Dual XO II Clock Board user guide
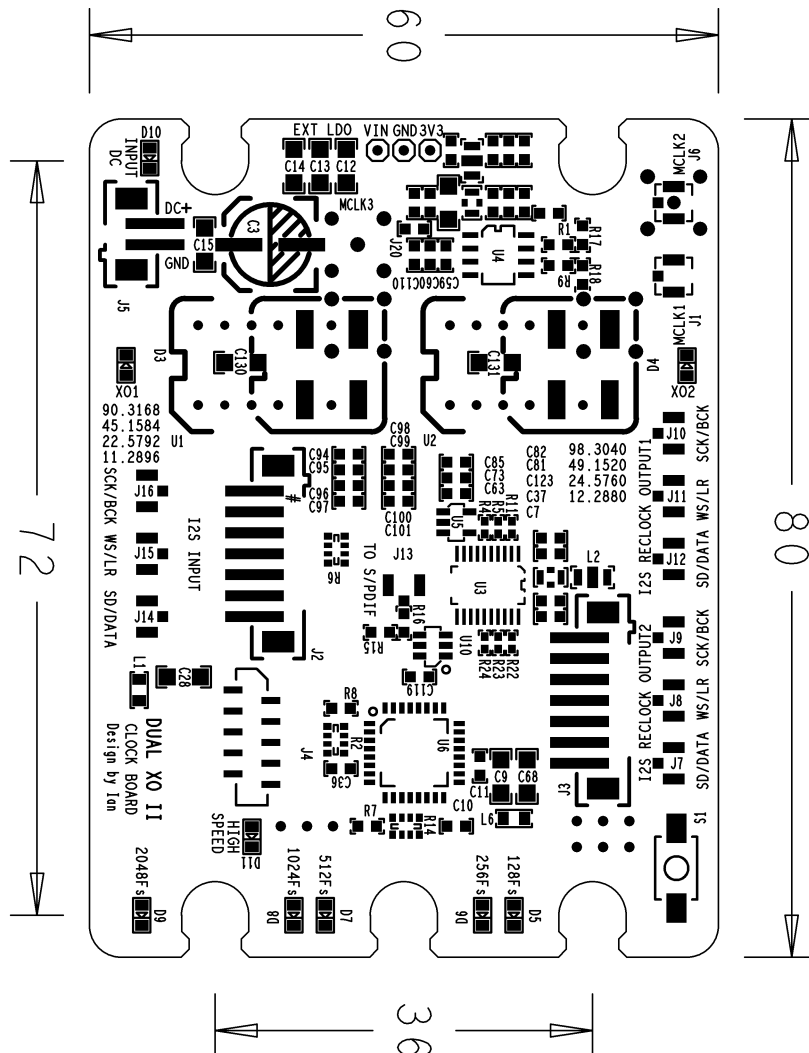
By Ian Jin and George Richardson Ver. 2.0

Description

The Dual XO II Clock Board is a multi-frequency clock board which was designed especially for the I2S FIFO I/ II KIT to improve the sound quality by employing two low jitter internal or external clock oscillators with frequency range from 11.2896MHz to 98.3040MHz. It comes with automatic Fs switching, dedicated low jitter fan-out buffers and ultra-high speed re-clocking. Four layers PCB design, enhanced bypassing/decoupling networks, impedance controlled traces and many other improvements work together to ensure outputting highest quality digital audio signals.

Features and specifications

- Multi-frequency MCLK output capability

- Automatic switching of the MCLK and Fs depending on the input I2S stream from 44.1KHz to 384KHz

- MCLK x Fs range: 128*Fs, 256*Fs,512*Fs,1024*Fs,2048*Fs

- I2S re-clocking input: LVTTL (3.3V) input level

- I2S re-clocking outputs: Two independent groups, natively support DAC in dual mono configuration
   With LVTTL (3.3V) logic output level and maximal re-clocking frequency of 600 MHz

- Power supply: open to external low-noise power supplies or battery

- Enhanced EMI filters and bypassing/decoupling networks

- New anti-vibration grommet solution

- Reserved for three point three support

- Stacking possibility

Layout and dimensions (in mm)

Connectors, sockets and button of the Double XO Clock Board

- **Three MCLK outputs:**

    J1 U.FL connector,

    J6 U.FL or SMA connector (optional),

    J20 SMA connector (optional)

- I2S re-clock input: J2, PH 2.0mm 7-pin connector, configured as:

1	2	3	4	5	6	7
GND	SCK/BCK	GND	WS/LR	GND	SD/DATA	GND

or, three U.FL coaxial cable connectors, configured as:

J16	J15	J14
SCK/BCK	WS/LR	SD/DATA

- Two groups of I2S re-clock output:

J3, PH 2.0mm 7-pin connector, configured as:

1	2	3	4	5	6	7
GND	SCK/BCK	GND	WS/LR	GND	SD/DATA	GND

Or, three U.FL coaxial cable connectors, configured as:

J9	J8	J7
SCK/BCK	WS/LR	SD/DATA

And, three U.FL coaxial cable connectors for the other group, configured as:

J10	J11	J12
SCK/BCK	WS/LR	SD/DATA

- Manual setting button: S1

Dual XO II clock board has two speed modes: NORMAL SPEED and HIGH SPEED. NORMAL SPEED is the factory default mode. Mode can be changed by the manual setting button. As well as to select XO and *Fs manually.

Manual settings	Operating
To set Dual XO II at HIGH SPEED mode	Press and hold manual button S1, *Fs LEDs will start to scan. Release S1 after D11 (HIGH SPEED) LED is turned on.
To set Dual XO II at LOW SPEED mode	Press and hold manual button S1, *Fs LEDs will start to scan. Release S1 after D11 (HIGH SPEED) LED is turned off.
To select *Fs and current XO manually (This option normally is not required, automatic Fs switching function will take over)	Press and hold manual button S1, *Fs LEDs will start to scan. During scan, At each desired *Fs, LED will flash for two times, XO1 and current *Fs will be selected if release S1 at the first time the LED turns on; or XO2 will be selected if release S1 at second time. Keep holding it for the next loop if your miss the LED.

- Two sockets for XOs: U1 and U2

Both sockets must be installed with proper XO. Standard DIP 3.3V clock oscillators with 14- or 8- pin configurations are available for U1 and U2. SMT oscillators are also available for Dual XO II with sockets non-populated (model B). For external XOs, two reserved SMA RF connectors can be used.

Speed mode has to be set correctly according to XO frequencies and I2S Fs range.   Please refer follow tables for details.

XO socket: U1

Speed mode to set *		Fs supported			
		44.1KHz	88.2KHz	176.4KHz	352KHz
XO Frequencies can be used *	11.2896 MHz	BOTH	NORMAL	Non-support	Non-support
	22.5792 MHz	BOTH	BOTH	NORMAL	Non-support
	45.1584 MHz	BOTH	BOTH	BOTH	NORMAL
	90.3168 MHz	HIGH	HIGH	HIGH	HIGH

XO socket: U2

Speed mode to set *		Fs supported			
		48KHz	96KHz	192KHz	384KHz
XO Frequencies can be used *	12.2880 MHz	BOTH	NORMAL	Non-support	Non-support
	24.5760 MHz	BOTH	BOTH	NORMAL	Non-support
	49.1520 MHz	BOTH	BOTH	BOTH	NORMAL
	98.3040 MHz	HIGH	HIGH	HIGH	HIGH

* Normally, set to HIGH SPEED mode for 90.3168/98.3040 MHz, set to NORMAL SPEED for all rest frequencies.

* XO frequencies don't have to be in pair. For example, 22.5792 MHz XO can be installed in U1, while 49.1520 MHz in U2. But need to avoid using 90.3168 or 98.3040MHz together with any lower frequency XO.

- I2S FIFO board interface: J4, 10-pin FPC/FFC 1.0mm connector, double sided contacts

- Optional DC input: J5

If there is an isolator board between Dual XO II and FIFO, You have to power the Dual XO from an independent power supply via J5. The input voltage range is DC 5V-6V. Dual XO II itself consume around 50mA current. So, 150mA can be good enough for it with two standard XOs. However, for a pair of OCXOs, power with more current will be required. That current will be calculated from the rated current of OCXOs.

When connecting to FIFO without an isolator board, please keep J5 unconnected, Dual XO II will be powered from FIFO directly. Otherwise, power supply will be shorted. If really want to power Dual XO II from an independent power supply from J5 in this case, L1 has to be removed to avoid any short circuit (this option is not

recommended).

- External 3.3V Power supply interface: VIN,GND and 3V3

External 3.3V power supply must be placed through the three pins. Low noise LDO, low voltage shunt regulator and many others are good options. You can try different solutions and pick up the favorite one according to your listing preference.

If want to power it directly by a 3.2V LifePO4 battery cell from J5 (with an isolator in your system), PIN VIN and PIN 3V3 have to be short by a jumper.

LED indicators

- Power supply indicator: D10, indicating 3.3V power supply is good when lit.

- XO indicators:

D3, indicating XO1(U1) is in using currently

D4, indicating XO2(U2) is in using currently

- Speed mode indicator: D11, indicating Dual XO II is in HIGH SPEED mode when lit. Otherwise, in LOW SPEED mode.
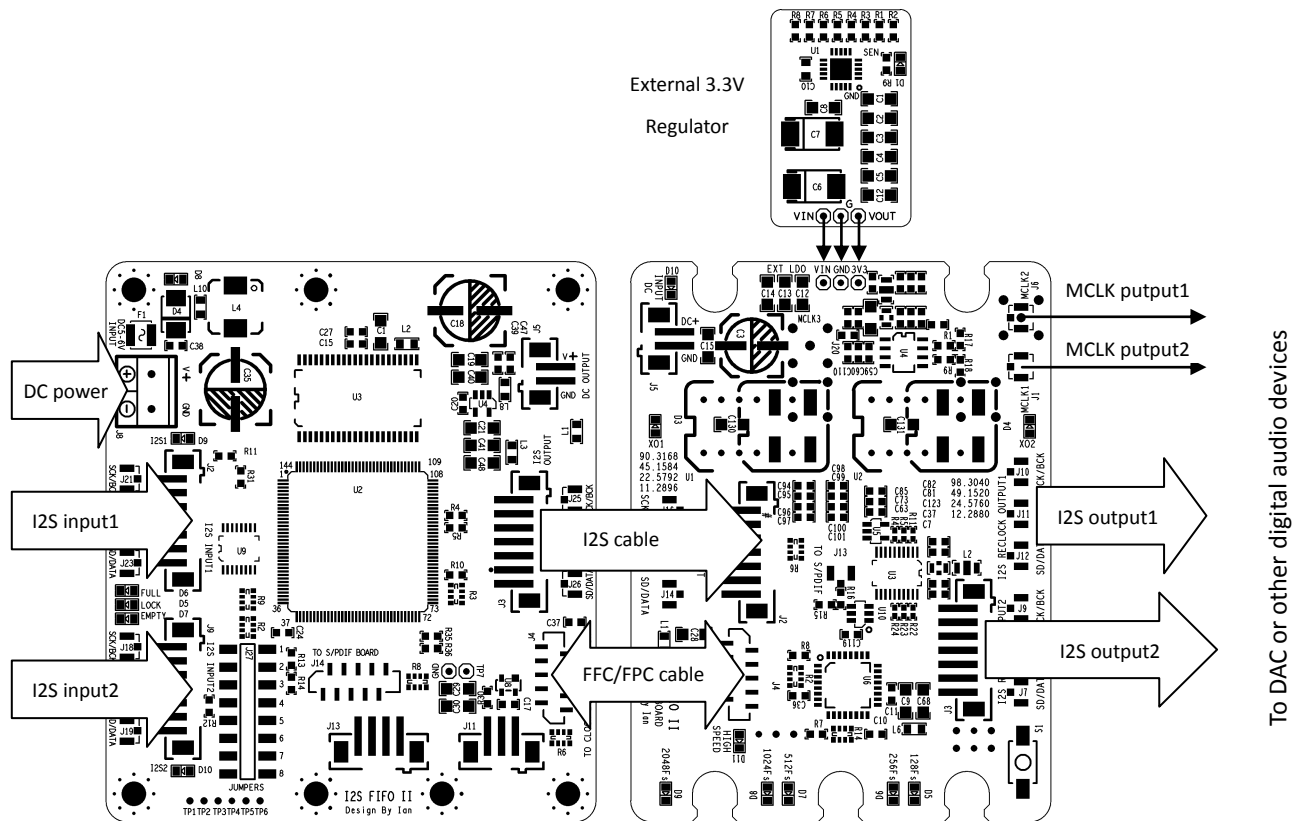
- *Fs LED indicators:

If system is running properly, one of the following Fs LED indicators will be lit to indicate current MCLK frequency is 128, 256, 512, 1024 or 2048 times of Fs.

Status of Fs LED indicators	Meanings
Only D5 (128Fs) is lit	MCLK frequency is 128 times of Fs
Only D6 (256Fs) is lit	MCLK frequency is 256 times of Fs
Only D7 (512Fs) is lit	MCLK frequency is 512 times of Fs
Only D8 (1024Fs) is lit	MCLK frequency is 1024 times of Fs
Only D9 (2048Fs) is lit	MCLK frequency is 2014 times of Fs

If none of them or more than one of them is lit, there might be some errors

Status of Fs LED indicators	Possible errors
All Fs indication LEDs are off	FIFO doesn't receive any I2S signal.
Both 128Fs and 2048Fs LEDs are solid lit (might be together with one another)	Input I2S signal is in invalid audio frequency, for example, Fs is 32KHz.
All Fs indication LED are lit or flashing at high speed	Input I2S signal is not supported by current XO, For example, you are playing 384KHz I2S signal, but you installed a 24.5760 MHz XO in socket U2.

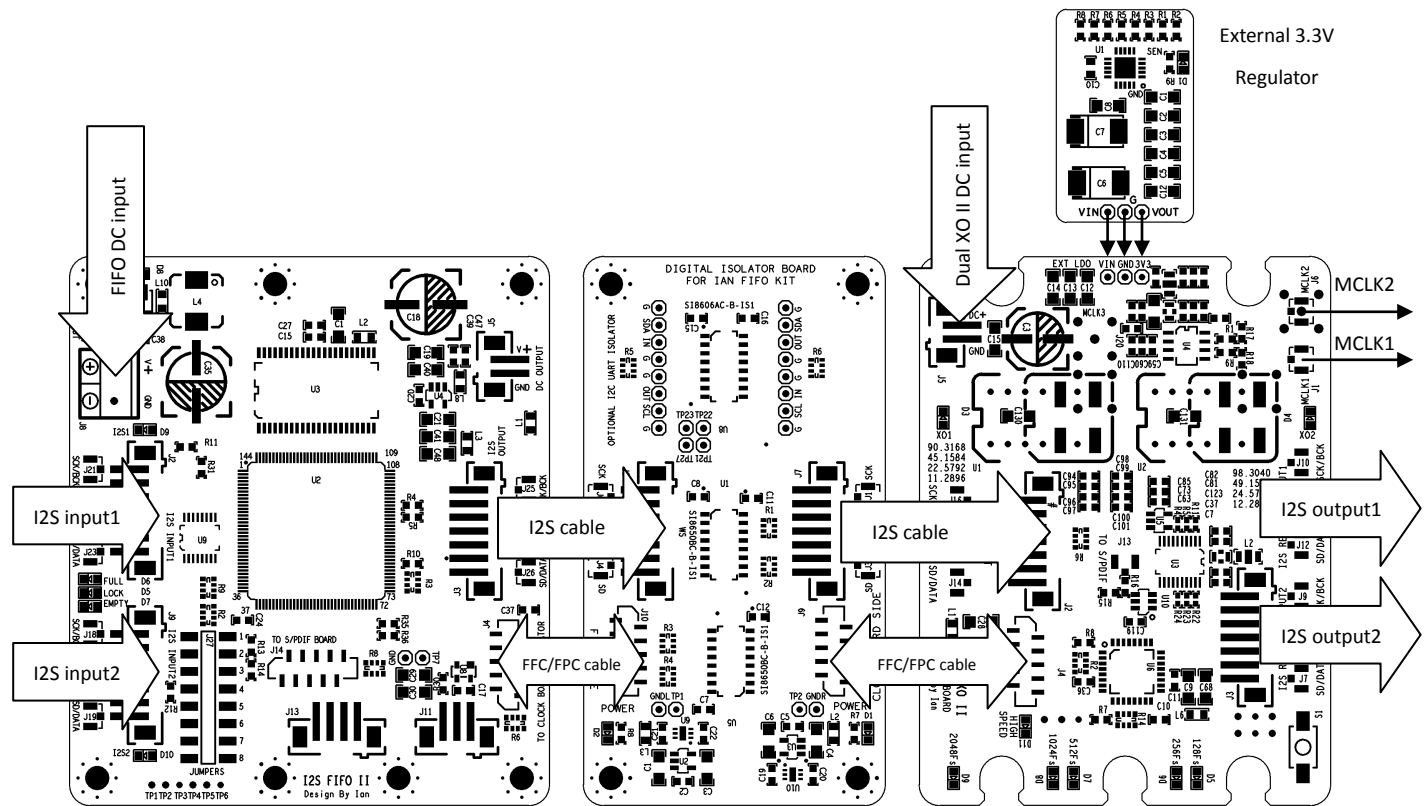## Using Dual XO II clock board directly with a FIFO KIT

* Please keep J5 un-connected on Dual XO II, clock board will be powered by FIFO board in this case

* You can use U.FL cables for I2S RECLOCK OUTPUT1 or PH2.0 cable for I2S RECLOCK OUTPUT2.

Functionally they are equivalent. However, to work with dual mono DACs, U.FL cables with same length would be

highly recommended for both of the I2S output ports.

Using Dual XO II clock board with a FIFO KIT through an isolator board

* Please connect power supply of clock board to J5 of Dual XO II in this case

* You can use U.FL cables for I2S RECLOCK OUTPUT1 or PH2.0 cable for I2S RECLOCK OUTPUT2.

Functionally they are equivalent. However, to work with dual mono DACs, U.FL cables with same length would be

highly recommended for both of the I2S output ports.

* This is the recommended, "full feature" configuration.

KIT includes

- One assembled and tested Dual XO Clock Board (4 layers, double-sided SMT mounting)

- One 6" double-ended U.FL coaxial cable for MCLK output

- One 4" double-ended PH 2.0 mm 7-pin I2S bridge cable

- One 4" 10-pin FPC/FFC cable

- One 2P Ph2.0 power cable

- One 1P double-ended LDO bypass jumper

- 45.1584MHz and 49.1520MHz clock oscillators come installed on model A (XO sockets populated version) for function verification

Application notes and tips

- Selection of the XOs

The FIFO itself does not improve the sound, the clocks do.   Selecting a pair of really nice low jitter clocks for the Dual XO II Clock board is very important.   The two XO clock oscillators supplied with the board (model A) are just generic ones.   It is strongly recommended to replace them with better clocks to boost the sound quality. The CCHD-957 series XO oscillators from Crystek have been tested and found to be a good choice at a reasonable price.   OCXOs with similar or better phase noise performance are highly recommended.   Trying different clock oscillators for better sound is an interesting experience.

- Enable pin of the XOs

Many XO oscillators have an enable pin (normally it's pin1 for oscillators with 14- or 8- pin configurations).   The output is enabled when the pin is high (> 0.7×Vcc) or open.   The output is disabled (High-Z) when the pin is low. If a particular XO is not being selected for MCLK output, the control signal from the socket disables the XO by driving the enable pin low.   Usually this does not present a problem because switching between states is very fast.   However, some XOs take longer to switch.   For example, the Crystek CCHD-957 takes 1 ms.   That delay will generate a little switching noise on some DACs.   This problem can be solved in one of the following ways:

1. Use the optional SILENCE signal from J12 on the I2S FIFO BOARD to mute the DAC output during the moment of switching;

2. Or just leave the enable pin of that XO open without connecting into the socket.

- XO frequency and the sound

For a given Fs, different XO frequency may make DAC sounding slightly different. It was caused by internal digital filter configuration and has nothing to do with jitter. For example, to play a 44.1 KHz audio stream at some DAC chip (not all), with 22.5792 MHz (512Fs) and 11.2896 MHz (256Fs) XO installed on socket U1, I found the stereo stage changed a little bit. Please select XO frequency according to your personal preference. This case is not applied to the S/PDIF interface.

- Be aware that connecting the XO into the socket incorrectly may damage the XO. Make sure the pin position is correct (pin 1 faces the angled corner).

- Potentials of generic clock oscillators

For some generic clock oscillators, the internal crystal may not be that bad. The problem is usually that generic oscillators do not have a well designed power supply and clock driver.   In many cases, if fed with a high quality, low noise power supply and interfaced with a low jitter output buffer, they will perform better than originally.

- XO warm-up time

Please keep in mind that all of XO oscillators need warm-up time before really going sweet after power up, from a couple of minutes to half hour (even longer for some of them). So please wait for a while before you making any evaluation.

- External Regulator Solutions

When using a power source other than a 3.2V LiFePO4 battery cell (discussed below) an external 3.3V regulator must be connected to VIN, GND, and 3V3 on the Dual XO II Clock Board. The external regulator will significantly change the sound quality of the Dual XO II Clock Board. Careful selection of this regulator is required according to personal preference. Please note that generally, when choosing a regulator, one that performs well in an audio amplifier may not be a good candidate to power an oscillator. A good oscillator power

supply needs not only very low noise, but also must maintain that performance in high-frequency RF/VCO applications. Some of the possible regulator solutions are:

1, TPS7A4700 low-noise LDO board (recommended)

This LDO board has been determined to be one of the best ways so far to power the Dual XO II Clock Board. Although the LDO board can plug into the 3P SIP socket, it is preferable to solder it directly to the pins once you have determined to use it permanently. The TPS7A4700 regulator board can be placed either vertically or horizontally on the Dual XO II Clock Board.

The six output capacitors on the right side of the LDO board affect the sound of the Dual XO II Clock Board significantly. Changes and improvements can be made with different capacitors.

2, Third-party 3-pin "discrete" regulator boards

Many candidates are available, but be sure that the output current is sufficient to power the Dual XO II Clock Board, especially when works with OCXOs.

3, Shunt regulators

Any 3.3V shunt regulator works for Dual XO II. Some of them were reported good results.

4, Standard TO220-3 3.3V IC

A standard 3-pin LDO, such as an A78M33, will work and is pin-to-pin compatible with VIN, GND, and 3V3. This is not recommended, however, because of poor noise performance. The datasheet for the TI uA78M33, for example, indicates that the regulator may have as much as 200µV of noise.

- Battery power direct from a 3.2V LiFePO4 cell

To use direct battery power, the Dual XO II Clock Board must be used with an isolator board.

Steps to use a battery:

(1) Short VIN and VOUT with a jumper from the KIT

(2) Connect a 3.2V LiFePO4 battery (i.e., a single cell or multiple cells in parallel) using the battery management board (available separately) to DC input connector J5.

In this case, half of the isolator board will be powered by the same 3.2V battery automatically via the 10P FFC/FPC cable on J4. Usually it is not necessary to remove or bypass the LDO on the isolator board because most of the LDOs tested were able to power half of the isolator with a 3.2V input, although the LDO output will be a bit lower than 3.2V.

- Optional capacitors for bypassing islands

There are two reserved bypassing islands on Dual XO II. One is on the top side of PCB with eight 0603 SMT

capacitor footprints, which are C94, C95, C96, C97, C98, C99, C100, C101. The other one is on the bottom side of the PCB with four 0603 and two 1206 SMT capacitor footprints, which are C90, C91, C92, C93 and C88, C89. Assembling all or part of those capacitors may still have some potential to improve power supply quality. Recommended (but not limited to): 1000P or 0.1u NP0/C0G MLCC for 0603, 4.7u-20u X7R MLCC for 1206.

- Work with external oscillators

The two reserved SMA sockets on U1 and U2 work for connecting external oscillators. Dual XO II model B, which has XO sockets un-populated, is recommended for this application. If want to use both XO and SMA sockets, SMA sockets have to be assembled in advance at bottom side of PCB, and then the two XO sockets at top side.

-Driving a Dual-Mono DAC

The Dual XO II Clock Board was designed natively to support DACs operating in a dual-mono configuration. For a dual-mono DAC, it is highly recommended that the two sets of signals are connected to the DAC with 50Ω U.FL coaxial cables. The cables must be of the same length so that both sets of signals arrive at same moment. This is because every inch of cable causes a delay of roughly 120ps! (assuming the cable's velocity of propagation is .7C). In this case, U.FL sockets for the second group of I2S output have to be mounted on footprints of J7, J8, and J9.

- Anti-vibration solution:

Anti-vibration grommet or other anti-vibration solution is highly recommended to Dual XO II clock board. Both four points and three points support can be used. Anti-vibration screw grommet set can be sourced from DigiKey, such as 767KE-ND. Pick up the correct part number to match your standoff.