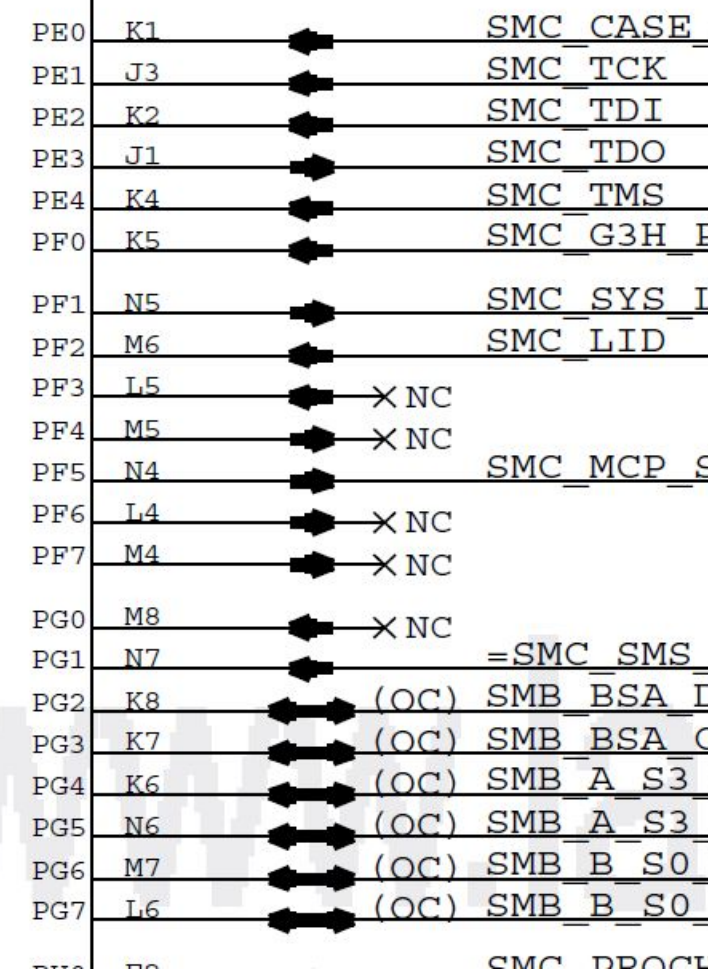
(DEBUG_SW_1)
(DEBUG_SW_2)



(EXCARD_CP)

(EXCARD_OC_L)

U4900
H8S2117
LGA-HF
(2 OF 3)
OMIT



8. SMC talks to U7000 and on SMBUS_CHGR_SDA data line. If reasonable current draw is measured on current sensing circuitry.

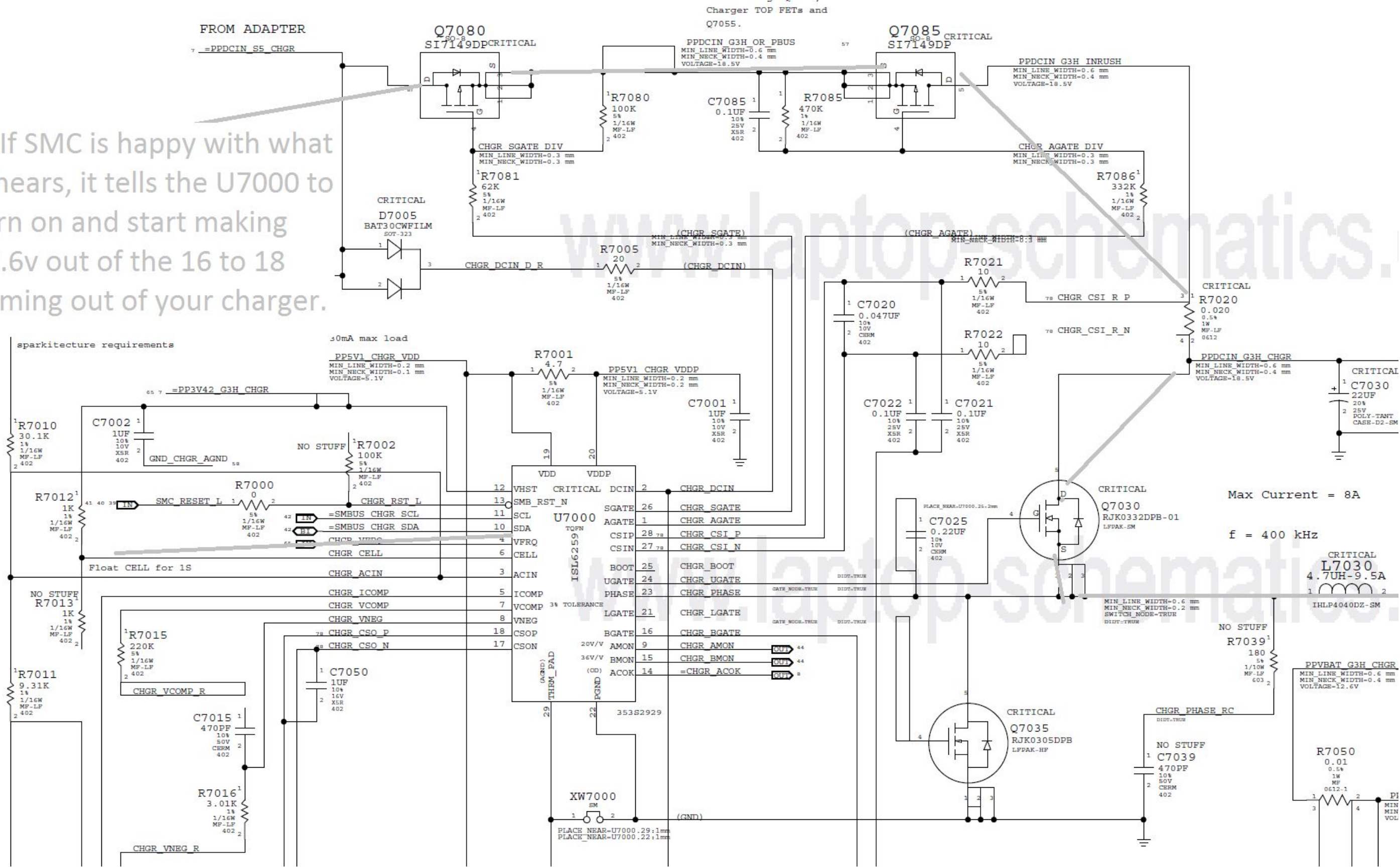


D

9. If SMC is happy with what it hears, it tells the U7000 to turn on and start making 12.6v out of the 16 to 18 coming out of your charger.

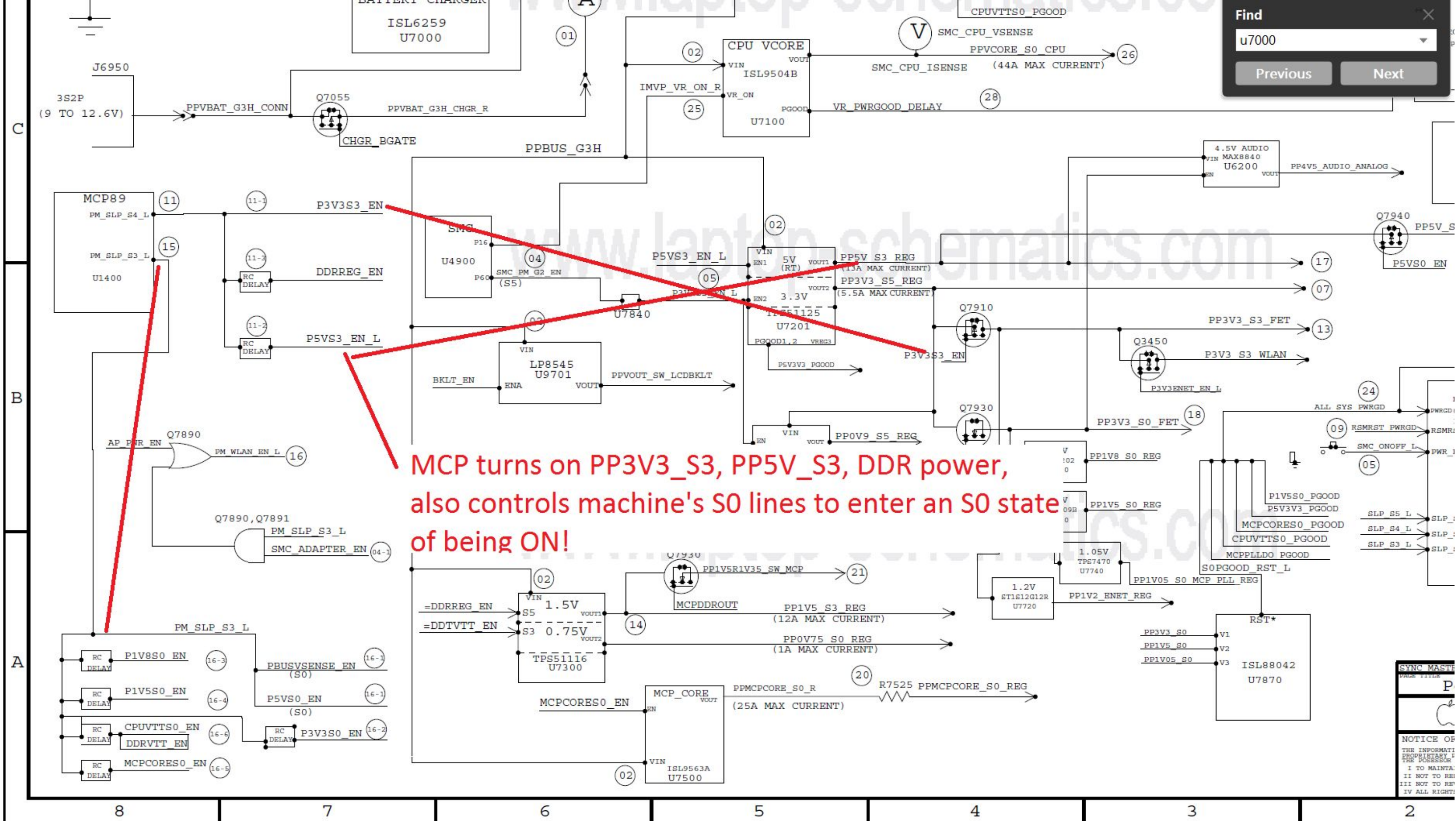
C

B



After this, the rest is dependent on your specific system

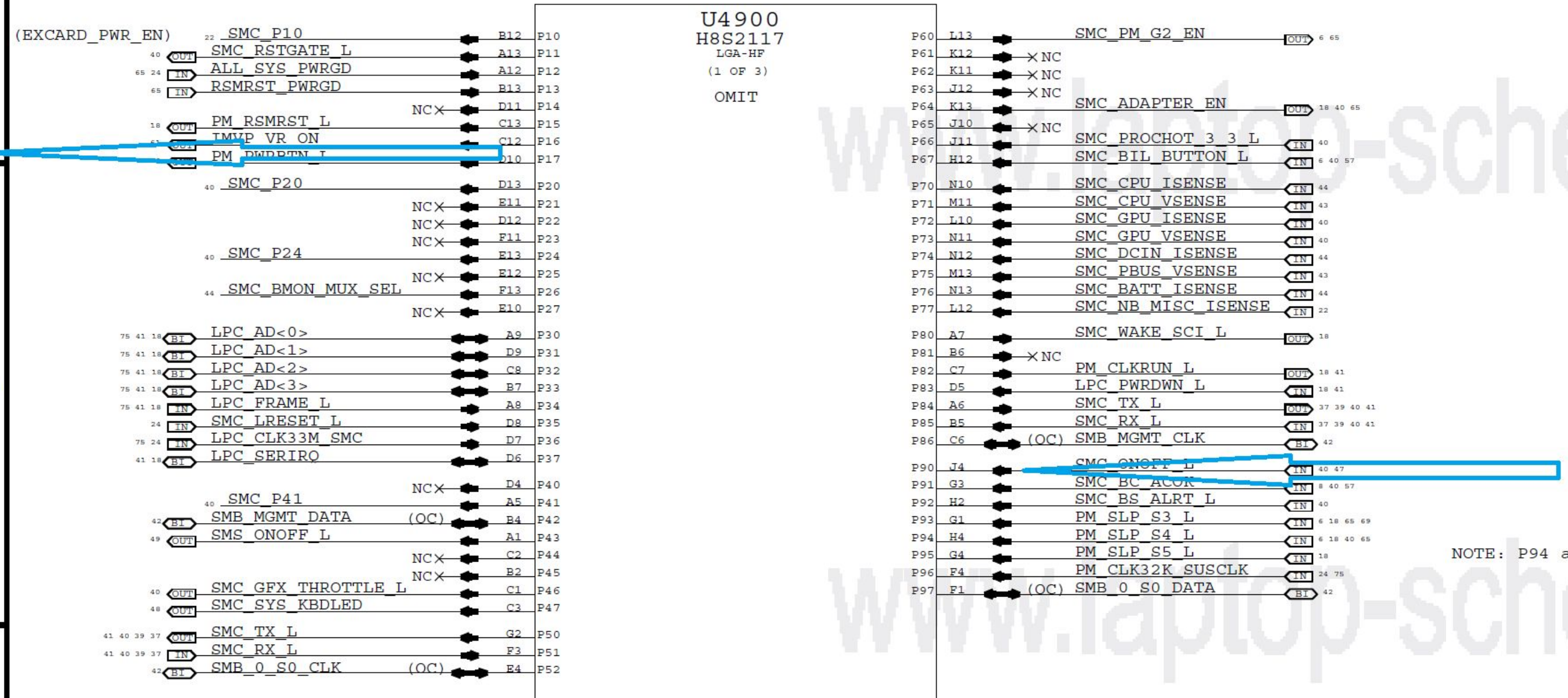
- After PPBUS_G3H and PP3V42_G3H are created, other power rails should start coming on.
- The PCH/PMU on the motherboard will create the enable signals for other chips to turn on their power lines, such as CPU power, PP5V_S3, and so on and so forth.
- Schematics usually come with a block diagram showing you what signals are responsible for creating what power lines.



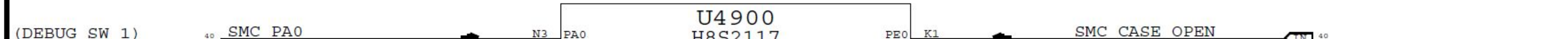
D

Here is an example of the SMC receiving SMC_ONOFF_L - this signal is high(3.4v) until you hit the POWER BUTTON and short it to GROUND. When SMC detects SMC_ONOFF_L shorted to ground, it sends out PM_PWRBTN_L which will tell the PCH that it's time to turn the computer on.

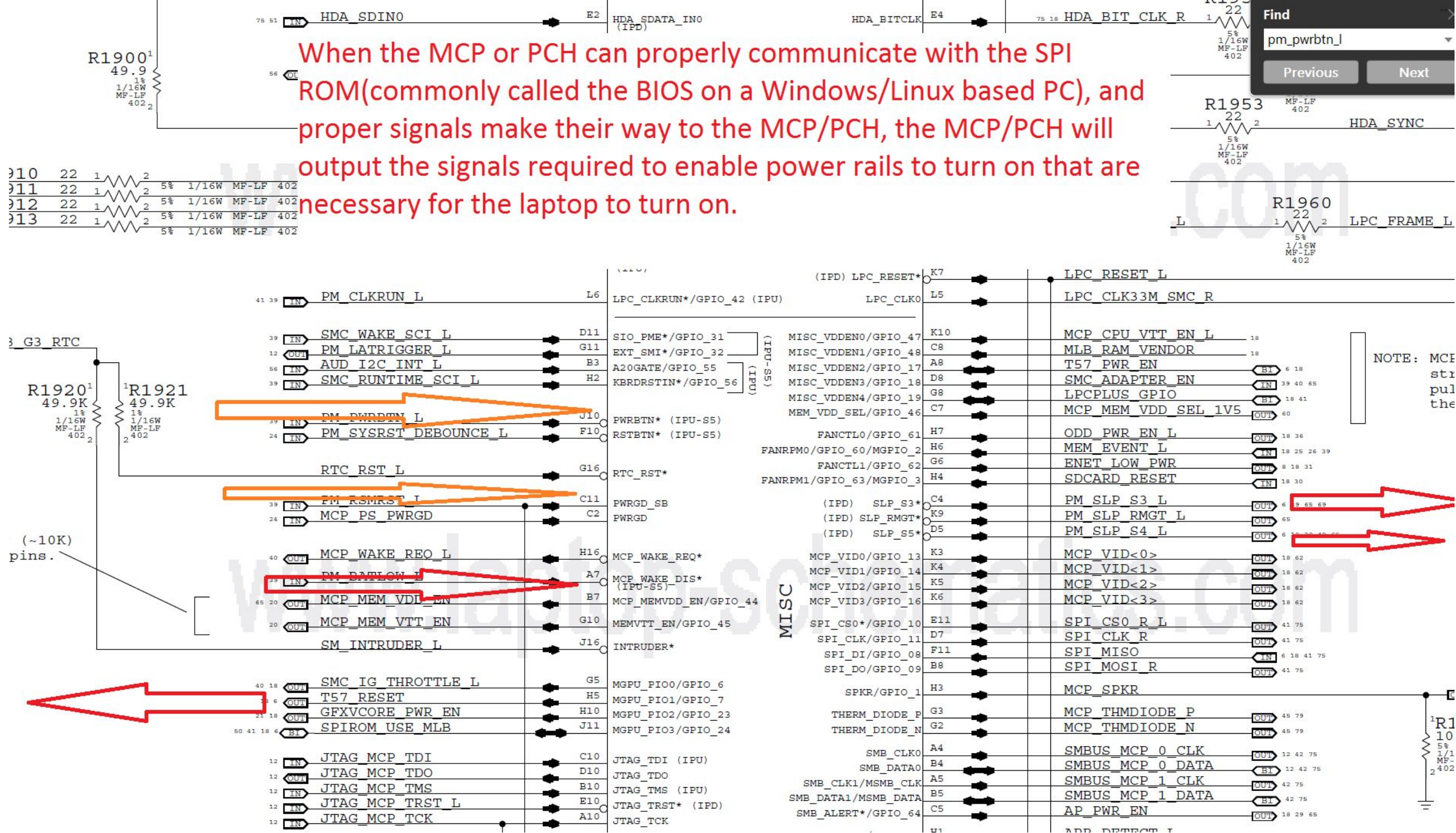
C



NOTE: P94 a



When the MCP or PCH can properly communicate with the SPI ROM (commonly called the BIOS on a Windows/Linux based PC), and proper signals make their way to the MCP/PCH, the MCP/PCH will output the signals required to enable power rails to turn on that are necessary for the laptop to turn on.



These signals differ from platform to platform

- I am not going to go over exact order and exact signals.
- It changes from model to model, but the same general idea applies.
- Check the power diagram page on the schematic to get an idea of what is going on.
- If Apple decided to be pricks and not include it in a specific diagram, check last year's and try to figure out what changed.

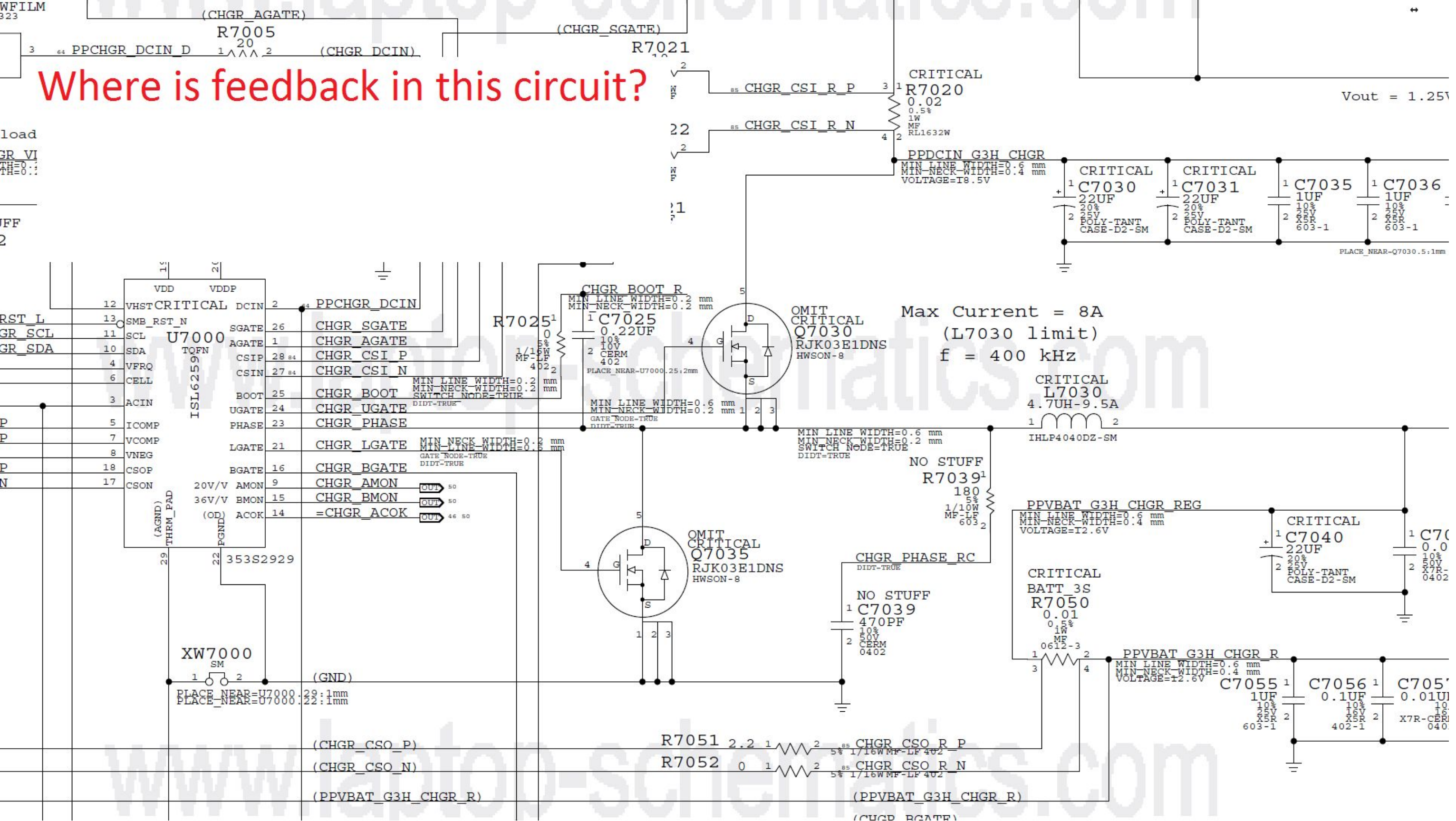
The BEST way to figure this out if you are unsure...

- CHECK KNOWN WORKING BOARDS!
- Compare & contrast. Analyze, and use your brain.
- A working board is an ANSWER KEY!
- Adults are allowed to CHEAT and CHECK THE ANSWER KEY!!
- What is different on the working board from your dead board?
- Never stop analyzing.
- Known working boards of the same type are the ultimate learning tool.

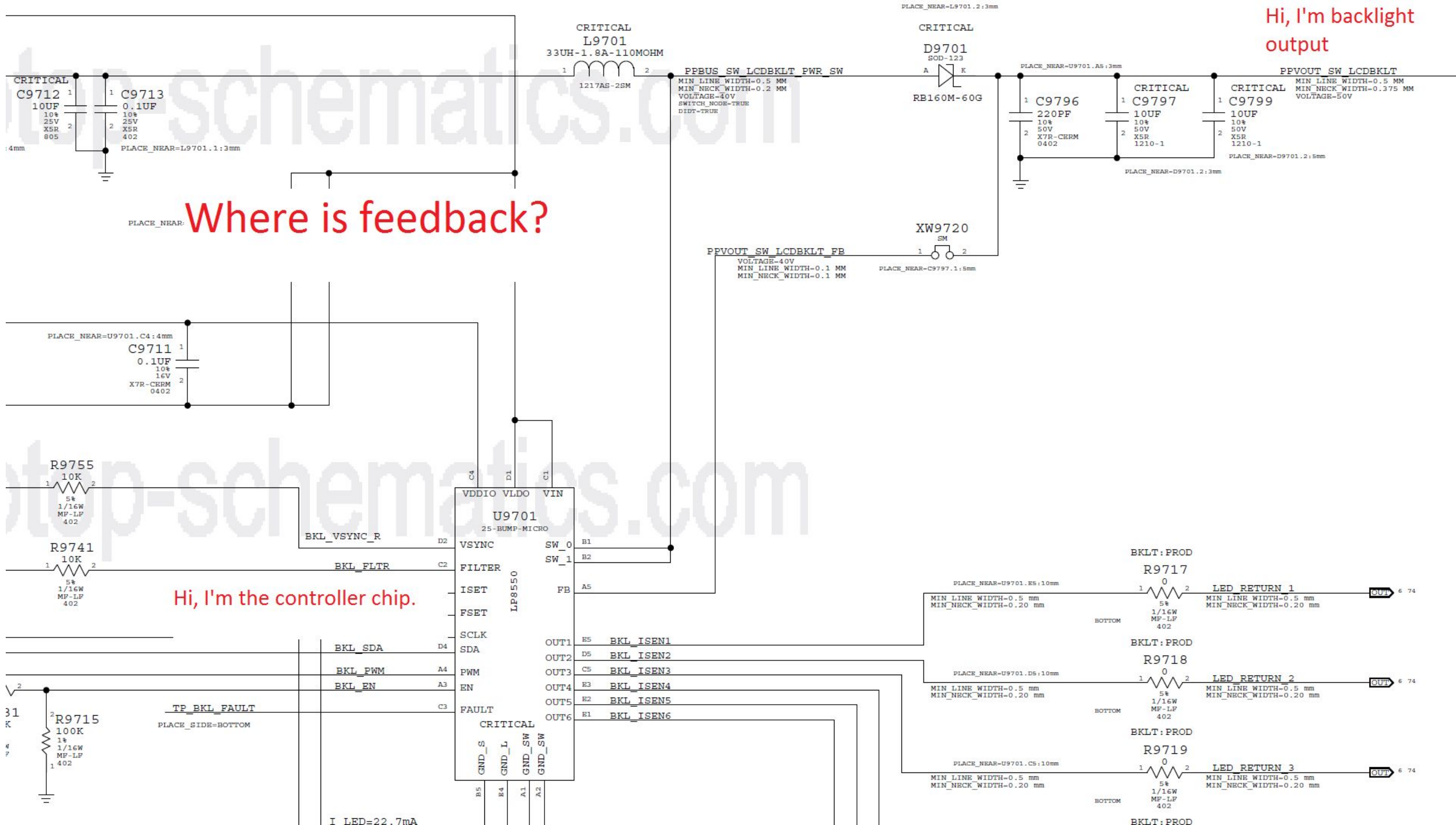
What is FEEDBACK and why does it matter?

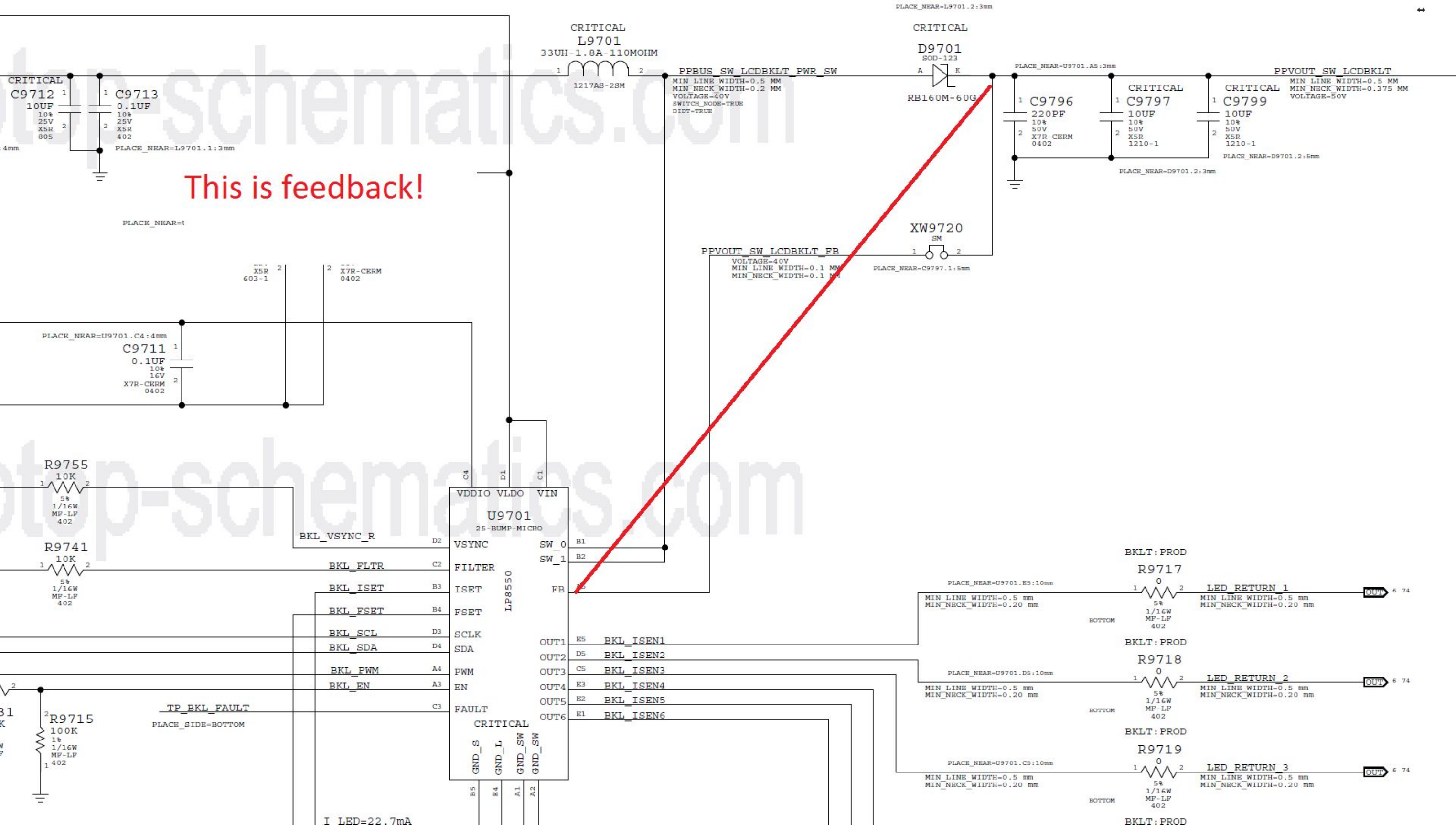
- These chips are cheap crap connected to other cheap crap.
- They are not to be trusted.
- Most power control chips in buck converters, DC to DC boost circuits, and power supplies in general like to know what they are doing.
- For this, feedback is used.
- Chip will change how it controls circuit based on feedback.

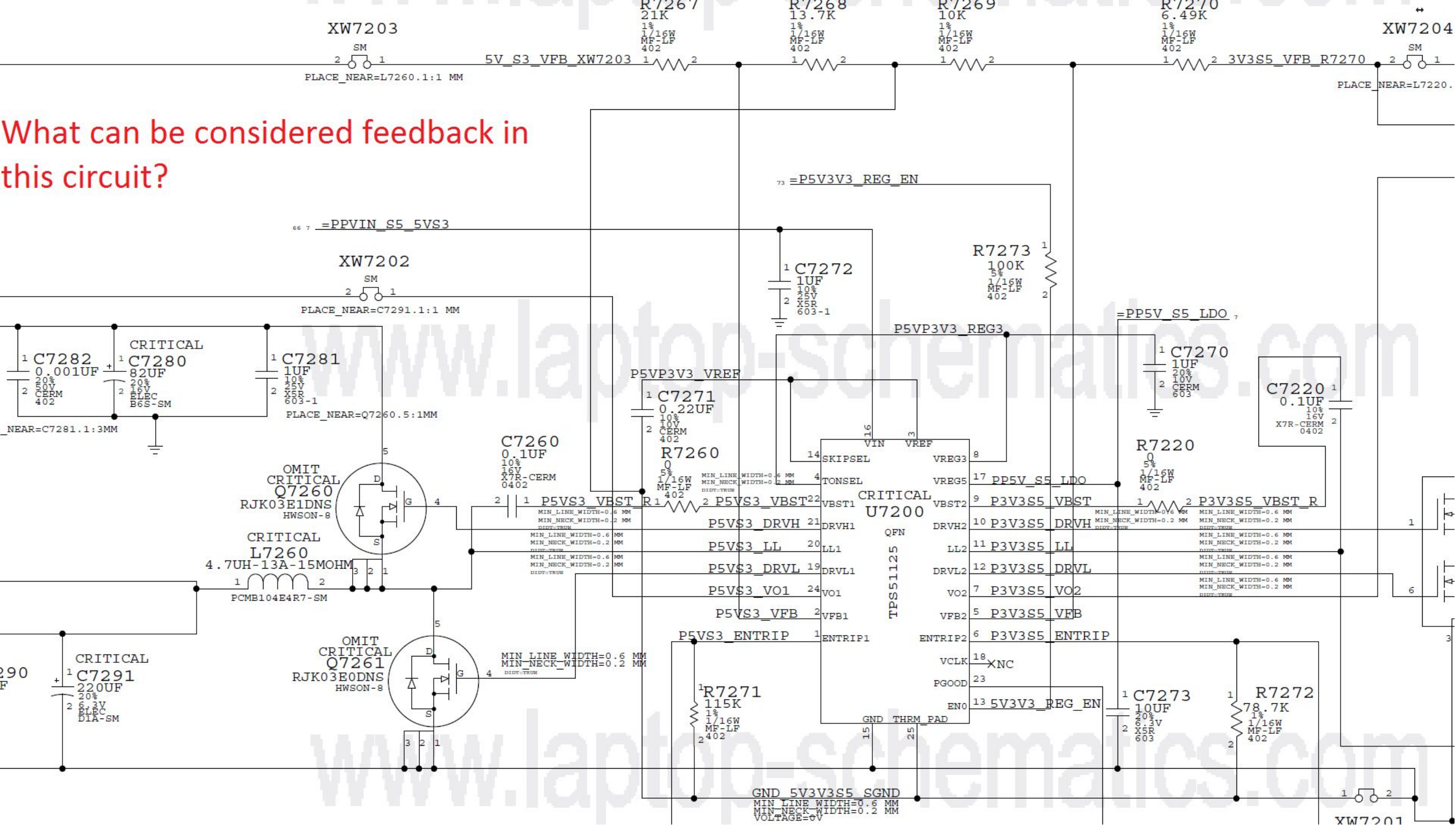
Where is feedback in this circuit?



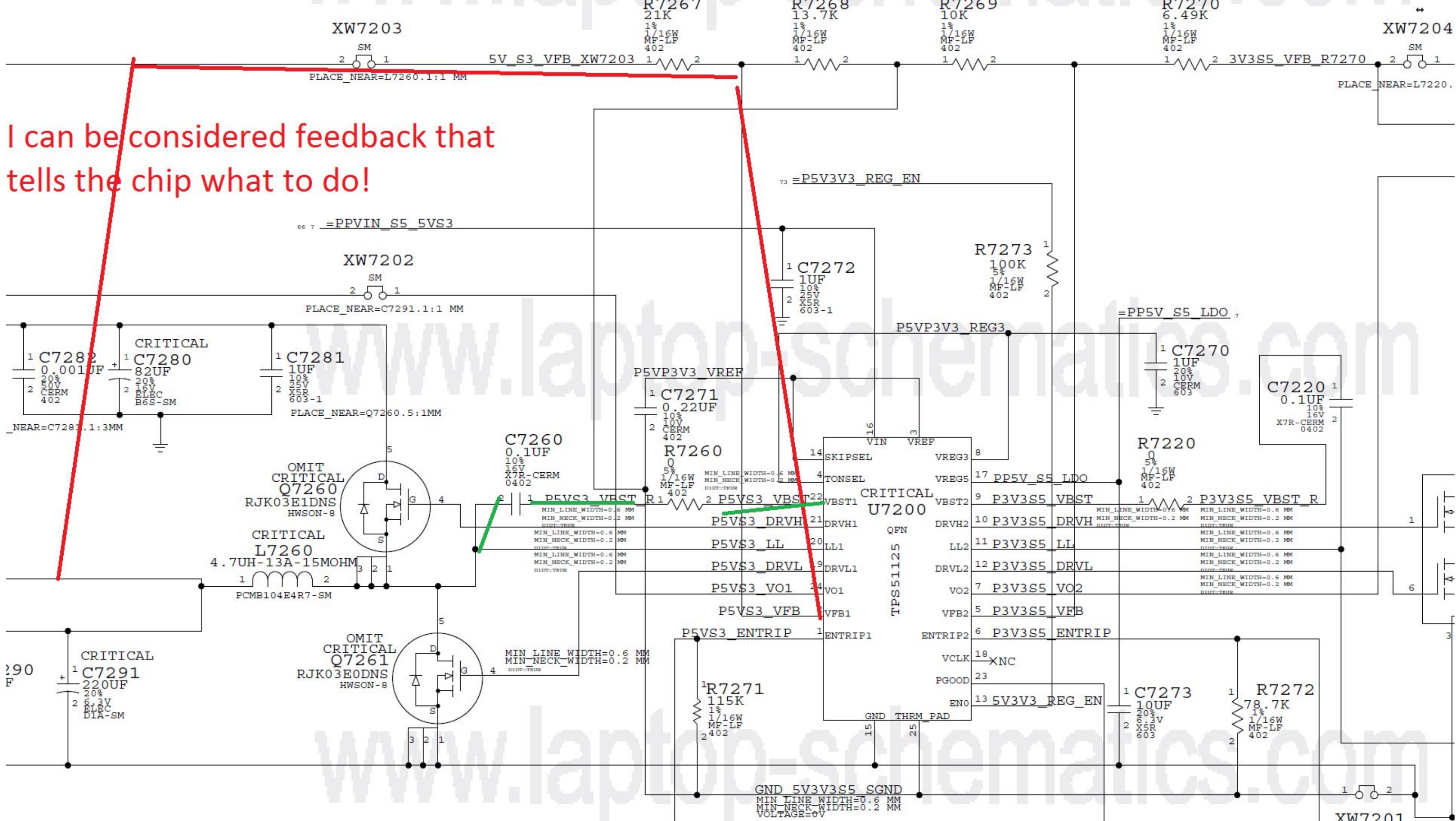
Hi, I'm backlight output







I can be considered feedback that tells the chip what to do!



Standard backlight circuit faults!

- Blown fuse.
- Short to ground on output through LCD, LCD connector, LCD cable, or internal board issue.
- Not being told to turn on.
- Open circuit – somewhere, the line has been burned away so power is not passing.
- Being told to turn on, but LED driver is unable to tell it to turn on.
- No feedback – LED driver cannot see what it is doing so it does not boost.

blown line between fuse and output transistor

5v not coming into LED driver.
Happened once in my lifetime.

Blown fuse.

SUPER COMMON!!!

voltage divider not
working,
so 12v goes to gate of
q9706
causing power to not
flow to circuit

rare.

blown trace from
output of
transistor to input of
coil. It happens.

Q9707 dead, not allowing bottom of voltage
divider to be sent to ground - ALMOST NEVER
HAPPENS

MOSFET	FDC638APZ
CHANNEL	P-TYPE
RDS (ON)	43 mOhm @4.5V
LOADING	0.715 A (EDP)

PPBUS SW LCDBKLT PWR
MIN LINE WIDTH=0.4 mm
MIN NECK WIDTH=0.25 mm
VOLTAGE=12.6V

THERE IS A SENSE RESISTOR BETWEEN
PPBUS_SW_LCDBKLT_PWR
AND PPBUS_SW_BKL
ON THE SENSE PAGE

*C9797 AND C9799 S
*PPBUS_SW_LCDBKLT_PW
*LCD_BKLT_PV

CRITICAL
L9701
33UH-1.8A-110MOHM

MIN LINE
MIN NECK
VOLTAGE=4
SWITCH NO
DIBT-TRUK

CRITICAL
C9712 10UF
10%
25V
X5R
805
PLACE_NEAR=L9701.1:4mm

C9713 0.1UF
10%
25V
X5R
402
PLACE_NEAR=L9701.1:3mm

C9710 1UF
10%
25V
X5R
603-1

C9714 0.01UF
10%
16V
X7R-CERM
0402
PLACE_NEAR=U9701.D1:3mm

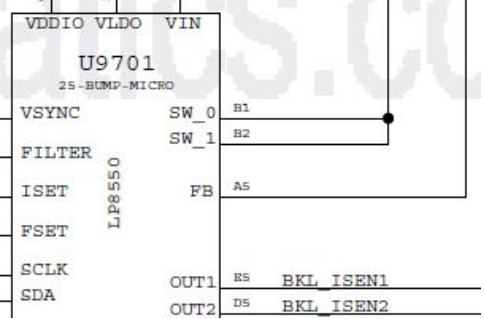
C9711 0.1UF
10%
16V
X7R-CERM
0402
PLACE_NEAR=U9701.C4:4mm

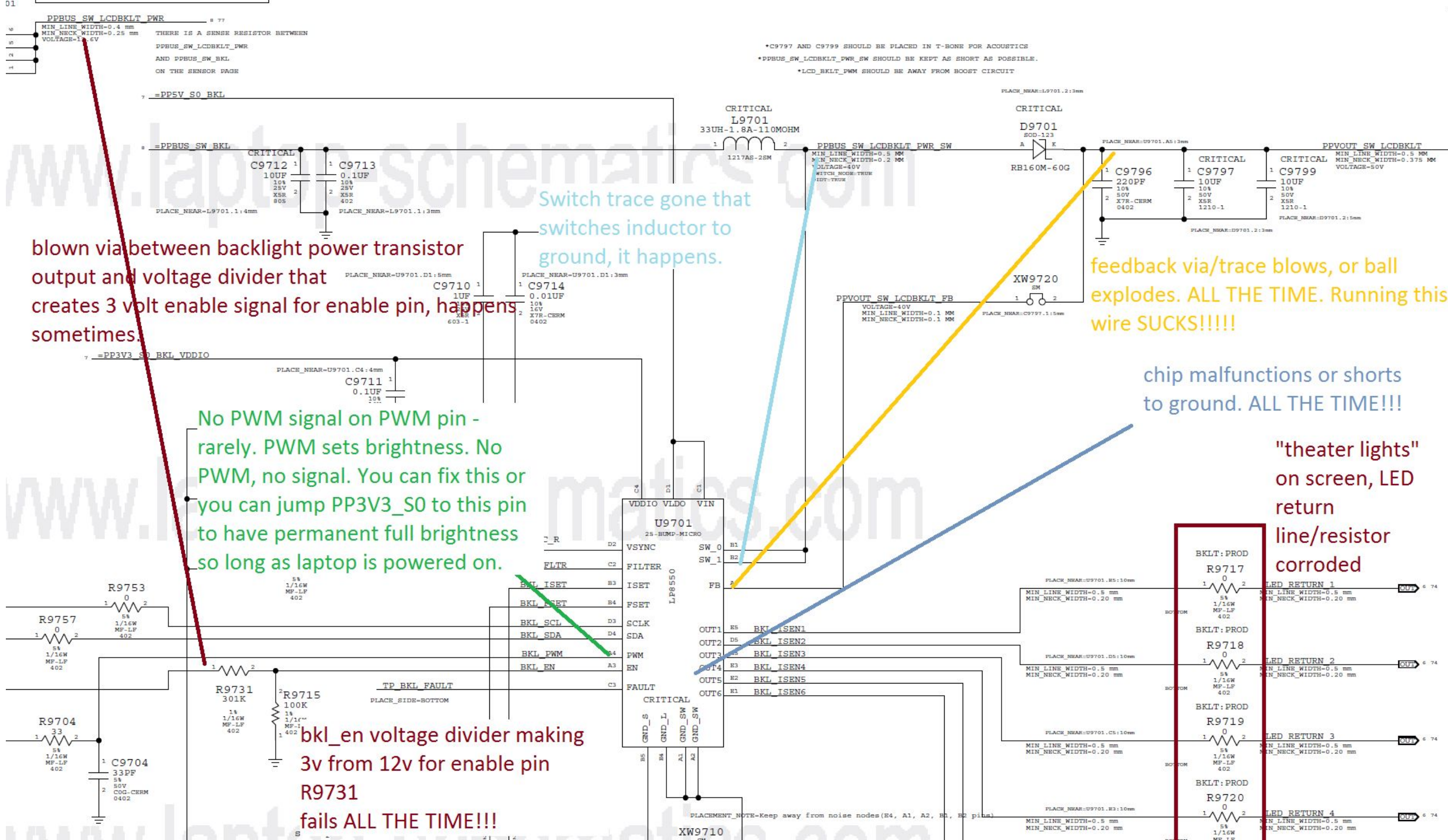
R9755 10K
5%
1/16W
MF-LF
402

R9741 10K
5%
1/16W
MF-LF
402

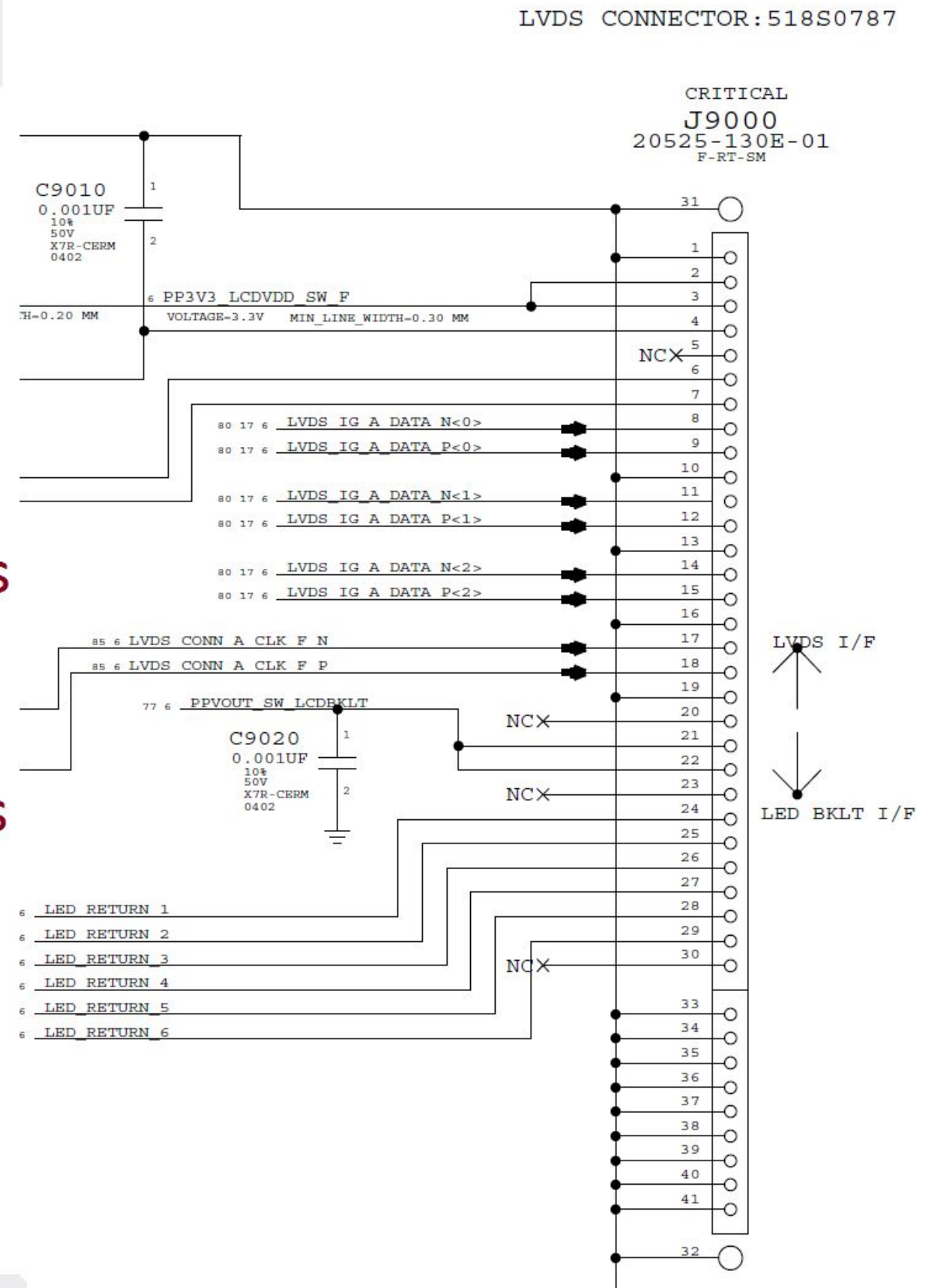
R9753 0
5%
1/16W
MF-LF
402

R9757 0
5%
1/16W
MF-LF
402



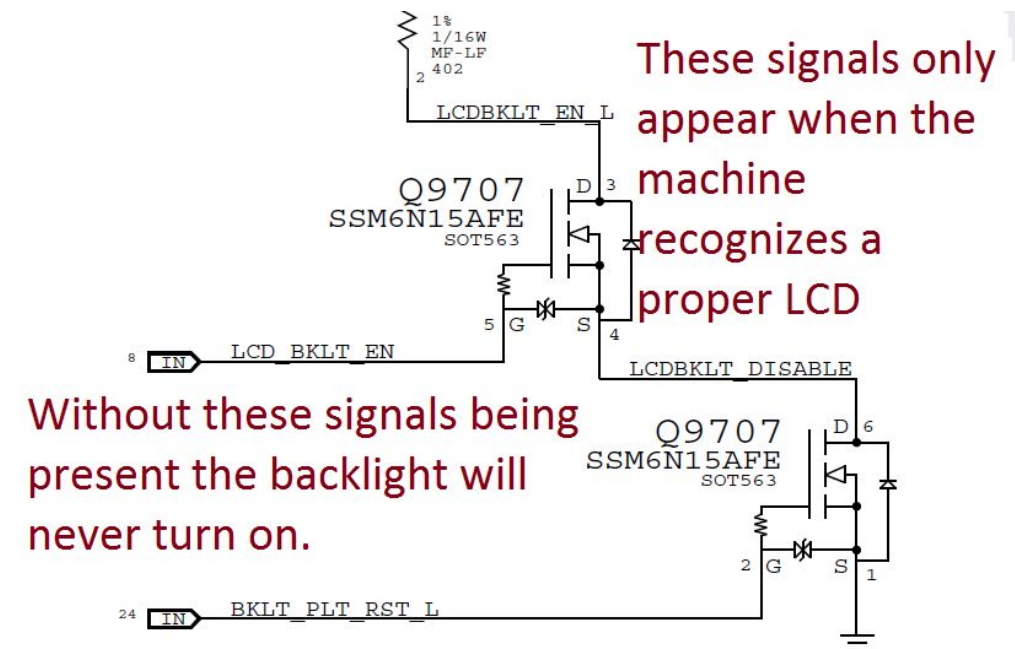


Shorts to ground inside the LCD connector happen ALL THE TIME! If you cannot find a short on backlight output and you have looked everywhere, remove the LCD connector. Even if the LCD connector is beautiful when you look at it at 45x, it can be fucked inside. Do NOT run power through it to find this short, this is a piece of metal and you will burn every internal board via before you find it.



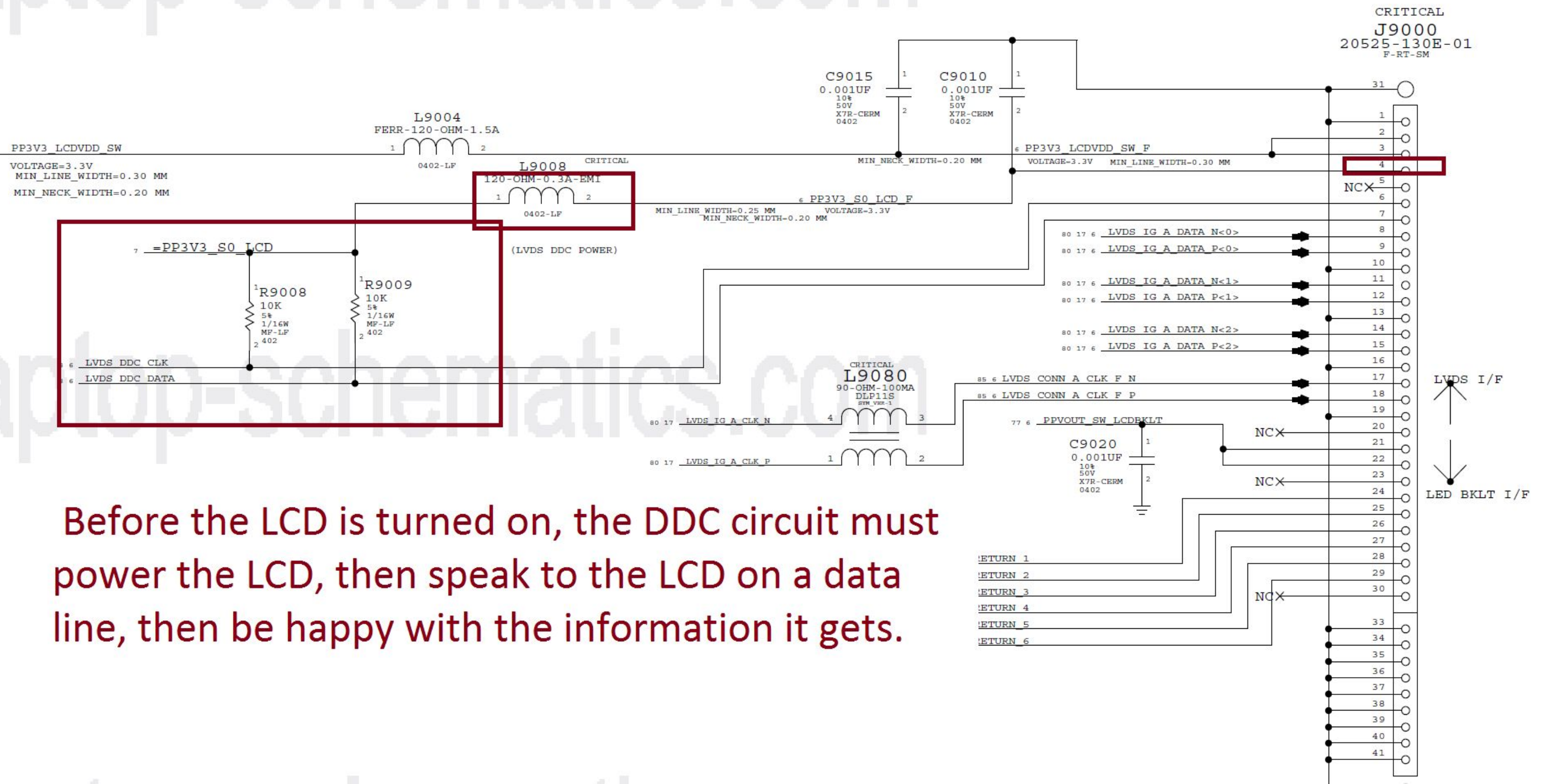
Hey, I have no backlight... right?

- People say they have no backlight when they have no image.
- If you do not have an image, you could have a bad screen, bad LCD cable, or DDC circuit is not recognizing screen.
- The PCH, GPU, GPU MUX will never issue power to Q9707 to allow power through to the backlight circuit if it does not see a proper screen!



WTF is a DDC circuit?

- The DDC circuit is the introduction between the monitor and the graphics processing of the computer.
- Hi computer, I'm a monitor. Hi monitor, I'm a computer.
- Computer, I have 1280x800 resolution. Please don't fuck with me and try to output more.
- LCD, my integrated graphics can do 4K like it aint nothin' but a thang, I'll give you 1280x800. And I see you're not shorted to ground, so even better.
- Picture comes on.
- DDC is the means to get the EDID block from the LCD.
- DDC also controls Brightness. This is all done on the i2c bus.

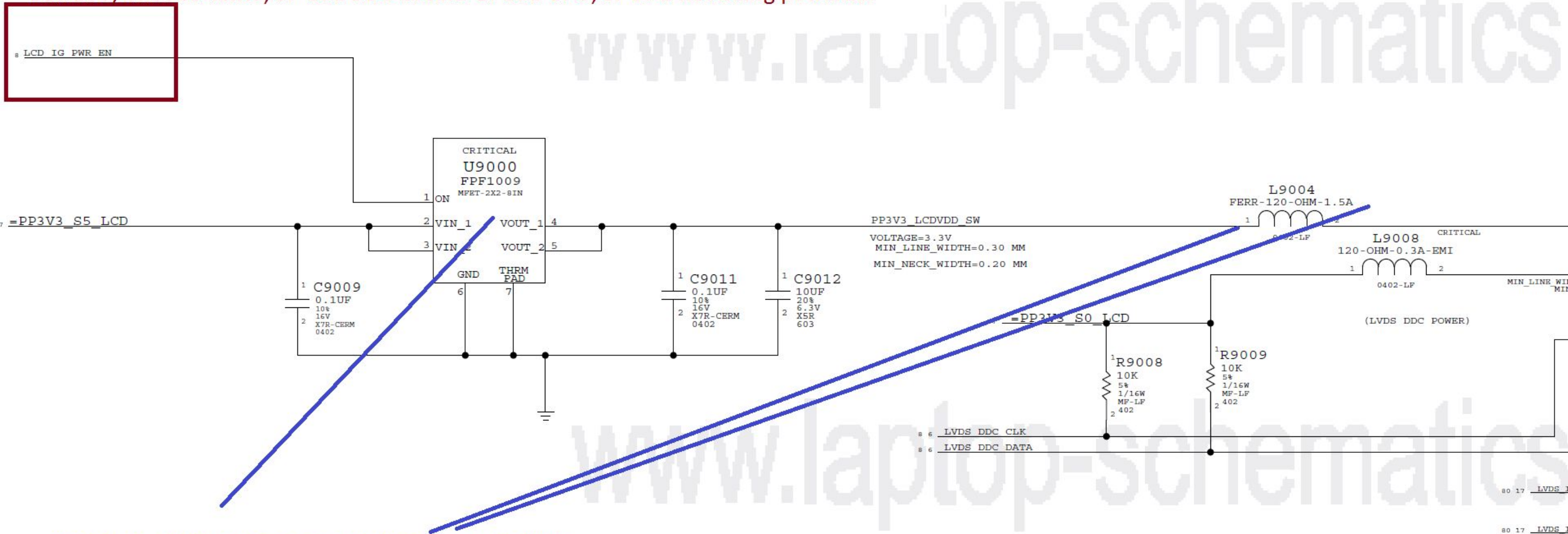


Before the LCD is turned on, the DDC circuit must power the LCD, then speak to the LCD on a data line, then be happy with the information it gets.

Make sure you check that you have an image.

- Use light from microscope ring around LCD. Do you see ink-like substance move around? That is LCD being “activated”
- On newer Retina LCDs it is almost impossible to see this, just shine bright light on back of LCD and wait for Apple logo or question mark folder to appear.
- Sometimes LCD is detected but not powered on. Then you have an issue with LCD power circuitry.

Is LCD_IG_PWR_EN present? If yes, LCD is DETECTED and you should have power to LCD; troubleshoot circuit powering LCD. If LCD_IG_PWR_EN is NOT present, LCD is not detected. Bad LCD, bad LCD cable, or bad DDC circuit. Or bad GPU, or GPU not being powered.



If LCD_IG_PWR_EN is present but 3v is not available on pins 2/3 of the LCD, either U9000 is not outputting power because it is broken, U9000 is not outputting power because it is not receiving power, or L9004 is blown. Troubleshoot accordingly.

Is the computer's “brain” even turning on?

- People often say “no image” when the proper issue is no brain.
- If the laptop turns on and there is no chime noise.
- If there is no chime noise and you do not measure CPU vcore, or MCP vcore, or power going to RAM, then the issue is not “no image” - it is “NO BRAIN!!!”
- Troubleshoot no brain accordingly.

If all voltage rails are present and it doesn't do anything...

- Bad SPI ROM chip.
- Corrupt SPI ROM.
- Corroded vias/traces to SPI ROM chip.
- SPI ROM chip talks to MCP or PCH to get everything working.
- Bad CPU, or bad GPU, or bad PCH – this will not be fun.

If CPU voltage rails are missing...

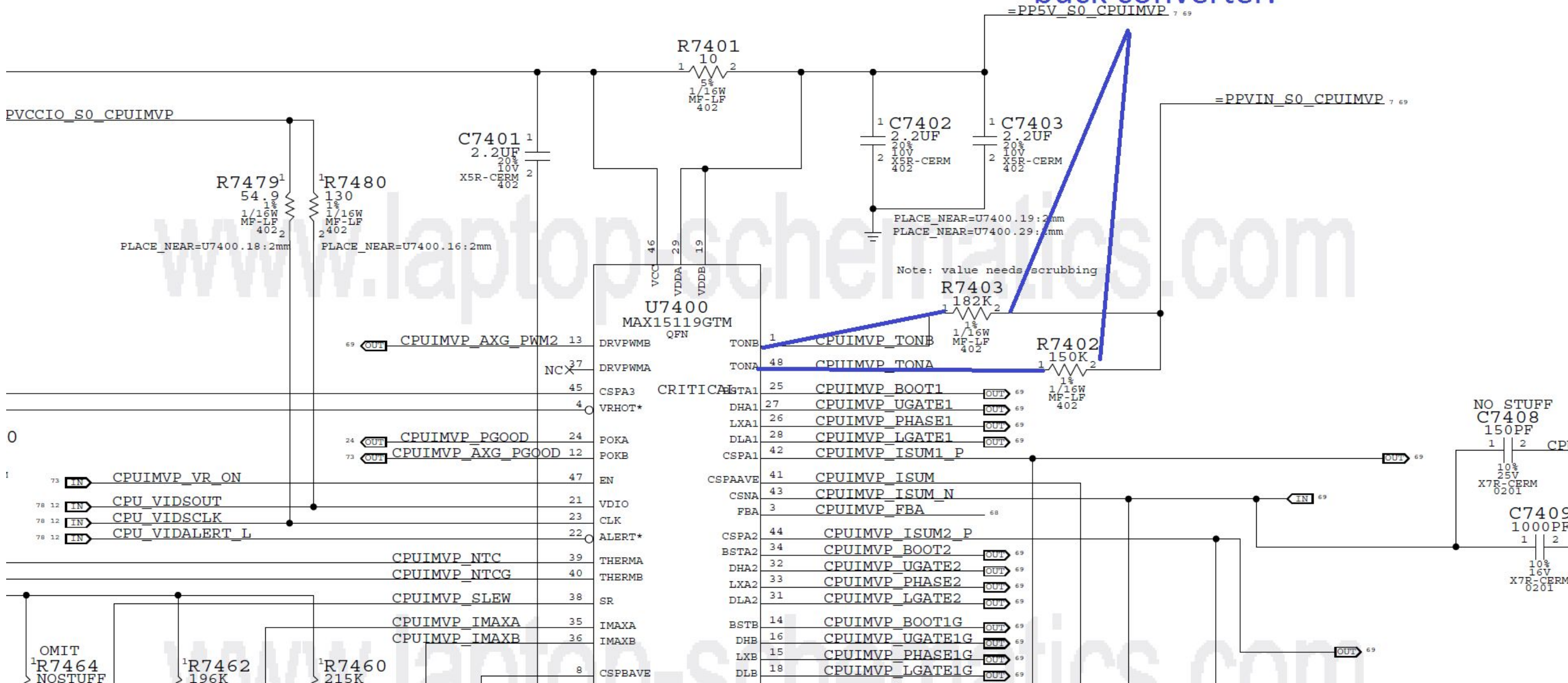
- Count your lucky stars and hope that they're fixable.
- Common issue as always is voltage controller IC is NOT BEING TOLD WHAT TO DO!!
- Check around CPU vcore area.

6

5

4

This sets switching frequency of buck converter.



I fixed it and they say it runs slow

- Running slow is often due to a sensor issue.
- Not slow as in slow hard drive, I mean slow as in the mouse stutters as it moves across the screen with no activity.
- The SMC likes to sense voltage levels, current usage, and temperatures from various different parts of the machine.
- If it receives information that is out of whack, it will turn the machine off, or make it run very slow as a means to protect itself from damage.

Run ASD to tell you what sensor is failing

- You will have to venture forth onto the internet to find ASD.
- There are different ASD for every model machine from every year.
- ASD will tell you what sensor is failing, and then it is your job to check the schematic and see what's going on.

PBUS voltage sense, VP0R example

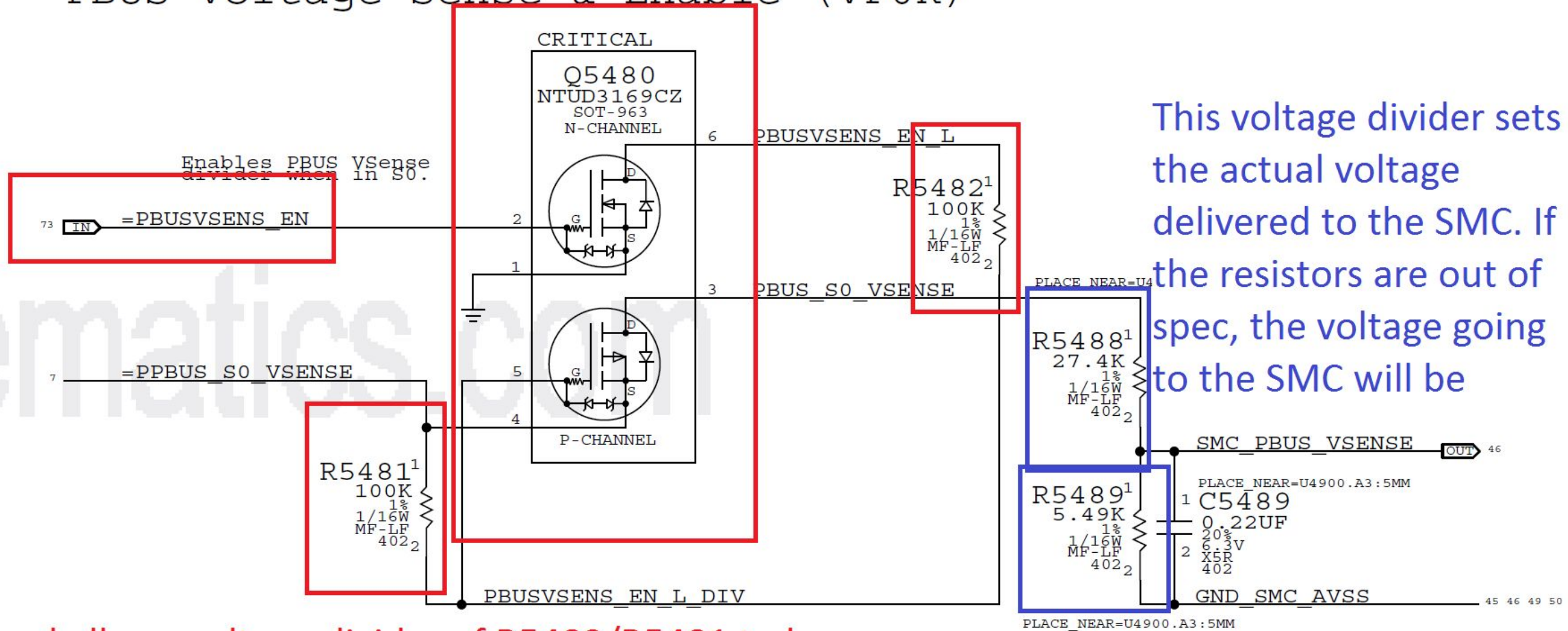
- This is a common sensor to fail. We look at various modes of failure.
- Reading above or below high point can be caused by voltage divider failure.
- Not reading anything can be caused by fucked SMC, fucked trace/via to the SMC, or sensor not being told to turn on.

Types of sensor failures

- Sometimes the sensor is not turning on.
- Sometimes the sensor is outputting improper data to the SMC because resistors in the line have gone bad.
- Sometimes the SMC itself is fucked.

Sometimes the data line on which the sensor is communicating is being brought down by something - dirt in a webcam connector, a bad webcam, a bad chip. Check if the line is topping out at the max spec'd voltage of that data line.

PBUS Voltage Sense & Enable (VP0R)



This voltage divider sets the actual voltage delivered to the SMC. If the resistors are out of spec, the voltage going to the SMC will be

This signal allows voltage divider of R5482/R5481 to become activated, so PPBUS_G3H voltage can move through P channel MOSFET, which then goes to the voltage divider and then the SMC. If NO sensor activity is read at all, check this.

i2c

i2c is one of the primary interchip communication busses

Shown as SDA and SCL on schematics and datasheets.

SDA - Data Line : SCL - Clock Line

Both lines will have a pullup resistor to a power rail - If the pullup is open, short, or out of spec i2c will not work properly

Its purpose is to provide communication/instruction to an IC. That is to say, even with power, ground, and enable, many ICs need programming over i2c to function.

The entire i2c bus can be monitored and communicated with via inexpensive external tools with a connection to SDA, SCL, and GND

Basic functionality can be determined with DMM and Oscilloscope. You won't know what the bits mean but you will know they are there.

How Apple plays dirty with LCD's

Unlike any other manufacturer, Apple includes a special validation/genuine string in the LCD EDID Block.

Before any power or data is sent to the LCD this must be validated via the DDC handshake.

In the event of liquid damage where your EDID data may get corrupted, an otherwise functional LCD will not turn on when this validation fails.

EDID data can be read, verified, and reprogrammed with inexpensive tools (Bus Pirate, or literally any other i2c programmer). It is a simple 2 wire i2c EEPROM

If backlight voltage gets sent to your EDID IC you can pretty much guarantee it will be corrupted.

Valid data can be pulled from the same model Macbook and programmed to the damaged lcd without issue.

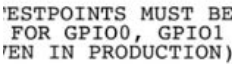
How to get 20V on USB-C powered machines

- Usually we look for “Green Light” (onewire circuit / pp3v42 covered earlier)
- USB-C machines have no light indicator -> Use Ammeter
- 20V on the ammeter is Equivalent to having “Green Light” on a Magsafe 1/2
- PP3v3LDO and why it matters.

What is this CD321X BS and how do they work?

- CD3215/CD3217 are the chips responsible for power provisioning, IO, orientation sensing etc.
- They have pins and voltages that self enable the moment they receive DC-IN from the charger
- LDO voltages and PP3v3G3H
- In most cases, all CD3215 must be functional to receive 20V on the charger.

ON VR PAGE



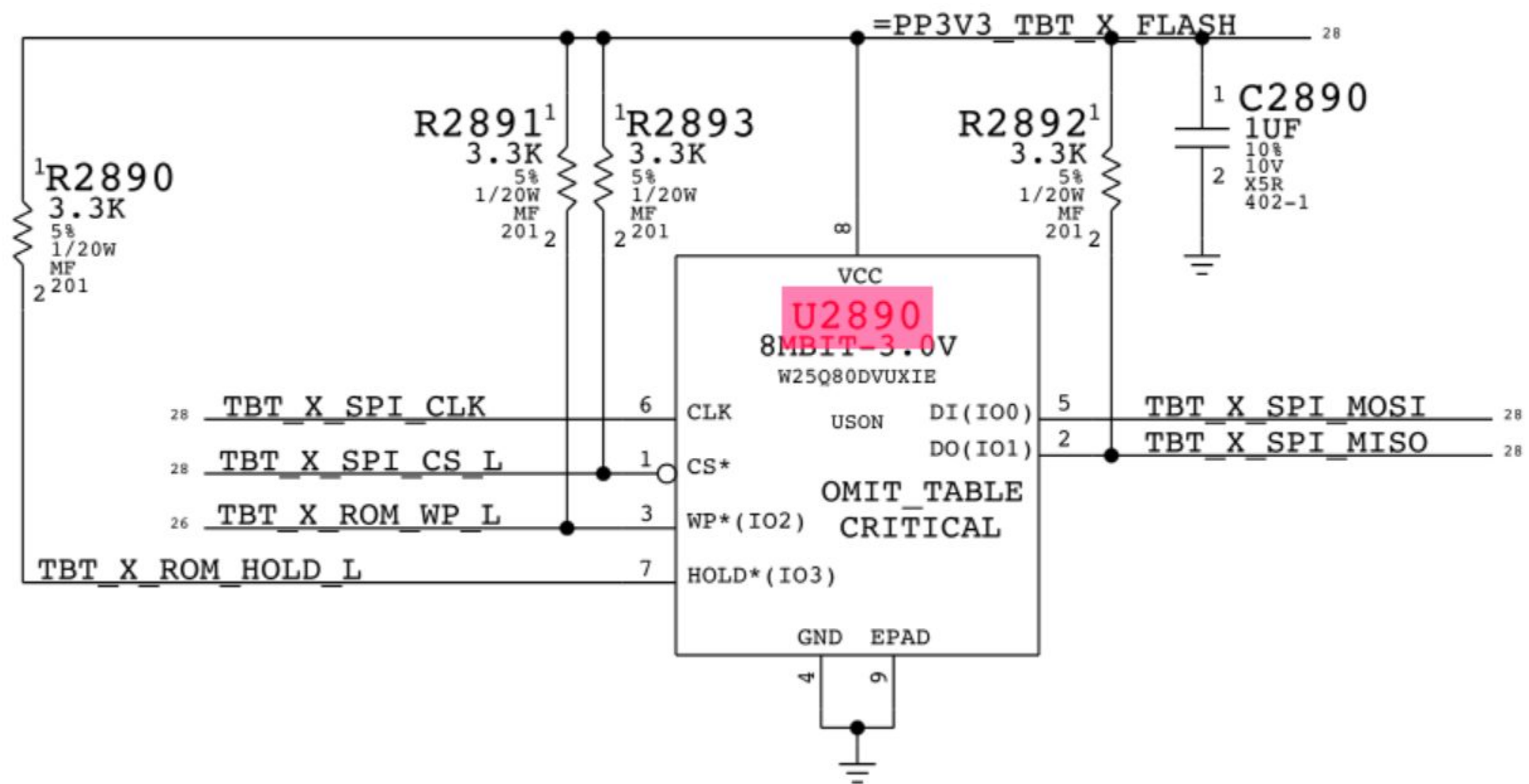
AUDIO SUPPORT
JACK CONNECTOR

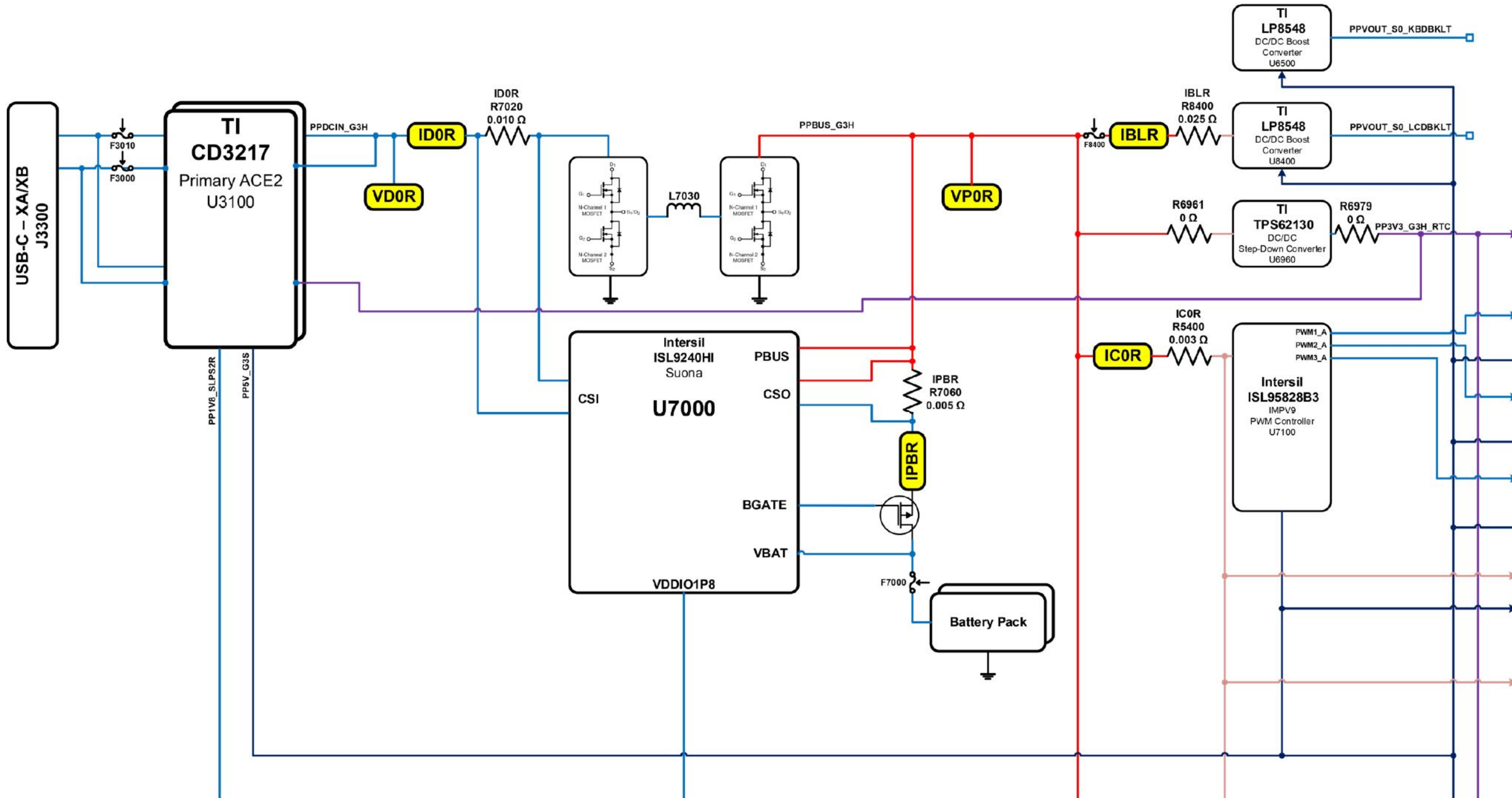
PIO3 FOR POWER GATE EN
ON BANSURI DESIGNS

30 =UPC_XB_I2C_STRAP
 26 =PP3V3_TBT_X_FLASH
 30 =PP3V3R1V8_UPC_XB

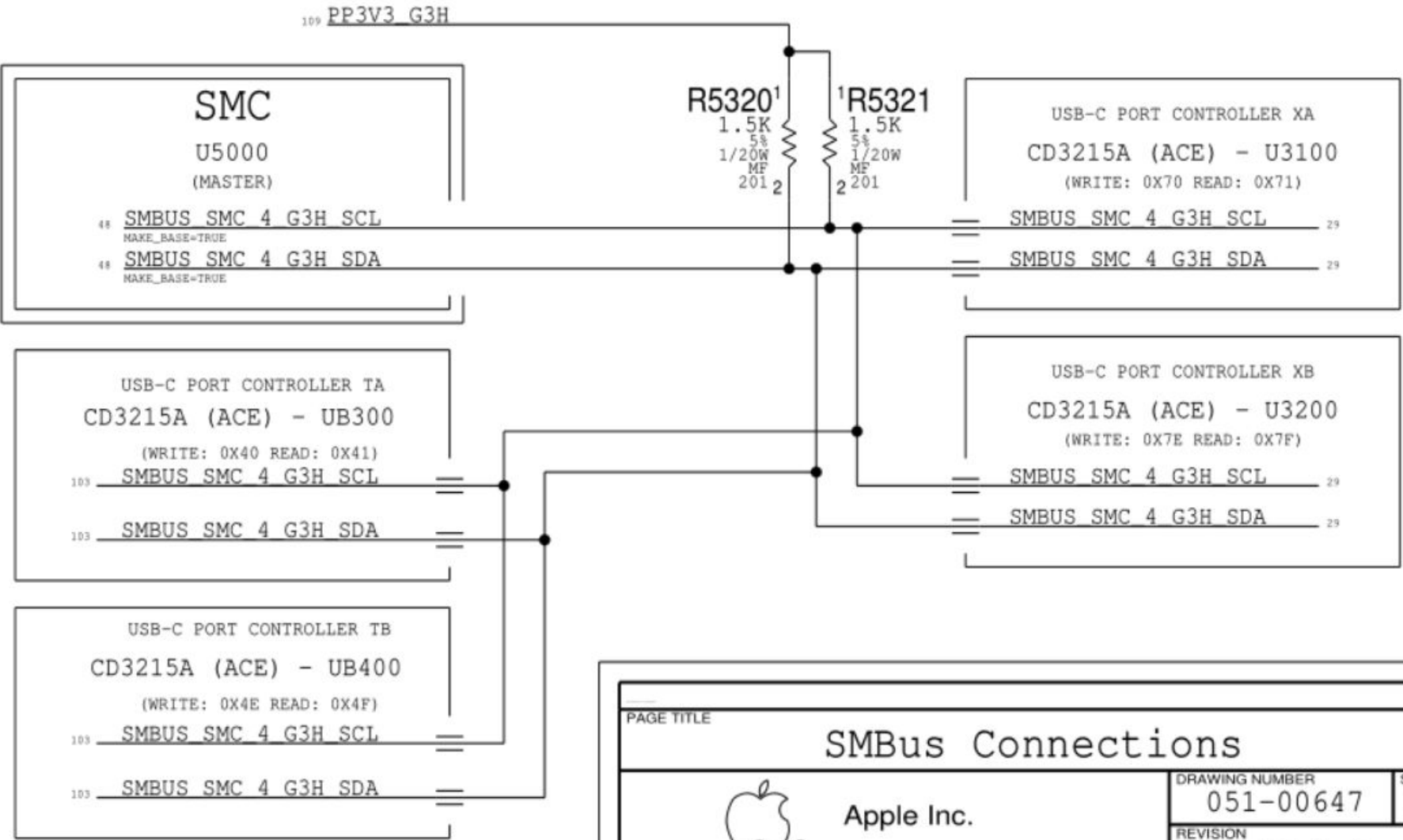
MAKE_BASE=TRUE

PP3V3_UPC_XB_LDO





SMC SMBUS "4" G3H CONNECTIONS



PAGE TITLE

SMBus Connections



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