SPL DC-64

Author: Vittorio Pascucci

Email: sideprojectslab@gmail.com

YouTube: https://www.youtube.com/channel/UCdhCaevoHxyzLeFTYkxkblA

Patreon: https://www.patreon.com/user?u=56214619

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Revision History

Date	Version	Revision
27/11/2023	0.1	First Draft
04/12/2023	0.2	Improved Pictures
09/12/2023	0.3	Completed specification list from actual measurements
14/12/2023	0.4	Updated Specification list & added instructions on how to jump the rectifier

Table of Contents

1 Introduction

DC-64 is a small form factor power supply designed to allow powering the Commodore 64 microcomputer with a single external DC power supply, thus replacing the original AC transformer.

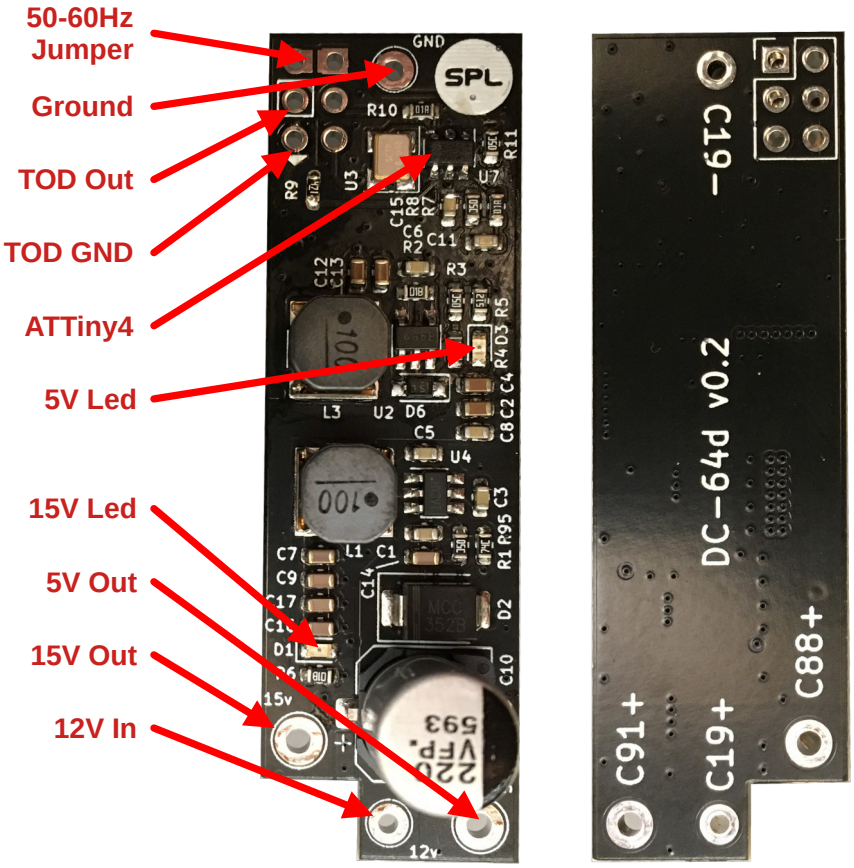

Figure 1: DC-64d Front & Back

Once DC-64 is installed inside the computer, the C64 can be powered externally with a single 12Vdc, 2A power supply. DC-64 generates all necessary additional internal voltages to power the various subsystems of the computer. In addition to this, DC-64 generates a configurable 50-60Hz, 5Vpp square wave that replaces the Time of Day (TOD) clock, originally generated from the AC power supply.

Two variants of DC-64 are available. These variants share identical power supply sections and only differ in the way the TOD clock is generated:

- **DC-64a:** (“a” for “analog”) generates the TOD clock with a “555-like” RC oscillator, must be calibrated by hand.

  The advantage of this board is that it is completely analog and does not rely on programmable ICs, thus simplifying the system design for DIY hobbyists that may want to put this board together on their own.

  The disadvantage of this approach is relatively low TOD clock stability over time and temperature, as well as relatively high cost due to the expensive nature of potentiometers for calibration.

- **DC-64d:** (“d” for “digital”) generates the TOD clock with an Atmel ATTiny4 microcontroller clocked with a precise, 6MHz crystal oscillator. The ATTiny acts as a configurable clock divider to generate 50-60Hz from the crystal clock.

  The disadvantage of this variant is that it relies on a microcontroller that needs a special, relatively expensive programmer to be flashed. While the board can be purchased with the microcontroller already flashed, the design is less friendly to DIY hobbyists that want to put the board together on their own.

  The advantage of this version is that the TOD clock is extremely stable over time and temperature and never requires calibration.

2 Compatible Motherboards

The DC-64 is designed to be compatible with all versions of the original C64 motherboard. A full list of the circuit revision that have been verified to be compatible is reported below, gray lines represent versions that should be compatible but have not been verified yet.

Assembly	Tested	Notes
C64 “Breadbin”		
326298 (1)(2)	yes	
250407	yes	Tested
250425	yes	
250441	-	
250466	yes	Tested
C64C		
250446	-	
250469 (1)	yes	Tested. Follow "C64C" Instructions (Chapter 3.2)

(1) The pitch of C19 (or C63 for assembly 250469) is smaller than that on the DC-64, therefore one or both pins of DC-64 needs to be bent or replaced with a wire in order to connect to the original pads of C19.

(2) There is not enough clearance to mount the DC-64 directly in place of C19. The DC-64 can still be used but its GND and 12V pins need to be replaced with short wires in order to position the board more flexibly. Special care shall be taken not to contact any other components or conductive parts of the computer when installing the DC-64 this way.

3 Installation

3.1 C64 “Breadbin”

The following considerations are accurate for all versions of the C64 “Breadbin” motherboard, though the exact position of the parts and pads mentioned is different between revisions:

- DC-64 is installed “in place of” C19, which must therefore be removed from the circuit. DC-64 is designed so that the Power-Ground terminal and the 12V terminal align perfectly with the mounting holes of C19 on the C64 motherboard.
    - The Power-Ground terminal of DC-64 is connected to the pad (hole) on the motherboard where the **negative** terminal of C19 would normally be connected.
    - The 12V terminal of DC-64 is connected to the pad (hole) on the motherboard where the **positive** terminal of C19 would normally be connected.
    - Make sure the DC-64 board does not touch the C64 motherboard. Preferably use male pins to connect the DC-64 to the C64 motherboard so that the male pin's isolation plastic will keep the DC-64 board high enough above the C64 motherboard.
- The 15V output of DC-64 is connected with a flying wire to the **positive** terminal of C88
- The 5V output of DC-64 is connected with a flying wire to the **positive** terminal of C91
- An external 12Vdc power source must be applied on pins 6 and 7 of the power connector, that were originally assigned to the 9Vac power supply. The polarity is not important because the voltage applied to these two pins is fed to the rectifier bridge present on the C64 motherboard (CR4).
- Once the DC-64 is installed, all current drawn by the C64 goes through the main fuse. It is therefore recommended to replace the original 1A fuse with a 2A one.

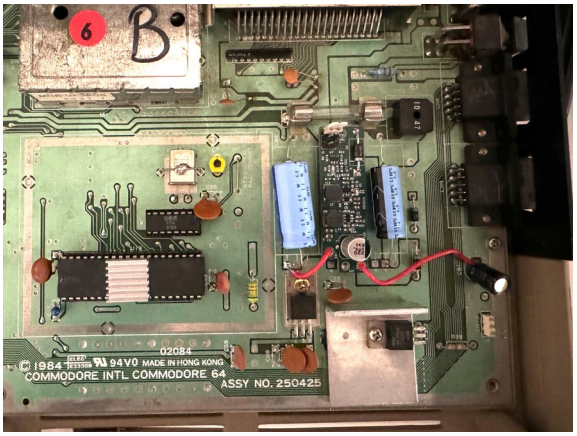

Figure 2: Assy 251425 Installation

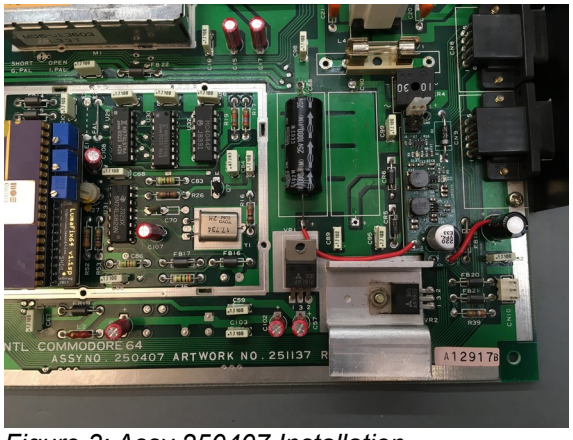

Figure 3: Assy 250407 Installation

3.1.1 Connecting the TOD Clock

- Identify the TOD output pin on the DC-64 as displayed in Figure 1.
- Cut one of the two leads of R5 on the C64 motherbard and nudge the resistor to the side to ensure it is disconnected.
- Connect the TOD clock to the positive terminal of CR1 on the C64 motherboard (see Figure 4).
- It is recommended to use a coaxial cable to perform this connection.
    - The cable's core connects the TOD terminal on the DC-64 bard to the positive terminal of CR1.
    - The cable's shield is **grounded ONLY on the DC-64 board**, on the pin marked as Ground next to TOD.

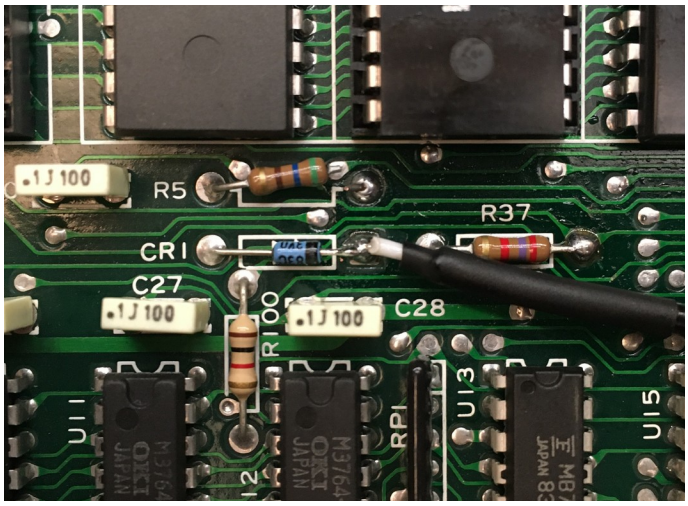

Figure 4: TOD Clock Connection

- The frequency of the TOD clock can be selected with the 50-60Hz jumper depicted in Figure 1. With the jumper left open TOD will have a frequency of 50Hz. Conversely, closing the jumper with a ball of solder will cause the ATTiny4 microcontroller to generate a 60Hz TOD clock.

3.2 C64C

Assy 250469 features a slightly different schematic compared to most other board versions. Device installation in this Assy differs in the following ways from the standard procedure detailed above:

- The DC-64 needs to be connected between the positive and negative terminals of C63 as opposed to C19
- Te DC-64 installation pins do not match the pitch of C63, therefore the either one or both pins may be removed and replaced by a wire.
- The 15V output of DC-64 is connected to the Cathode of CR3
- The 5V output of DC-64 is connected to pin 4 (middle) of the nearby DA2 header
- Prior to installing the TOD clock, R16 (instead of R5) must be severed or disconnected entirely
- The TOD clock is connected to the cathode of CR6 (instead of CR1)

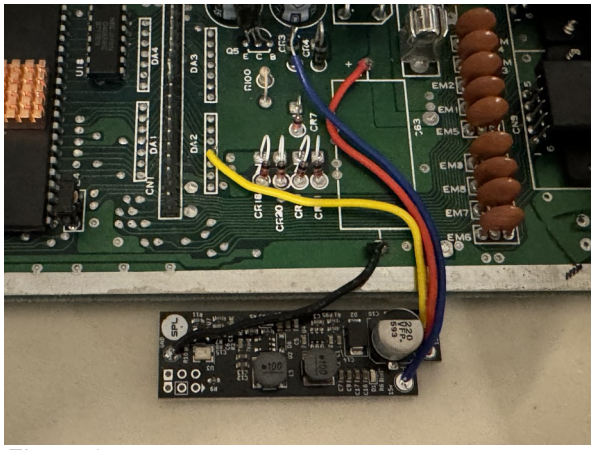

Figure 6

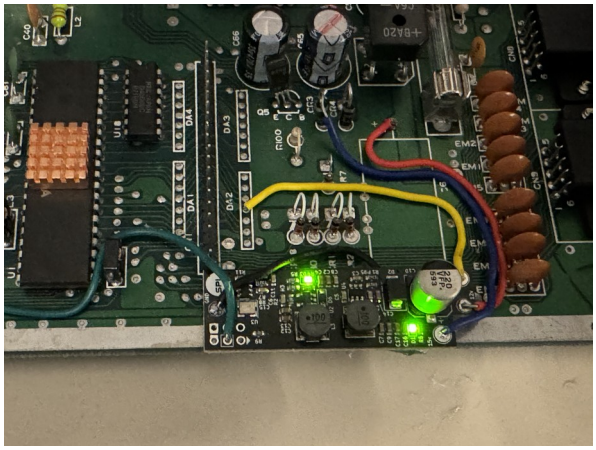

Figure 5

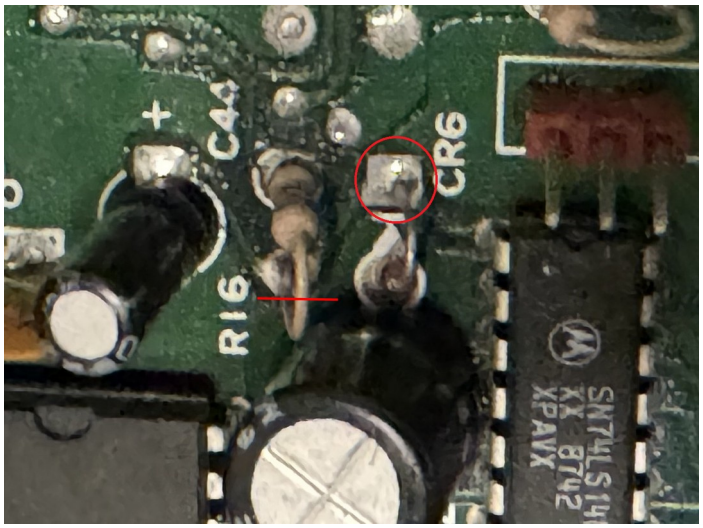

Figure 7

3.3 Installation Notes

- C19 is glued to the motherboard. In order to remove it:
  - Cut the two leads of C19.
  - Roll the capacitor by pushing it aside until the glue breaks.
  - Remove the remaining ends of the leads from the motherboard by melting the solder and gently pulling them out of their holes with pliers.
  - Remove any solder that may still obstruct the mounting holes of C19, with a solder wick or a desoldering pump.
- Once the DC-64 board is installed, all current feeding the system passes through the rectifier CR4. As a consequence of this the component dissipates a significant amount of power, becoming extremely hot (>90ºC) and lowering the voltage feeding the DC-64 by more than 2V from the externally supplied voltage, which in turn negatively affects its efficiency.
  - It is recommended to bypass the negative "leg" of CR4. This will halve the amount of power dissipated by the component and dramatically lower its temperature.
  - In this case **the orientation of the lines from the external supply does matter**, as the current does not pass through a full rectifier. However by leaving one "leg" of the rectifier connected the supply current is prevented from flowing in the opposite direction, thus preventing damage to the board in case the supply voltage terminals are swapped.
  - It is recommended to connect the negative terminal of the external 12Vdc power supply to pin 7 of the original power connector and the positive terminal of the external 12Vdc power supply to pin 6 of the original power connector.
  - The pins of CR4 that need to be shorted are (i) the pin that is connected to the negative terminal of the original power connector and (ii) the pin connected to the C64 system ground, which can be found on most exposed metallic surfaces.

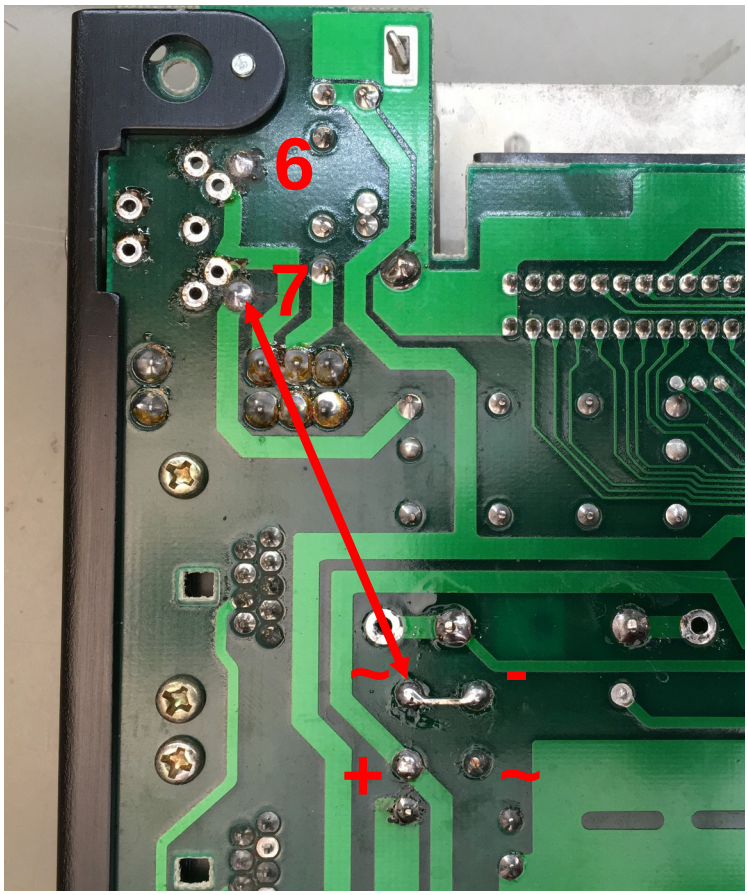

Figure 8: CR4 Rectifier Bypass Example

4 Specifications

4.1 Requirements

	Min	Recommended	Max	Unit
External DC Voltage (V_I)	11	12	13	V
External DC Current (I_I)	1.5	>2	-	A

4.2 Absolute Maximum Ratings

Operating outside of these limits for any period of time may result in permanent damage to the DC-64 board as well as the Commodore-64 it is installed in.

Measured with $T_{room}{}^{(1)} = 60°C$, $V_I = 11.5V$ when applicable.

	Min	Max	Unit
External DC Voltage (V_I)	11	13	V
External DC Current (I_I)	1.5	-	A
Output Current 5V (I_{o5v})	-	2.5	A
Output Current 15V (I_{o15v})	-	450	mA

(1) T_{room} represents the temperature of the air at a distance of approximately 3cm from the board. Therefore, when the DC-64 is operating inside the Commodore 64, T_{room} represents the temperature of the air inside the computer, which may be 15ºC to 20ºC higher than actual room temperature.

4.3 Typical Characteristics

Measured with $T_{room} < 35°C$, $V_I = 11.5V$

	Min	Typ	Max	Unit
Output Voltage 5V (V_{o5v})	4.92	4.96	5.01	V
Output Voltage 15V (V_{o15v})	14.9	15.2	15.4	V
Output Current 5V (I_{o5v})	-	1	2.5	A
Output Current 15V (I_{o15v})	-	150	450	mA
Output Voltage Ripple 5V	-	50	80	mVpp
Output Voltage Ripple 15V	-	80	100	mVpp

5 Limitations & Precautions

- The original AC power supply **SHALL NOT BE USED** when the DC-64 is installed in the system.
- Use only a 12Vdc external power supply that can deliver at least 2A. The 12Vdc power must be connected to pins 6 and 7 of the original power connector (regardless of polarity).
- Never run the C64 without a fuse installed when the DC-64 is installed in the system. The DC-64 has no internal fuse and relies on the fuse on the C64 motherboard for safety shutdown. The recommended maximum current for the fuse is 2A.
- The C64's rectifier bridge is now carrying all the current powering the system, this results in the component dissipating more than 2W and therefore **overheating**. While rectifiers can operate at very high temperatures (> 100ºC) without failing, it is still recommended to place a small heat sink on top of the rectifier bridge.
- Remember that the Ground terminal of the external 12Vdc power supply **IS NOT THE SYSTEM GROUND** of the C64 and shall never be used as such. The system ground is only found AFTER the rectifier bridge, therefore there may be upwards of 1V difference between the Power supply ground and the system ground.
- User port accessories are not guaranteed to work when the DC-64 is installed in the system, and may be damaged due to the absence of an AC (positive and negative) voltage being supplied to the user port. It is therefore recommended **NEVER TO CONNECT** user port accessories to a system that has been modded with DC-64.
- Custom dual-SID solutions may draw too much current from the 15Vdc output of DC-64 which is limited to 500mA. In case such a multi-SID solution is implemented in the system, it is recommended to assess its total current consumption and ensuring that it is safely within specs before installing the DC-64.
- Operating the DC-64 outside of its maximum specifications may result in damage of the board, the computer and any accessories connected to the computer. Particular caution shall be taken not to exceed the maximum rated current for the 5V supply of DC-64 which is used to power all digital electronics on board of the C64.