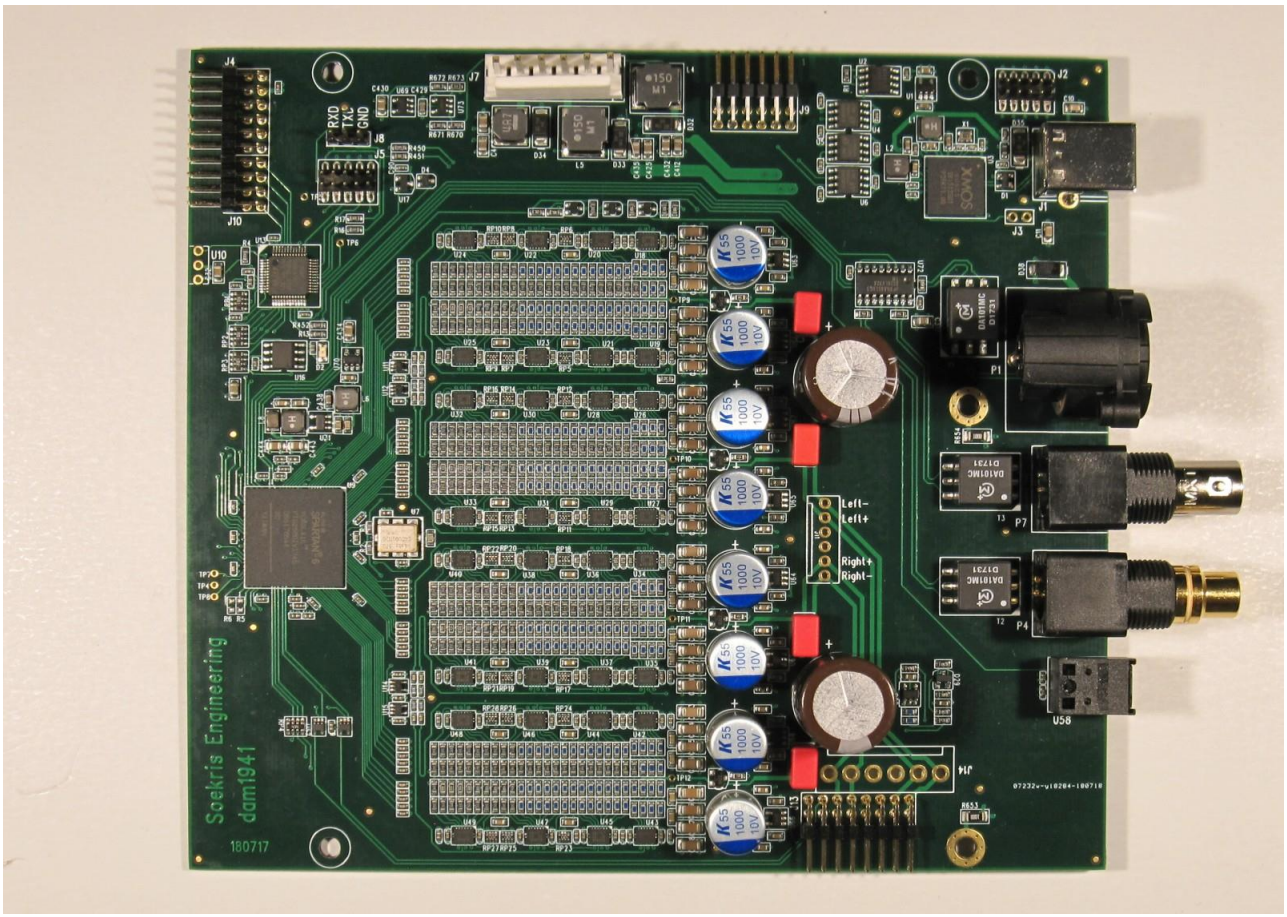
Discrete R-2R Sign Magnitude DAC Module



The Soekris dam1921/dam1941 discrete R-2R Sign Magnitude DAC is a highly integrated OEM module with absolute highest sound quality, designed to be used in a DAC using the OEMs own power supplies and output buffers. Input is USB, I2S and Coax/Toslink SPDIF, with reclocking FIFO. Clocking is with ultra low jitter digital programmable oscillator. The board has support for different levels of user interfaces, from just a basic DAC to a DAC/HeadAmp with full volume controls. Outputs are directly from the R-2R Sign Magnitude resistor networks, the dam1941 have four resistor networks for full balanced outputs, the dam1921 have just two of them mounted, for single ended outputs. The board is manufactured in Denmark using high reliability advanced surface mount technology.

We also offer a set of bare PCBs as example implementation of a Power Supply Board, an Output buffer Board and an User Interface / Display Board, they can be used for testing and as baseline for you own designs.

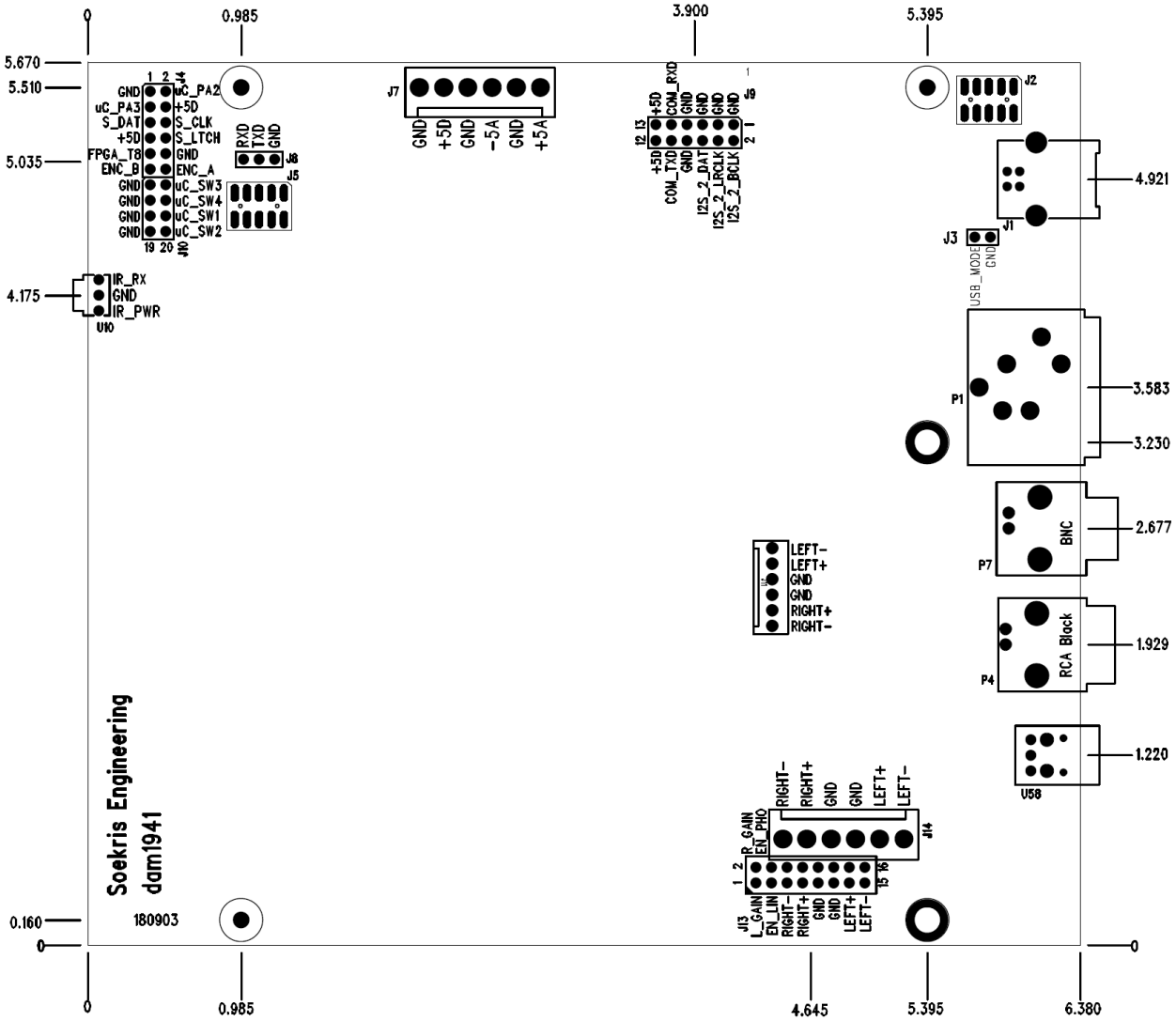
The dam1941 is the fully mounted balanced version, the dam1921 is the same board with only half the resistor networks mounted so it’s single ended, but otherwise the same.

Quick Specifications

Product Name	**dam1941-12**	**dam1921-02**
THD @ -1db	< 0.005 %	< 0.008%
THD @ -60dB	< 0.02 %	< 0.03%
Clock Jitter RMS	0.3 pS typical	
Resistor Precision	27 bit, 0.01% / 0.02% Resistors	27 bit, 0.02% resistors
S/N ratio at 20 Khz Bandwith	132 dB unweighted	129 dB unweighted
Frequency Range +0.1dB -1.0dB	20hz - 20Khz	
Input SPDIF	Up to 24 bit / 192 Khz	
Input USB / I2S PCM	Up to 24 bit / 384 Khz	
Input USB / I2S DSD	Up to DoP128 and DSD256	
Digital volume control	-90 dB to +10 dB	
Output Line	SE 1.3V RMS, Bal 2.6V RMS, Zout 625R	
Power Input	+5V max 0.6A, -5V max 0.1A	
Board Size	144 x 162 x 30 mm	

Interface

Pinout and mechanical drawing, component side view, all measurement are in inches, connector position are to center of connectors.



Pin Description J7, Power Connection, 6 pins MTA156 Header.

Pin	Name	Type	Description
1	GND	Power	Ground
2	VCC5D	Power Input	+5V Digital Power
3	GND	Power	Ground
4	VEE5A	Power Input	-5V Analog Power
5	GND	Power	Ground
6	VCC5A	Power Input	+5V Analog Power

Pin Description J4, User Interface, 2x10 pins 0.1" Header, Right Angle.

Pin	Name	Type	Description
1	GND	Power	Ground
2	uC_PA2	I/O	Spare Signal, Connected to uC
3	uC_PA3	I/O	Spare Signal, Connected to uC
4	+5D	Power Output	+5V Digital Power to Display Board
5	S_DAT	Output	Serial Data to Display Board
6	S_CLK	Output	Serial Clock to Display Board
7	+5D	Power Output	+5V Digital Power to Display Board
8	S_LTCH	Output	Serial Latch to Display Board
9	FPGA_T8	I/O	Spare Signal, Connected to FPGA
10	GND	Power	Ground
11	ENC_B	Input	Connected to B Signal on Encoder
12	ENC_A	Input	Connected to A Signal on Encoder
13	GND	Power	Ground
14	uC_Switch3	Input	Input Select Switch to uC
15	GND	Power	Ground
16	uC_Switch4	Input	XFeed Select Switch to uC
17	GND	Power	Ground
18	uC_Switch1	Input	Filter Select Switch to uC
19	GND	Power	Ground
20	uC_Switch2	Input	Output Select Switch to uC

Pin Description J13, Output to Buffer Board, 2x8 pins 0.1" Header, Right Angle.

Pin	Name	Type	Description
1	L_Gain	Output	Control Signal to Increase Output Buffer Gain 8 dB
2	R_Gain	Output	Control Signal to Increase Output Buffer Gain 8 dB
3	EN_LIN	Output	Control Signal to Enable Line Output
4	EN_PHO	Output	Control Signal to Enable Headphone Output
5	Right-	Output	Right Negative Output from R-2R Resistor Network
6	Right-	Output	Right Negative Output from R-2R Resistor Network
7	Right+	Output	Right Positive Output from R-2R Resistor Network
8	Right+	Output	Right Positive Output from R-2R Resistor Network
9	GND	Power	Ground
10	GND	Power	Ground
11	GND	Power	Ground
12	GND	Power	Ground
13	Left+	Output	Left Positive Output from R-2R Resistor Network
14	Left+	Output	Left Positive Output from R-2R Resistor Network
15	Left-	Output	Left Negative Output from R-2R Resistor Network
16	Left-	Output	Left Negative Output from R-2R Resistor Network

Note: Right- and Left- are no connects on the dam1921.

Pin Description J7, Signal Output, Holes for soldering.

Pin	Name	Type	Description
1	Left-	Output	Left Negative Output from R-2R Resistor Network
2	Left+	Output	Left Positive Output from R-2R Resistor Network
3	GND	Power	Ground
4	GND	Power	Ground
5	Right+	Output	Right Positive Output from R-2R Resistor Network
6	Right-	Output	Right Negative Output from R-2R Resistor Network

Pin Description J8, Serial Console, 1x3 pins 0.1" Header.

Pin	Name	Type	Description
1	GND	Power	Ground
2	TXD	Output	RS-232 Serial Input for Management, TTL Level
3	RXD	Input	RS-232 Serial Output for Management, TTL Level

Pin Description J9, 2nd I2S input, 2x6 pins 0.1" Header

Pin	Name	Type	Description
1	GND	Power	Ground
2	I2S BCLK	Input	2nd I2S Bit Clock
3	GND	Power	Ground
4	I2S LRCLK	Input	2nd I2S LR Clock
5	GND	Power	Ground
6	I2S DAT	Input	2nd I2S Audio Data
7	GND	Power	Ground
8	GND	Power	Ground
9	RXD	Input	RS-232 Serial Output for Management, TTL Level
10	TXD	Output	RS-232 Serial Input for Management, TTL Level
11	+5D	Power Output	+5V Digital Power
12	+5D	Power Output	+5V Digital Power

Pin Description U58: Toslink Optical SPDIF Digital Audio Input.

Pin Description P4: RCA Coax SPDIF Digital Audio Input.

Pin Description P7: BNC Coax SPDIF Digital Audio Input.

Pin Description P1: AES/EBU SPDIF Digital Audio Input.

Pin Description J1: USB UAC2 Digital Audio Input.

Electrical Characteristics

The dam19x1 is powered by VCC5D for the digital parts and VCC5A and VEE5A for the analog parts. The USB Interface is powered from USB Power. 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	4.7	5.0	5.3	V
VCC5A	Analog Positive Power	4.7	5.0	5.3	V
VEE5A	Analog Negative Power	-4.7	-5.0	-5.3	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	0		3.3	V

Current Consumption

VCC5D	Digital Power		250	350	mA
VCC5D	Typical Display		80	150	mA
VCC5A	dam1921 Analog Positive Power		25	45	mA
VEE5A	dam1921 Analog Negative Power		25	45	mA
VCC5A	dam1941 Analog Positive Power		45	85	mA
VEE5A	dam1941 Analog Negative Power		45	85	mA
USB	USB Power for USB Interface		100	200	mA

Analog Audio Output

The dam19x1 is a Sign Magnitude R-2R DAC, built with a high number of small very high precision thin film resistors. The outputs are ideal voltage sources with an output impedance of 625 ohm per R-2R Resistor Network, 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.

The dam1941 can be set for “Parallel” mode, in that case it will be single ended outputs with an output impedance of 313 ohms.

Digital Audio Inputs

The USB and I2S inputs 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 inputs can take up 24 bit / 192 Khz PCM only. As default the dam1921/dam1941 will autoselect between the USB and SPDIF inputs with active signals, with priority to the SPDIF so when there is no valid SPDIF signal the USB input will be selected.

Software Configuration and Control

The dam1921/dam1941 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, line output startup volume
        filter = linear | mixed | minimum | soft
        mode = normal | parallel
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 dam19x1 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 dam19x1 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.

Status Messages

Rx.xx	uManager firmware version
Mx	Configuration mode.
Ix	Input select mode, 7 = Auto, 0 = USB, 1 = AES/EBU, 2 = BNC, 3 = RCA, 4 = Toslink, 5 = I2S.
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, -90 to +10, default set to 0
Px	Phase, N = Normal, I = Inverted, default is Normal
Xx	Crossfeed Mode 0..3, 0 = off, 3 = max, only valid when headphones are selected

Command Messages

Ix	Input select mode, 7 = Auto, 0 = USB, 1 = AES/EBU, 2 = BNC, 3 = RCA, 4 = Toslink, 5 = I2S.
Fx	Filter Type, 4 = linear, 5 = mixed, 6 = minimum, 7 = soft
Vxxx	Volume, -90 to +10
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Xx	Crossfeed Mode 0..3, 0 = off, 3 = max, only valid when headphones are selected

The dam19x1 will acknowledge all command messages as status messages.

Custom filters

The dam1921/dam1941 upsamples everything to the final 2.8/3.1 Mhz DAC sample rate in two steps, there are three different filters in the dam19x1:

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.
Please note that biquad number 16 to 23 is reserved for the crossfeed function.

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/

Power Supply psu1951

The psu1951 is an optional bare PCB and provided as an example, you're free to provide your own more advanced power supply, although the psu1951 is good by itself. As a minimum you need to mount the +-5V sections, the +-12V sections are if you use a buffer solution that require higher voltages. Please note that the buf1961 will work just fine at +-5V using the standard parts in the BOM. The psu1951 has space for a 115/230V selector for worldwide use, if you don't need it you can mount wires instead. **Please note that the text on the PCB is incorrect for J4, it should be like J1.** The regulator IC's U1, U4 and U5 should be mounted on the small heatsinks using thermal isolator pads.

Output Buffer buf1961

The buf1961 is an optional bare PCB and provided as an example, you're free to provide your own more advanced buffer, although the buf1961 is good by itself. It can be mounted in three versions, as Single Ended In / Single Ended Out and Single Ended In / Balanced Out for the dam1921, and Balanced In / Balanced Out for the dam1941. If the buffer opamps are with rail to rail outputs, like the recommended parts, the buf1961 works fine with +-5V power, otherwise higher supply voltage is needed, which a fully mounted psu1951 can supply. Please note the only the Power pins on J5 should be connected, it will get GND though J4 from the dam19x1. The buf1961 is for Line Output, a headphones amplifier is something you need to find yourself if you want the functionality. Any headphones amplifier should have a +8 dB gain control, using the pins from J13 to control the gain for each channel. There should also be enable circuit for line out and headphones. There are footprints on the buf1961 for dual opamps in both so package and for dip sockets in case you want to experiments with different opamps. Most dual opamps should work as long as it's unity gain stable. We can recommend three TI parts:
The opa1678, a new high performance low cost all CMOS part.
The opa1652, a high performance dual part with jfet input.
The opa1612, a well renowed high performance dual bipolar part.

User Interface dsp1941

The dsp1941 is an optional bare PCB and provided as an example, you're free to provide your own version. The dsp1941 is designed for the full user interface ala dac1541, if you don't need the headphones control section you can cut the PCB at the point where the ground layer ends.
It uses smd parts for the shift registers, those should be mounted first. The LED should be mounted last to fit your case. Buttons:
S5: Input Select
S3: Filter Select
S8: CrossFeed Select
S4: Output Select
Please see the dac5141 manual for buttons usage and display information.