

9028Q2MPi ESS DAC HAT user's guide

By Ian Jin and Greg Stewart Jul. 24, 2023 Ver. 1.1

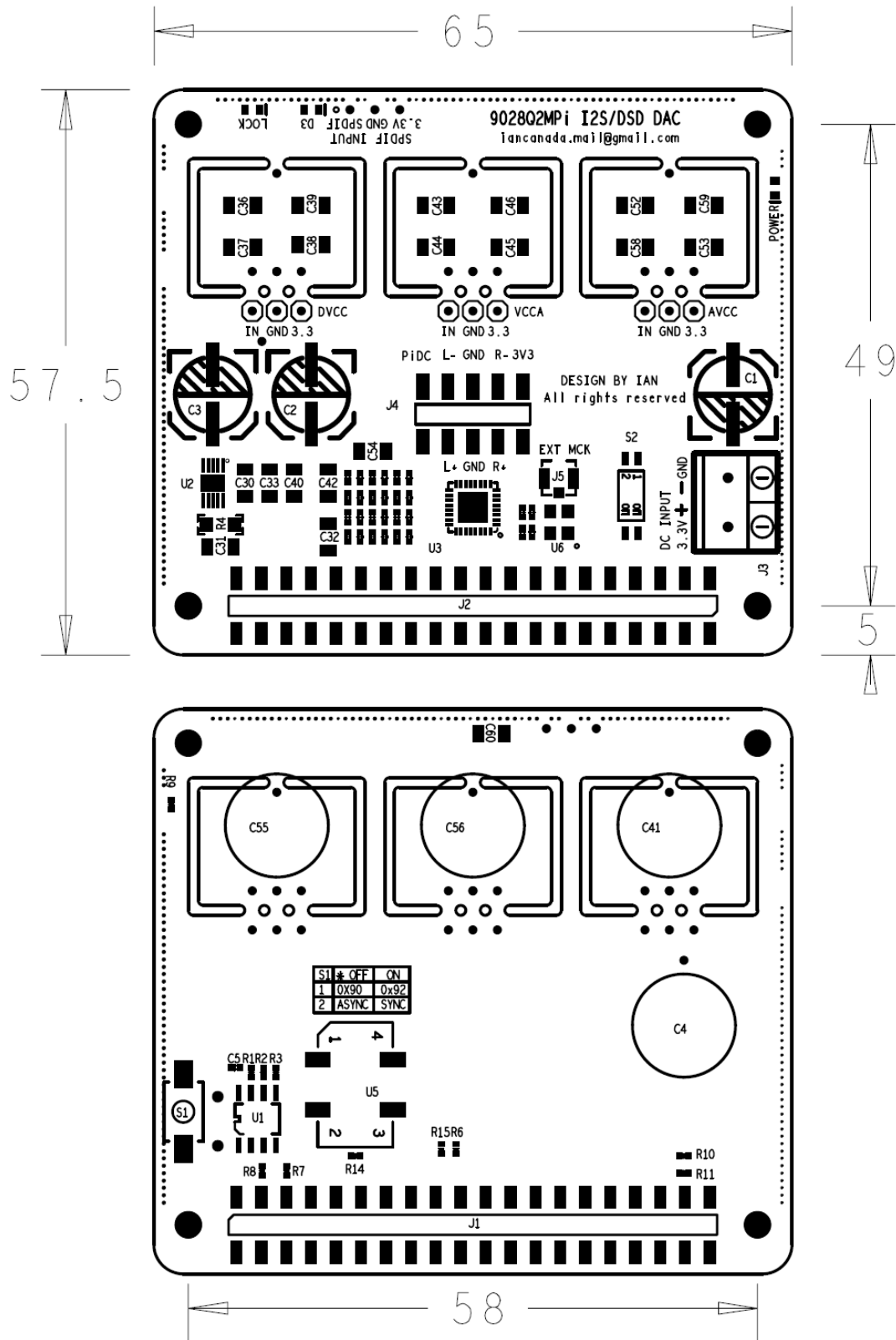
A. Introduction

9028Q2MPi ESS DAC HAT is an audiophile grade DAC core board for RaspberryPi. Based on the latest ES9028Q2M SABRE32 reference DAC technologies, it targets the highest possible sound quality and performance for DIY audiophiles.

B. Highlighted Features and Specifications

- ES9028Q2M 32bit core RaspberryPi DAC HAT.
- Supports up to 384KHz 16/24/32 bit PCM, native DSD512, and DSD128 via DoP and S/PDIF.
- Jumper selectable Asynchronous and Synchronous clock mode.
- 50MHz internal asynchronous clock or external synchronous clock range from 22.5792MHz to 98.3040MHz.
- Settings controlled by either external ESS controller or possible Linux driver.
- To eliminate ground and EMI noise, ESS controller or Linux driver operates in isolated mode when used with FifoPi or IsolatorPi I/II.
- Raw balanced current output enables use of a variety of external output stage solutions, both current-to-voltage conversion (I/V) or voltage direct modes. Plug-compatible external output board available. Third party I/V stage boards can be used via adapter PCB.
- 403 Ohm output impedance provides strong current output.
- Ready for 3.3V ultra capacitor power supply or LifePO4 battery power supply.
- Can power AVCC, DVCC and VCCA separately.
- Can automatically switch between PCM, DSD, DoP and S/PDIF.
- DIY friendly with many modification and upgrading opportunities.

C. Layout and Dimensions (in mm)



D. Quick-Start Guide

1. Connect the 9028Q2MPi ESS DAC HAT on top of RaspberryPi.
2. Connect an output board on top of 9028Q2MPi.
3. Connect the ESS Controller into GPIO connector J2 (unless you have a Linux driver for dual mono ES9028Q2M loaded on your RaspberryPi).
4. Install a micro SD card loaded with your preferred distro and player combination into your RaspberryPi.
5. Connect a 3.3V / 100mA (minimum) low noise DC power to J3 (ultra capacitor or LifePO4 battery direct recommended).
6. If needed, connect the appropriate power to the output board.
7. Power the Raspberry Pi (with your preferred distro and player micro SD card installed) as usual. 9028Q2MPi and output stage can be powered at same time or before.
8. Connect to the RaspberryPi as usual. In the player's configuration dialog, select generic I2S DAC (for hardware based volume control from ESS controller), or PCM5122-compatible DAC (such as Hifiberry DAC+) if you desire additional hardware volume control from player UI. Restart the player if required.
9. Adjust volume to 0dB or other suitable level for the first time before turning on the rest of your audio system.
10. Enjoy the music.

E. Connectors

J3: DC power input

Connect a 3.3V DC / 100mA (minimum) power supply to the 2-pin 5.0mm terminal J3, MAINTAINING CORRECT POLARITY!!! Any low noise linear 3.3V power supply will work. We prefer a direct-connected 3.3V ultra capacitor / LifePO4 battery power supply for best possible sound quality. The 9028Q2MPi consumes around 50mA average with 50MHz MCLK operating in asynchronous mode (default).

J5: External MCLK input (u.fl coaxial cable socket)

When operating the 9028Q2MPi in Synchronous mode, connect the external MCLK signal from a FifoPi or similar synchronous clocking source using a u.fl coaxial cable. DO NOT connect to J5 when operating in Asynchronous mode (default).

J4: Fully balanced ES9028Q2M raw current output

Connect an output stage board as below:

pin number	Descriptions
1	NC
2	RaspberryPi 5V, internally connected to RaspberryPi GPIO pins 2 and 4
3	L+, Left positive current output
4	L-, Left negative current output
5	GND

6	GND
7	R+, Right positive current output
8	R-, Right negative current output
9	NC
10	AVCC (ES9028Q2M AVCC 3.3V voltage rail)

S/PDIF input

Connect an optional 3.3V LVTTTL logic level optical S/PDIF receiver or other S/PDIF as below.

pin number	Descriptions
1	SPDIF input
2	GND
3	3.3V power, internally connected to J3

40 pin GPIO connectors

pin number	J1 40 PIN GPIO connector to board below (RaspberryPi, IsolatorPi I/II, FiFoPi, or similar)	J2 40 PIN GPIO connector to HAT on top of 9028Q2MPi
1,17	3.3V from preceding board	3.3V from preceding board
2,4	5V from preceding board	5V from preceding board
6,9,14,20,25,30,34,39	GND	GND
3	I2C DA	I2C DA
4	I2C CL	I2C CL
27	ID DA	ID DA
28	ID CL	ID CL
12	SCK input	SCK from preceding board
35	LRCK/D1 input	LRCK/D1PIN from preceding board
40	SD/D2 input	SD/D2 PIN from preceding board
All other pins	same pin from preceding board	same pin from preceding board

40 pin GPIO connector note: All input/output signals are LVTTTL (3.3V) logic level except power and ground.

F. Jumper Settings (Jumper switch S2 is located at top side of PCB)

Jumper Switch S2	OFF (default)	ON
2	Asynchronous clock mode	Synchronous clock mode Must have synchronous external MCLK connected to J6 when set in on position
1	I2C address: 0x90	I2C address: 0x92

G. LED indicators

LED	Description	On Indicates...
D3	LOCKL	ES9028Q2M DAC is locked to input music signals
D7	POWER	3.3V power applied

H. How to produce the best sound quality from your 9028Q2MPi

Run your 9028Q2MPi in Synchronous mode

We prefer running this DAC with a synchronous MCLK than the default Asynchronous mode. To do that, switch to Synchronous clock mode by:

1. Installing a FifoPi between the RaspberryPi and the 9028Q2MPi DAC (see FifoPi user's manual for installation and configuration details).
2. Installing a pair of really nice clocks into the FifoPi according to your personal preference. The quality of these clocks is very important to the sound quality and sonic signature.
3. Connecting the MCLK signal from the FifoPi to J5 on the 9028Q2MPi using a u.fl coaxial cable. Cable length should be as short as possible.
4. Setting pin2 or both pin1 and pin2 of jumper switch S2 to 'ON' position.
5. Setting DPLL bandwidth to lowest level 1 for both PCM and DSD in the ESS Controller, at the "DPLL Bandwidth" setting panel (see ESS Controller manual for configuration details).
6. Power up and enjoy the music.

After performing the above steps, your 9028Q2MPi now is using an MCLK that is synchronous to the music signal and is largely bypassing the DPLL.

Further gains can be made by stopping the DPLL and enabling True Sync mode. BUT there are limitations to True Sync mode with the ES9028Q2M:

- It supports PCM format only. DSD and DoP are not supported.
- MCLK has to be 128FSR

If you do not follow these limitations, True Sync mode does not work properly. Also, once you have enabled True Sync mode on the 9028Q2MPi, the lock LED stays on continuously.

Enable True Sync mode on your 9028Q2M by:

1. Selecting "True SYNC with DPLL stopped" in the ESS Controller at the "Normal/True SYNC mode" setting panel.
2. Setting both PCM bandwidths to "No band width 0".

See ESS Controller manual for configuration details.

Isolate your 9028Q2MPi from the ESS Controller

ESS Controller contains a micro-processor. It generates EMI noise that can impact sound quality. Connecting the ESS Controller through an isolator eliminates any direct electronic connections between ESS controller and 9028Q2MPi and prevents this noise from reaching the DAC. The 9028Q2MPi grounds will be cleaner when configured this way.

To run the ESS Controller in isolated mode, you need to use a FiFoPi or IsolatorPi I/II between your RaspberryPI and 9028Q2MPi and connect the ESS Controller to the non-isolated GPIO connector of the FiFoPi or IsolatorPi I/II.

Power your 9028Q2MPi directly from a 3.3V ultra capacitor or LiFePO4 battery power supply

We have found using a directly-connected (no LDO on the output) 3.3V ultra capacitor or LiFePO4 battery power supply to be a significant improvement over most traditional power supplies. To do this, connect the supply directly to J3 OBSERVING CORRECT POLARITY!!!

Power your 9028Q2MPi voltage rails separately

For the ultimate power experience, you can power the three voltage rails on your 9028Q2MPi separately. You do this by removing the three decoupling network daughter boards from the 9028Q2MPi PCB using a side cutter. Then feed three separate 3.3V power supplies to the 3.3V and GND pins at DVCC/GND, VCCA/GND and AVCC/GND. 3.3V ultra capacitor power and LiFePO4 battery power supply are of course always preferred.

Select an output board(s) that matches your preferred listening style

Which output board is used makes a significant contribution to both the sound quality and sonic signature produced from your ES9028QMPi. The standard op-amplifier I/V board (and what opamps you use in the board), OPA861 I/V board, OPA1632 I/V board, a discrete I/V board, Transformer Output board, and so on, will all sound different. Also whether you use them in single-ended or balanced mode will also impact the sound quality and sonic signature. Please choose the output board best suited to your system and your personal preferences. Also use the balanced XLR outputs if you can in your system. In most cases, we have found the balanced XLR output produces better overall sound quality than the single ended output.

Experiment with the settings of your ES9028Q2MPi using the ESS Controller

Many of ES9028Q2MPi settings can be programmed using the ESS Controller. Some that make a difference sonically include DPLL bandwidth for both PCM and DSD format, the seven preset FIR filters, OSF bypassing, IIR bypassing. Using the guidelines in the ESS Controller manual to safely set these settings, feel free to experiment and find the best settings for your ES9028Q2MPi setup and your system based on listening.

I. Other upgrade options

Install optional on-board super capacitors

You can install optional small-footprint super capacitors on your ES9028Q2MPi:

Reference	Description	Device Package	Location	Notes
C4	Optional super capacitor for DC input J3	Dimension 11.5mm Through Hole	Bottom Side of PCB	Rated voltage MUST be higher than the power supply voltage. Normally 5.5V
C41	Optional super capacitor for DVCC			
C56	Optional super capacitor for VCCA			
C55	Optional super capacitor for AVCC			

Use local 3.3V low noise regulators

If you do not use a directly-connected (no LDO) 3.3V ultra capacitor or LiFePO₄ battery power supply, but instead use a more traditional power supply, you can install three 3.3V low noise regulators for DVCC, AVCC and VCCA and then feed the appropriate voltage (typically 5V) at J3 ALWAYS OBSERVING POLARITY!!!

You do this by removing the three decoupling network daughter boards from the 9028Q2MPi PCB using a side cutter. Then install three similar-sized low-noise LDO regulator boards at the IN, GND, and 3.3V pins at DVCC/GND, VCCA/GND and AVCC/GND. For the best performance, we recommend LT3042/LT3045 low noise regulator boards or similar. Again, DC input voltage (J3) needs to be 5V or higher according to the requirements of the LDO boards.

Upgrade the on-board 50MHz clock

If you are running your ES9028Q2MPi in Asynchronous mode, you can upgrade on-board XO clock to a higher grade lower jitter one such as a 50MHz CCHD950 or equivalent. Higher frequencies up to 100MHz are also possible. You do this by removing the originally-installed XO U5 and then installing a new XO clock to the U4 pads on the bottom side of PCB. If you are operating your ES9028Q2MPi in Synchronous mode with a FifoPi or equivalent, there is no need to upgrade the originally-installed XO U5 as it is not being used in this configuration.

J. Troubleshooting

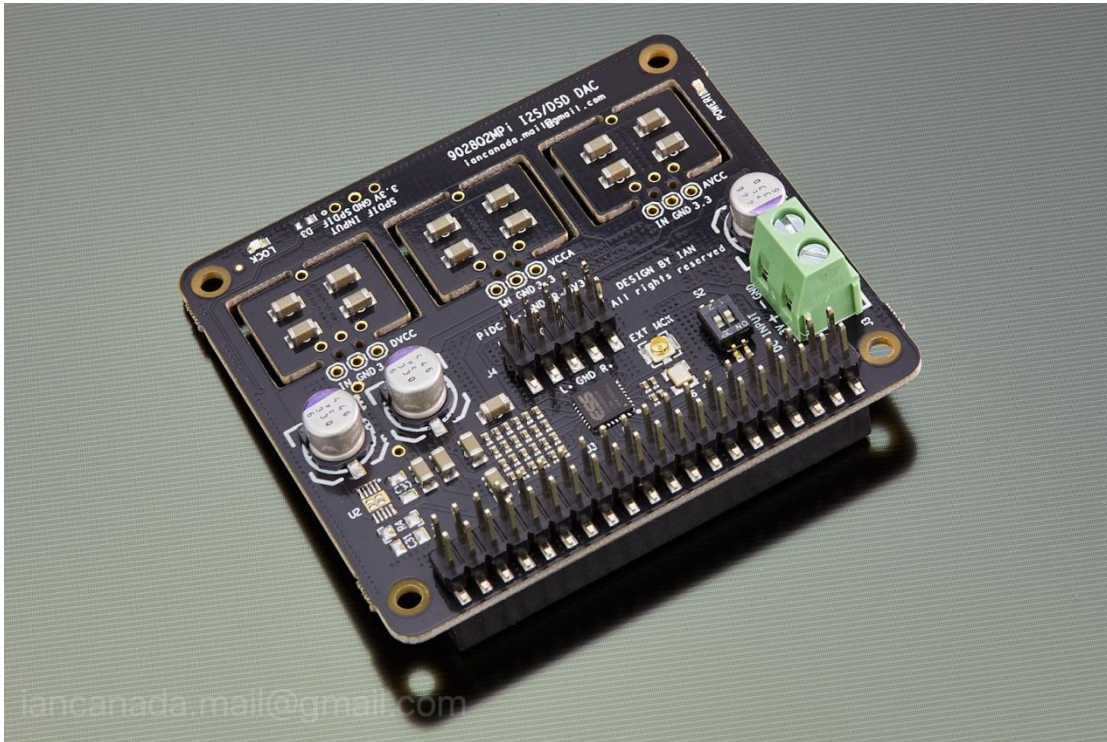
Sync mode issue

Q: We I connect the MCK u.fl cable from FifoPi to the J5 to run the DAC in the sync mode, the lock LED D3 keep flashing and the DAC doesn't sound correctly.

A: To run the DAC at sync mode, you also have to set both jumpers on S2 to "ON" positions. After doing so, the issue was fixed. Please read page5 for details.

K. ES9028Q2MPi DAC HAT pictures

1. ES9028Q2MPi DAC HAT as shipped



2. Getting started with Asynchronous mode (default)

Raspberry Pi + ES9028Q2MPi DAC HAT + ESS controller + I/V board



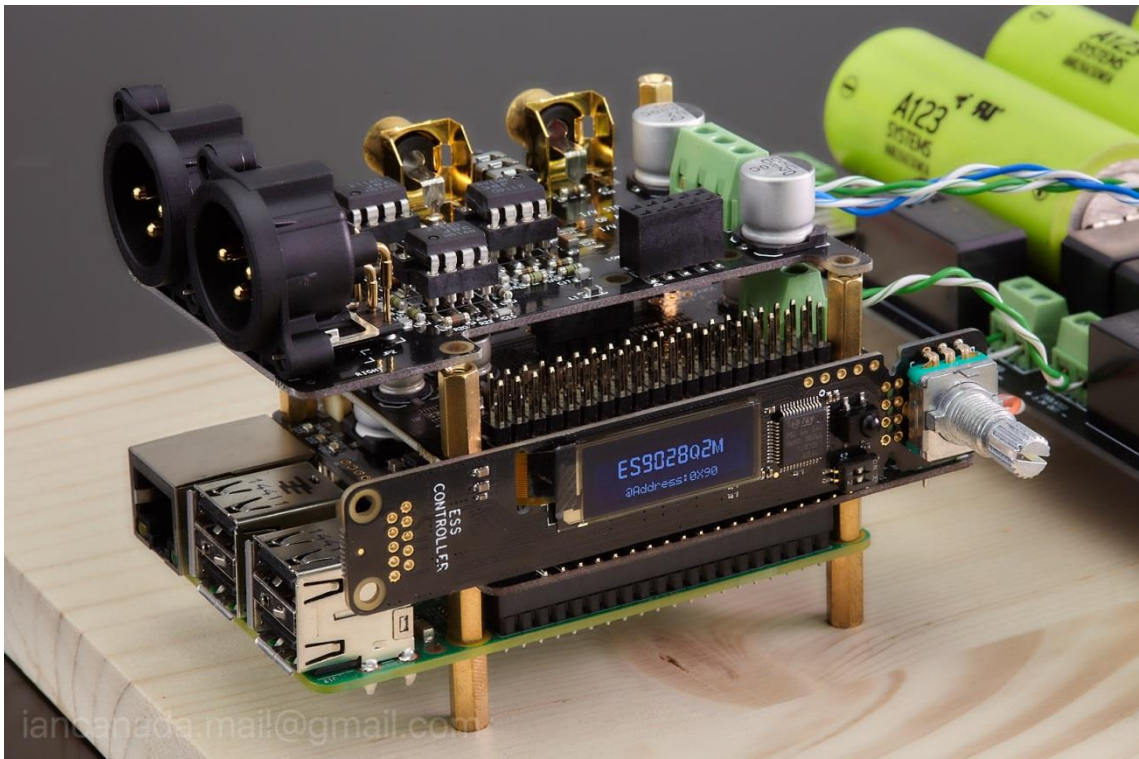
3. Running in isolated Asynchronous mode

Raspberry Pi + IsolatorPi I/II + (DoP decoder) + ESS controller + ES9028Q2MPi DAC HAT + I/V board



4. Running in Synchronous mode (highly recommended for best possible sound quality)

Raspberry Pi + FifoPi + ESS controller + ES9028Q2MPi DAC HAT + I/V board



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