

9038Q2MPi Dual Mono DAC HAT user's guide

By Ian Jin, Dec 30, 2018 Ver. 1.0a

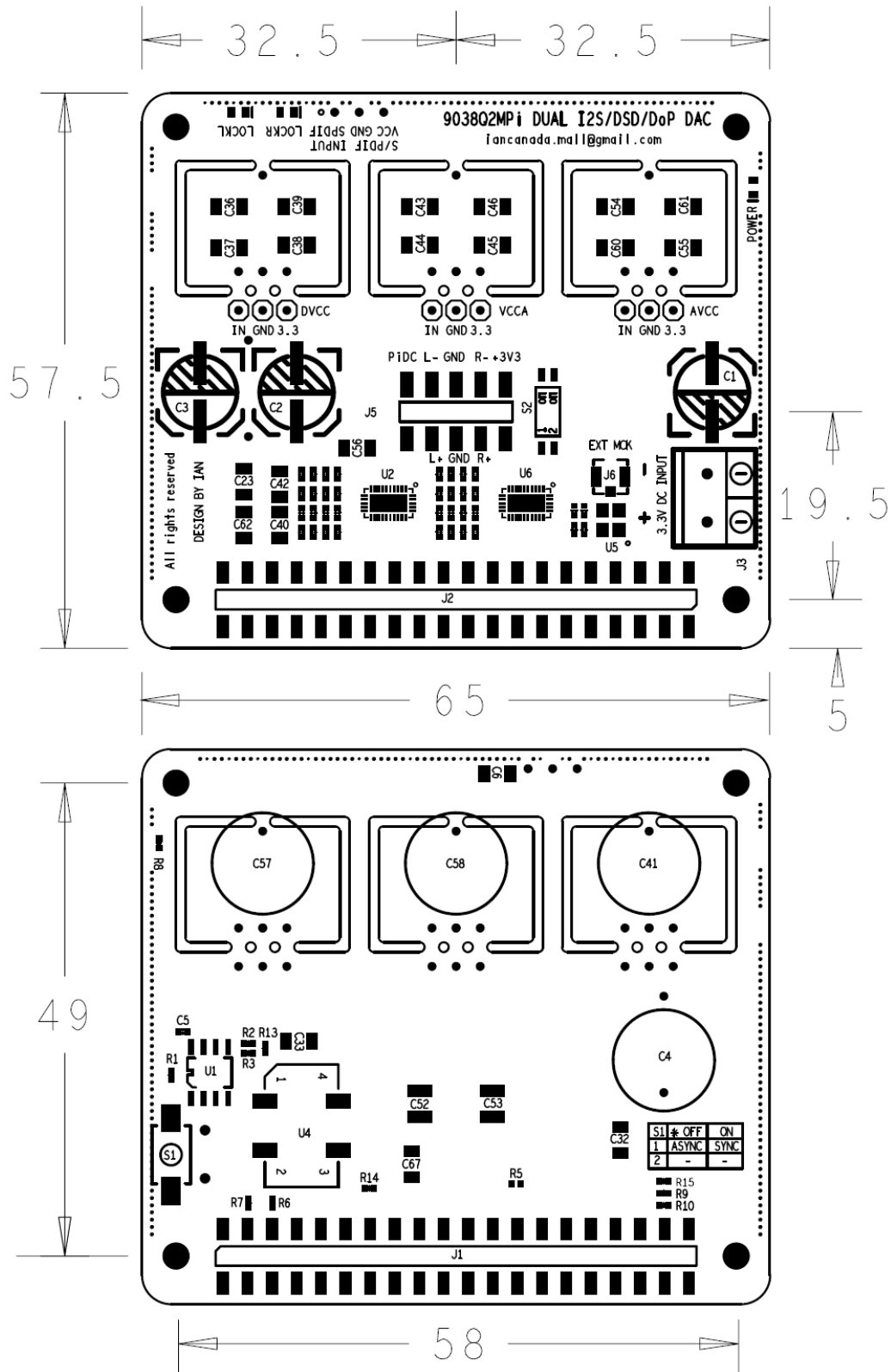
A. Introduction

9038Q2MPi Dual Mono DAC HAT is an audiophile grade DAC core board for Raspberry Pi. Based on the latest ES9038Q2M SABRE32 reference DAC technologies, it targets the highest possible sound quality and performance for audio DIYers.

B. Highlighted Features and Specifications

- ES9038Q2M 32bit core DAC HAT with dual mono architecture for Raspberry Pi.
- Up to 768KHz 16/24/32 bit PCM, native DSD1024, DSD256 via DoP and S/PDIF support.
- Jumper selectable asynchronous and synchronous clock mode.
- 100MHz internal asynchronous clock or external synchronous clock range from 22.5792MHz to 98.3040MHz.
- Works with either external ESS controller or possible Linux driver.
- All register settings can be programmed through the external ESS controller or possible Linux driver.
- To eliminate the ground loop and EMI noise, ESS controller or Linux driver can work in isolated mode when FifoPi or IsolatorPi is integrated in system.
- Raw balanced current output makes it suitable to work with different kind of external I/V solutions. Compatible external I/V stage board can be plugged on top of it. Third party I/V stage boards can also be used through adapter PCB.
- 389 Ohm output impedance in dual mono configuration which is much lower than the normal stereo architecture.
- Ready for 3.3V ultra capacitor power supply or LifePO4 battery power supply.
- Possible to power AVCC, DVCC and VCCA separately .
- Independent lock LED indicators for both left and right DAC block.
- Can automatically switch between PCM, DSD, DoP and S/PDIF.
- DIY friendly with a lot of modding and upgrading options.

C. Layout and Dimensions (in mm)



D. Getting start

1. Plug the 9038Q2MPi Dual Mono DAC HAT on top of RaspberryPi;
2. Plug the I/V board on top of 9038Q2MPi;
3. Plug the ESS controller into GPIO connector J2 (unless you have Linux driver for dual mono ES9038Q2M);
4. Connect 3.3V low noise DC power to J3 (ultra capacitor or LifePO4 battery direct is preferred);
5. Power the Raspberry Pi (with player installed) as usual. 9038Q2MPi and I/V stage can be powered at same time of before.
6. In the player's setup manual, select general I2S DAC (for pure ESS controller hardware based volume control), or PCM5122 compatible DAC (such as Hifiberry DAC+) for additional hardware volume control from player UI. Restart the player if it is required.
7. Adjust volume to 0dB or other suitable level at the first time of use. Enjoy the music.

E. Connectors

J3: DC power input

A 3.3V DC power supply must be connected to this 2-pin 5.0mm terminal for the ES9028Q2MPi to operate. Any low noise linear 3.3V power supply is good for this DAC HAT. But direct 3.3V ultra capacitor power supply or LifePO4 battery power supply would be preferred for best possible sound quality. It consumes around 50mA average current with 100MHz MCLK. Generally use a supply that provides 100mA as a minimum.

J6: External MCLK input in u.fl coaxial cable socket

This connector connects to external MCLK signal through u.fl coaxial cable when it's running at synchronized clock mode. Please keep this connector unconnected at asynchronous mode (default).

J5: Fully balanced ES9038Q2M raw output connector

To connect to external I/V stage board.

| PIN number | Descriptions |
|------------|--|
| 1 | NC |
| 2 | Pi5V, internally connected to Raspberry Pi GPIO PIN2 and PIN4. |
| 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, ES9038Q2M AVCC 3.3V voltage rail |

S/PDIF input

To connect to optional optical S/PDIF receiver or other receiver in LVTTTL logic level.

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

40PIN GPIO connectors

| PIN# | J1 40 PIN GPIO connector to connect to Raspberry Pi | J2 40 PIN GPIO connector to other HAT on top of DAC |
|-------------------------------|---|---|
| 1,17 | 3.3V from Raspberry Pi | Connected to the same 3.3V PINs of J1 |
| 2,4 | 5V from Raspberry Pi | Connected to the same 5V PINs of J1 |
| 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 | Connected to same SCK PIN of J1 |
| 35 | LRCK/D1 input | Connected to same LRCK/D1PIN of J1 |
| 40 | SD/D2 input | Connected to same SD/D2 PIN of J1 |
| All other PINs | Connected to same PIN of J2 | Connected to same PIN of J1 |

Note1: All input/output signals are in LVTTTL (3.3V) logic level except analog output signals.

F. Jumper settings

Jumper switch S2 is located at top side of PCB.

| Jumper Switch S2 | OFF (default) | ON |
|---------------------|--------------------------|--|
| 1 | Asynchronous clock mode. | Synchronous clock mode Must have synchronous external MCLK connected to J6 when set at on position |
| 2 | Reserved | Reserved |

G. LED indicators

| LED | Descriptions | Notes |
|-----|--------------|--|
| D2 | LOCKL | Lit when left ES9038Q2M DAC U2 is locked to input music signals |
| D3 | LOCKR | Lit when right ES9038Q2M DAC U6 is locked to input music signals |
| D7 | POWER | Lit when this DAC HAT is powered |

H. Ways to improve sound quality

Run DAC with synchronous clock

It was confirmed that running this DAC with synchronous clock has better sound quality than the default asynchronous mode. The following steps are needed to switch to this synchronous clock mode:

1. Install a FifoPi between Raspberry Pi and this ES9038Q2M Dual Mono DAC (see FifoPi user's manual for configuration details).
2. Connect the MCLK signal from FifoPi to this DAC by an U.FL coaxial cable. Cable length should be as short as possible.
3. Set pin1 of jumper switch to 'ON' position.
4. Choose a pair of really nice XO for FifoPi according to personal preference. Those XOs will be very important to the sound quality and sound style.
5. Set DPLL bandwidth to lowest level 1 for both PCM and DSD in ESS controller setting manual.

Now, the ESS DAC already has the MCLK that is synchronous to the music signal. So you can enjoy the better quality music from the ESS DAC at synchronous clock mode.

Furthermore, it's also possible to try the true SYNC mode by stopping the DPLL of ESS DAC while works in synchronous mode. To do so, you will need another two more steps:

1. At "Normal/True SYNC mode" setting page, select "True SYNC with DPLL stopped".
2. Set PCM bandwidth to "No band width 0".

However, this true SYNC mode is not perfect for ES9038Q2M. It supports PCM format only. DSD and DoP are not

supported. And MCLK has to be fixed at 128FSR. Lock LED will also keep lit if this true SYNC mode is enabled. It cannot be guaranteed to work properly if conditions are not met.

Make the ESS controller running isolated from DAC

ESS controller itself is a micro-processor. It can generate EMI noise that impacts the sound quality of DAC. Running it at isolated mode will eliminate all electronic connections between ESS controller and DAC thus stops the noise from being injected into DAC. Much cleaner DAC ground plan will be expected under this configuration.

It's very easy to run the ESS controller at isolated mode. The only thing needs to do is to plug it onto the non-isolated GPIO connector of FifoPi or IsolatorPi.

Power DAC directly from a 3.3V ultra capacitor power or LiFePO4 battery power

To improve the power supply performance, it is highly recommended to use 3.3V ultra capacitor power or LiFePO4 battery power directly to J3 for this DAC. Any LDO or regulator will degrade the performance of passive power supply.

Power voltage rails separately

It is possible to power the three voltage rails separately. To do so, we need to break the three decoupling network daughter boards from the DAC PCB first by using a side cutter. Then feed three independent 3.3V power supplies to PINs of DVCC/GND, VCCA/GND and AVCC/GND. 3.3V ultra capacitor power and LiFePO4 battery power supply are always preferred.

Try best suitable I/V stage boards and XLR balanced analog output

I/V stage boards are also very important to sound quality. Different I/V solution can play music in different style. Standard op-amplifier I/V stage, transformer I/V stage, OPA861 I/V stage, discrete I/V stage and so on, they all sound in different style. Please choose the best suitable I/V stage for this DAC according to personal preference. Also try to use the balanced analog output from XLR connectors on I/V board. In most of the cases, balanced output has better sound quality than the SE output.

Try best suitable register settings

Many of register settings can be programmed from the ESS controller. Such as DPLL bandwidth for both PCM and DSD format, seven preset FIR filters, OSF bypassing, IIR bypassing. Please try the best suitable register settings according to the real listening test. Please see ESS controller user's manual for details.

I. Other options to upgrade

Assemble optional on-board super capacitors

It is possible to assemble some optional small size super capacitors to this DAC HAT

| Reference | Description | package | Location | Notes |
|-----------|---|----------------------------------|-----------------------------|---|
| C4 | Footprint of 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 |
| C57 | Footprint of optional super capacitor for DVCC | | | |
| C58 | Footprint of optional super capacitor for VCCA | | | |
| C41 | Footprint of optional super capacitor for AVCC | | | |

Use 3.3V low noise regulators

It is also possible to use three 3.3V low noise regulators for DVCC, AVCC and VCCA if don't use 3.3V passive power supply.

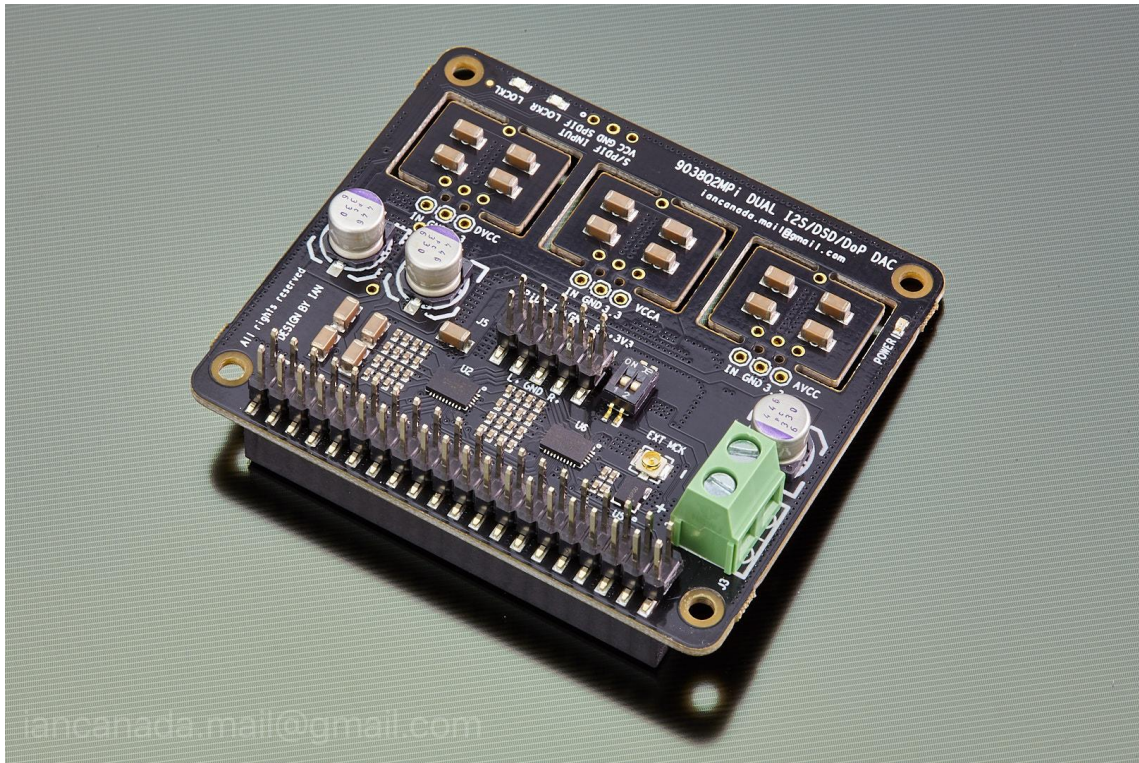
To do so, we need to break the three decoupling network daughter boards first from the DAC PCB by using a side cutter. Then assemble three same size low noise LDO boards at the same position. LT3042/LT3045 low noise regulator board would be recommended for this application. DC input voltage (J3) needs to be 5V or higher according to the LDO boards.

Upgrade on-board 100MHz XO

It is possible to upgrade on-board XO with a higher grade low jitter one such as 100MHz CCHD950 or equivalent. To do so, we need to remove the old XO U5 first, and then assemble the new XO to footprint U4 at bottom side of PCB. Please note that the on-board XO works for asynchronies only. No need upgrade this on-board XO if you run this DAC in synchronized mode with FifoPi.

J. ES9038Q2Mpi Dual Mono DAC HAT picture

1. ES9038Q2Mpi dual mono DAC HAT



2. Getting start with asynchronous mode (default)

Raspberry Pi + ES9038Q2Mpi dual mono DAC HAT + ESS controller + I/V board



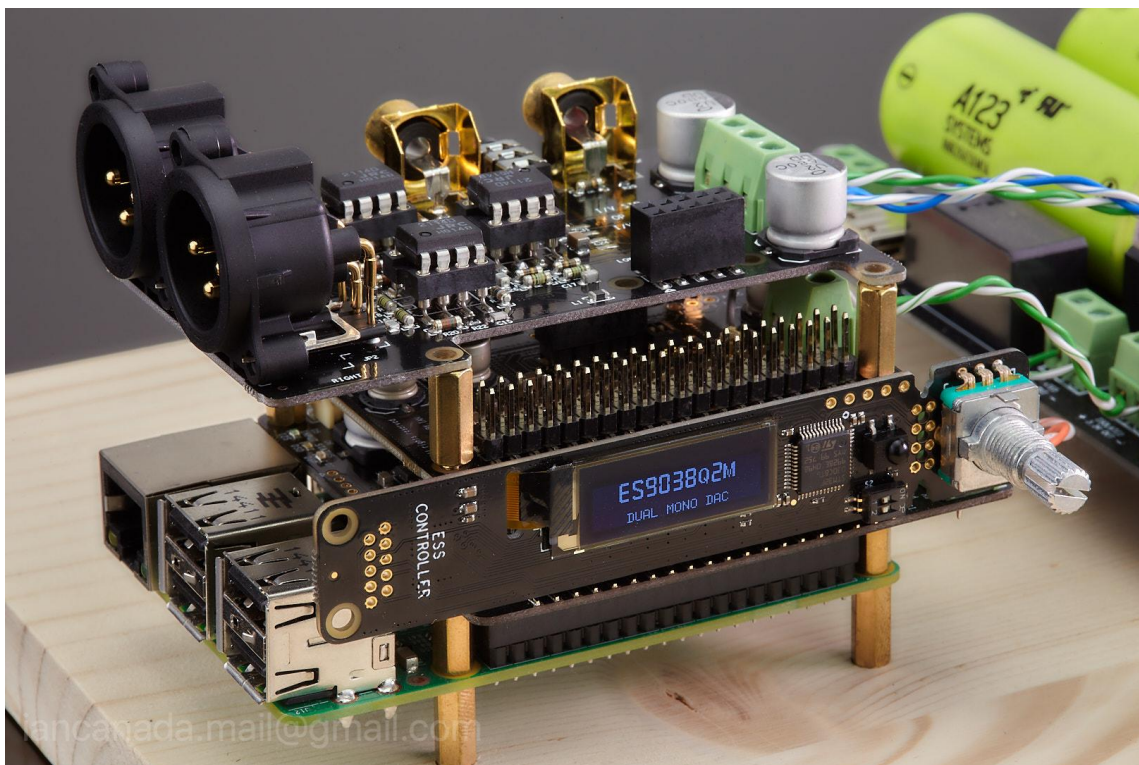
3. Run it at isolated asynchronous mode

Raspberry Pi + IsolatorPi II + ESS controller + ES9038Q2Mpi dual mono DAC HAT + I/V board



4. Run this DAC HAT at synchronized mode (highly recommended)

Raspberry Pi + FifoPi + ESS controller + ES9038Q2Mpi dual mono DAC HAT + I/V board



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