UNIVERSAL ROBOTS

Troubleshooting UR Initialization

Version 2.0, January 2018

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Scope

This document covers troubleshooting steps to determine if there are failed components when a robot will not initialize. The contents of this document are the property of Universal Robots and should not be shared without explicit permission. This document does not describe how to disassemble the controller or robot to do these checks. Use of this should document should be accompanied by the electrical schematics. Further references are provided below.

Whenever following any steps recommended in this guide it’s always critically important to use proper ESD protection measures (ESD wrist strap) and be careful not to inadvertently short-out a live terminal to earth ground while things are disassembled. Use of this should be accompanied by having the electrical schematic available. Further references are described below.

Keywords, Abbreviations, Definitions

Table 1: Keywords, Abbreviations, and Definitions

Keywords	Abbreviations	Definitions
Initialization	--	The start-up sequence of the robot, during which all major component sub-systems are powered and checked for errors. Most often, if initialization is successful, the robot will be fully functional for normal operation.
Technical Support Engineer	TSE	The UR personnel that oversees troubleshooting errors and providing means to get the robot running as soon as possible.
Safety Control Board	SCB	A major component in the system, this board handles all IO for the robot. It is a common source of errors in the system.
Return Merchandise Authorization	RMA	Part of the process of returning a product to receive a refund, replacement, or repair during the product's warranty period.
Teach Pendant	TP	A major component in the system, this is the interface for the End-User to program the robot and react to errors.
Safety Control Board	SCB	A major component in the controller, this board handles all IO for the robot. It is a common source of errors in the system.
Motherboard	MB	The main controller of the system, which runs Linux and the Polyscope software. The controller connects to the SCB board to read IO states, and externally to any

Roles and Responsibilities

Table 2: Roles and Responsibilities

Roles	**Responsibility**
UR-Support	The engineer at Universal Robots responsible for helping the Contact fix the robot. Has intimate technical knowledge of the robot for troubleshooting and can initiate RMAs when needed. Should be polite and responsive to contact.
Contact	The senior person at the distributor that maintains hands-on technical experience with the robot. This person oversees coordinating support for the End-User
End-User	The person or company pays for and uses the robot day-to-day. This person should not be contacting UR-Support directly. Instead, the End-User should contact the Distributor for help first.

Procedure

Proper initialization of the robot is a multi-phase process.

I. Operator presses power on button in upper right-hand corner of teach pendant (TP). This could be achieved via remote power on also through some contacts on the IO. When you press this button controller boots, does some checks and eventually you should see the Polyscope GUI on the TP. You might see a message like **“The robot cannot proceed with normal operation; Robot: NO CONTROLLER”** with a choice to ‘Go to initialization screen’… this is normal and you should press this button to get to initialization screen.
II. After step I. the robot state is typically ‘Power Off’. The next step (from robot initialization screen) is to press the **ON button** on the touch screen.
III. Step II. gets robot into ‘Idle’ state. From this point, you press the **START button** on touchscreen. Brakes release and robot state changes to ‘Normal’.

Complete initialization is a 3-step process (NORMALLY, presuming there are no Estops active, safeguard stop inputs active, etc). You could have a failure during any phase of this initialization process.

The robot may not initialize for a number of reasons:

- Lack of AC power
- Failure of 12V power supply
- Bad connections
- Failed current distributor relay
- Failed 48V power supply
- Safety Control Board
- Estop and power jumpers on SCB
- Motherboard
- Teach pendant (internal components and power button, estop, etc)
- Failures of joints
- Communication failures

The following sections describe in order the way to troubleshoot the robot.

A. TP Power Button No Green Light

Pressing the power button on TP (teach pendant) does not cause it to glow green

When you press the power button in the upper right corner of TP, it should normally enable the green light on button immediately. If this does not happen it could be indicative of a few different issues:

1. Is 120/230VAC properly connected to robot controller?
2. Check 12VDC power – Normally, when AC power is present to enclosure and internal 12V PS is working the topmost LED on SCB will be lit.
3. SCB could be the failure.

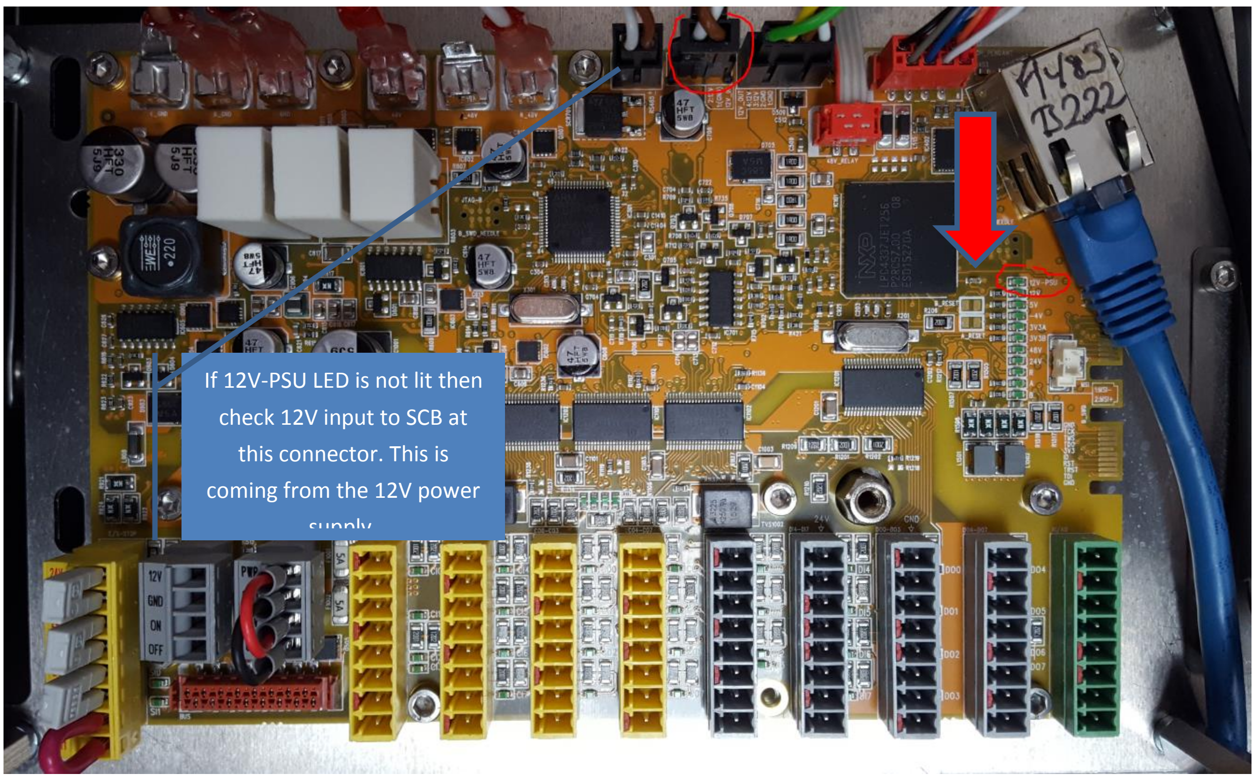


Figure 1: 12V Power Supply LED on the SCB

If the 12V LED is not lit then it could be the 12V power supply, SCB or AC power into power supply. Check that there is 12VDC coming from power supply at the 12V power connector (black connector with a brown and white wire at top of figure). If there is 12vdc on this connector and LED on SCB is OFF then problem is with SCB. HOWEVER, SCB could be indicating that it has 12V but not able to pass that 12V signal through to TP or MB due to internal failure of SCB. If there is no voltage on this connector then it could be 12V PS or AC power into PS. Move on to next sections of this guide to check AC power and 12V PS.

4. **Checking that 110/208 VAC power is getting to the controller and PS**. The only way to do this is remove the chassis from inside the enclosure. Before doing this disconnect the AC power connector from the enclosure so no AC voltage is present while you take it apart. Also, use proper ESD protective measures. The chassis can be removed from enclosure by removing a few bolts and then setting the chassis on top of the enclosure opening. The bolts that need to be removed are the two on top holding the handle on and 2 nuts in back of enclosure holding chassis to enclosure. You will also need to remove the black and orange wires that lead from SCB to the energy eater device and the grounding lug on TP cable to give more freedom to TP cable.

When you get the chassis out of enclosure to the point of exposing the terminal blocks where you can measure AC voltage it will look something like this:

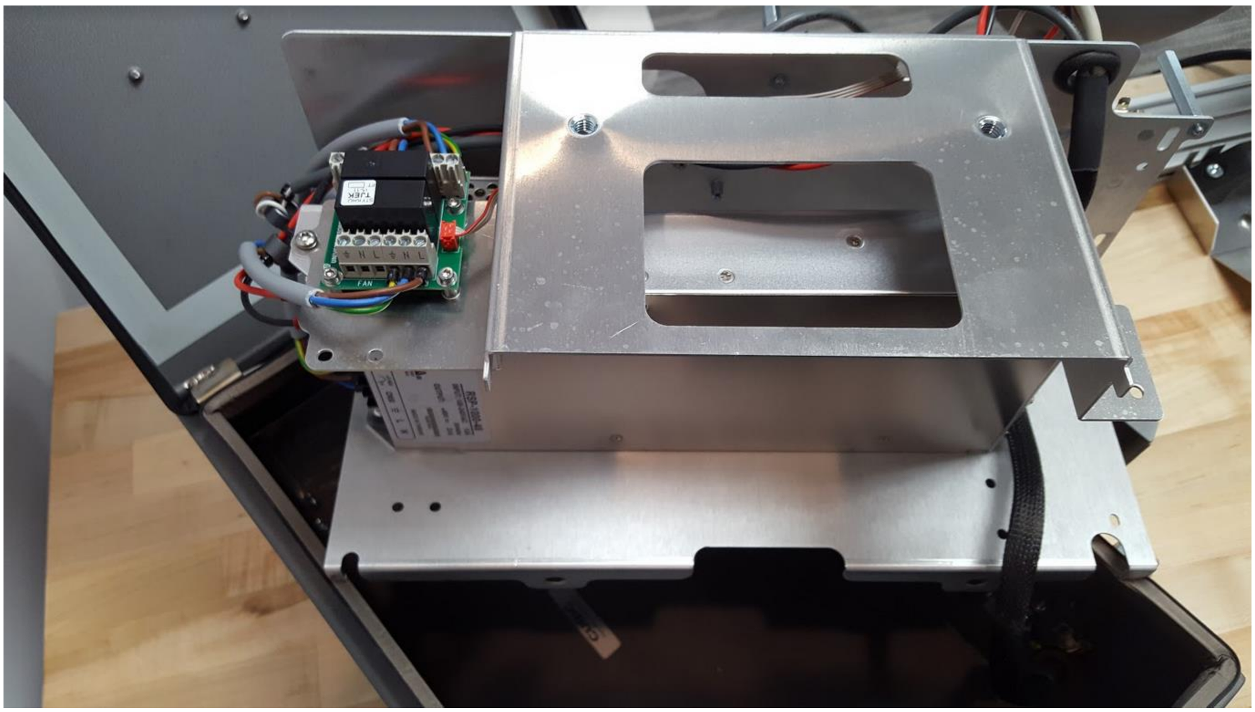


Figure 2: Chassis removed from Controller

NOTE: In this configuration, you need to be EXTREMELY careful not to have any exposed terminals shorted out to ground.

Reconnect AC power cable to enclosure. Now you can measure AC voltage. You should have 120/230VAC (depends on local line voltage) at measurement PT1 and PT2.

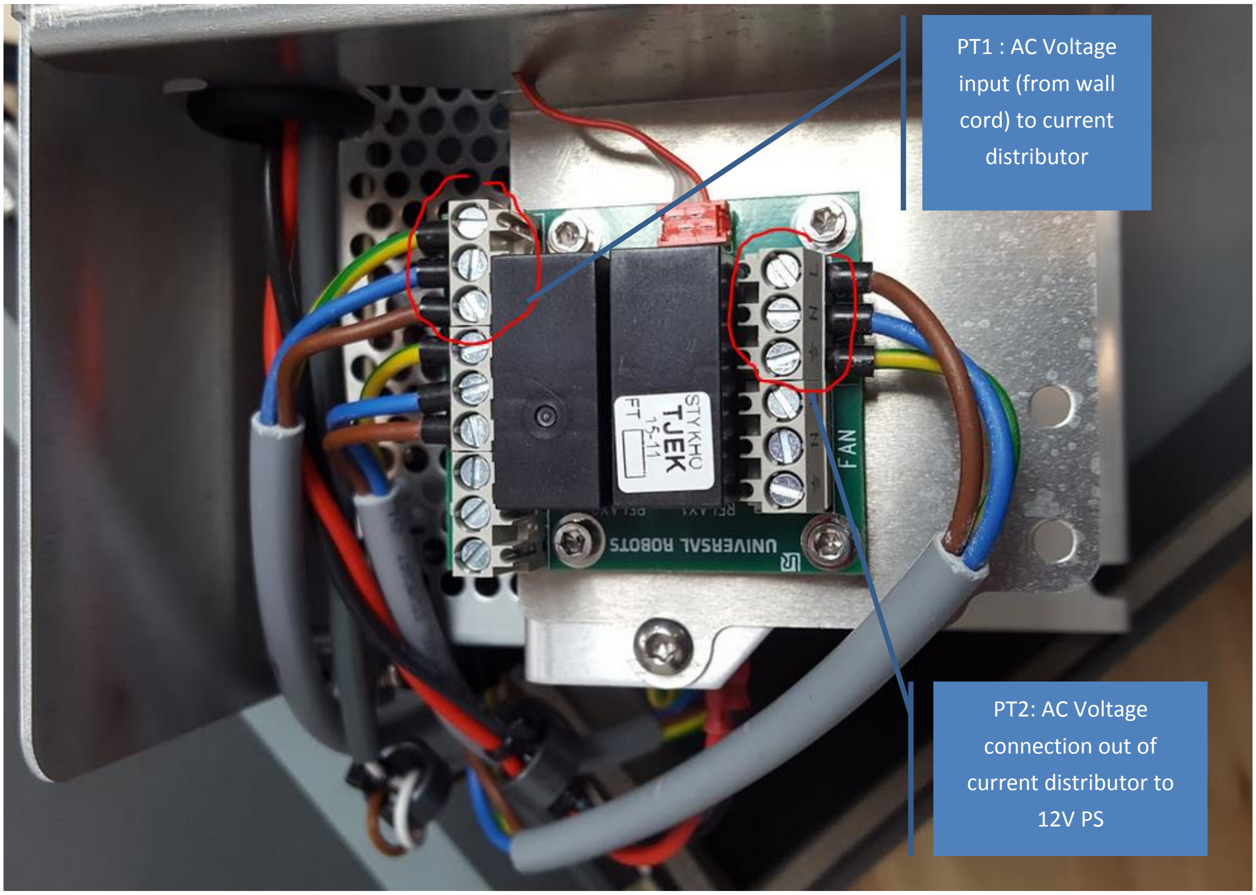


Figure 3: Current Distributor Relay PT1 & PT2

If you don't have AC voltage at PT1 then it's a problem in cable/connection leading back to AC input of enclosure (it IS plugged in to AC power – right?). **If there is voltage at PT1 but not at PT2 then the failure is in the current distributor board.**

If you have proper AC voltage at measurement PT1 and PT2 then check the 12V PS (see next section).

5. Check 12V power supply. Chassis needs to be out of enclosure for this check.

See red arrow in image below. If this LED is not lit then from the previous step you can get access to the 12V PS and while AC power is connected to enclosure you should see the LED ON on the 12V power supply itself. You can also measure the output of the power supply directly.

This is the point where you measure 12VDC coming out of the power supply.

If this power supply is indicating voltage (12VDC) and the LED is lit here, BUT not lit on the SCB, then check the wiring. If there is 12V at the SCB but LED of SCB is NOT lit then SCB is bad.

Figure 4: DC measurement on 12V power supply

6. Check 8 pin cable/connector leading from upper RH corner of SCB out to pendant. If this connector has been removed or is missing certain connections it will prevent signal from PB on TP from getting back to SCB.

If 12V-PSU LED on SCB is lit, but pressing the power on button on TP does not cause the power button light to illuminate to green, then it could be the connection to the TP. This connector is shown here and you should check that it is connected and no pins within connector are compromised :

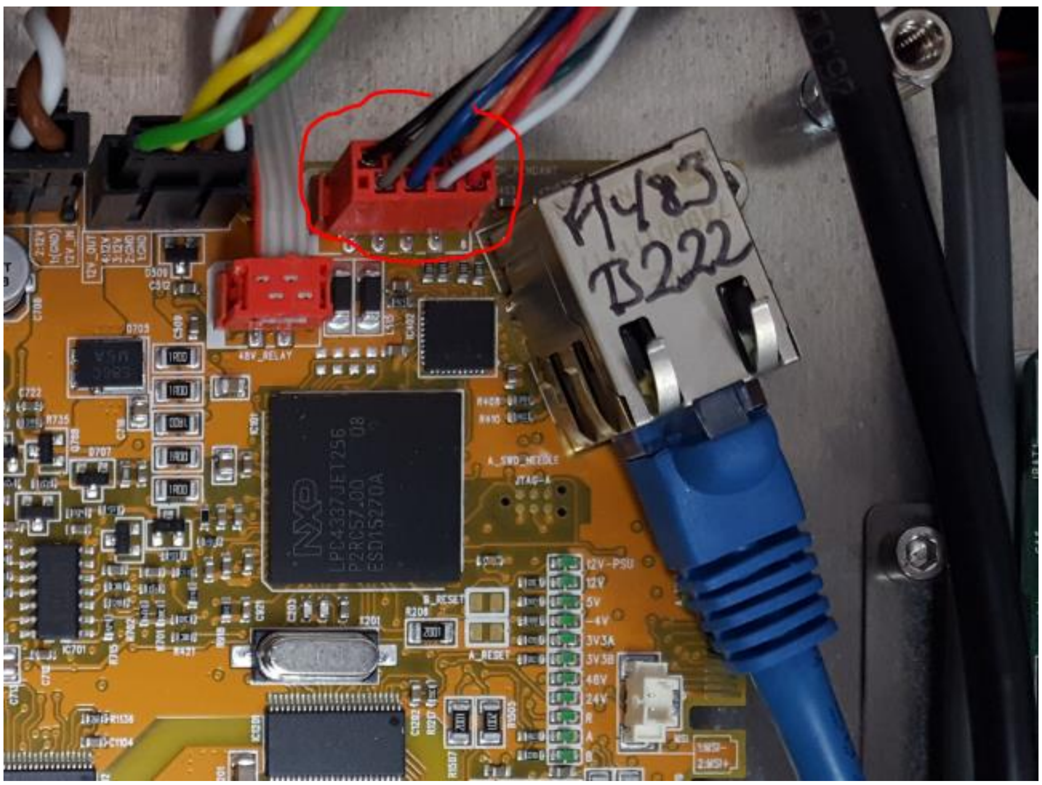


Figure 5: TP connection on SCB

If this connecting is OK it could be a broken cable (conductors inside cable) or a bad connection inside TP itself. See next two sections.

7. It could also be a broken TP cable (typically unlikely for this signal, but possible)

An effective method for testing this is to use the ‘remote power on’ terminals to power up the robot. These terminal are shown here:

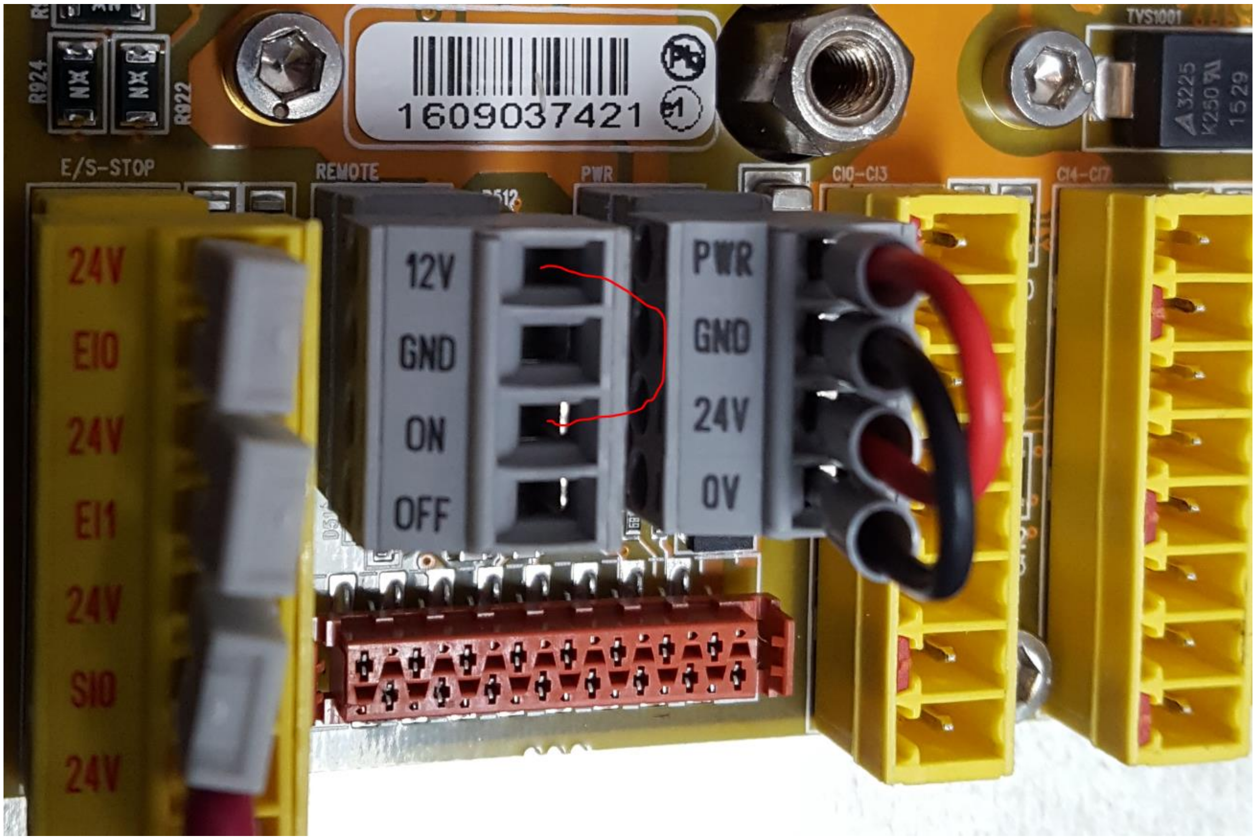


Figure 6: Remote power terminals on SCB

If you jumper from 12V to ON terminal (even just briefly) it will indicate a ‘power on’ signal to the SCB. If the SCB if functioning properly it will begin the power up sequence. You will see the LED’s change on the SCB. It will go from just having the topmost 12V-PSU LED lit to having multiple other LEDs lit.

At the beginning of the power on sequence you should see this on the SCB :

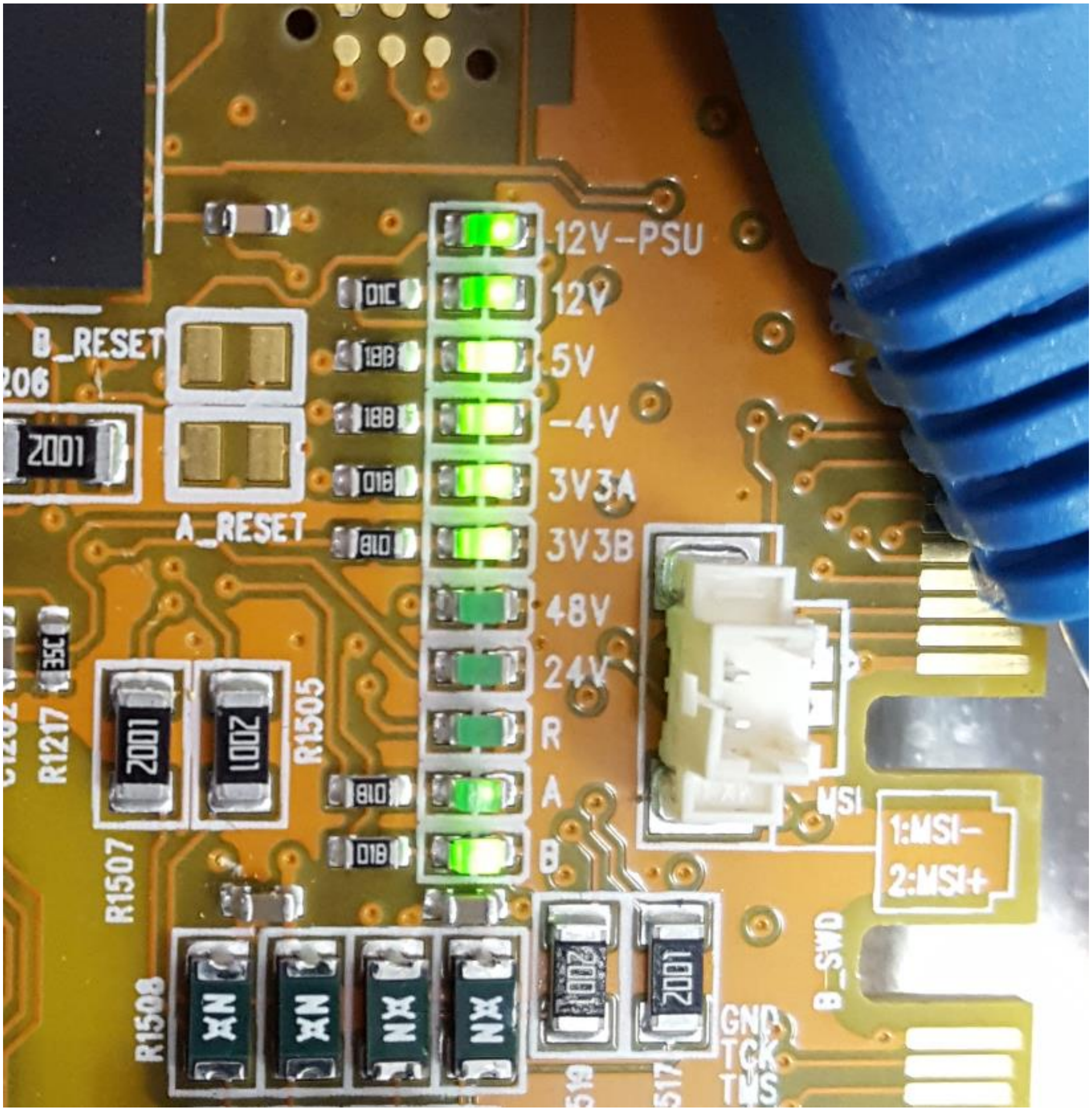


Figure 7: LEDs of SCB

If you get this status change as a result of jumpering the remote power terminals then the TP cable is bad or the connection inside the TP is bad. You should get a new TP.

8. Could be a broken connection inside TP. Maybe it was dropped and the connection on power button inside TP is loose. The TP is not serviceable so we will not get into details on how one might check the connections inside.

B. TP Power Button Working, but Screen is Black

Pressing the power button on TP allows power button to glow green but TP is black

If, after pressing power button at TP, it DOES glow green, but the TP display **remains completely blank during entire initialization attempt** AND the SCB indicates it is powering up OK (see Figure A.7 for LEDs), then it could be the cable to the TP or connection within the TP.

One way to test the TP to see if it's video is dead would be to plug in an external monitor with a HDMI cable, into the MB (motherboard) connection. If this works, you get proper video showing controller initializing, then you need a new TP.

C. TP Shows Only “Universal Robots”

Pressing the power button on TP allows power button to glow green but TP only shows a brief ‘Universal Robots’ banner covering the top 1/3 of the screen

This banner is generated by electronics within the TP, independent of any signal from MB DVI output. It will look like this:

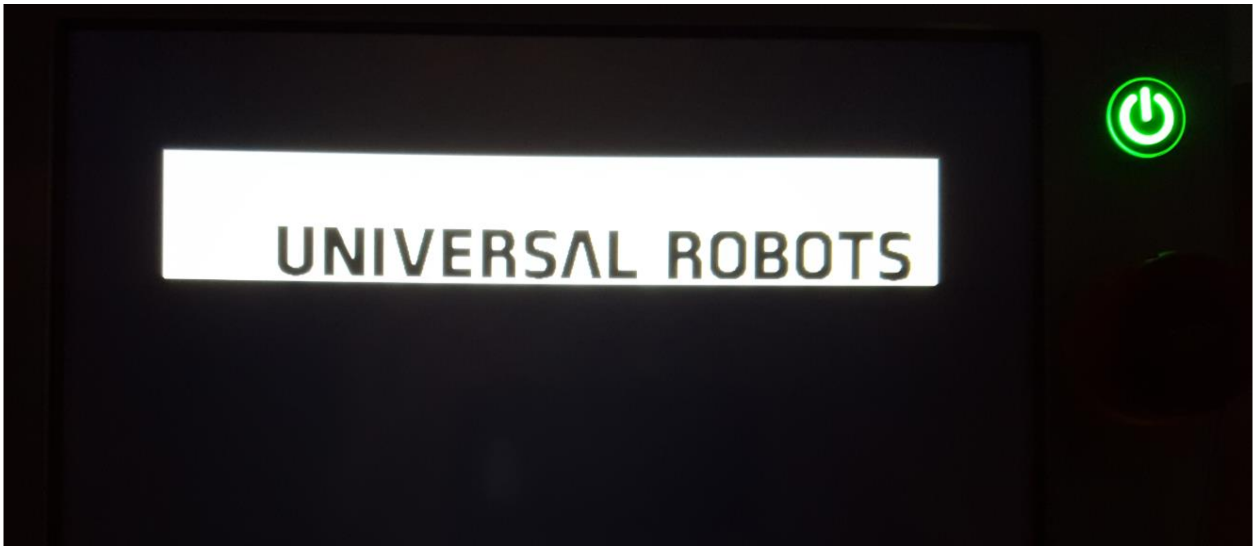


Figure 8: TP graphic banner

If you only see this banner, and then it goes away and in the lower left hand corner you see a small message indicating “DVI – No signal”, followed by “Scanning Ports – No Signal” AND, then the whole screen goes blank after that, then this is caused by a couple of potential issues.

1. It could be the power connection from SCB to MB. (MB is not getting power from SCB)
    a. See next section (SCB seems like it’s not applying power to MB)
2. It could be the DVI signal going from MB to TP is bad. (bad connection or cable to TP)
    a. Check DVI cable connection at MB, but it could be just some signals in the cable. Check pins in male end of TP’s DVI cable where it plugs into MB connector. Maybe someone removed connector and bent some pins while trying to put it back on clumsily.
    b. If MB is getting power, seems to be booting and plugging-in an external monitor shows that system is initializing then it’s the TP that is bad.
3. It could be that the MB is bad. See next section (Sympton D) to get more details on MB troubleshooting.

D. TP starts, but MB does not Appear to be Working

Pressing the power button on TP allows power button to glow green but TP only shows a brief 'Universal Robots' banner covering the top 1/3 of the screen, MB does not appear to be booting. (checking to see if MB might be bad)

How can we tell if MB is attempting to boot? The most obvious and telltale sign is the messages on the TP screen. The other sign is the LED indicator on the Ethernet port leading from MB to SCB. This LED will glow green.

After the TP banner described above, **IF MB is beginning to boot**, the screen will look like this (you will see these messages from the Linux OS of the controller booting) :

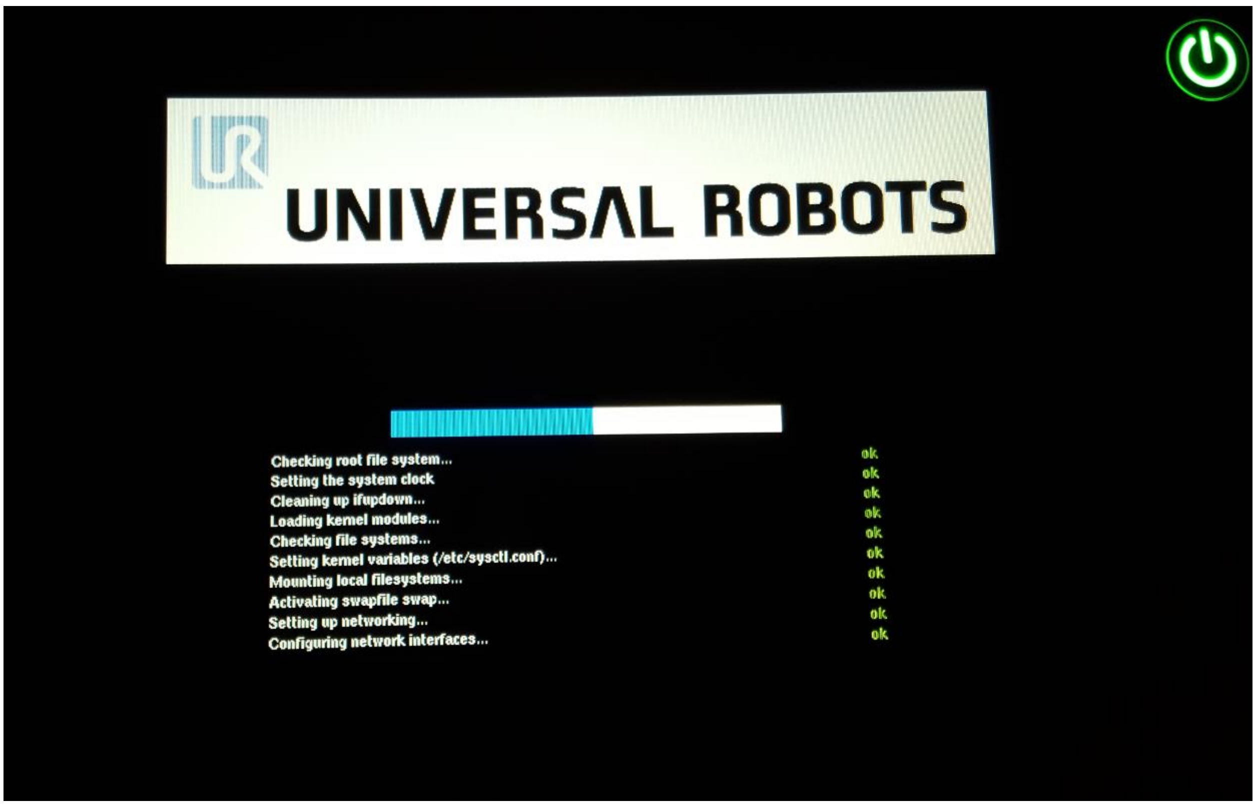


Figure 9: Initial Indication of MN booting Linux Kernel

The LED on the Ethernet port (indicating that MB has begun to initialize) can be seen here :

This is Ethernet cable leading to the SCB. The connection of these cables is also critical (which port on MB).

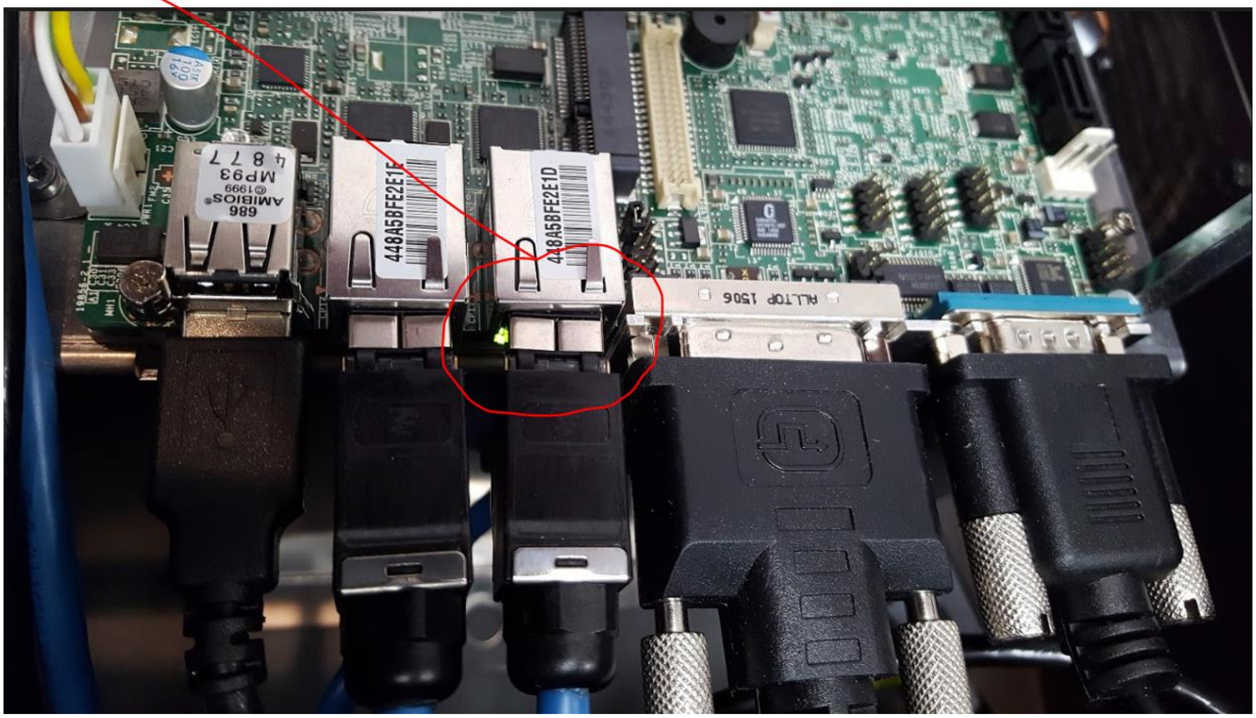


Figure 10: SCB Ethernet port on the MB

If you DON'T see any activity from MB on the TP screen or the Ethernet port then you should check to see if MB is getting power from SCB. When you press the power button on upper right hand corner of TP you should immediately be able to read 12V going from SCB to MB. This is via a 4 pin connector shown here :

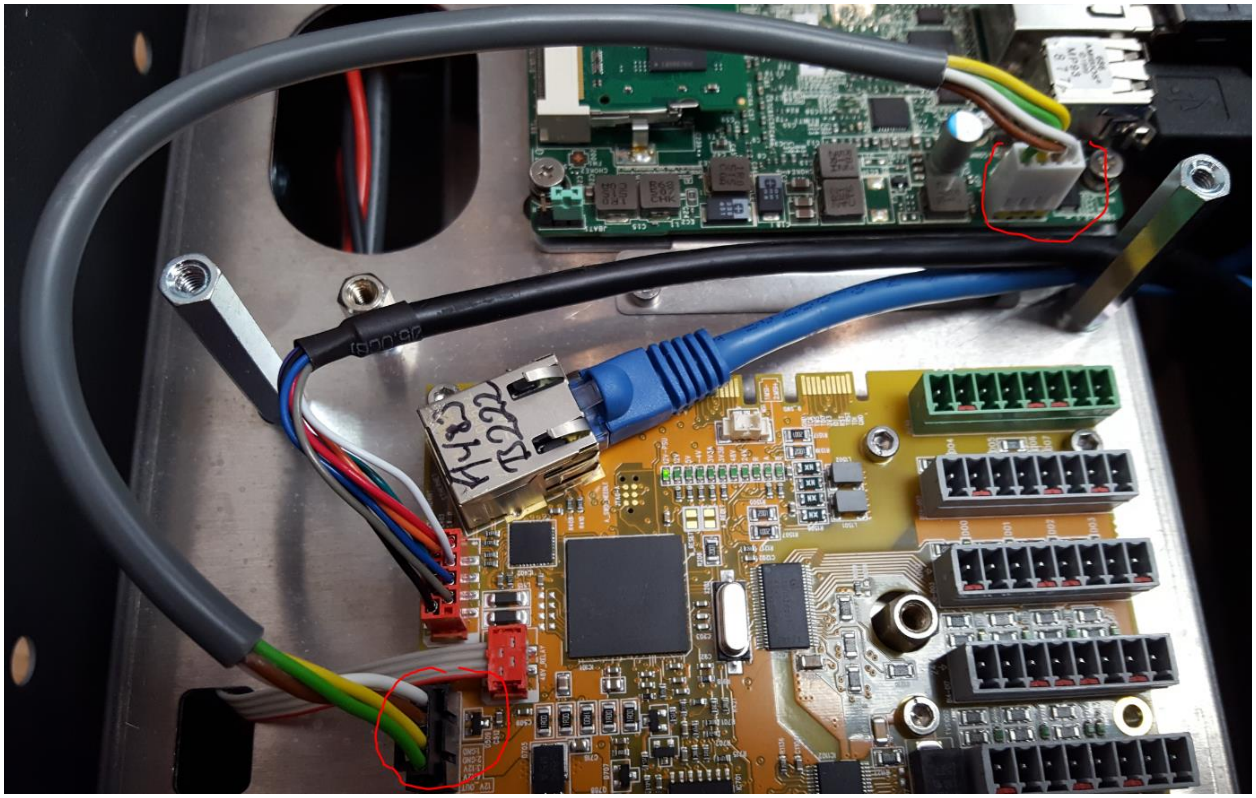


Figure 11: Power cable (4pin) from SCB to MB

The easiest place to measure the voltages coming from the SCB is at the SCB. Remove the connector at the SCB and you should measure 12vdc on green and yellow pins. White and brown wires are DC ground. You can safely measure on these pins by placing the negative terminal of your DVM (digital volt meter) on the chassis of the controller and then just placing your positive probe of DVM on green or yellow wire pins at SCB connector. Be careful not to short a +12V pin to ground.

If you have proper voltages at both end of this cable, and MB is getting power from SCB, ***but not booting***, then the MB is bad. (as a side note, the SCB LEDs will show that the top 6 LEDs are active, as well as the bottom two A&B flashing).

E. Boot Media Not Found

MB attempts to boot showing message “Reboot and select proper boot device or insert boot media in selected boot device and press a key”

If this message shows up on the TP screen this indicates the MB attempted to boot but it does not have valid media to boot from. This may mean the compact flash storage media is missing (CB3 controller) or the USB flash is missing (CB3.1 controller) or they could be highly corrupted.

Contact your distributor and get a new flash drive.

F. Error “Safety Board Failed”

System initializes to point of generating message “Safety Message – Fault, RobotInterface : C201A0: Setup of safety board failed”

If you get this message and then go to initialization screen and message at top, next to Robot status is ‘Fault’, then this indicates a communication problem between MB and SCB via Ethernet. Check the Ethernet cable between MB and SCB (unplug and re-plug both ends). You will have to shut down robot after fixing cable and do a cold reboot. It could also be that the cables are swapped (the two Ethernet ports on MB). Only one port can is configured for communicating directly to the SCB from MB. Below is how that connection is supposed to look.

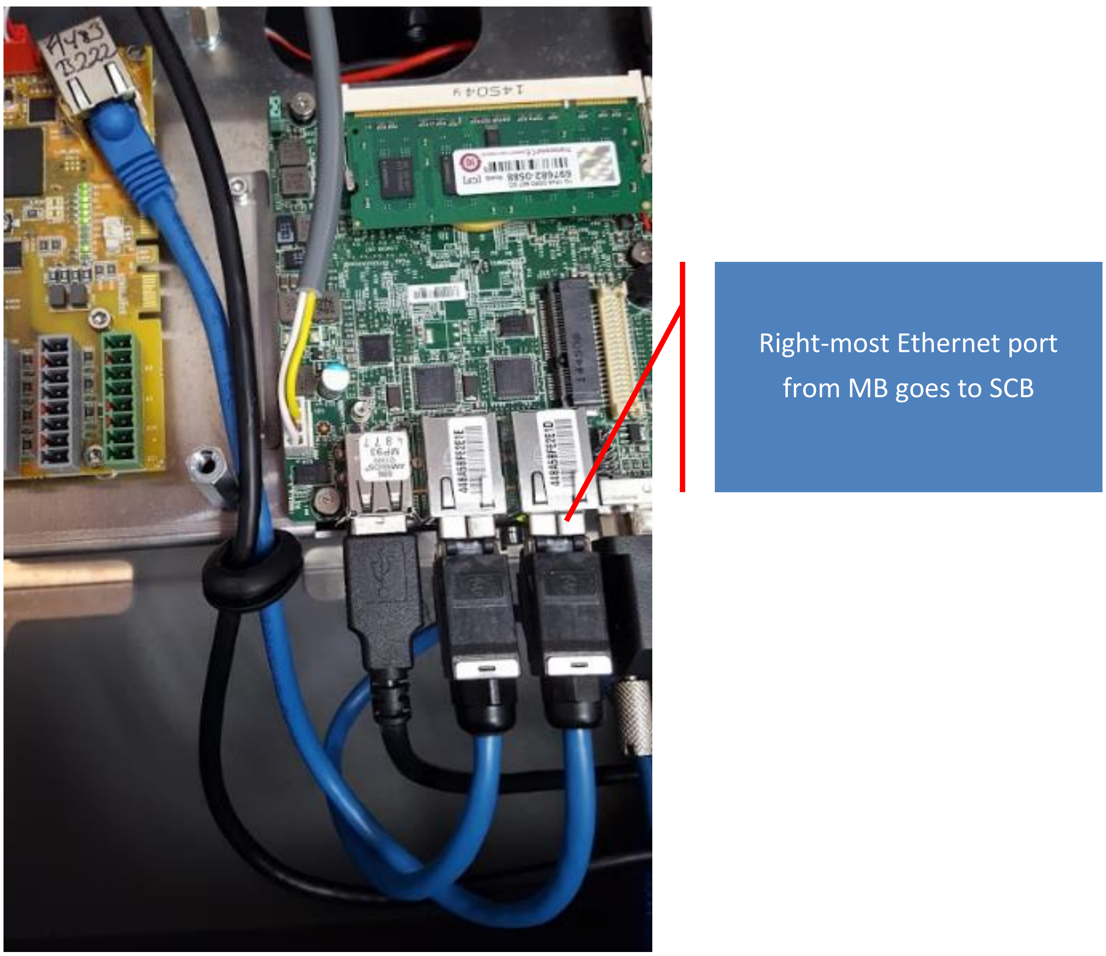


Figure 12: Correct Ethernet connections for MB

H. Error "Power Supply Failure"

System initializes to point of generating message "Safety Message – Fault, SafetyA : C72A1: Power Supply Unit Failure: 0 PSUs are active" :

You would only get to encounter this symptom if everything preceding it checked out ok. With this type of symptom, the diagnosis is usually indicating a failed 48V PS or current distributor or SCB.

This message **can be** accompanied by 5 clicks from within the control enclosure (although not always) that are coming from the current distributor relay attempting to energize the 48 volt power supply. The SCB will attempt multiple times (for multiple PS's in the case of a UR10). The message looks like this :

Figure 13: Power Supply Failure Alarm

This could indicate a failure of the current distributor relay, wiring from current distributor to 48V PS or the 48V PS itself or SCB output driving current distributor. In the case of a UR5 there is only one 48V PS. In the case of UR10 there are two so it could be that only one PS of UR10 is bad.

From this fault message (Figure G.1 above) you can click on ‘Go To Initialization Screen’ and attempt to RESTART again.

1. If you hear the 5 clicks (or some number of relay clicks) and get this message again then the SCB is doing what it’s supposed to; it is attempting to energize the relay and hence the 48 power supply(s). If this is the case then you can test the 120/230 VAC input to the 48V PS from the current distributor :

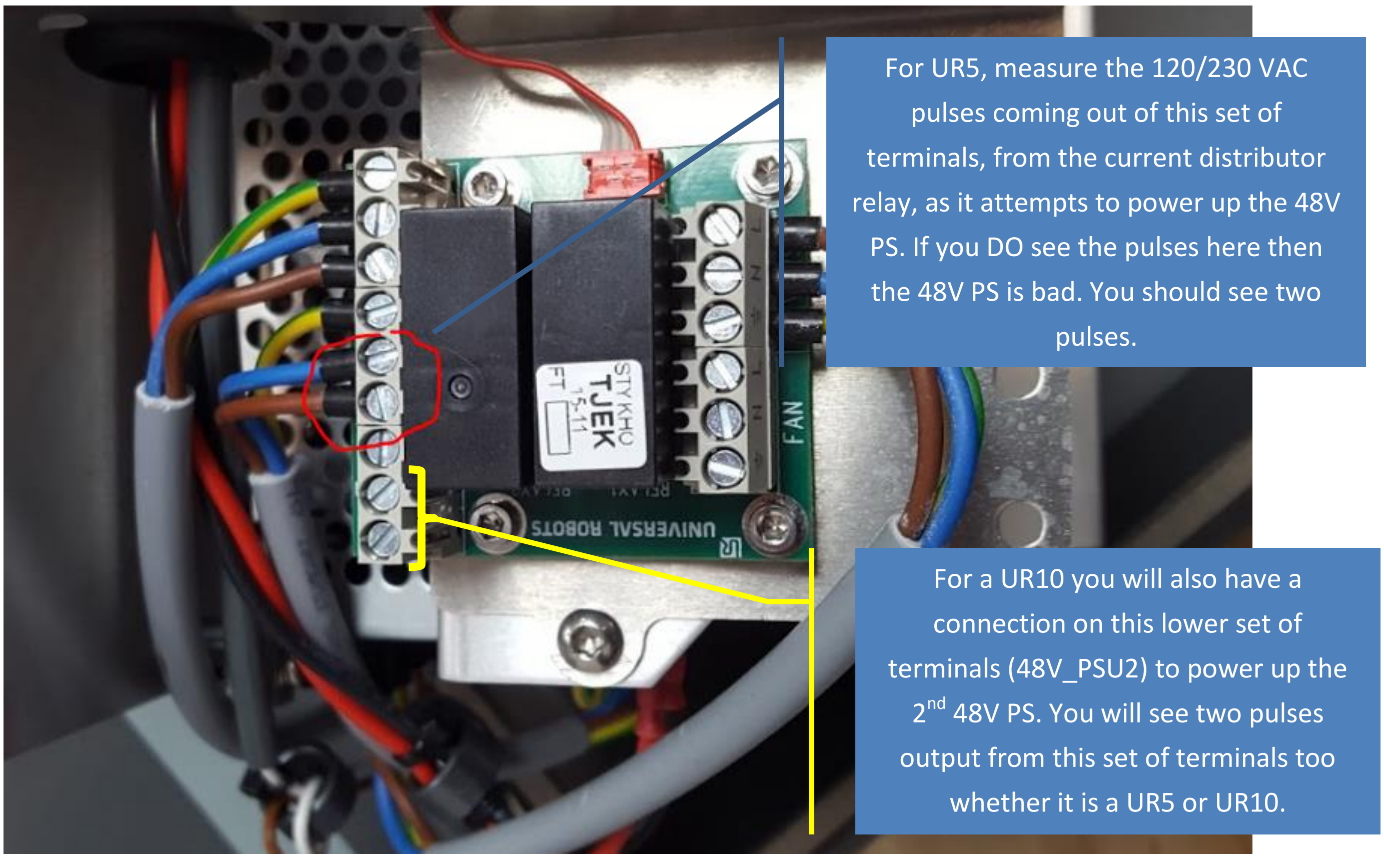


Figure 14: VAC input to 48V PS on current distributor

IMPORTANT NOTE : At this point in troubleshooting, it you get pulses coming out of one relay, but NOT the other, and it is a UR5 you are working on, then it could be that only one relay is bad and you could simply move the feed to the 48V PS to the other set of terminals coming out of the current distributor (from 48V_PSU1 to 48V_PSU2 terminal set) as a temporary solution until you get a new current distributor.

2. If you DO NOT get the 120/230VAC pulses at these terminals then it could be the current distributor relay is bad OR the ribbon cable connecting SCB to the current distributor relay is bad OR the output of the SCB that drives this relay is bad.

To test output of SCB to see if it's working properly, you need to check the signals on the 4 pin ribbon cable leading from SCB to current distributor relays. The easiest place to test this is at the SCB with the connector removed. Be careful removing this connector, it is fragile! Best practice is to gently pry on one of the outer wings while slightly pulling up one side of connector, then do same on other side.

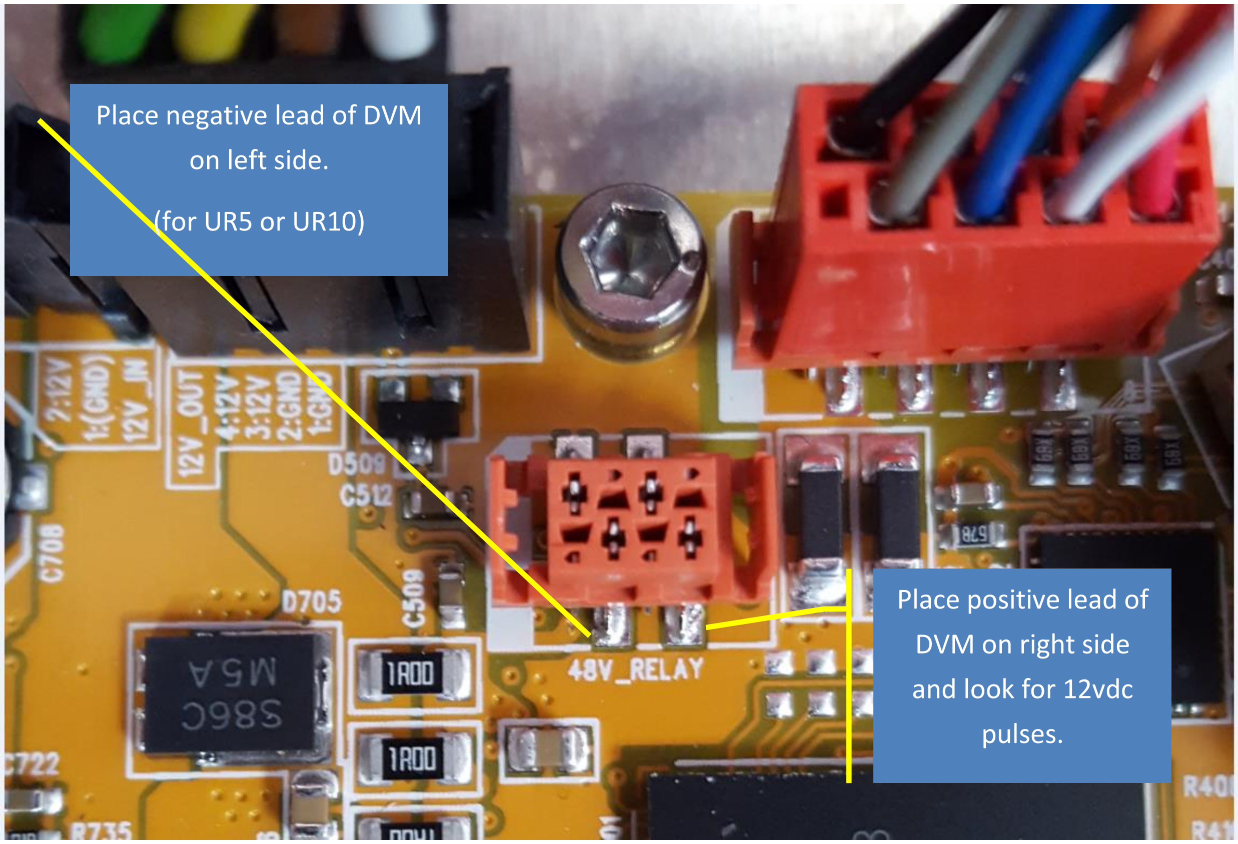


Figure 15: Connector header for 4pin ribbon cable from SCB to current distributor

When you go to the initialization screen and click on RESTART (if you are measuring signals on these pins) you will see 12vdc pulses (at least two) as SCB attempts to energize 48V PS. If you get pulses coming out of the SCB '48V_RELAY' connector then the SCB is ok and if the previous step showed that the no 120/230vac pulses coming out of the current distributor then the current distributor is bad.

3. If you did not get any 12vdc pulses coming out of connector in Figure F.3 then the SCB is bad.

I. Error “SPI Output Error Detected

System initializes to point of generating message “Safety Message – Fault, SafetyA : C192A20: Safety system fault: SPI output error detected”

When you see this message in Polyscope the most likely indicator is that the SCB does not have a 24V supply. Check the 24V jumper or external power supply if you are using one. Here is where the jumper is located:

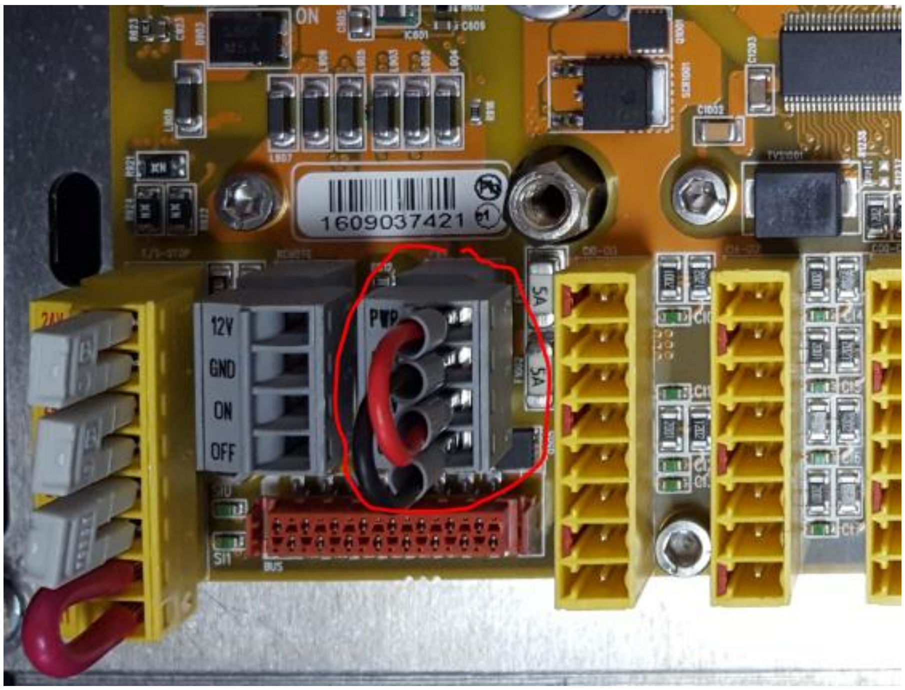


Figure 16: SPI output error SCB 24V jumper

This could also indicate a problem within the SCB itself too (more rare case).

J. Error Robot Estop Disagreement

System initializes to point of generating message “Safety Message – Fault, SafetyA : C192A2: Safety system fault: Robot emergency stop disagreement”

This message indicates and issue with the estop inputs. Most likely source is the external estop input. If you are just using the jumper that comes from the factory then check all the terminals on this connector to make sure they are tight. This estop input is a dual channel safety signal so both EI0 and EI1 must be intact signals. If there is an external Estop P somewhere (or it’s coming from a PLC) then make sure the wiring is OK and the dual contacts must close/open within 100ms of each other to adhere to the specification for this type of safety input signal.

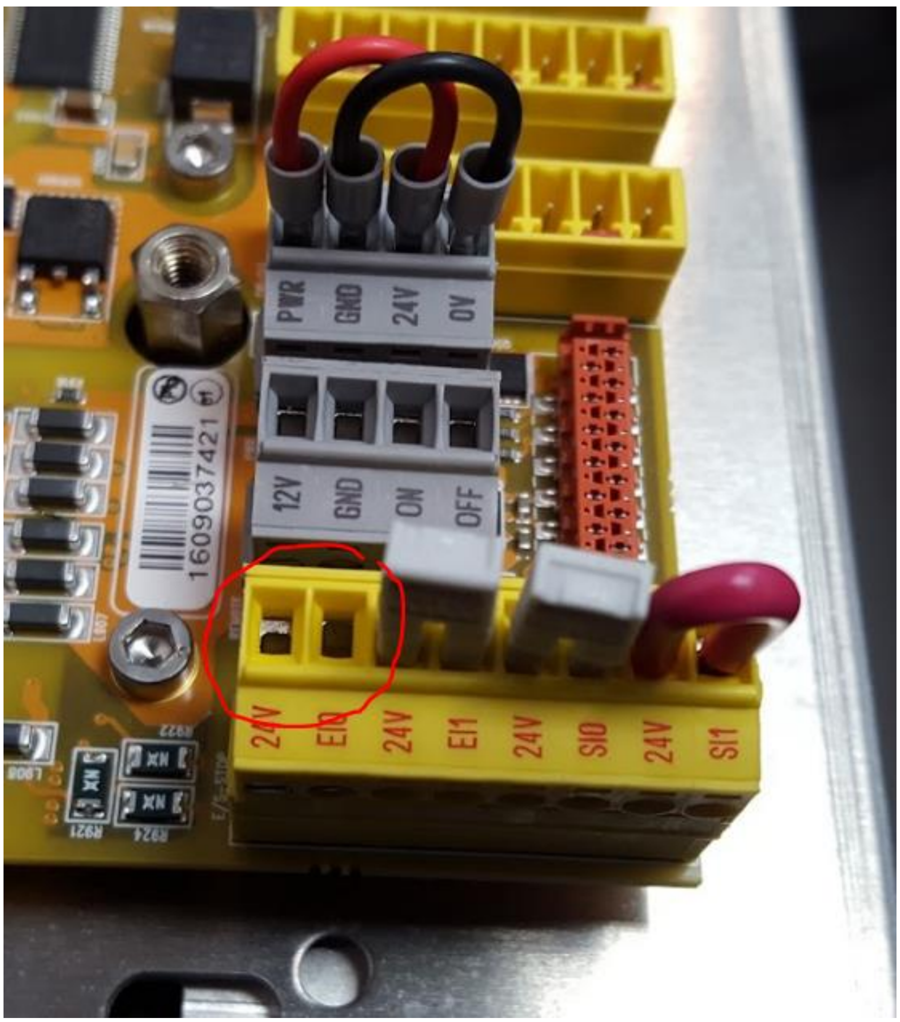


Figure 17: Estop Jumper Missing

K. Error Safeguard Stop Disagreement

System initializes to point of generating message “Safety Message – Fault, SafetyA : C192A4: Safety system fault: Safeguard stop disagreement”

This message comes from improper signal integrity of safeguard stop input(s). These signals are connected at this jumper :

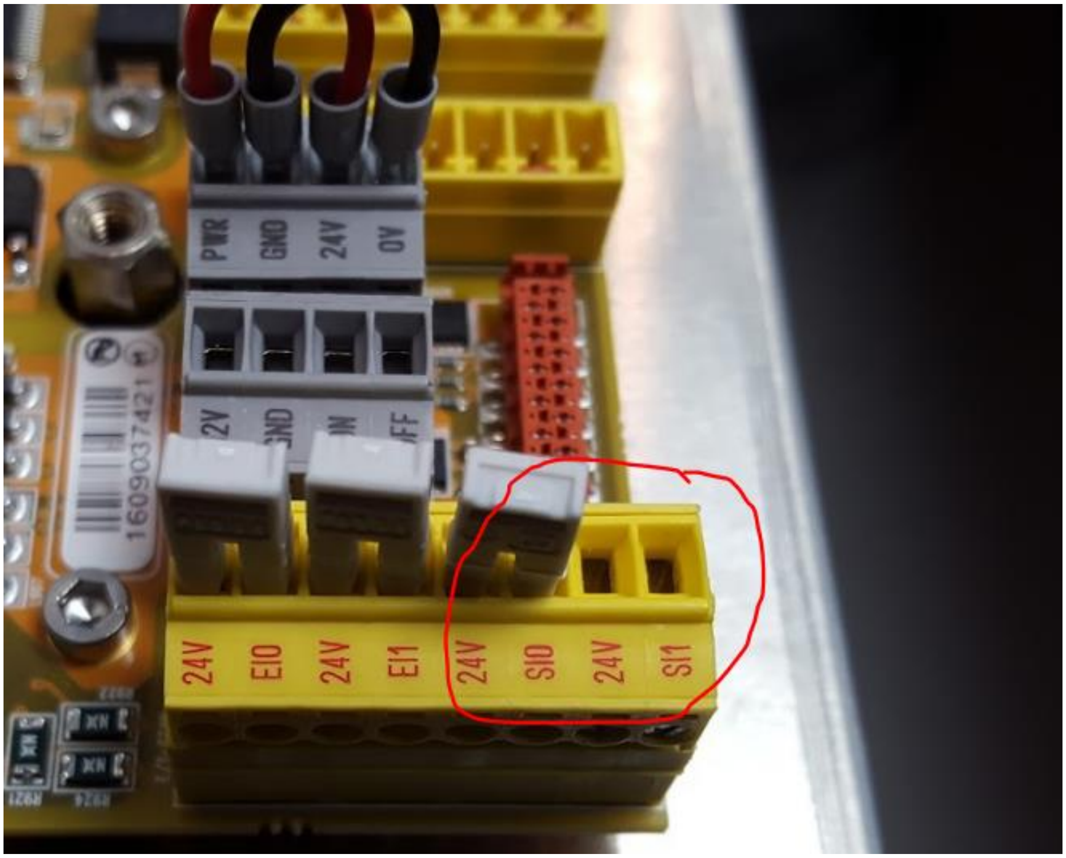


Figure 18: Safeguard jumper missing

These are hard-wired signals. They have nothing to do with configuration settings in Polyscope.

L. Error Communication with Controller Lost

"Safety Message – Fault, SafetyA : C4A1: Communication issue: Communication with Controller lost"

Error log shows "C103A1: Communication issue: Connection to Safety Control Board Lost". This 2nd message does not show up as a popup dialog on the Polyscope GUI. This message only gets inserted into the error log history and **the robot will be in an Estop state with brakes engaged.** This message indicates that communication between MB and SCB has been lost.

Check Ethernet cable between SCB and MB. Might need to do a cold restart of entire controller.

WHAT WE'VE COVERED SO FAR

Thus far we've covered typical errors that might occur during initialization caused by components within the controller. Now we'll focus on issues that might happen outside the controller (cable to arm and joints within arm itself).

M. Error Cable Not Connected

Error popup "C50A100: Robot powerup issue: Cable not connected"

This is indicating the cable running from controller to robot base is disconnected somehow. Maybe it was pinched also or maybe pins within the connector are compromised.

N. Press On, Robot Remains in Power Off

Attempt to press ON button (at Initialize Robot screen) but the Robot state remains as POWER OFF.

So, we've gotten to a point where we're attempting to finish the initialization of the robot but we press ON button on touchscreen and nothing happens (no popups, etc). You might check error log history and see nothing of value there either. The screen will look like this:

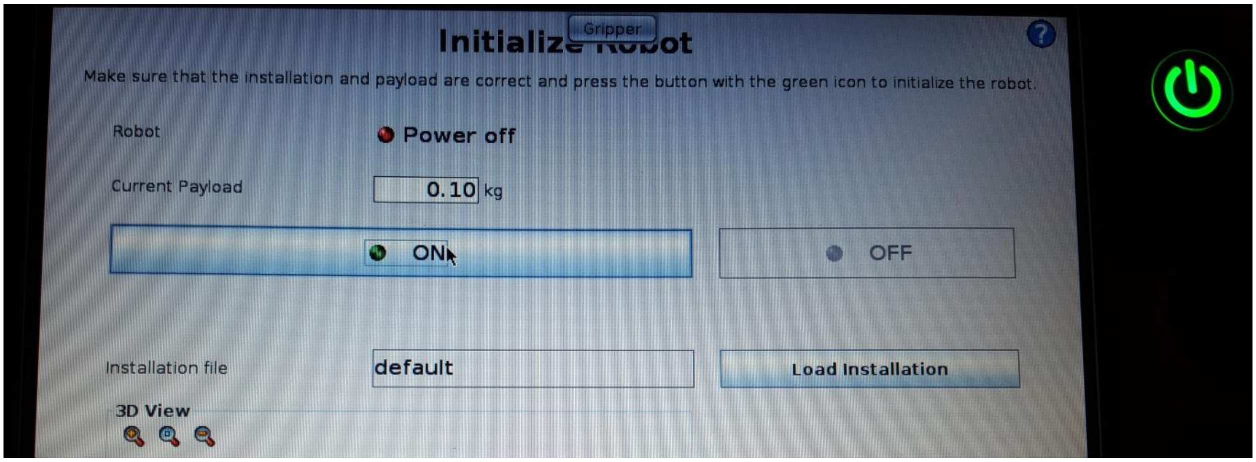


Figure 19: Robot does not power up when On is pressed

This is a case where you need to enter Expert mode and go into Low Level Control to diagnose the initialization of joints. For help in entering Expert mode go to the Service manual and search for 'expert'.

Once you get into Low Level Control you can 'Turn Power On' to individual joints, signal them to 'Go To Idle' mode, 'Arm' and see the status. The most likely cause of the symptom 'BB' is that some joint is not able to initialize and it is preventing the whole arm from powering up properly. So, we want to use Low Level Control to isolate which joint is causing the problem. The problem could be:

- Lost communications to the joint (bad connection)
- Joint does not have power (pinched cable, bad connection)
- Damaged PCB within joint (ESD damage or something catastrophic like that)

When you enter Low Level Control, before doing anything, the screen will look like this :

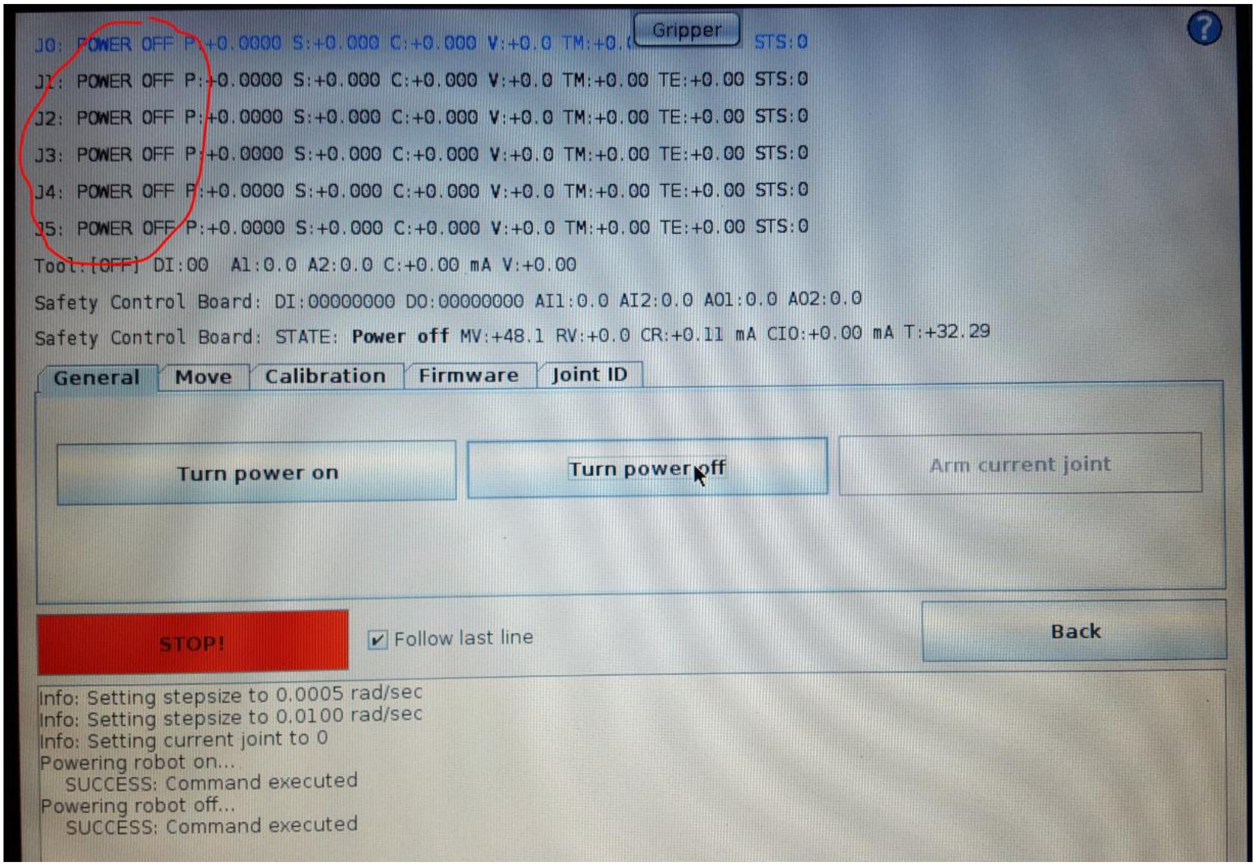


Figure 20: Initial screen of Low Level Control. All joints show status of Power Off

Notice that all joints show a status of “POWER OFF”.

If everything is working ok, the normal progression of state of the joints within the Low Level Control screen is :

STATE	PRESS BUTTON	JOINT TRANSITIONS TO…
Power off	Turn power on	Bootloader
Bootloader	Go to Idle	Ready
Ready	Arm robot	Brake release and then OK

After all of this is complete the individual joints can be jogged via Move tab, very carefully; you are in Expert mode now.

For our example, we press ‘Turn Power On’ and it might change to this:

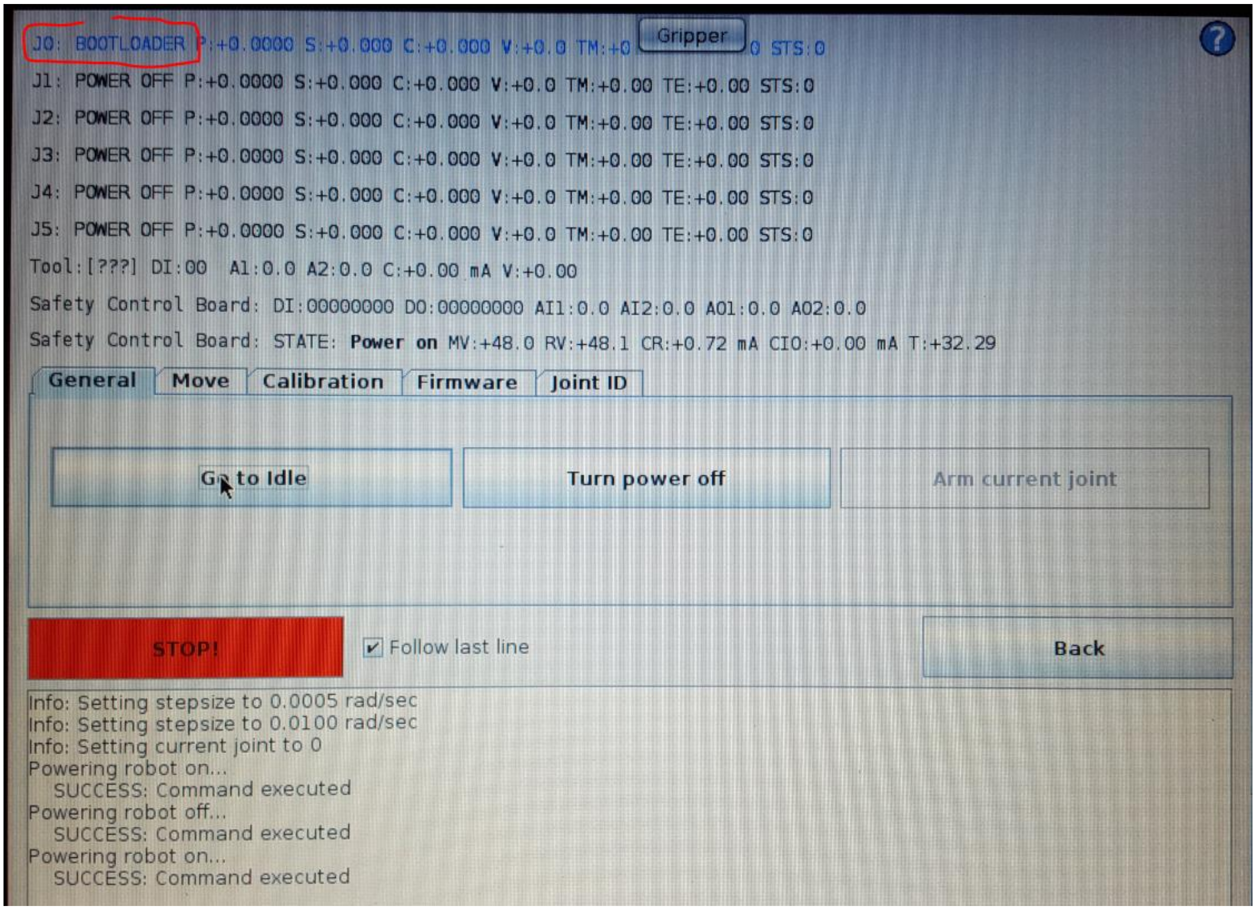


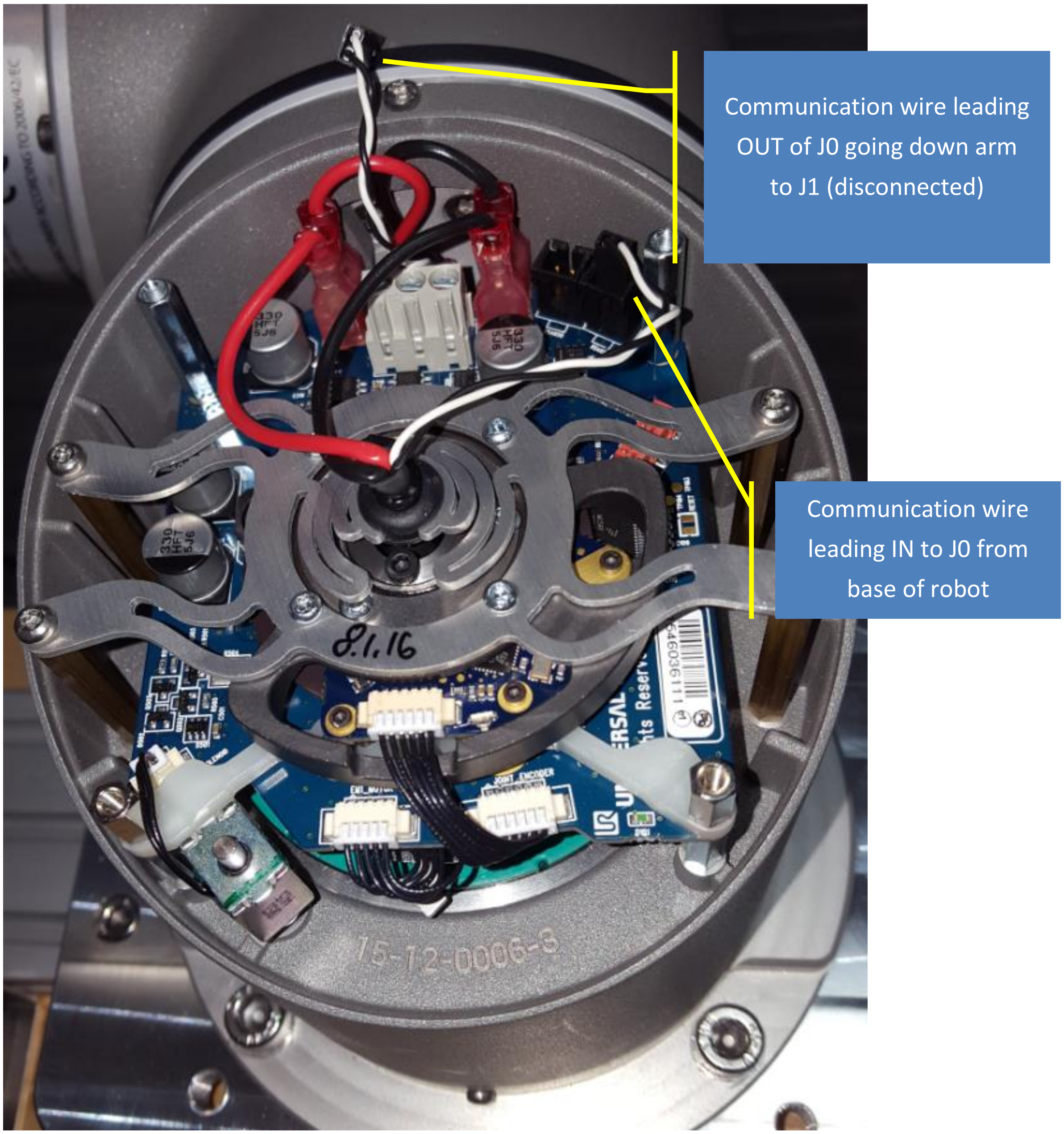
Figure 21: Low Level Control screen after "Turn Power On" is pressed

In this example only J0 (base) goes to ***bootloader*** mode. If all joints were ok they should have all went to bootloader mode. However, in this example we have disconnected the RS485 communications wire leading out of J0 and into J1. So, the only joint in the arm that can communicate is J0. This could be caused by a bad communication wire connection or a bad joint (maybe J1 is broken so badly that it does not pass the communication signal downstream to other joints). Maybe the joint was changed and the communication wire got pinched (damaged) in the process.

From this screen if we press ‘Go to Idle’ J0 will transition to BOOTING and then READY if it’s ok. However, if we try to take the next step and press ‘Arm Current Joint’ (the blue highlight joint is the selected one) the controller will stop sending 48V to the arm and all joints go back to POWER OFF. This is because you cannot ‘arm’ an individual joint when the others are in a POWER OFF state.

The point of all this is to show that Low Level Control can be used to selectively enable certain parts of the arm to determine which one might be causing the problem. From the service kit there is also an RS485 jumper that can be used to jumper around a joint (or more than one) to isolate an individual joint that you suspect is the culprit and determine if all the others are ok.

The following image shows how we disconnected the comm wire (black and white twisted pair) leading out of J0 so that only J0 was active on the arm :



So, using this simple example and a bit of knowledge presented here you can use this technique to diagnose an individual joint and determine which joint might be preventing the robot from initializing.

References and Resources

Table 3: References and Resources

Document Name	Location	Description
Service Manual	https://www.universal-robots.com/download	
Service and Troubleshooting Training/Presentation	https://universal-robots.account.box.com/	
CRM database	CRM	

Revision History

Table 4: Revision History

Date	Editor	Notes
Dec 2016	Brent Bartson	Initial creation (using controller version 3.3.3.292 and SCB firmware revs 504/256)
Jan 2017	BAB	Ver 1.0, Symptom A – added more diagnostics for SCB error.
Jan 2018	Chris Savoia	Version 2.0, Changed formatted for TOC, added major sections, all information to Procedure