

# UcPure MkIII

## The Pure Ultra-capacitor Power Supply

By Ian Jin Apr.8, 2023 Ver3.0a



iancanada.mail@gmail.com

## A. Introduction

UcPure MkIII is a pure ultracapacitor power supply. It makes use of the 3000F or higher capacitance ultracapacitor pack to achieve an ultimate power supply performance. Because it is a pure passive power supply, there will be no feedback and no active components involved when it's turned on. At the pure output mode, only the pre-charged ultracapacitor pack will be applied to the load. It's also capable of delivering up to 1000A dynamic current with less than 0.58mOhm internal ESR (continuous output mode, decided by the 3000F ultracapacitors pack). It could be so far the best low noise and ultra high dynamic power supply in the real world. Sound quality of sensitive audio applications such as low jitter clock oscillators, DACs, FIFOs and many other circuits will be benefited from this UcPure MkIII power supply. UcPure MkIII can be setup for 3.3V, 5V(default) and 15V configurations.

UcPure MkIII equipped with a SYNC charging function to be able to re-charge the ultracapacitors during music stops.

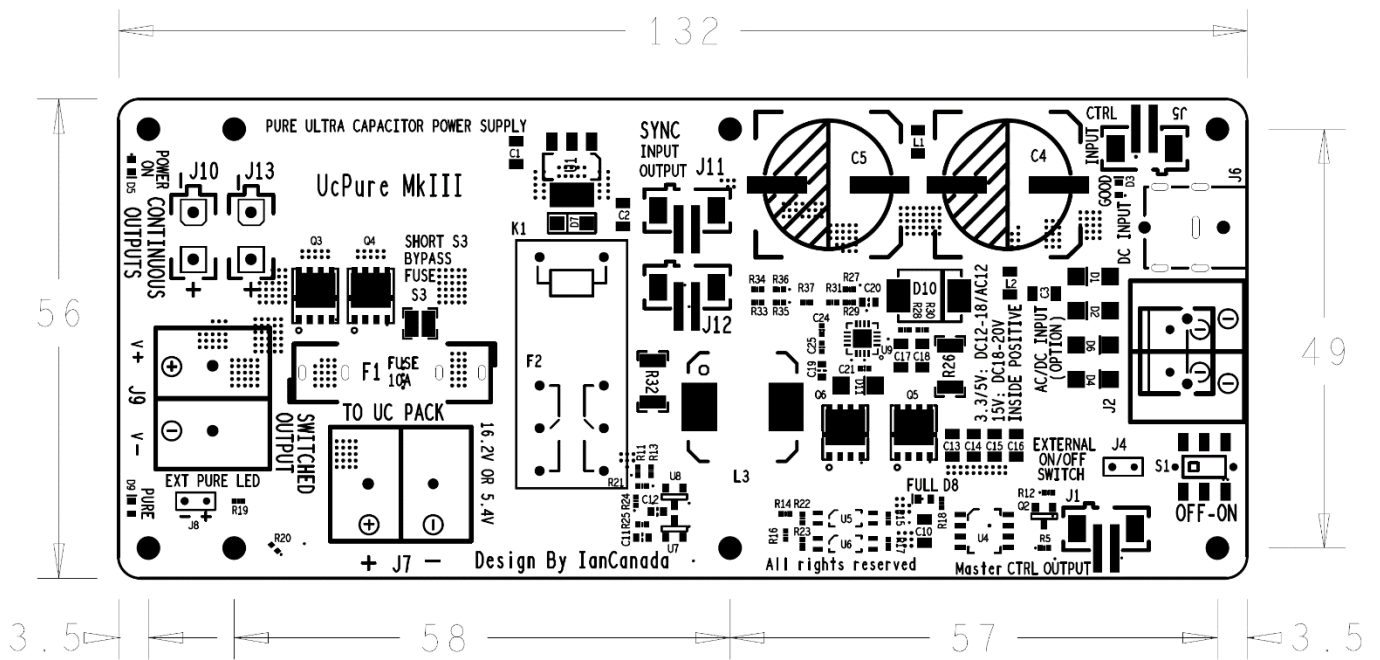
## B. Specifications and Highlighted Features

- Pure ultracapacitor power supply.
- Ultracapacitors work in class A mode which current going only in one direction.
- Output can be configured to 3.3V, 5V(default) and 15V
- Has both switched and continuous (great for clock oscillators) outputs
- Outputs are 100% isolated from charger, input and other circuit when it is turned on at pure mode
- Has built-in on/off control switch (on-board or external)
- Has an isolated on/off control management chain that can be set up in a group of power supplies.
- Optical isolators are used for all internal operating logics.
- Can use 9V to 20V DC input for 3.3V/5V configuration and 18V-20V DC input for 15V configuration. AC 9V-12V input is also possible for 3.3V/5V configuration.
- Pre-Charging current has 3A (default) and 1.5A two settings to be suitable for different input power supplies.
- Built-in protection scheme to prevent ultracapacitor from exhausted and low output voltage
- Dynamic output current: up to 1000A (decided by the ultracapacitors )
- Output ESR: Less than 0.58 mOhm (3.3V or 5V configuration, decided by the ultracapacitors)
- Output noise: Decided only by the ultracapacitors
- Heavy duty design for 24/7 operation

### C. UcPure MkIII new features

- Add a powerful SYNC UC charging function. Can re-charge the UCs during music stops. This feature can avoid the output voltage drop or trigger the protection mode even if you listen to music for a very long time. SYNC control signal can be connected to the MUTE signal of a FifoPiQ7. More UcPure MKIII can work together with this signal as a control chain. This signal is isolated from UcPure MkIII so it doesn't affect the power supply performance at all.
- Upgrade to higher capacitance, higher voltage and ultra-low ESR smoothing capacitors. Make the UcPure MKIII works better for both AC and DC input and tolerance more to different input power supplies.
- Upgrade to heavy-duty high-performance 10A fast acting standard 5\*20mm glass fuse
- Bigger and stronger ON/OFF switch on top side of the PCB
- More than one UC groups can be in parallel to improve performance more

### D. Layout and Dimensions (in mm)



## E. Getting started

1. Make sure the jumper settings are settled correctly for 3.3V, 5V(default), or 15V configurations.
2. Connect a fully empty ultracapacitor pack to J7. Make sure the polarity is correct. 3.3V and 5V configurations need a pack with two 3000F ultracapacitors. The 15V configuration needs a pack with six 3000F ultracapacitors. Ultracapacitor pack has to have built in balancer/protection boards.
3. Connect the load to J9
4. Make sure the on-off control switch S1 is at the off position and then connect a 18V-20V standard laptop power adapter with 3.5A or higher rated current to DC input J6 (inside is positive). The input LED D3 will be lit and the pre-charge mode will start. It may take up to an hour or so at the first time of charging the ultracapacitor pack. The full LED D8 will be lit once the ultracapacitor pack is fully charged.
5. Turn the on-off switch to the on position. Both output LED D5 and pure LED D9 will be lit.

Now you can enjoy the performance of the ultimate UcPure MkIII ultracapacitor power supply.

## F. Principle of operating

UcPure MkIII has three operation modes

### 1. Pre-charge mode

UcPure MkIII will work in pre-charge mode when it is off while the input power supply is connected. In this mode, the ultracapacitor pack will be connected to the dedicated onboard CC-CW ultracapacitor charger. The constant charging current can be programmed to 3A (default) or 1.5A according to the jumper settings. The full LED D8 will be lit after the ultracapacitor pack is fully charged.

### 2. Pure output mode

UcPure MkIII will go to the pure output mode if it is turned on while the full LED D8 is lit. In this mode, only the ultracapacitor pack will be connected to the outputs. The charger and all other circuits will be disabled and disconnected from the output. All the monitoring and controlling jobs will be performed through the optical isolators. So the outputs will be 100% isolated from the rest of the circuit. Both pure LED D9 and output LED D5 will be lit to indicate the UcPure MkIII is running in the pure output mode.

### 3. Protection mode

Because only ultracapacitor pack is connected to power the load, after running for a long time at pure mode (normally hours), the output voltage will be dropped below a threshold voltage. To protect the output from going low voltage, UcPure MkIII protection mode will be triggered in this case. The CC-CV charging circuit will be connected again to re-charge the ultracapacitor pack. The output doesn't stop in this protection mode but the low noise performance will be degraded slightly meanwhile (active circuits involved). After a couple of minutes, the UcPure MkIII will be automatically switched back to

the pure output mode once the ultracapacitor pack is fully charged again.

#### 4. SYNC mode

SYNC mode is a powerful feature for UcPure MkIII. You can enable this feature by connect a SYNC control signal to FifoPi Q7. In this case, the UcPure can charge the ultracapacitors by synchronized to the music when music is paused or stopped. Even if it's already in pure mode.

SYNC mode can be used to avoid the output voltage drop or trigger the protection mode even if you listen to music for a very long time.

UcPure will be back to the pure mode again when music plays.

#### Note:

The ultracapacitor pack will be disconnected by the relay from the UcPure MkIII when the input power is absent. The switched output J9 will be also off in this case. However, the continuous output J10 will still be connected to the ultracapacitor pack without stop.

### G. Jumper settings

Configurations	S2	S4	S6	Ultracapacitor Pack
3.3V	0 (short)	0 (short)	0 (short)	2 *3000F
15V	Open	Open	Open	6 * 3000F
5V (default)	21K 0603 1%	0 (short)	12K 0603 1%	2 * 3000F

Charging current	S5	Charging time	DC/AC Input current
1.5A	Open	Slower	Lower
3A (default)	short	Faster	Higher

### H. Connectors

#### J6: DC power input connector (5.5/2.5mm, positive terminal inside)

A good quality 18V to 20V standard laptop power supply with 3.5A or higher rated current is recommended for all the configurations. Or for 3.3V/5V configurations, the input range can be DC9V to 20V. This DC input has to be independent and cannot be shared with other devices.

**J2: Optional AC/DC input barrier terminal block alternative to J6 (not installed by default)**

Configurations	AC input	Or DC input (bi-directional)	Rated current
3.3V/5V	AC 12V/3.5A or higher	DC 9-20 V	Higher than 1.5A/3A according to the jumper settings
15V	AC 15V/3.5A or higher	DC 18-20 V	Higher than 1.5A/3A according to the jumper settings

Note: J6 has to be kept unconnected if J2 is used.

Note: AC coil has to be independent and cannot be shared with other devices.

Note: Better to open S5 for lower charging current configuration when AC input is used.

**J7: Ultracapacitor pack connector (barrier terminal block)**

Ultracapacitor pack must be connected to this connector to operate.

Please make sure the screws are tightened up and never reverse the positive and negative terminals.

**J9: Switched output (barrier terminal block)**

This is the switched output of UcPure MkIII. This output will be turned on and off when UcPure MkIII is on or off.

Normally the load is connecting to this output.

A fuse F1 is installed to this output to protect from over current or short circuit.

The Littlefuse P/N of this fuse is 0217010.MXP, but you can use any 10A fast acting 5\*20mm standard glass fuse.

**J10, J13: Continuous output (2 PIN Molex Mini-Fit connector)**

This continuous output is specially designed for clock oscillators, sine to square convertors and many other analog applications that need continuous power for long time break-in. The continuous output is non-switched, so the output will be always there no matter UcPure MkIII is on or off. The only way to turn off this output is to disconnect the connector by unplugging the cable.

J10 and J13 are equivalent to each other. J13 could be optional

The related Molex P/Ns of the cable are

Housing: 39012020

Terminal: 39000038

Same F1 fuse is also applied to this output to protect from over current or short circuit.

**J4: Optional external on/off control switch connector, in 2-pin, 2.54mm (not installed by default)**

External on/off control switch is functionally equivalent to the on-board switch S1.

To use the external on/off control switch, On-board switch S1 must be at off position.

External on/off switch is not supplied in the package.

**J5: Slave on/off control input in 2-pin PH2.0, isolated and non-polarity**

UcPure MkIII can be controlled remotely from this slave control input. UcPure MkIII will be turned on when

a 3V-12V control voltage is applied to this input. The control signal is non-polarity and will be optically isolated from UcPure MkIII.

To use the remote on/off control, On-board switch S1 must be kept at off position.

#### **J1: Master on/off control output in 2-pin PH2.0**

1: Control signal –

2: Control signal +

To set up a control chain of a power supply group, we can connect J1 to the slave input of the following UcPure MkIII or other power supplies through the supplied control cable.

#### **J8: Optional external pure LED connector**

External pure LED indicator can be connected to this connector to indicate pure status.

This connector was no installed by default.

#### **J11, J12: SYNC control signal input/output in 2-pin PH2.0**

1: SYNC control signal –

2: SYNC control signal +

To enable the SYNC mode, SYNC control signal + needs to be connected the FifoPiQ7's MUTE output, while the SYNC control signal – needs to be connected to the FifoPiQ7's clean side GND.

With a built in isolator, this control signal is non-polarity and will be optically isolated from UcPure MkIII.

J11 an J12 are equivalent to each other.

### **I. LED indicators**

D3: Power input indicator. Indicating that the power input voltage is applied when lit.

D5: Power on indicator. Indicating that the UcPure MkIII is turned on and output voltage is applied to J9 when lit.

Note: D5 has no business with the continuous output

D9: Pure output indicator. Indicating UcPure MkIII is in pure output mode when lit.

D8: Full indicator. Indicating ultracapacitor pack is fully charged when lit.

### **J. Application notes**

#### **1. Ultracapacitors**

External ultracapacitor pack is needed for UcPure MkIII to operate. The capacitance of ultracapacitors have to be 3000F or higher.

Maxwell BCAP3000 P270 and BCAP3000 P300 are recommended but not limited. Other 3000F/2.7V or higher capacitance/voltage ultracapacitors are also good for UcPure MkIII.

It could be a good idea buying an ultracapacitor pack directly. It will have built-in balancer/protection boards and other accessories. Ultracapacitors and the balancer/protection boards can be sourced from eBay, Mouser, Digikey, Amazon, Aliexpress and other on-line stores.

## 2. ESR of UcPure MkIII

ESR of the switched output J9 = Ultracapacitor pack ESR + Fuse resistance + MOSFET ESR

ESR of the continuous output J10 = Ultracapacitor pack ESR + Fuse resistance

Take an example, at 3.3V/5V configuration with BCAP3000 P270 ultracapacitors

ESR (J9, switched) =

0.58mOhm (ultracapacitors) + 12.5mOhm (fuse) + 0.8mOhm (MOS FETs) = **13.88mOhm**

The resistance of wires has also to be taken into account for the ultra low ESR power supply such as the UcPure MkIII.

16 AWG or bigger wires are highly recommended for both supercapacitor pack and outputs.

To reach better ESR performance, we can also bypass the fuse F1 by shorting S3 with solder. In this case, ESR (J9, switched) will be reduced to **1.38mOhm** and J10 (continuous) will be only **0.58mOhm**.

**But have to be aware of the risk of damaging in case of short circuit.**

If really want to, I would suggest only doing this upgrade after the whole system is settled.

## 3. How long the pure time will last before triggering the protection mode

The pure time can be calculated.

Take for instance. If the output voltage drops from 3.4V to 3.0V (UcPure MkIII 3.3V configuration), the charge released will be  $Q = 1500 * 0.4 = 600$  (Coulombs).

If the load (FifoPi clean side together with SinePi) consumes 50mA current, the pure time will be:

$T = 600 / 0.05 = 12000$  seconds = 3.33 hours

After that time, the protection mode will be triggered to re-charge the ultracapacitor pack. However the protection mode will take only 3.33 minutes to fully charge the ultracapacitor pack again. UcPure MkIII will go back to the pure output mode after that time. So, this scheme doesn't really affect the listening experience much.

## 4. How to integrate UcPure MkIIIs into a power supply group

For a power supply group, please connect the Master control output of the first power supply (3V to 12V) to the Slave control input J5 of UcPure MkIII, and then the master control output J1 of UcPuer to the next power supply or another UcPure MkIII to make a control chain. UcPure MkIII slave control input is optical isolated and non-polarity.

## 5. What are the suitable applications using a PurePi MkIII

UcPure MkIII will work great for all kinds of ultra-low noise applications such as low jitter oscillators, sine to square convertors, FifoPi clean side, DAC/ADCs, I/V stages, MM/MC phone amplifiers, pre-amplifiers and many other circuits. UcPure MkIII could be the best possible performance power supply for those applications. However, high current applications may not suitable very well for UcPure MkIII though it can deliver up to 1000A dynamic current, for it could trigger the protection mode often.



## 6. Possible 12V output configuration

UcPure with 3000F ultra capacitors could be the best low noise power supply in the real world. I know a lot of people want a 12V configuration to upgrade their DDDAC or other project, now the solution is here:

1. Replace S2 with a 390K 0603 resistor, can be RT0603DRE07390KL
2. Keep S4 OPEN
3. Replace S6 with 232K 0603 resistor, can be RR0816P-2323-D-36D

Under this configuration, the UcPure will be:

12.6V: fully charged

10.3V: Trigger the protection mode to re-charge the UCs

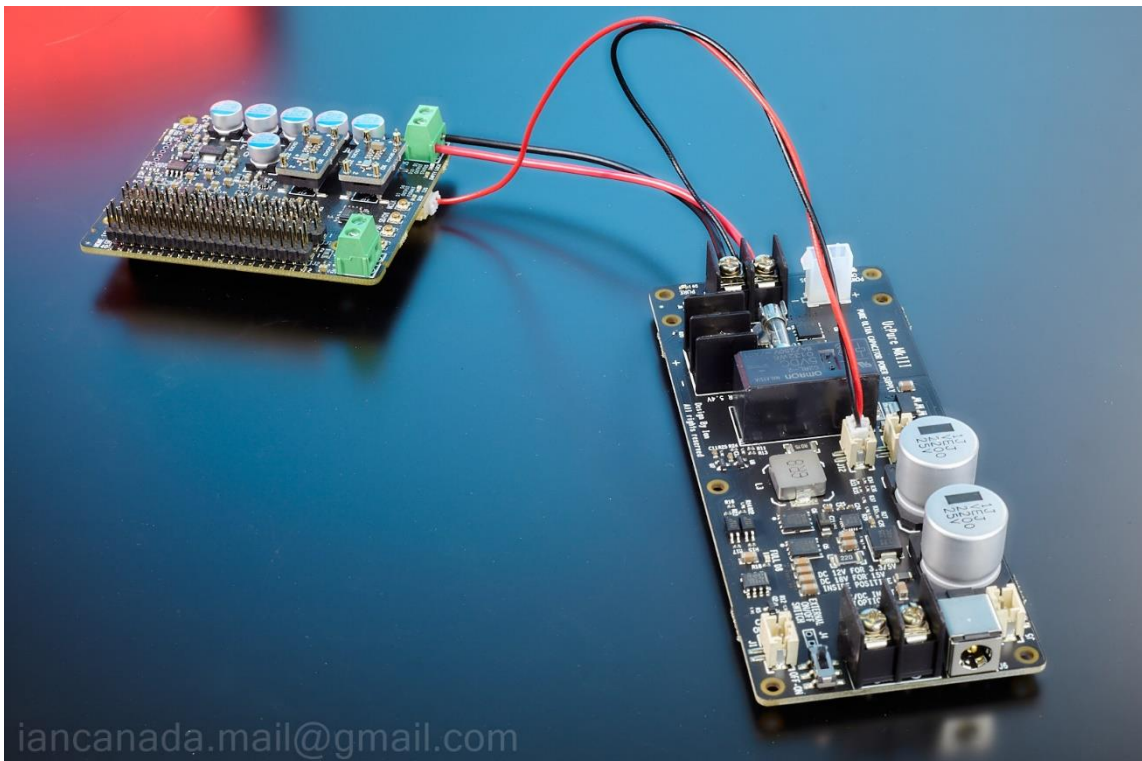
12.33V: Back to pure mode when reach this voltage

Please make sure all the voltages are correct before connecting to your DAC if you want to change to this configuration.

## 7. How to enable the SYNC mode

SYNC mode is disabled by default. To enable this feature, you will need

4. Connect the two-pin connector of the supplied SYNC cable to either J11 or J12.
5. Connect the one-pin connector of the supplied SYNC cable to J14 of a FifoPi Q7 (MUTE signal).
6. Connect the black wire of the supplied SYNC cable to the FifoPi Q7 clean side GND. Can be either GND of J5 of FifoPi Q7, or the negative terminal (-) of J7 of the UcPure MkIII (no matter Q7 is connected to J7 or J10 or J13).



If you want more UcPure MkIII run at SYNC mode as a group, you can connect the rest of SYNC connector (J11 or J12) to J11 or J12 of the next UcPure MkIII by a PH2.0 cable as a control chain.

### 8. How to push the performance of the UcPure MkIII to the limit

The best performance of UcPure MkIII comes from a special continuous output mode that the wires of the output are connected directly to the positive and negative terminals of the ultracapacitor pack.

In this case, the ESR of UcPure MkIII will be exactly the ESR of ultracapacitors, say **0.58mOhm** for 3.3V/5V configuration.

Both fuse and wires to the ultracapacitor pack will be bypassed. So, shorting S3 is no longer a necessary.

I suggest using a connector to make it possible to disconnect the load from the ultracapacitor pack.



### K. Pictures of UcPure

1. UcPure MkIII in 3.3V/5V configuration



2. UcPure MkIII in 15V configuration



## **L. History of revising**

Sep 23, 2021 V0.9b released

Dec.24, 2021 V1.0 released, Change max AC input voltage to 15V

Nov.03, 2022 V2.0 released for UcPure MkII

Apr.8, 2023 V3.0 released for UcPure MkIII

© 2023 IanCanada. The firmware code embedded in the UcPure MkIII is the property of Ian Jin. You are granted a non-exclusive, non-transferable, non-sublicenseable, royalty-free right to use the UcPure MkIII solely for your own, non-commercial purposes. You may not distribute, sell, lease, transfer, modify, adapt, translate, reverse engineer, prepare derivative works of, decompile, or disassemble the software provided. All rights reserved.