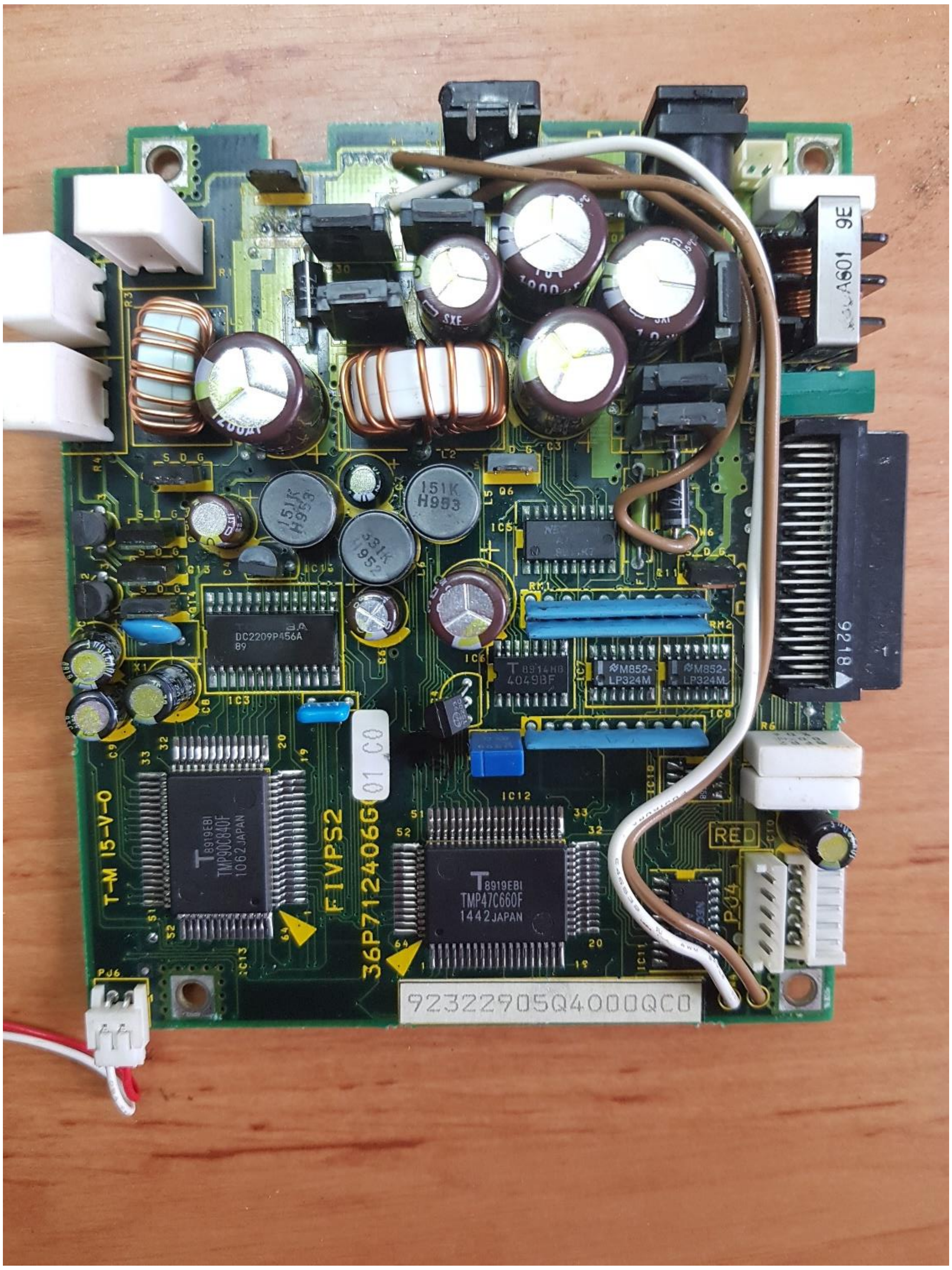
T1600 Power Supply Unit (PSU) Troubleshooting guide



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Introduction

This guide should come with a schematic for the FIVPS2 revision of the PSU board, in PDF format.
The FIVPS3 and FIVPS4 revisions of the board are slightly different but the schematic and this guide still mostly apply.

This document guides you through various troubleshooting steps for these boards. It includes different approaches to troubleshooting, depending on the tools available.

Failure mode indication

The PSU board has a single failure mode indicator. When any problem is detected in the supply rails, supply current and/or battery charge current (including the SUB-battery) the supply shuts down and the DC-IN LED blinks on and off at a constant rate.

Key differences in the revisions

The FIVPS3 and FIVPS4 models differ mostly in the number and capacity of the DC-DC converter capacitors. The FIVPS2 model has two capacitors for the +12V and +5V rails where the FIVPS3 and FIVPS4 models only have a single, larger capacity for each.

The layout on the FIVPS3 and FIVPS4 models is also slightly different due to this change.
The SUB-battery circuitry on the FIVPS4 is also different, the SMD voltage regulator “IC15” is replaced by a TO-220 type and a couple of resistors have been removed.

Furthermore, the push-pull transistors driving the DC-DC converter MOSFETs are of a different type, resulting in different values for the accompanying resistors.

Assumptions

As this is a troubleshooting guide it is assumed that all capacitors have already been replaced and any obviously damaged traces beneath the capacitors have been checked and repaired where needed.

How this guide is laid out

This guide is split into different steps, each step testing specific parts.
Work your way through the steps in order, do not skip any steps unless instructed to.
When the board powers on be sure to perform the after repair checks in Step 7.

Required & recommended tools

At the bare minimum, these tools are required to successfully troubleshoot these boards:

- Multimeter (a relatively fast digital or analog multimeter is recommended)
- Soldering iron
- Leaded solder
- Desoldering pump, -iron, or -station
- Cotton swabs/Q-tips
- 99% Isopropyl alcohol
- Breadboard and various electronics (to test MOSFETs/Transistors) **or**
    - Component/transistor tester (for example a GM328 or LCR-T4)
- 1 or 2 LEDs and one 330 Ohm current-limiting resistor (status indicators for the 5VB rail)

These tools are not required but highly recommended as they make the process easier and faster:

- (Digital) storage oscilloscope (DSO)
- Solder wick/braid
- Flux (either a flux pen or gel-type)
- (Rotating) PCB holder
- Tweezers
- SMD rework station (hot-air soldering station)

Components

Capacitors

As the required capacitors vary between versions, these will not be listed here.
A couple of things should be considered when ordering replacement capacitors:

- Voltage and capacitance should be equal to the original capacitors.
- Component height should be equal or less than the original capacitors.
- Use a known, high-quality brand like Panasonic, Würth or Rubycon.
- Use low-ESR capacitors.
- Use 105°C rated capacitors.
- Ideally, the footprint (pin pitch) should be equal.

Failing to use high-quality capacitors can lead to premature failure.

MOSFETs and Transistors

Identical replacement MOSFETs and transistors are increasingly difficult to find and prices are high.
A parametric search on various component distributors did not yield any viable drop-in replacements.

The components mentioned below are available on Ebay and AliExpress through various sellers in the UK, USA, and China. I had good results with components ordered from AliExpress but your milage may vary.

Due to the high prices, I recommend not ordering a complete set of replacement parts but instead track down the defective components using this guide and replace only those.

Component label	Component name
Q1, Q4, Q7	2SK814
Q2, Q3, Q11	2SK1059
Q5, Q12, Q13, Q14	2SJ132
Q6	2SJ133
Q10, Q15	2SA1244O

Tip: Always order one or two more than you need to save on shipping. New components can also be bad and you might also damage your new component during further testing.

Other components

Though not very likely there are various other components that can fail.
Most notable is the SMD-diodes used for the –9V and -22V DC-DC converters (“6”and “8”, BAS16W) and MOSFET Q29 (drop-in replacement: ZXMN6A11ZTA)

Step 1 – Visual inspection

Check for any obvious broken traces and missing or blown components. Do a thorough, methodical inspection of the entire board, top and bottom and work left to right, top to bottom. Use a piece of paper as a guide and to mask off the area not being inspected.
Verify continuity of any suspect traces, replace damaged components where needed.
Verify continuity of the green 10A PCB fuse

Step 2 – Verify continuity

Before powering up the board verify continuity to all critical components using a multimeter. Check continuity between these points:

- Push-pull transitor output to MOSFET gate:
  - Q4 ->
    - R37 -> Q22
    - R36 -> Q23
  - Q5 ->
    - R17 -> Q20
    - R16 -> Q19
  - Q6 ->
    - R33 -> Q21
    - R32 -> Q18
  - Q7 ->
    - R28 -> Q17
    - R29 -> Q16
- Push-pull transistor base to their respective pins on IC5 and IC11.
  - Q22 & Q23 -> IC5 Pin 15
  - Q20 & Q19 -> IC5 Pin 17
  - Q21 & Q18 -> IC5 Pin 16
  - Q17 & Q16 -> IC5 Pin 14
- Push-pull transistor combination connectivity to +12V after the fuse
  - Q23 -> Fuse
  - Q20 -> Fuse
  - Q21 -> Fuse
- Push-pull transistor combination for VCC connectivity to +18V
  - Q17 -> C6 (positive)
- Push-pull transistor combination to GND
  - Q22 -> GND
  - Q19 -> GND
  - Q18 -> GND
  - Q16 -> GND
- DC-DC converter output to the respective pin on PJ2
  - C1/C2 (positive) -> PJ2 Pin 47,46,45, etc.
  - C46/C3 (positive) -> PJ2 Pin 50, 41, 39
  - C4 (negative) -> PJ2 Pin 49
  - C5 (negative) -> PJ2 Pin 17
- 12V, 5V and 18V(int) DC-DC converter output to their respective voltage dividers
  - C46 & C3 (positive) -> R157 -> R156 -> GND
  - C1 & C7 (positive) -> R61 -> R62 -> GND
  - C6 (positive) -> R57 -> R58 -> GND
- Voltage divider outputs to their respective 10K current limiting resistors
  - R157 -> R92
  - R61 -> R91
  - R57 -> R96

This should reveal any broken traces in the main DC-DC converters not covered by the visual inspection in step 1.

Step 3 – Measure offline voltages

Connect a 12V 2A power supply to the DC Barrel jack connector and verify the DC-IN LED lights up. If no DC-IN LED is present a LED can be soldered to the pads for PJ6. Pin 2 (connected to R90) is the positive, Pin 1 is the negative.

Probe the voltages on the DC-DC converter MOSFETs, the points to probe are listed in table 2 and marked in fig. 1. All points should be at 12V.

MOSFET & pin	Probe point
Q14 Source (pin 3)	#1
Q1 Drain (pin 2)	#2
Q5 Source (pin 3)	#3
Q6 Source (pin 3)	#4
Q2 & Q3 Drain (pin 2)	#5

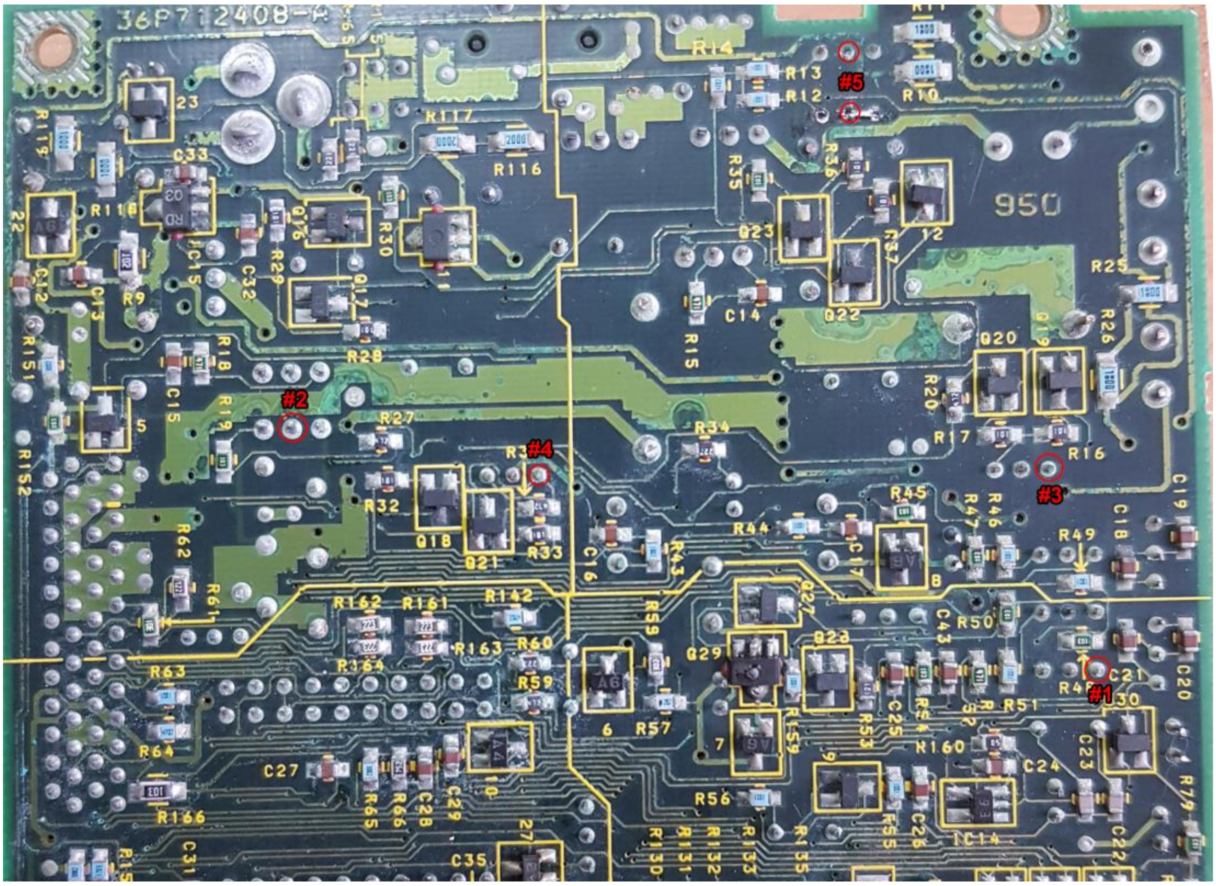


Figure 1

Step 4 – Measure online voltages

Solder a LED with a series current-limiting resistor (330 Ohms should do) to pins 1 & 2 of IC2.
Note that ping 1 & 3 are swapped on the silkscreen! Pin 2 is the ground pin.
This LED will be used as an indicator to see when IC13 is powered off.

Probe the positive pin of C6 with your multimeter and press the power button on the PSU board to power it up. You meter should jump up to around 18V.
If not, Q29 is likely to be damaged, replace it.

If you have an oscilloscope continue with step 4a.
To continue testing with only a multimeter follow step 4b.

Step 4a.1 – Check MOSFET PWM signals (DSO)

Set your oscilloscope to trigger at around ±3V, rising or falling edge, depending on the rail to be measured. This a "safe" value that prevents triggering from capacitive or inductive coupling.

Set your scope to 50µS/div and 5V/div.

Probe the gate pin (pin 1) on Q4, Q5, Q6 and Q7, set the scope to single-shot trigger mode.
Press the power button on the PSU board to power it up, the LED connected to IC2 should light up.

Between testing the different MOSFETs wait for the indicator LED soldered to IC2 to turn off, this should take ~30 seconds. *Only then* power up the board again.

The scope should show a 12V ~70KHz PWM waveform like below for a couple of milliseconds.

> If no PWM signal is measured, redo the measurements on the base of the accompanying push-pull transistors to verify their operation. If a PWM signal is observed now verify that 12V is present on the NPN transistor's collector. If all looks good, replace the push-pull transistors.

Note: the PWM signal for the 12V rail may not show up in certain circumstances, like the 5V rail not powering up or overshooting. This is expected behavior as the 12V line is one of the last to power up. Correct the other faults first.

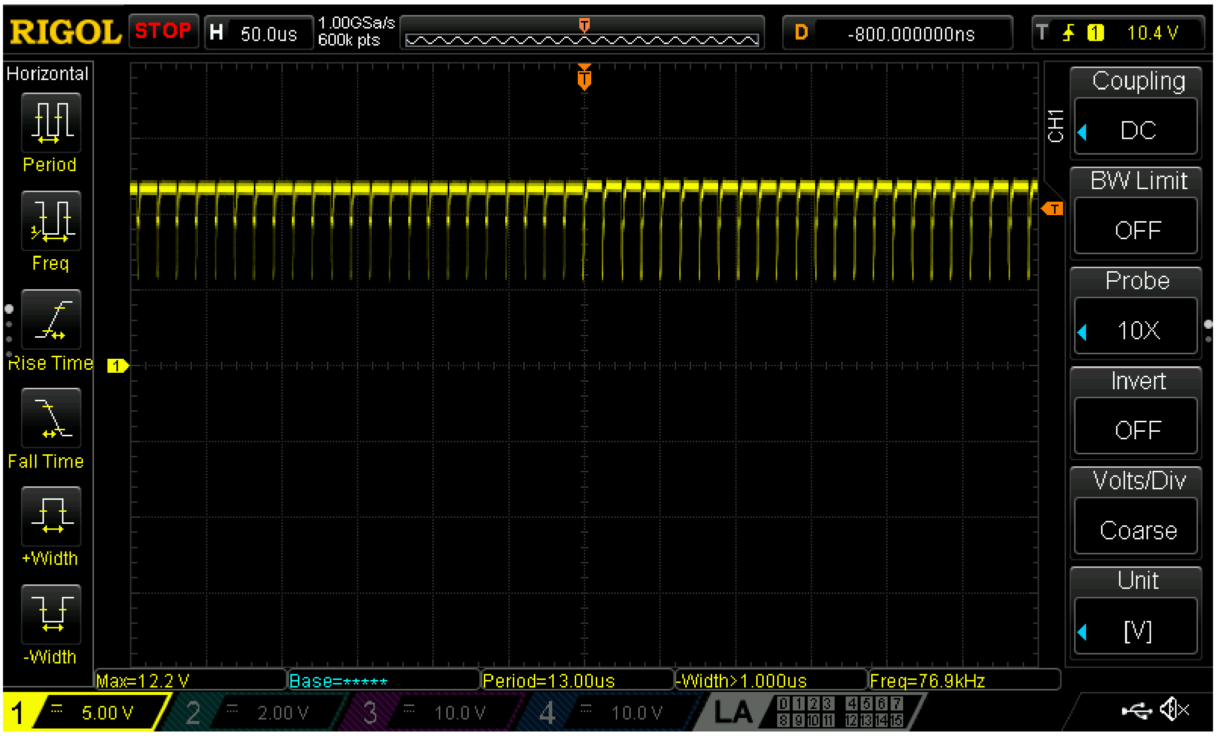


Figure 2

Step 4a.2 – Check MOSFET output signals (DSO)

If all PWM signals are present on the MOSFET gates, measure the MOSFET outputs for Q4, Q5, Q6 and Q7. Q5 and Q6 should be probed at their drain (pin 2) while Q4 and Q7 should be probed at their source (pin 3). A waveform like below should appear.

Note: As stated above, the PWM signal for the 12V rail may not show up until other faults are corrected.

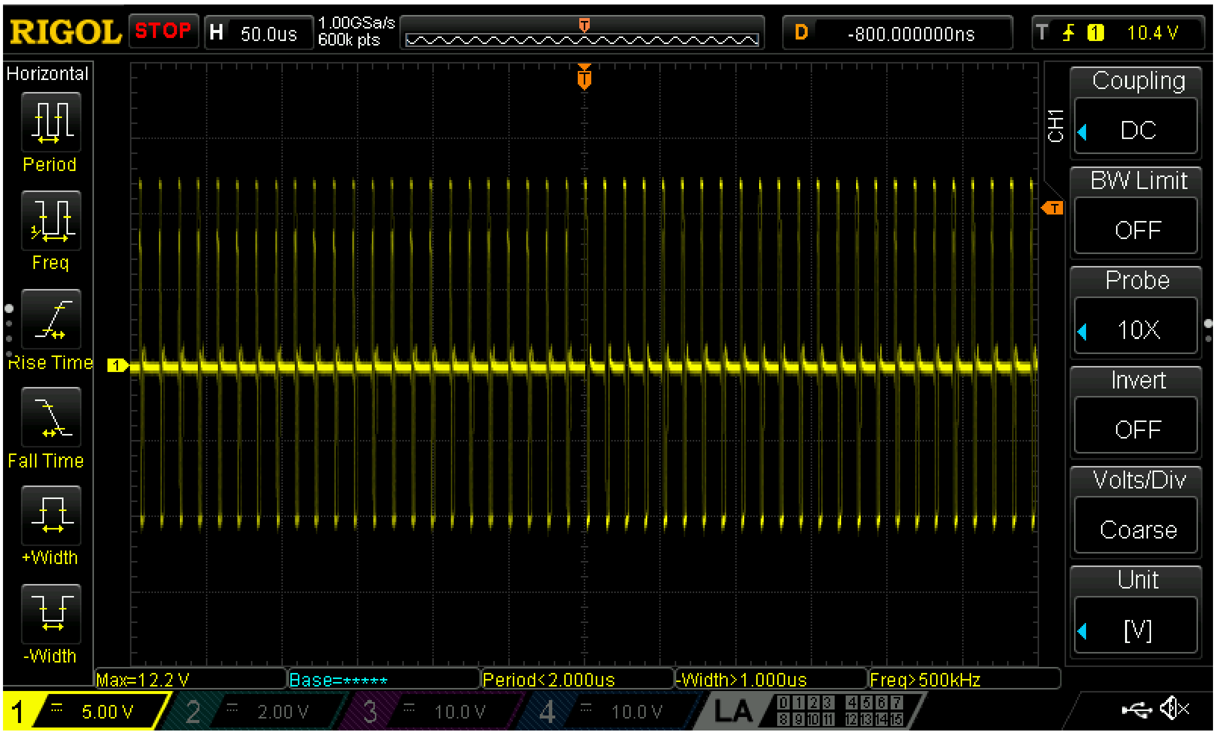


Figure 3

Replace any MOSFET that receives a PWM signal on its gate and 12V on its source/drain but does not actually switch any current.

Skip to step 5 to verify the diodes before powering on again, damaged diodes can kill your new MOSFET instantly.

Step 4b.1 – Check MOSFET PWM signals (Multimeter)

Probe the MOSFET gate for Q4, Q5, Q6 and Q7.
Press the power button on the PSU board to power it up, the LED connected to IC2 should light up.

Between testing the different MOSFETs wait for the indicator LED soldered to IC2 to turn off, this should take ~30 seconds. *Only then* power up the board again.

Your multimeter should jump up to around 12V shortly.

Note: the PWM signal for the 12V rail may not show up in certain circumstances, like the 5V rail not powering up or overshooting. This is expected behavior as the 12V line is one of the last to power up. Correct the other faults first.

> If no signal is measured, redo the measurements on the base of the accompanying push-pull transistors to verify their operation. If a signal is observed now verify that 12V is present on the NPN transistor's collector. If all looks good, replace the push-pull transistors.

Step 4b.2 – Check MOSFET output signals (Multimeter)

Probe the MOSFET outputs for Q4, Q5, Q6 and Q7. Q5 and Q6 should be probed at their drain (pin 2) while Q4 and Q7 should be probed at their source (pin 3).
You should see your meter spike toward the upper limit for the voltage rail, 12V, -9V, -22V and 5V, respectively.

Note: As stated above, the PWM signal for the 12V rail may not show up until other faults are corrected.

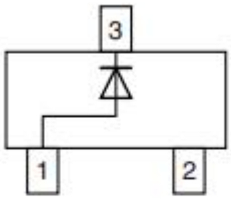
Replace any MOSFET that receives a PWM signal on its gate and 12V on its source/drain but doesn't actually switch.
Skip to step 5 to verify the diodes before powering on again, damaged diodes can kill your new MOSFET instantly.

Step 5 – Test the DC-DC converter diodes

Switch your multimeter to diode testing mode.

Desoldering inductors L2, L3, L4 and L5 might be useful to verify correct diode operation though it is not necessary.

Verify diodes “3”, “6”, “8” and dual-diode “2” have the expected forward voltage drop and do not allow reverse current to flow. Normal in-circuit parameters are ~0,5-0,7V forward and ~1.5V reverse. Replace any failed diodes.



Step 6 – Check 12V MOSFETs

The 12V DC-DC converter is switched on by the microprocessor as one of the last steps in the start-up process.
These MOSFETs (Q2 & Q3) tend to fail open, meaning no current is flowing to the switching transistor (Q4) for the 12V DC-DC converter.
Verify 12V is present at L3 when switching the supply on. This will be a short pulse when there are other failures causing the microprocessor to shut down the converters.
Remove *both* MOSFETs when a failure is suspected, they are wired in parallel. Test and replace where needed.

Step 7 – Verify your work

At this point, all defective components in the DC-DC converter section of the board should have been verified as working or be replaced with new parts.
Set your multimeter to Volts DC and press the power button to power up the board.

If the DC-IN LED still blinks immediately after powering up skip to step 8.

If the DC-IN LED stays solid the supply should now be running.

Verify the voltages on connector PJ2, the correct values are shown in the below diagram.
All 12V, VCC and RAMV signals are common, not all pins need to be verified (e.g.: Verifying pin 13 also verifies pin 15).

PJ2 Pin #	Signal	Voltage
13, 15	RAMV	5V (also when off)
17	LCDV	-22V
27, 29, 30, 31, 33, 34, 35	VCC	5V
39, 41	HDHV	12V
49	N9V	-9V
50	P12V	12V

If the supply powers off after a (short) while of running correctly verify RAMV is stable at 5V.
If RAMV slowly creeps up and the supply enters error-state at 5.5V desolder and test Q10 and Q15.
Replace defective transistors where needed.

Step 8 (Optional) – Check other connections and ICs

Check all other connections for the DC-DC converters using the schematic.
This includes all connections to and between ICs.

Verify the clock signal for both IC12 (500KHz) and IC13 (20 MHz)

If the board still does not work start over from step 1 to verify nothing was missed.

If no problems are found it is time to dive in deeper.

This is a more in-depth troubleshooting step that involves SMD soldering/desoldering.
Do not attempt this step without a hot-air soldering station.

Remove IC5, IC11 and IC6 and verify their operation or replace them with new ones. A SOIC-to-DIP adapter PCB comes in very handy.

Appendix A – Useful documents and links

GitHub repository for this document:
https://github.com/fust/T1600-PSU

Toshiba T1600 Maintenance manual:
http://www.minuszerodegrees.net/manuals/Toshiba/Other/Toshiba%20T1600%20-%20Maintenance%20Manual.pdf

Toshiba T1600 Flyer:
http://www.minuszerodegrees.net/manuals/Toshiba/Other/Toshiba%20T1600%20-%20Flyer.pdf

US patent application for the PSU logic:
https://patentimages.storage.googleapis.com/24/4b/7b/25d6e03be718e9/US5383140.pdf

US patent for the battery charge logic:
https://patentimages.storage.googleapis.com/fa/c7/e2/4c02829354891c/US5300874.pdf

US patent for the battery-powered computer system:
https://patentimages.storage.googleapis.com/7d/e9/e5/fd65858366b1ec/US5553294.pdf

Datasheet library:
http://chip.tomsk.ru/chip/ChipDoc.nsf/vc1

Toshiba datasheet library:
https://mirrorservice.org/sites/www.bitsavers.org/components/toshiba/_dataBook/

My website:
https://thomwijtenburg.nl

Appendix B – Datasheets

(IC12) TMP47C660F
https://datasheetspdf.com/pdf-file/1217168/Toshiba/TMP47C660F/1

(IC13) TMP90C840F
https://datasheetspdf.com/pdf-file/538388/Toshiba/TMP90C840F/1

(IC5 & IC11) uPA1600
https://pdf1.alldatasheet.com/datasheet-pdf/view/113080/NEC/UPA1600.html

(IC6) 4049BF
https://www.infinite-electronic.si/datasheet/66-TC4049BF-ELNF.pdf

(IC7 & IC8) LP324M
https://pdf1.alldatasheet.com/datasheet-pdf/view/9224/NSC/LP324M.html

(IC14) TC7SU04FU
https://pdf1.alldatasheet.com/datasheet-pdf/view/32045/TOSHIBA/TC7SU04FU.html

(Q29) Unknown. Direct replacement ZXMN6A11ZTA
https://www.diodes.com/assets/Datasheets/ZXMN6A11Z.pdf

("9") 02CZ18
https://datasheetspdf.com/pdf-file/1259546/Toshiba/02CZ18/1

(Diodes marked "A6") BAS16W
https://www.vishay.com/docs/85539/bas16.pdf

(Diodes marked "A9") 1SS294
https://toshiba.semicon-storage.com/ap-en/semiconductor/product/diodes/detail.1SS294.html