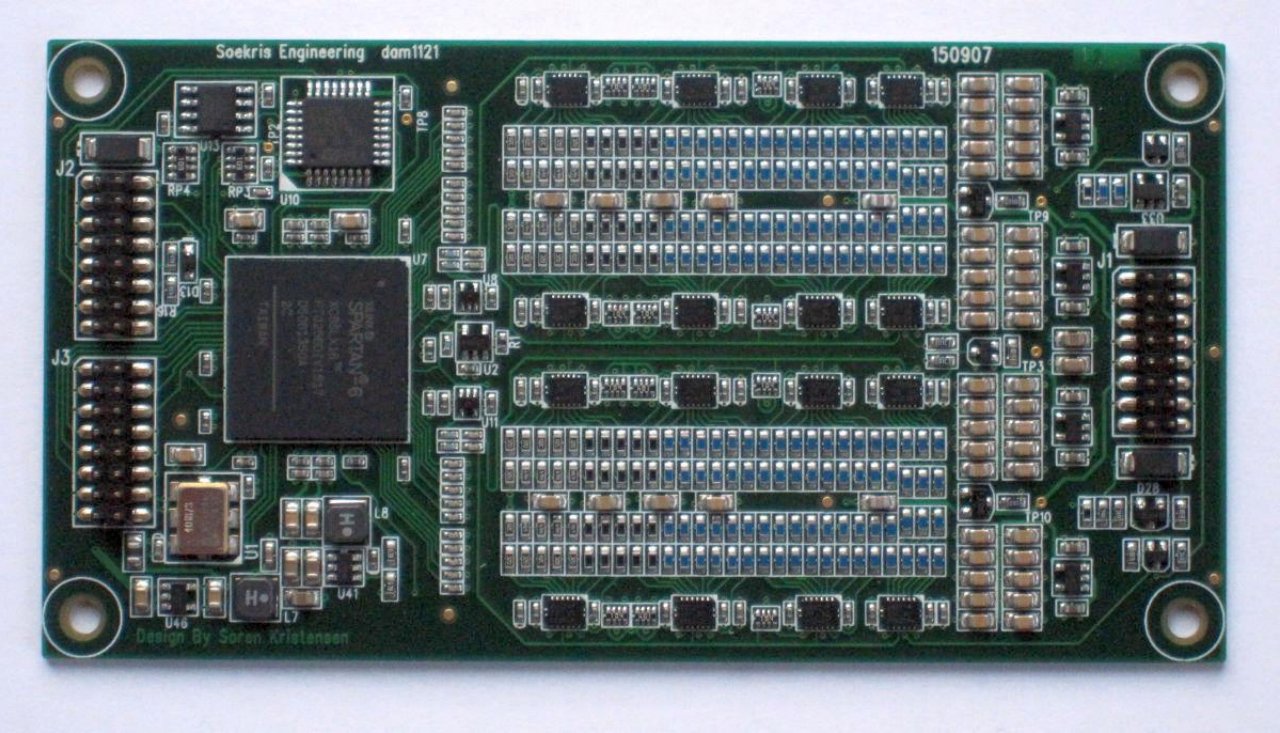
# Discrete R-2R Sign Magnitude DAC Module



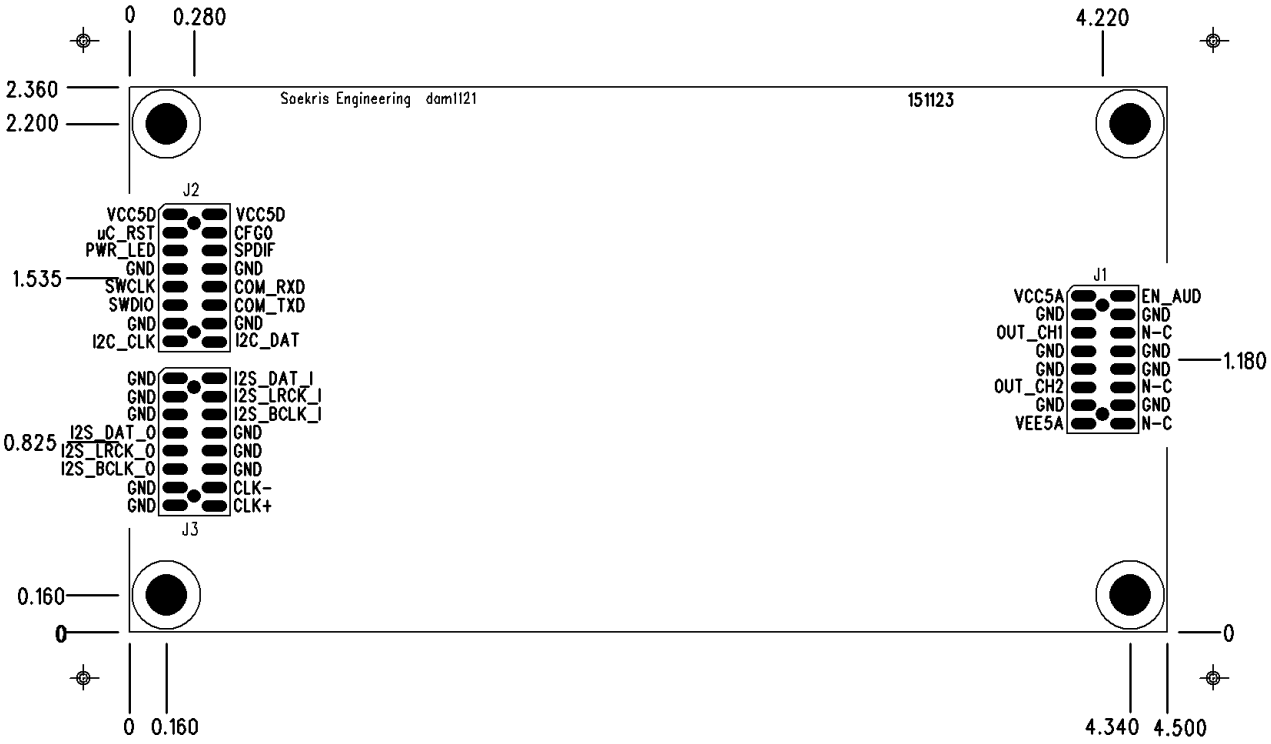

The Soekris dam1121 discrete R-2R Sign Magnitude DAC is a small OEM module with absolute highest sound quality, designed to be integrated in all kinds of audio products. Input is I2S and SPDIF, with reclocking FIFO. Clocking is with low jitter digital programmable oscillator, either on board or off board. Multiple board can be syncronized for balanced or multichannel use. The board is manufactured in Denmark using high reliability advanced surface mount technology.

## Quick Specifications

| Product Name | **dam1121-01** | **dam1121-02** |
|---|---|---|
| THD @ -1db | < 0.006 % | < 0.008% |
| THD @ -60dB | < 0.03 % | < 0.05% |
| Clock Jitter RMS | 0.3 pS typical | 0.8 pS typical |
| S/N ratio at 20 Khz Bandwith | 129 dB unweighted | |
| Frequency Range +0.1dB -1.0dB | 20hz - 20Khz | |
| Input SPDIF | Up to 24 bit / 192 Khz | |
| Input I2S PCM | Up to 24 bit / 384 Khz | |
| Input I2S DSD | Up to DoP128 and DSD256 | |
| Digital volume control | -80 dB to +10 dB | |
| Output Line | SE 1.4V RMS, Bal 2.8V RMS, Zout 640R | |
| Power Input | +5V max 0.4A, -5V max 0.05A | |
| Board Size | 60 x 120 x 8 mm | |

## Interface

The dam1121 signal and output connectors are three 2x8 pins 2mm male headers, is designed to be mounted directly on a mainboard with three 2x8 pins 2mm female headers, but can also be connected using headers with cables. Pinout and mechanical drawing, component side view, all measurement are in inches, connector position are to center of connectors.




## Pin Description J2

| Pin | Name | Type | Description |
|---|---|---|---|
| 1 | VCC5D | Power | +5V Digital Power 1 |
| 2 | VCC5D | Power | +5V Digital Power 2 |
| 3 | uC_RST | Input PU | Active low reset to uC, normally not used |
| 4 | CFG0 | Input | Config 0 strap pin |
| 5 | PWR_LED | Output OC | Active low, blinking when unlocked, on when locked |
| 6 | SPDIF | Input | SPDIF digital input |
| 7 | GND | Power | Ground |
| 8 | GND | Power | Ground |
| 9 | SWCLK | I/O | uC Debug connection, for factory use only. |
| 10 | COM_RXD | Input | uC Control serial data out, 3.3V digital level |
| 11 | SWDIO | I/O | uC Debug connection, for factory use only. |
| 12 | COM_TXD | Output | uC Control serial data in, 3.3V digital level |
| 13 | GND | Power | Ground |
| 14 | GND | Power | Ground |
| 15 | I2C_CLK | I/O PU | I2C control interface for external clock generator |
| 16 | I2C_DAT | I/O PU | I2C control interface for external clock generator |

**Pin Description J3**

| Pin | Name | Type | Description |
|---|---|---|---|
| 1 | GND | Power | Ground |
| 2 | I2S_DAT_I | Input | I2S PCM Left/Right Data / I2S DSD Right Data |
| 3 | GND | Power | Ground |
| 4 | I2S_LRCK_I | Input | I2S PCM Word Clock / I2S DSD Left Data |
| 5 | GND | Power | Ground |
| 6 | I2S_BCLK_I | Input | I2S PCM/DSD Bit Clock |
| 7 | I2S_DAT_O | Output | I2S Data / Config 1 strap |
| 8 | GND | Power | Ground |
| 9 | I2S_LRCK_O | Output | I2S Word Clock / Config 2 strap |
| 10 | GND | Power | Ground |
| 11 | I2S_BCLK_O | Output | I2S Bit Clock / Config 3 strap |
| 12 | GND | Power | Ground |
| 13 | GND | Power | Ground |
| 14 | CLK- | I/O LVDS | LVDS Master Clock - |
| 15 | GND | Power | Ground |
| 16 | CLK+ | I/O LVDS | LVDS Master Clock + |

**Pin Description J1**

| Pin | Name | Type | Description |
|---|---|---|---|
| 1 | VCC5A | Power | +5V Analog Power |
| 2 | EN_AUD | I/O OC | Enable Audio Output, PU when Master |
| 3 | GND | Power | Ground |
| 4 | GND | Power | Ground |
| 5 | OUT_CH1 | Analog | Output Audio 1 / Left Output / Balanced + |
| 6 | N-C | | Reserved for future use |
| 7 | GND | Power | Ground |
| 8 | GND | Power | Ground |
| 9 | GND | Power | Ground |
| 10 | GND | Power | Ground |
| 11 | OUT_CH2 | Analog | Output Audio 2 / Right Output / Balanced - |
| 12 | N-C | | Reserved for future use |
| 13 | GND | Power | Ground |
| 14 | GND | Power | Ground |
| 15 | VEE5A | Power | -5V Analog Power |
| 16 | N-C | | Reserved for future use |

## Electrical Characteristics

The dam1121 is powered by VCC5D for the digital parts and VCC5A and VEE5A for the analog parts. Both VCC5D pins need to be powered. There is no requirement for specific ramp up/down, although to avoid DC voltage on the outputs all power pins should ramp up and down within 0.5 sec of each other.

## Operating Conditions

| Pin | | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| VCC5D | Digital Power | 4.5 | 5.0 | 5.5 | V |
| VCC5A | Analog Positive Power | 4.5 | 5.0 | 5.5 | V |
| VEE5A | Analog Negative Power | -4.5 | -5.0 | -5.5 | V |
| | Ripple and Noise on all Power Pins | | 2 | 20 | mV PP |
| | | | | | |
| Input Pins | Input Voltage Low | -0.5 | | 0.8 | V |
| | Input Voltage High | 2.0 | | 3.9 | V |
| Output Pins | All Digital Outputs except Clock | 0 | | 3.3 | V |
| LVDS Clock Pins | Differental Threshold | -100 | | +100 | mV |
| | Input Common mode Range | 0 | | 2.4 | V |
| | Output Swing | | 0.35 | | V |
| | Output common mode Range | | 1.2 | | V |
| Config Pins | Pull Up / Down Resistors | 1 | 3.3 | 10 | KOhm |

## Current Consumptation

| | | | | | |
|---|---|---|---|---|---|
| VCC5D | Digital Power | | 250 | 350 | mA |
| VCC5A | Analog Positive Power | | 20 | 50 | mA |
| VEE5A | Analog Negative Power | | 20 | 50 | mA |

## Config Strap Pins

The Config 0 and the I2S output pins are sampled at power up to set board mode, connect resistors from pins to: pulldown to GND is 0, pullup to VCC is 1.

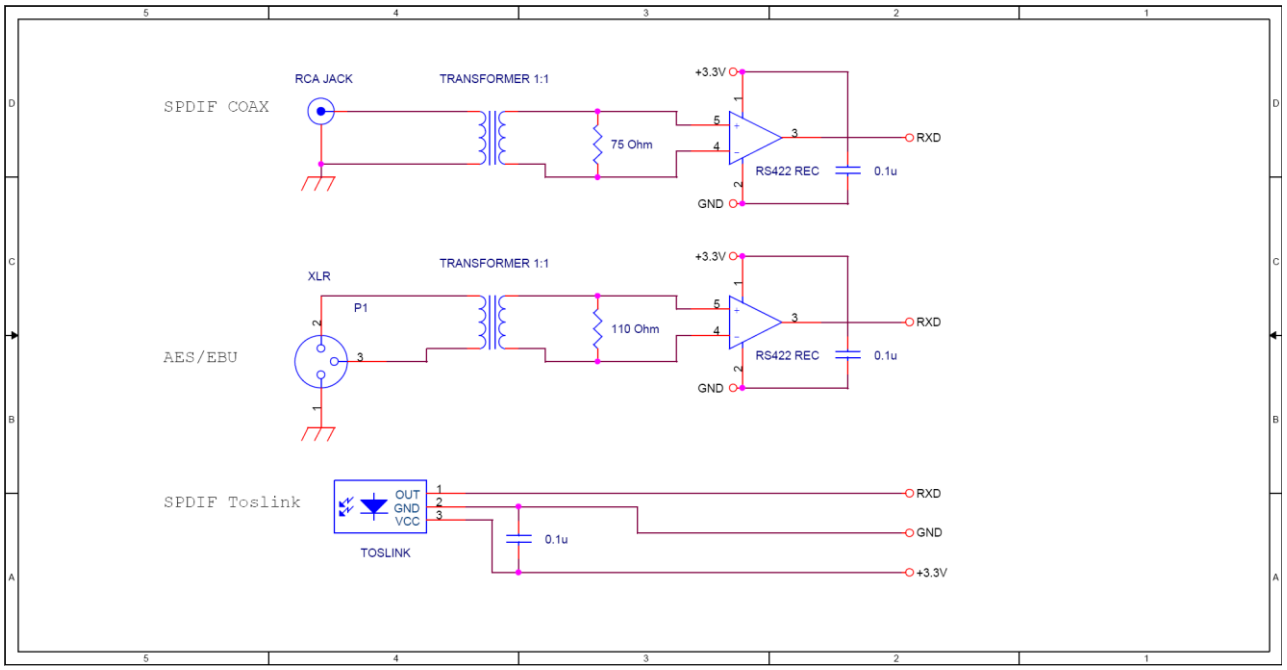
| | | |
|---|---|---|
| Config 0 | 0 | Board is Master, SPDIF and I2S are Inputs and I2S Output is active, Clock is Output, EN_AUD is Input / Output |
| | 1 | Board is Slave, I2S is Input from Master Output, Clock is Input, EN_AUD is Input. |
| | | |
| Config 3..1 | 000 | Stereo Non Inverted, OUT_CH1 is Right Ch, OUT_CH2 is Left Ch |
| | 001 | Mono Balanced Left Ch, OUT_CH1 is Positive, OUT_CH2 is Negative |
| | 010 | Mono Balanced Right Ch, OUT_CH1 is Positive, OUT_CH2 is Negative |
| | 011 | Stereo Inverted, OUT_CH1 is Right Ch, OUT_CH2 is Left Ch |
| | 100 | |
| | 101 | |
| | 110 | |
| | 111 | |

## Analog Audio Output

The dam1121 is a Sign Magnitude R-2R DAC, built with a high number of small very high precision thin film resistors. The output is an ideal voltage source with an output impedance of 640 ohm, so no I-V converter is needed and should be avoided. There is no requirement for a specific load, but low impedance loads will reduce the output voltage.

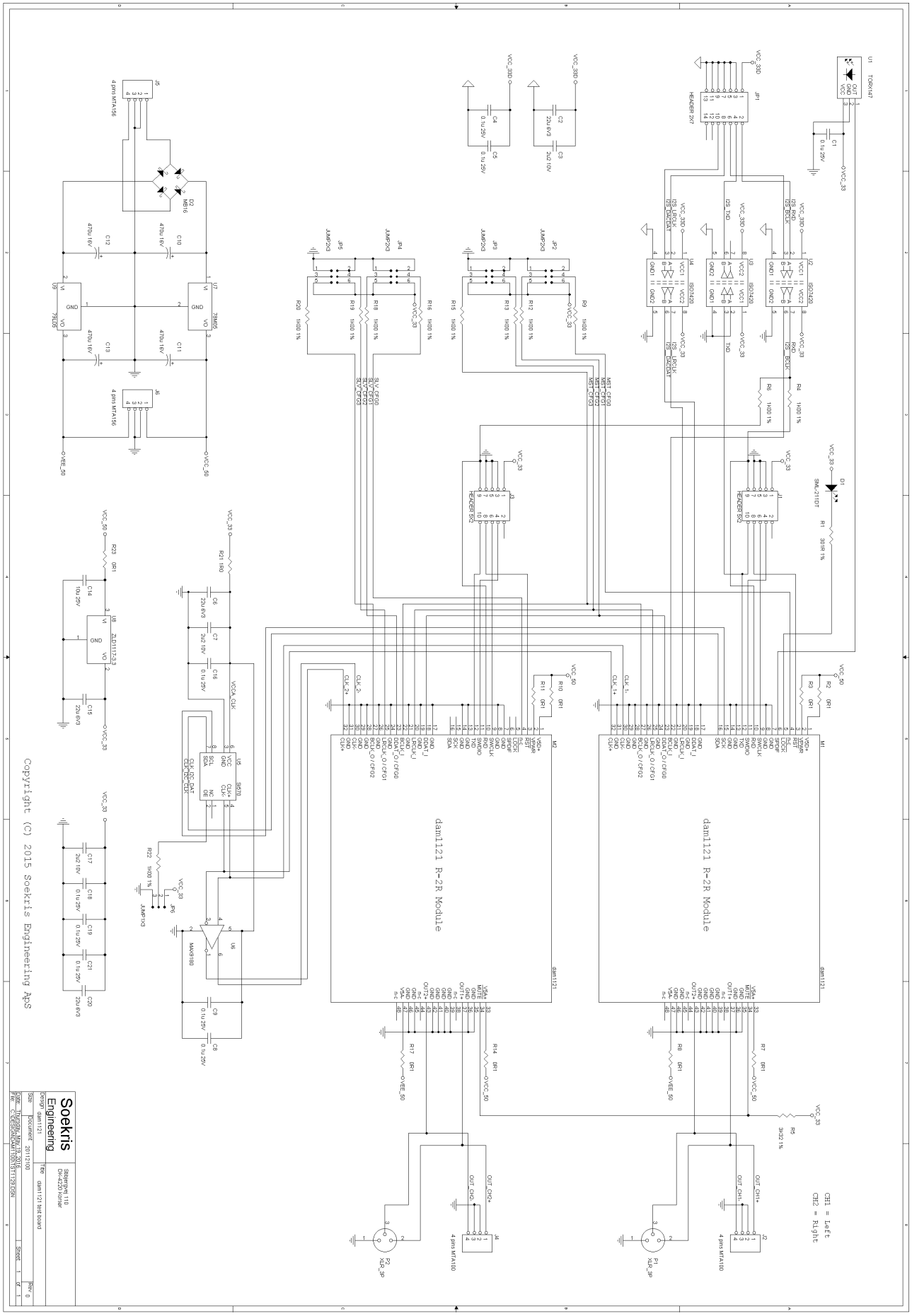
## Digital Audio Inputs

The I2S input can take up to 24 bit / 384 Khz PCM and up to 5.6 Mbit DoP and 11.2 Mbit DSD, the I2S format must be with 32 bits per audio word. The SPDIF is digital only and can take up 24 bit / 192 Khz PCM only. As default the dam1121 will autoselect between the I2S and SPDIF inputs, with priority to the SPDIF so when there is no valid SPDIF signal the I2S input will be selected. The recommended schematics for connection of different SPDIF interface standards is seen below. When using multiple SPDIF inputs a switch is needed.




## Example Schematics and Clocking

Below is an example of how to use the dam1121 in a fully balanced configuration and how to connect an external master oscillator. The dam1121 when configured as master will check for the presence of an external Silicon Labs Si570 oscillator and if found, will disable the internal Si514. The LVDS clock signal must be connected, terminated and routed carefully. It is point to point and must be terminated correctly at the far end only, the dam1121 internal LVDS receiver have a 100 ohm termination. It can have only very short stubs so when connecting multiple boards the master clock must be buffered individually to each board beside the master board. That mean when used as in the balanced example schematics, the optional external oscillator and the LVDS buffer must be placed very closed to the J3 connector on the dam1121 configured as master.


dam1121 R-2R Module
dam1121 R-2R Module
CH1 = Left
CH2 = Right
Soekris Engineering
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## Software Configuration and Control

The dam1121 have a small 32 bit ARM based microcontroller with a small monitor for configurations, the uManager, and control functions over the serial port. At power up in will be in control mode, where short commands can be used to set the volume and filter type.

The uManager monitor can be entered by entering "+++" followed by a one second pause. It will then write the signon message and a "#" prompt, then waiting for commands. The uManager is a command line driven program for configuration and downloading new firmware. Typing "?" or "Help" at the command prompt will show a short list of commands available.

## uManager Commands

```
? or Help               show this help
set par=value           set paramter to value, set alone to show
        conspeed = 9600 | 19200 | 38400 | 57600 | 115200
        volume = fixed -80 - +10, startup volume
        filter = linear | mixed | minimum | soft
download                download and update system flash
update                  update uManager firmware
filters [all]           show selected or all filters
df [adr]                dump flash content
exit                    exit uManager
```

The default serial port is set for 115200, n,8,1, but the speed can be changed with "set conspeed=" command, the default volume is "0 db", the default filter is "mixed".

## Updating firmware

The dam1121 firmware can be upgraded though the serial port, either in one step or you can upgrade the uManager, FPGA or Filters seperately. When upgrading uManager you need to also enter an "update" command, but not if only download new FPGA firmware or new filters.

To update the dam1121 firmware you need to have the Serial Port connected and working with a terminal emulator software package, t.ex. Hyperterminal on Windows. Enter the uManager by typing "+++", following by a pause. You should then get the uManager promt, you then type:

```
# download
```

Start download session using 1K Xmodem CRC protocol, when all is downloaded you also need to update the uC with new firmware, but only if you downloaded a new version:

```
# update
```

You then need to do a power cycle to restart everything, you can then enter uManager again to verify the new revisions.

### Serial Port runtime Control

When in the normal runmode the controller will send short status messages and receive short commands over the serial port using the COM_RXD and COM TXD signals. When using multiple boards it's recommended to connect all the COM_RXD signals together so all boards receive same commands, and then just use COM_TXD signal from the master boards to receive the status messages.

### Status Messages

| | |
|---|---|
| Rx.xx | uManager firmware version |
| Mx | Configuration mode, see table above |
| Ix | Input select mode, 3 = Auto, 0 = USB, 1 = SPDIF |
| Fx | Filter Type, 4 = linear, 5 = mixed, 6 = minimum, 7 = soft |
| Lxxx | Link Speed, 000 = unlocked, 044-384 PCM speed, 02M, 05M & 11M DSD speed |
| Vxxx | Volume, -80 to +10, default set to 0 |
| Px | Phase, N = Normal, I = Inverted, default is Normal |

### Command Messages

| | |
|---|---|
| Ix | Input select mode, 3 = auto, 0 = USB, 1 = SPDIF |
| Fx | Filter Type, 4 = linear, 5 = mixed, 6 = minimum, 7 = soft |
| Vxxx | Volume, -80 to +10 |
| Px | Phase, N = Normal, I = Inverted |

The dam1121 will acknowledge all command messages as status messages.

### Custom filters

The dam1121 upsamples everything to the final 2.8/3.1 Mhz DAC sample rate in two steps, there are three different filters in the dam1121:

FIR1, when input is PCM it will upsample from incoming sample rate to 352/384 Khz in one step, with different filter lenght based on incoming sample rate, when input is DSD it will be filtered and decimated to 352 Khz . There can be four different set of filter types.

IIR, bank of 15 biquads operating at 352/384 Khz, with one used for the CD de-emphasis filter, none otherwise used for the basic DAC.

FIR2, upsampling from 352/384 Khz to 2.8/3.1 Mhz. There can be four different types, usually matching those in FIR1

All filters are using 32 bit coefficients, with up to 67 bit MAC accumulator. The filter file format is the same as used in the dam1021, the files are available at http://www.soekris.dk

Recommended Windows filter software package is rePhase, available at

https://sourceforge.net/projects/rephase/