FEATURES

- **Up to 384kHz PCM sampling frequency**
- **Up to 32 bits PCM resolution**
- **DSD up to 256x**
- **DoP or native DSD**
- **USB 2.0 Audio Class device**
- **Bit-perfect, asynchronous transfer**
- **Low jitter on-board oscillators**
- **Kernel Streaming, WASAPI, ASIO and direct sound operation (Windows)**
- **Float and Integer mode (OSX)**
- **Compatible with Windows XP, Vista, 7, 8 and 8.1 (32 and 64 bits)**
- **Compatible with MacOS (10.6.5 and later)**
- **Compatible with Linux**
- **Accepts all common high-quality files' sampling frequencies: 44.1, 48, 88.2, 96, 176.4, 192, 352.8 and 384kHz, as well as DSD64 and DSD128**
- **LVCMOS I^{2}S output**
- **5V or 3.3V/1.8V supply**
- **5V bus supply option**
- **Small form factor (55.9 x 36.2 mm)**
- **Hardware, I2C or UART control interface**

APPLICATIONS

- **High performance audio USB input for DAC's, streaming players, class-D amplifiers**
- **USB-to-S/PDIF or USB-to AES-EBU adaptors**

DESCRIPTION

M2TOEM-04 is a high performance USB-to I^{2}S converter which allows for asynchronous audio transfer from a computer provided with an USB 2.0 or 3.0 port to a digital audio device or equipment provided with I^{2}S/DSD interface.

Depending on the version, M2TOEM-04 operates up to 384kHz, 32 bits and DSD256.

No specific programming skills are required to integrate M2TOEM-04 in an existing or new design. All the software, firmware and microcode is provided either in the IC's used on the board or as drivers.

Two strip connectors carry all I^{2}S, supply and control signals for an easy integration on a motherboard.

Various supply options allow for different layouts: M2TOEM-04 can be directly powered by the USB bus itself or various external supply layouts can be implemented.

Depending on the version , control signals or interface peripherals (I^{2}C or UART) carry information about interface status, base clock selection and multiplication factor (x1, x2, x4 and X8). Also, mute/reset and "DSD present" signals are available.

Low-capacity high speed protection on USB bus lines allow for easy CE marking. USB connector chassis can be earthed or grounded by means of a plated hole on the PCB.
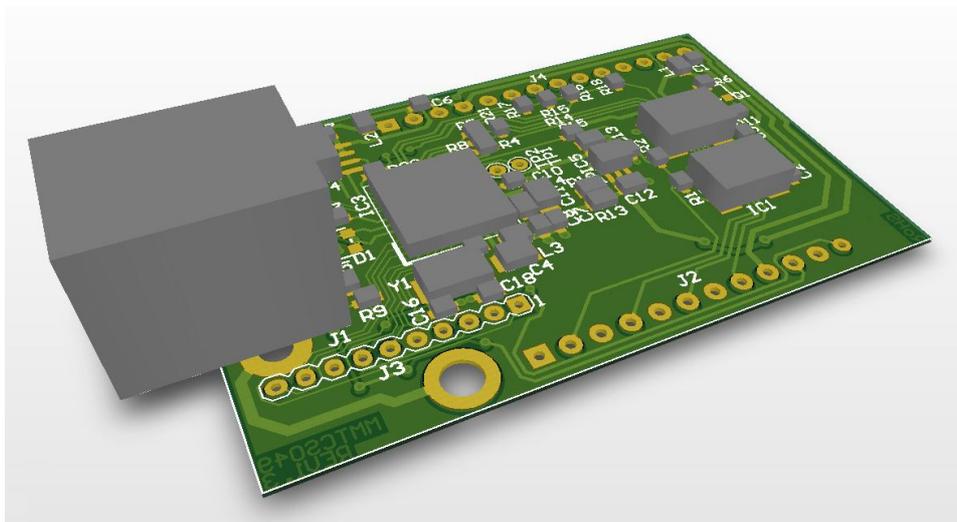
ORDERING INFORMATION[1]

Compose the part number following the indications below.

M2TOEM-04 - s - f - d - h

s - supply option:
  B = bus powered
  E5 = external 5V or bus powered with external filter
  E3 = external 3.3V
  O3 = external 3.3V with separate 3.3V supply for oscillators

f - PCM sampling frequency:
  1 = 44.1 to 192kHz
  3 = 44.1 to 384kHz

d - DSD option:
  DOP = DSD is passed though as DoP
  DSD = DSD is delivered in native format (DATAL, DATAR, DSDCLK)

h - host interface:
  H = hardware pins
  I = I2C
  U = UART

Example: part number for version powered with external 3.3V, handling up to 384kHz, delivering DSD in native format and communicating with the host by a UART is: M2TOEM-04-E3-3-DSD-U.

Example: part number for a version compatible with M2TOEM-01-1 is: M2TOEM-04-B-1-DOP-H.

(1) All versions are RoHS compatible.

ABSOLUTE MAXIMUM RATINGS [1]

over operating free-air temperature range (unless otherwise noted)

			UNIT
Supply voltage range (with respect to GND)	5V$_{IN}$		5.5V
	3.3V$_{IN}$		3.63V
Output current	any output pin		10mA
T$_A$ Operating free-air temperature range			0°C to 60°C
T$_j$ Junction temperature range			0°C to 70°C
T$_{stg}$ Storage temperature			-40°C to 125°C

(1) Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the devices on the board. These are stress ratings only, and functional operation of the devices on the board at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect board reliability.

RECOMMENDED OPERATING CONDITIONS

	MIN	NOM	MAX	UNIT
5V$_{IN}$ (M2TOEM-04-B-x-x-x and M2TOEM-04-E5-x-x-x)	4.5	5	5.5	V
3.3V$_{IN}$ (M2TOEM-04-E3-x-x-x and M2TOEM-04-O3-x-x-x)	3.0	3.3	3.6	V
OSCV$_{IN}$ (M2TOEM-04-O3-x-x-x)	3.0	3.3	3.6	V
Operating junction temperature range, T$_j$	0		70	°C

ELECTRICAL CHARACTERISTICS

T$_j$ = 0°C to 60°C and recommended supply voltage range (unless otherwise stated)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
I$_{CC}$	M2TOEM-04-E5-x-x-x Bus connected			TBD	mA
	M2TOEM-04-E5-x-x-x No bus			TBD	mA
I$_{CC33}$	M2TOEM-04-E3-x-x-x Bus connected			TBD	mA
	M2TOEM-04-E3-x-x-x No bus			TBD	mA
	M2TOEM-04-O3-x-x-x Bus connected			TBD	mA
	M2TOEM-04-O3-x-x-x No bus			TBD	mA
I$_{CCOSC}$	M2TOEM-04-O3-x-x-x			30	mA
V$_{OH}$	I^{2}S, MCLK pins	2.9			V
	All pins except I^{2}S, MCLK, I$_{OUT}$=4mA	2.4			V
V$_{OL}$				0.4	V
MCLK		22.5972		24.576	MHz
SCLK	M2TOEM-04-x-1-x-x	2.8224		12.288	MHz
	M2TOEM-04-x-3-x-x	2.8224		24.576	MHz
LRCK	M2TOEM-04-x-1-x-x	44.1		192	kHz
	M2TOEM-04-x-3-x-x	44.1		384	kHz
DSDCLK	M2TOEM-04-x-1-DSD-x		2.8224		MHz
	M2TOEM-04-x-3-DSD-x	2.8224		5.6448	MHz
Baud Rate	M2TOEM-04-x-x-x-U		115200		bps
SCL	M2TOEM-04-x-x-x-I		100		kHz

J2 PIN DESCRIPTION

PIN	TYPE	NAME	FUNCTION
1, 3, 5, 7, 11	Power	GND	Ground return for high speed signals
2	Output	MCLK	Master clock from on-board low-jitter oscillators
4	Output	SCLK/DSDCLK	I^{2}S Bit clock or DSD clock[1]
6	Output	LRCK/SDATAR	I^{2}S Sampling frequency or DSD data right[1]
8	Output	SDATA/SDATAL	I^{2}S Serial Data[1]
9	-	RESERVED	Internal 3.3V, **do not connect**
10	-	RESERVED	Reserved, **do not connect**
12	Hi-Z	#RST	Board reset, drive with open collector

(1) DSD interface available on M2TOEM-04-x-x-DSD-x versions only

J4 PIN DESCRIPTION

PIN	TYPE	NAME	FUNCTION
3, 5, 11, 14	Power	GND	Ground return for supply and low speed signals
1	Power	5V$_{BUS}$	Bus 5V output
2	Power	5V$_{IN}$	External 5V input [1]
4	Power	3.3V$_{IN}$	External 3.3V input [1] [2]
6	Output	MUTE-DSD	Mute/no data signal or DSD detected[4], active high
7	Output	CLKSEL1-SDA-TX	Fs multiply factor MSB or I2C SDA or UART TX[5][8]
8	Output	CLKSEL0-SCL-RX	Fs multiply factor LSB or I2C SCL or UART RX[6][8]
9	Output	#RESET	Reset signal for external devices, active low
10	Output	24/22	Indicates which oscillator is selected[7]
12	-	NC	Not connected
13	Power	OSCV$_{IN}$	External oscillator power input[1] [2] [3]

(1) Leave unconnected on M2TOEM-04-B-x-x-x.
(2) Leave unconnected on M2TOEM-01-E5-x-x-x.
(3) Leave unconnected on M2TOEM-01-E3-x-x-x.
(4) MUTE signal on M2TOEM-04-x-x-DOP-H versions, DSD signal on M2TOEM-04-x-x-DSD-H versions
(5) CLKMUX1 signal on M2TOEM-04-x-x-x-H versions, SDA signal on M2TOEM-04-x-x-x-I versions, TX signal on M2TOEM-04-x-x-x-U versions
(6) CLKMUX0 signal on M2TOEM-04-x-x-x-H versions, SCL signal on M2TOEM-04-x-x-x-I versions, RX signal on M2TOEM-04-x-x-x-U versions
(7) Available on M2TOEM-04-x-x-x-H version only
(8) An external 2K2 pull-up is required
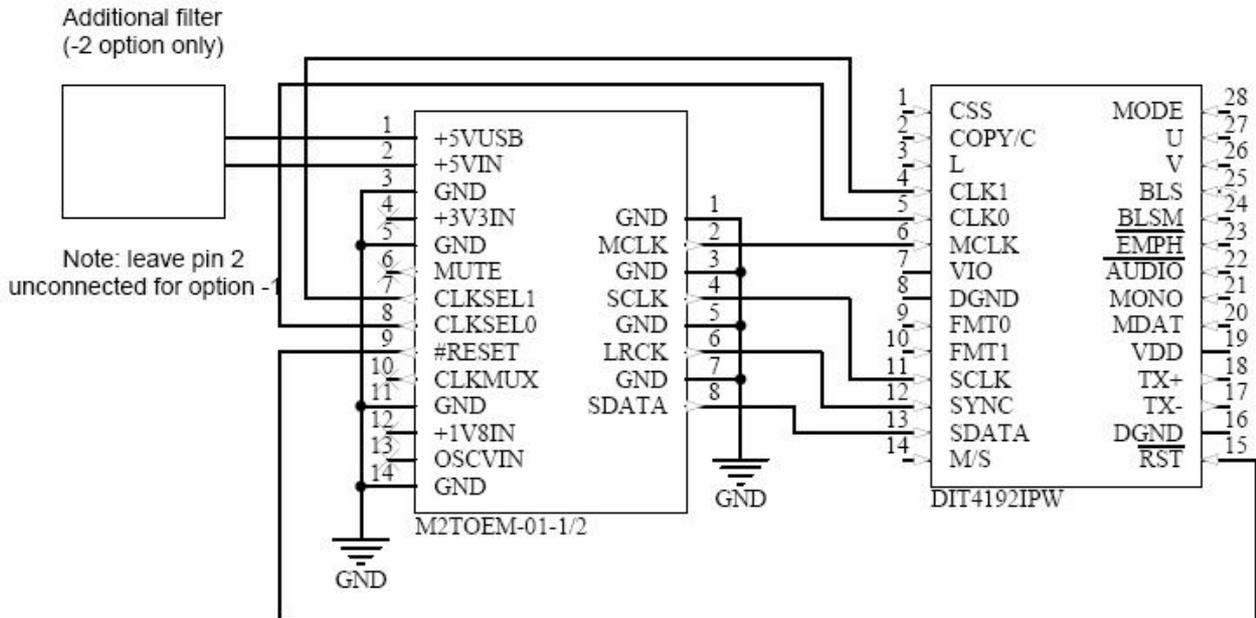
TYPICAL APPLICATION CIRCUITS

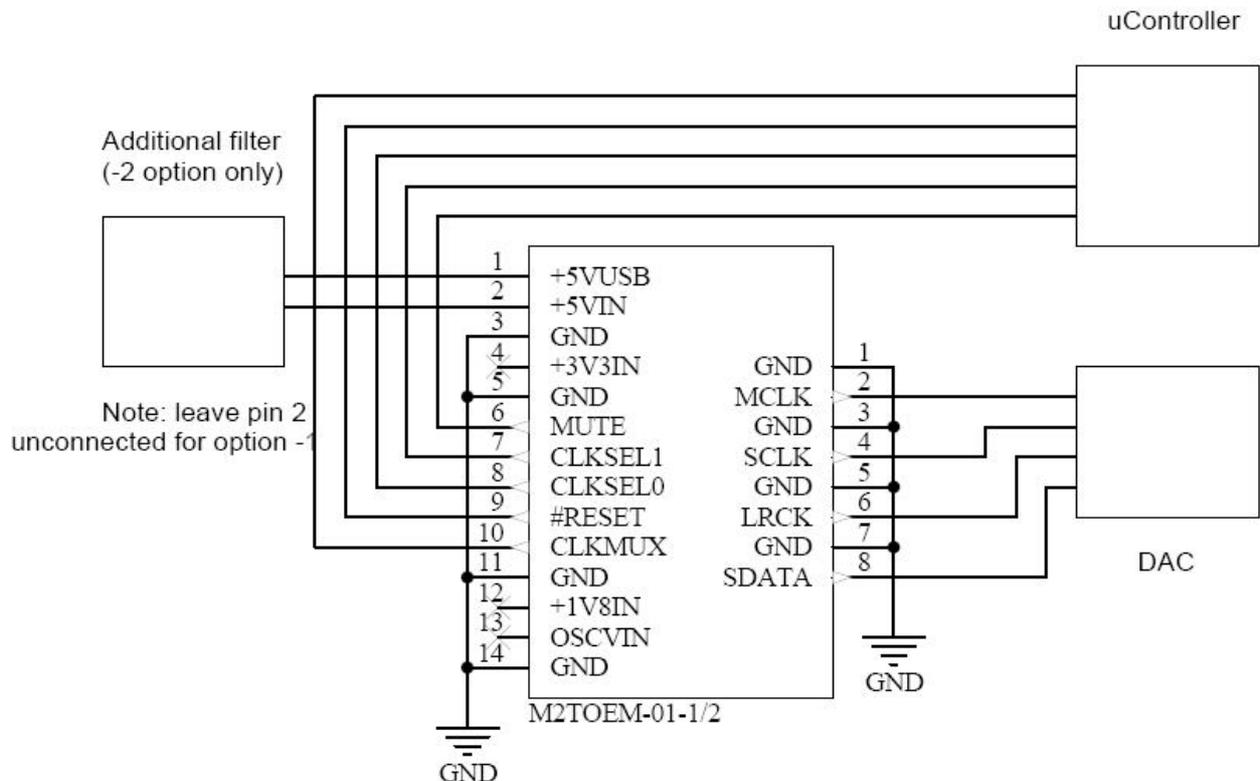**Figure 1. Standalone USB-S/PDIF adaptor**

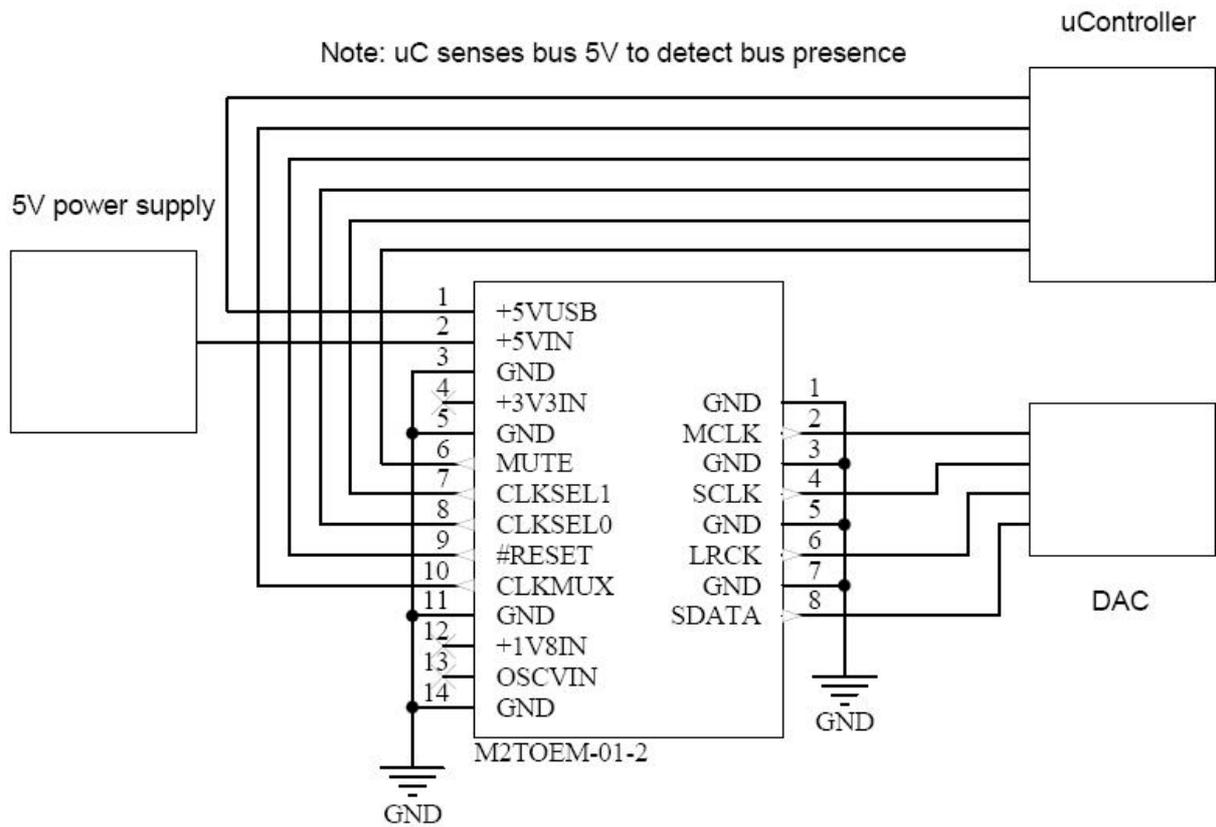**Figure 2. Bus powered USB interface for D-to-A converter**

Figure 3. 5V-powered USB interface for D-to-A converter (3.3V LVCMOS outputs)
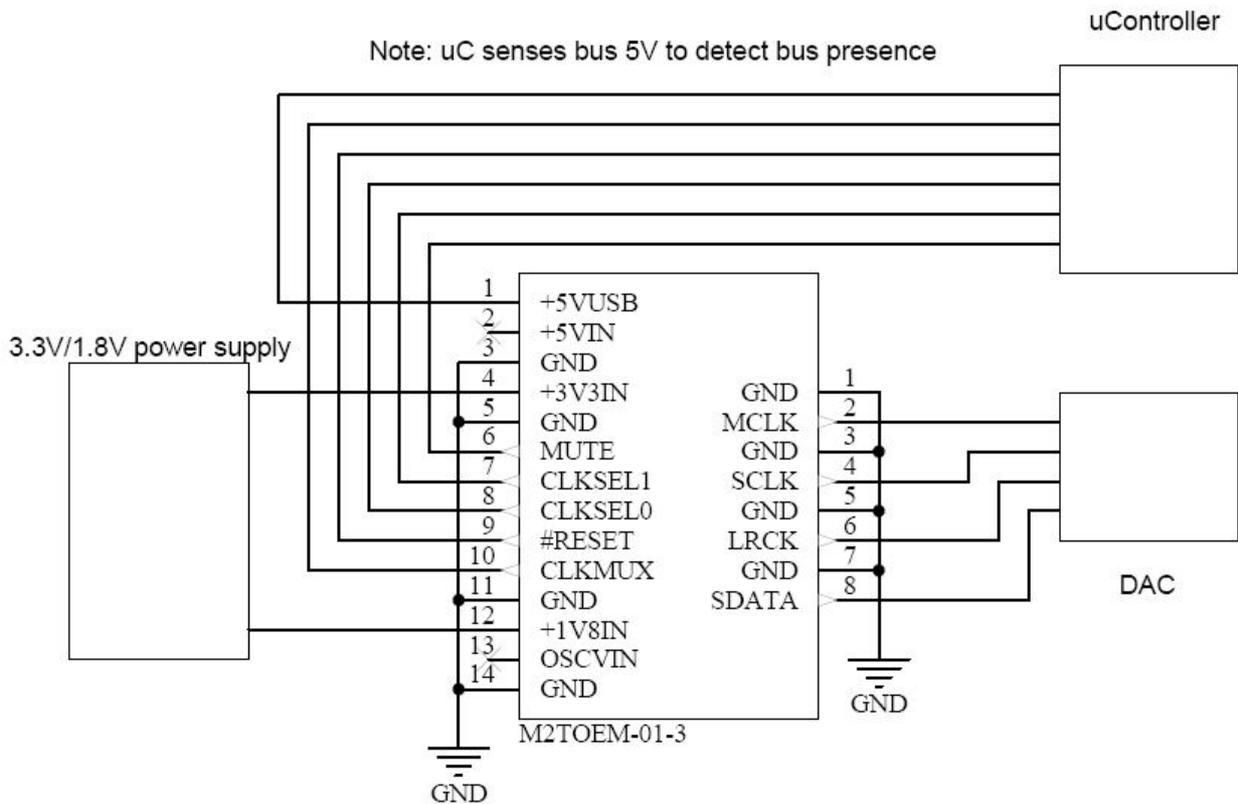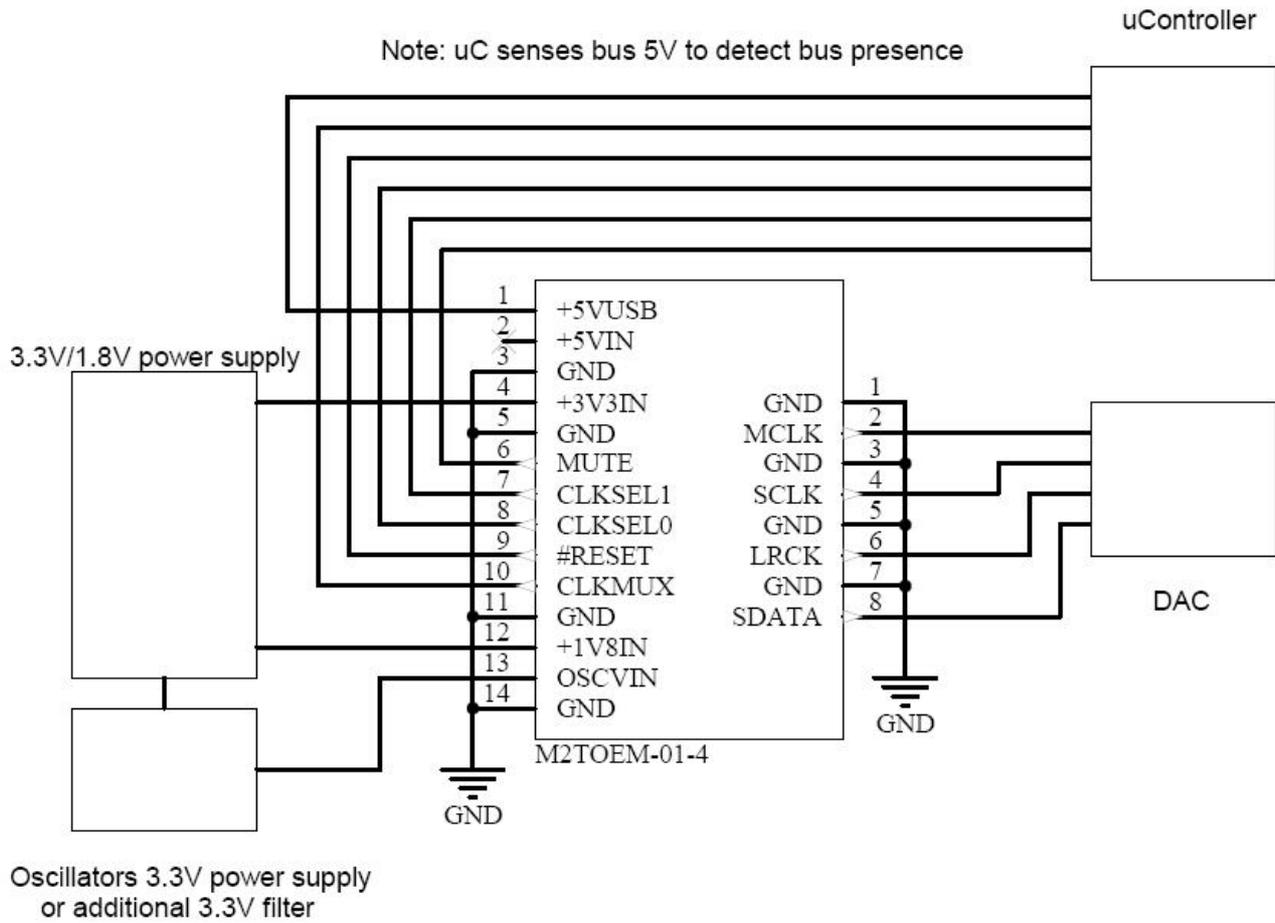

Figure 4. 3.3V-powered USB interface for D-to-A converter

Figure 5. 3.3V-powered USB interface with filter or separate supply for oscillators

APPLICATION INFORMATION

The I²S output of M2TOEM-04 is always active, regardless of the state of the bus (connected or not connected). Upon reset, the output interface sets for 44.1kHz. Subsequent playback of files with different sampling frequency causes the interface parameters to change accordingly.

CLKSEL[1..0] indicators and MCLK/LRCK ratio for M2TOEM-04-x-x-x-H versions

The relationship between MCLK and LRCK is indicated by CLKSEL[1..0] as reported by the following table (format is compatible with TI digital audio transmitter DIT4192 settings for sampling frequencies up to 192kHz):

CLKSEL[1..0]	MCLK/LRCK ratio
00	128
01	256
10	64 (M2TOEM-04-x-3-x-H versions only)
11	512

Table 1. Clock multiplication ratios

Example: when a 44.1kHz file is played back, CLKSEL[1..0] are 11, because MCLK frequency is 22.5792MHz (22579.2/44.1=512).
CLKSEL[1..0] can be used to indicate to a DAC or a uController which frequency is used at the moment, or to drive a multiplexer/divider should MCLK be too high at low sampling rates.

CLKMUX indicator and oscillator selection for M2TOEM-04-x-x-x-H versions

Two high precision, low jitter oscillators are used on M2TOEM-04. Depending on the sampling frequency of the file to be played back, one of the two oscillators must be selected. The selection is performed automatically and is indicated by CLKMUX output as reported in the following table:

CLKMUX	MCLK
0	22.5792MHz
1	24.576MHz

Table 2. Clock selection

Sampling frequency information delivered by M2TOEM-04-x-x-x-I and M2TOEM-04-x-x-x-U versions

All versions provided with serial interface, being it master I2C or UART, deliver sampling frequency information on one byte according to Table 3.

BYTE VALUE (HEX)	SAMPLING FREQUENCY (kHz)
0x01	44.1
0x02	48
0x03	88.2
0x04	96
0x05	176.4
0x06	192
0x07	352.8[1]
0x08	384[1]
0x09	DSD64[2]
0x0A	DSD128[1][2]
0x0B	DSD256

Table 3. Sampling frequency information encoding

(1) M2TOEM-04-x-3-x-I version only
(2) M2TOEM-04-x-x-DSD-I version only

A byte is sent every time the driver communicates a change in the sampling frequency. With M2TOEM-04-x-x-x-U versions, the host can query the board for sampling frequency by sending the hex value 0x00 to the M2TOEM-04.

Supply options

Depending on the option selected, M2TOEM-04 can be powered in different ways. Option -B-x-x-x is for standalone applications, such as USB-to-S/PDIF or USB-to-AES-EBU adaptors. It gets power directly from USB bus. Option -E5-x-x-x allows for external 5V supply, but can also be used for standalone application when extra filtering of USB supply is required. Options -E3-x-x-x and -O3-x-x-x are best suited to applications in which a good, clean supply is available. Option -E3-x-x-x requires 3.3V from a motherboard or an external supply board. Option –O3 allows for extra filtering of oscillator 3.3V supply to further reduce jitter.

Communication with host

Depending on version, M2TOEM-04 can deliver operation information to the host in various ways.
M2TOEM-x-x-x-H versions use an hardware interface to encode sampling frequency and, in case, format information, as well as reset or status information.
M2TOEM-04-x-x-x-I versions use a master I²C interface to communicate sampling frequency information.
M2TOEM-04-x-x-x-U versions use a UART to communicate sampling frequency information.

I²C interface (version M2TOEM-04-x-x-x-I)

When the I²C interface is chosen, the M2TOEM-04 is bus master. Whenever the sampling frequency changes, the M2TOEM-04 sends two bytes on the bus: the first one is 0x00 (slave address for broadcast transmission), the second one is a value dependent on the new sampling frequency, as detailed in Table 3.
The broadcast address (a.k.a. General Call Address) is a special address all slave devices on the bus accept. Using the broadcast address allows designers to add the board to every I2S slave device without the need to change the slave parameters, and even to add the board to a multi-master setup.

Galvanic isolation of M2TOEM-01

In certain applications it is desirable to galvanically isolate the module from the downstream circuit. This can be easily accomplished using specific IC's, like those in Analog Devices' ADuM140x and ADuM540x series, to translate high speed signals. The latter (which also include an isolated DC/DC converter) is particularly suitable to M2TOEM-04-E5-x-x-x, M2TOEM-04-E3-x-x-x and M2TOEM-04-O3-x-x-x which require an isolated supply. Check the power capability of ADuM540x modules before using them: when needed, it's possible to synchronize more than one module to obtain more power. Please visit ADI website for more details. I2C signals may be isolated using specific isolators live ADuM1251. Slow signals (CLKSEL[1..0], CLKMUX, MUTE, #RESET) may also be isolated using optocouplers.
M2TOEM-04-B-x-x-x is self-powered from the bus, therefore it doesn't require an isolated supply. In this case, either an ADuM140x or totem-pole output logic optocouplers can be used for MCLK and I2S signals.

Drivers

M2TOEM-04 is an USB 2.0 Audio Class compliant device, therefore it is natively supported by OSX (10.6.5 onwards) and Linux (with ALSA), without the need for a driver. As well, certain

players running on Android, which handle peripherals in user space mode, can access M2TOEM-04.
A driver is still required to use M2TOEM-04 under Windows. A driver can be purchased from specific software houses like Thesycon, or a standard driver provided by XMOS can be used. M2Tech provides technical support in both cases, please contact M2Tech for details.

Migrating from M2TOEM-01 to M2TOEM-04

Replacing an M2TOEM-01 with an M2TOEM-04 is quite straightforward, provided some aspects are kept into due consideration.

First of all, designer should pay attention to the different current requirements: the M2TOEM-04 requires more current on 5V and 3.3V supplies. Therefore, designs in which an M2TOEM-01-2, M2TOEM-01-3 or M2TOEM-01-4 version was used, can be updated provided the supplies can deliver the higher current to the M2TOEM-04 on 3.3V or 5V supply pins.

Host side, no compatibility is given, as the M2TOEM-04 is an USB 2.0 Audio Class compliant device, while the M2TOEM-01 is a bulk device with proprietary transport mechanism. This imply that the M2TOEM-04 doesn't need any driver for operation with Apple computers or Linux computers (provided OSX 10.6.5 or later is used with Apple computers and a recent ALSA mixer is part of the Linux Kernel), while a driver, other than the one used for the M2TOEM-01, must still be used with Windows computers. The manufacturer including the M2TOEM-04 in his designs must therefore deliver a suitable driver to customers.

Mechanically, the M2TOEM-04 has same form factor and pinout as the M2TOEM-01. The only difference is the lack of the non-plated hole in the M2TOEM-04 PCB.

The equivalence table below gives customer support for choosing the right M2TOEM-04 version as a replacement for an M2TOEM-01 board.

M2TOEM-01	M2TOEM-04
-1	-B-1-DOP-H
-2	-E5-1-DOP-H
-3	-E3-1-DOP-H
-4	-O3-1-DOP-H

Table 4. Equivalence between M2TOEM-01 and M2TOEM-04

MECHANICAL DATA
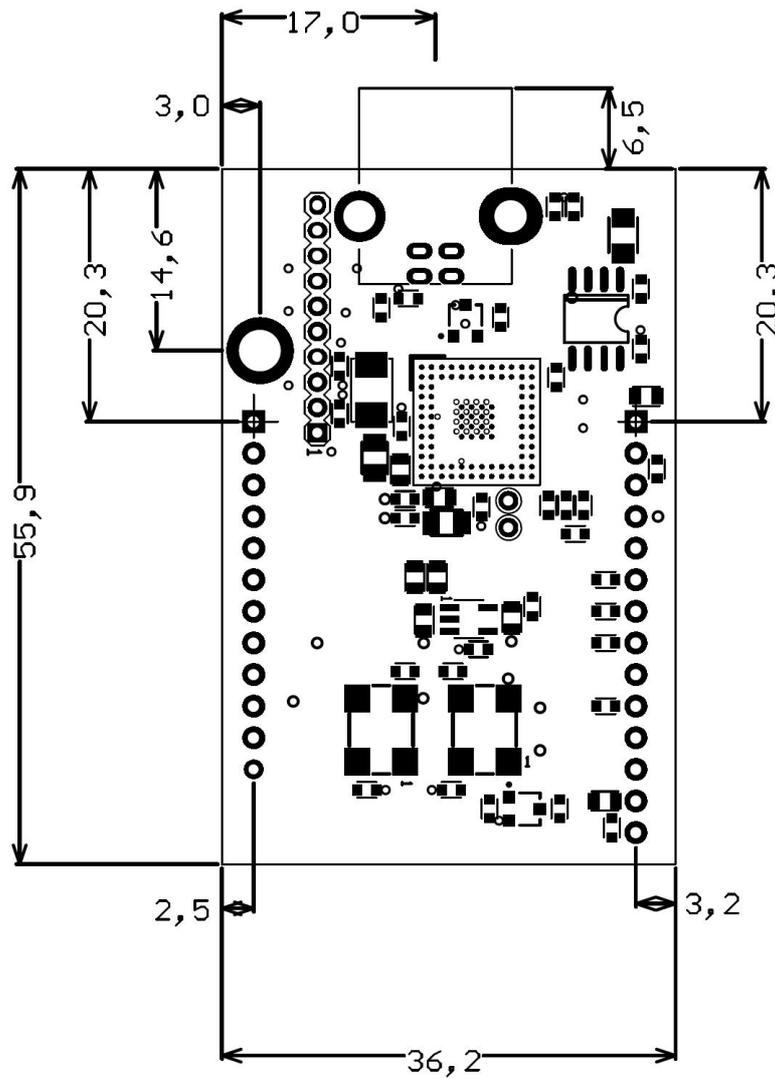
All sizes in millimeters

IMPORTANT NOTICE

M2Tech Srl (M2Tech) reserves the right to make corrections, modifications, enhancements, improvements,
and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to M2Tech's terms and conditions of sale supplied at the time of order acknowledgment.

M2Tech warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with M2Tech's standard warranty. Testing and other quality control techniques are used to the extent M2Tech deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

M2Tech assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using M2Tech components and boards. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

M2Tech does not warrant or represent that any license, either express or implied, is granted under any M2Tech patent right, copyright, mask work right, or other M2Tech intellectual property right relating to any combination, machine, or process in which M2Tech products or services are used. Information published by M2Tech regarding third-party products or services does not constitute a license from M2Tech to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from M2Tech under the patents or other intellectual property of M2Tech.

Reproduction of M2Tech information in M2Tech data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. M2Tech is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of M2Tech products or services with statements different from or beyond the parameters stated by M2Tech for that product or service voids all express and any implied warranties for the associated M2Tech product or service and is an unfair and deceptive business practice. M2Tech is not responsible or liable for any such statements.

M2Tech products are not authorized for use in safety-critical applications (such as life support) where a failure of the M2Tech product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of M2Tech products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by M2Tech. Further, Buyers must fully indemnify M2Tech and its representatives against any damages arising out of the use of M2Tech products in such safety-critical applications.

M2Tech products are neither designed nor intended for use in military/aerospace applications or environments unless the M2Tech products are specifically designated by M2Tech as military-grade or "enhanced plastic." Only products designated by M2Tech as military-grade meet military specifications. Buyers acknowledge and agree that any such use of M2Tech products which M2Tech has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

M2Tech products are neither designed nor intended for use in automotive applications or environments unless the specific M2Tech products are designated by M2Tech as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, M2Tech will not be responsible for any failure to meet such requirements.

Mailing address: M2Tech Srl, Via Carlo del Prete, 2, I-56121 Pisa (PI) Italy
Copyright © 2014-2017 M2Tech Srl