VS1000 Audio Module

Features

- Plays audio from micro SD card or SPI Flash
- Uses powerful Ogg Vorbis audio format
- Both firmware and content can be customized
- Triggered via USB, UART or IO pins
- Very simple to use, UART is enough to send commands
- High perfomance analog CD quality output
- Supports low bit rates and various sample rates
- Operates from a single supply (3.4...6.0V)
- Line output
- Headphone output
- SPI FLASH for code and/or data storage
- Micro-SD connector for data storage
- Most internal nodes are routed to pinheaders for easy access and customization

Applications

- Elevators
- Ticket machines
- Audio user's manuals
- Vending machines
- Car accessories
- Alarm systems
- PC accessories
- Speaking hi-tech toys
- Development board for VS1000 chip

Description

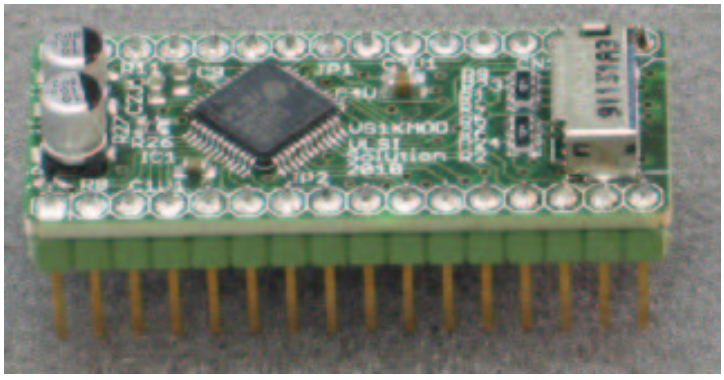
The VS1000 Module is a small, low-cost, high performance, easy to use audio player that is controlled from the IO-pins, UART or USB. It can be used as a "plug-in" audio board in electronic systems or as a standalone small audio player.

The product is supported by design services, audio content preparation and pre-programming. It is also fully configurable by the user by using free Integrated Development Tools (VSIDE) for the VS1000 IC. The use of the module does not require any advanced information from the user.

Pin headers of the PCB are compatible with DIL32 footprint 2.54 pitch 15.24 mm wide (100 mils pitch, 600 mils wide). This makes it possibe to use standard DIL32 ZIF sockets or solder it by using DIL32 footprint.

The left row of the PCB has digital connections for external buttons, LEDs or other circuitry. The right row has power connections, analog connections, a serial port and USB. These can be used to interface the board with a PC and VSIDE or a host microcontroller.

The VS1000 Module operates from a single power supply. The board has 16 Mbits of on-board FLASH and a Micro-SD card connector for playing license free Ogg Vorbis audio files. The module can boot from the on-board FLASH memory.



Contents

List of Figures

1 Disclaimer

All properties and figures are subject to change.

2 Definitions

B Byte, 8 bits.

b Bit.

Ki “Kibi” = 2^{10} = 1024 (IEC 60027-2).

Mi “Mebi” = 2^{20} = 1048576 (IEC 60027-2).

VS_DSP VLSI Solution’s DSP core.

W Word. In VS_DSP, instruction words are 32-bit and data words are 16-bit wide.

3 Placement and pinout

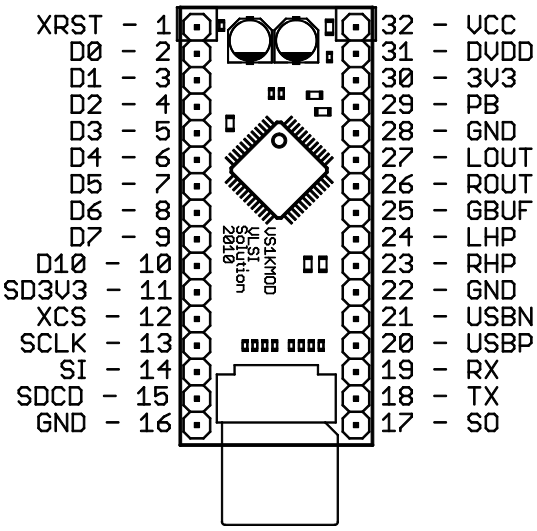


Figure 1: Pinout.

Pin	Name	Description		Pin	Name	Description
1	XRESET	Active Low reset for VS1000		32	VCC	Input Voltage. Power supply for the board. 3.4V - 6V allowed
2	D0	General purpose I/O pin		31	DVDD	Output of DVDD regulator, for external circuitry
3	D1	General purpose I/O pin		30	3V3	Output of 3V3 regulator, for external circuitry
4	D2	General purpose I/O pin		29	PB	Powerbutton. For turning the VS1000 on and off
2 5	D3	General purpose I/O pin		28	GND	Ground. Connected to ground plane
6	D4	General purpose I/O pin		27	LOUT	Left channel line out (AC-coupled)
7	D5	General purpose I/O pin		26	ROUT	Right channel line out (AC-coupled)
8	D6	General purpose I/O pin, 100K pulldown		25	GBUF	Headphone common output (note DC-bias)
9	D7	General purpose I/O pin, 100K pullup		24	LHP	Headphone left channel output (note DC-bias)
10	D10	General porpose I/O pin		23	RHP	Headphone right channel output (note DC-bias)
11	SD3V3	Controls the 3.3V regulator on board, 100K pulldown		22	GND	Ground. Connected to ground plane
12	XCS	SPI bus Chip Select, 100K pullup		21	USBN	USB negative signal
13	SCLK	SPI bus clock input		20	USBP	SUB positive signal
14	SI	SPI bus data input		19	RX	Serial port receive, 100K pullup
15	SDCD	SD card detected		18	TX	Serial port transmit
16	GND	Ground. Connected to ground plane		17	SO	SPI bus data output

4 Dimensions

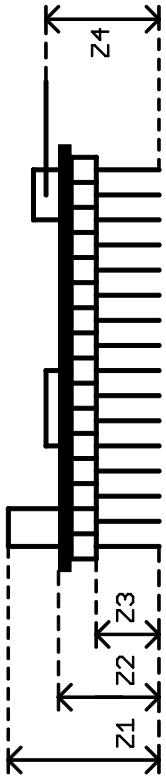


Figure 2: Top layer PCB layout

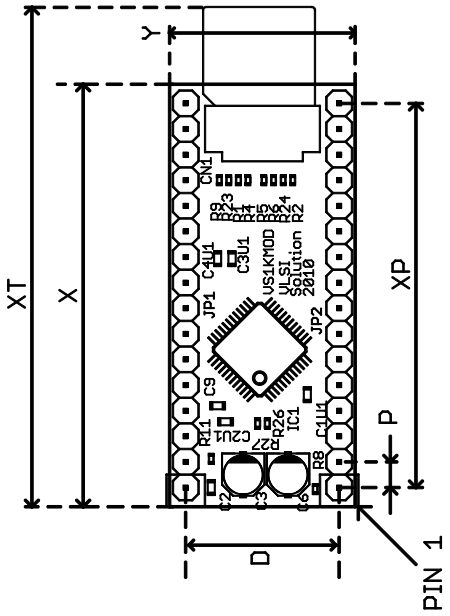


Figure 3: Top layer PCB layout

Parameter	Symbol	Min	Typ	Max	Unit
Width of PCB	Y		18.40		mm
Length of PCB	X		41.91		mm
Total length (includes USB connector)	XT		40.65		mm
Length of pin connector	XP		38.10		mm
Maximum height of module	Z1		16.60		mm
Minimum height of module	Z2		11.60		mm
Pitch of pins	P		2.54		mm
Pin height	Z3		6.80		mm
Distance from lower pin row to upper pin row	D		15.24		mm
Distance to Micro-SD card centerline	Z4		14.40		mm
Pin type and size	PT		0.65 square		mm

5 Characteristics & Specifications

5.1 Absolute Maximum Ratings

Parameter	Symbol	Min	Max	Unit
Supply voltage	VCC	-0.3	6.0	V
Voltage at Any Digital Input		-0.3	IOVDD+0.3[1]	V
Total Injected Current on Pins			±200 [2]	mA
Operating Temperature		-40	+85	°C
Storage Temperature		-65	+150	°C

[1] IOVDD is output of the programmable regulator of the VS1000 chip. Must not exceed 3.6 V
[2] Latch-up limit

5.2 Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Operating temperature		-40		+85	°C
Ground [1]	GND		0.0		V
Supply voltage [2]	VCC	3.6		6.0	V
Analog positive supply[3]	AVDD	2.75	2.8	3.6	V
Digital positive supply [3]	CVDD	2.2	2.3	2.65	V
I/O positive supply[3]	IOVDD	1.8	2.8	3.6	V
Input clock frequency[4]	XTALI	12	12[5]	13	MHz
Internal clock frequency, USB connected	CLKU	48		48	MHz
Internal clock frequency, USB disconnected	CLKI	12		48	MHz
Master clock duty cycle		40	50	60	%

[1] Do not float ground for latch-up immunity.
[2] At least 4.0 V is required for compliant USB level.
[3] Regulator output of the VS1000 device. Can be controlled by the firmware.
[4] The maximum sample rate that can be played with correct speed is XTALI/256. With 12 MHz XTALI sample rates over 46875 Hz are played at 46875 Hz.
[5] To be able to use USB, XTALI must be 12 MHz.

5.3 Analog Characteristics of Audio Outputs

Unless otherwise noted: AVDD=3.3V, CVDD=2.4V, IOVDD=2.8V, TA=-40..+85°C, XTALI=12 MHz, Internal Clock Multiplier $3.0\times$. DAC tested with full-scale output sinewave, measurement bandwidth 20..20000 Hz, analog output load: LHP to GBUF 30 Ω, RHP to GBUF 30 Ω, LOUT: 10k Ω, LOUT: 10k Ω.

Parameter	Symbol	Min	Typ	Max	Unit
DAC Resolution			18		bits
Dynamic range (DAC unmuted, A-weighted, min gain)	IDR		96		dB
S/N ratio (full scale signal, no load[1])	SNR		92		dB
S/N ratio (full scale signal, 30 ohm load[2])	SNRL	75	90		dB
Total harmonic distortion, max level, no load[1]	THD		0.01		%
Total harmonic distortion, max level, 30 ohm load[2]	THDL		0.1	0.3	%
Crosstalk (LOUT/ROUT to ROUT/LOUT), no load[1]	XTALK0		75		dB
Crosstalk (LHP/RHP to RHP/LHP), 30 ohm load, without GBUF [3]	XTALK1		75		dB
Crosstalk (LHP/RHP to RHP/LHP), 30 ohm load, with GBUF	XTALK2		54		dB
Gain mismatch (LOUT/ROUT to ROUT/LOUT)	GERR	-0.5		0.5	dB
Frequency response	AERR	-0.05		0.05	dB
Full scale output voltage	LEVEL	450	530	600	mVrms
Deviation from linear phase	PH		0	5	°
Analog output load resistance	AOLR		30[4]		Ω
Analog output load capacitance	AOLC			100	pF
DC level (GBUF, LHP, RHP)		1.1		1.3	V
GBUF disconnect current (short-circuit protection)			130	200	mA

[1] Characteristics with no load are measured from LOUT/ROUT outputs towards GND such that LHP/RHP outputs are not loaded.
[2] Characteristics with 30 Ω load are measured from LHP/RHP outputs towards GBUF such that LOUT/ROUT outputs are not loaded.
[3] Loaded from LHP/RHP pin to analog ground via 100 μF capacitors.
[4] AOLR may be lower than *Typical*, but distortion performance may be compromised. Also, there is a maximum current that the internal regulators can provide.

5.4 Analog Characteristics of Regulators

Parameter	Symbol	Min	Typ	Max	Unit
IOVDD					
Recommended voltage setting range		1.7		3.6	V
Voltage setting step size		50	60	70	mV
Default setting, reset mode [1]			1.8		V
Default setting, active mode [2]			1.8/3.6[3]		V
Load regulation			4.0		mV/mA
Line regulation from VCC			2.0		mV/V
Continuous current			30[4]	40	mA
CVDD					
Recommended voltage setting range		1.8		2.6	V
Voltage setting step size		35	48	55	mV
Default setting, reset mode [1]			1.8		V
Default setting, active mode [2]			2.2		V
Continuous current			30[4]	35	mA
Load regulation			2.0		mV/mA
Line regulation from VCC			2.0		mV/V
AVDD					
Recommended voltage setting range		2.6		3.6	V
Voltage setting step size		35	46	55	mV
Default setting, reset mode [1]			2.5		V
Default setting, active mode [2]			2.7		V
Continuous current			30[4]	70	mA
Load regulation			1.5		mV/mA
Line regulation from VCC			2.0		mV/V

[1] Device enters reset mode when XRESET pin is pulled low.
[2] Device enters active mode when XRESET pin is pulled high after reset mode. Regulator settings can be modified by custom firmware (in on-board FLASH).
[3] Depends on GPIO0_7 pin status in boot.
[4] Device is tested with a 30 mA load.

5.5 Analog Characteristics of VCC voltage monitor

Parameter	Symbol	Min	Typ	Max	Unit
Trigger voltage	AMON		1.07×AVDD		V
Hysteresis			50		mV

VCC voltage monitor causes interrupt when it is activated. The purpose is to shut down the system by the firmware before voltage level causes functionality error.

5.6 Analog Characteristics of CVDD voltage monitor

Parameter	Symbol	Min	Typ	Max	Unit
Trigger voltage	CMON	1.40	1.53		V
Hysteresis			2		mV

CVDD voltage monitor causes internal hardware reset of the system.

5.7 Analog Characteristics of USB

Parameter	Symbol	Min	Typ	Max	Unit
Drive low level, 2.32 mA load		0.065		0.102	V
Drive low level, 6.1×AVDD mA load		0.171×AVDD		0.270×AVDD	V
Drive low level, 10.71×AVDD mA load		0.300×AVDD		AVDD	V
Drive high level, -2.32 mA load		AVDD-0.165		AVDD-0.065	V
Drive high level, -6.1×AVDD mA load		0.650×AVDD		0.829×AVDD	V
Drive high level, -10.71×AVDD mA load		0		0.700×AVDD	V
USBP level, with 15 kΩ pull-down		2.7		0.943×AVDD	V
High-Level input voltage (single-ended)		0.7×AVDD		AVDD+0.3	V
Low-Level input voltage (single-ended)		-0.2		0.3×AVDD	V
Differential input common voltage, AVDD≥3.3V		0.8		2.5	V
Differential input signal level, AVDD≥3.3V		200			mV
Input leakage current		-2.0		2.0	µA

5.8 Power Consumption

Parameter	Symbol	Min	Typ	Max	Unit
Current Consumption of Reset mode (XRESET=0V) @ 25 °C			24	48	µA
UART player application VCC=6.0V IOVDD=3.3V AVDD=2.8V CVDD=2.5V					
Total Power, play mode, LHP and RHP with 30Ω load to GBUF			120		mW
Total Power, play mode, LOUT and ROUT with 10kΩ load			120		mW
UART player application VCC=4.0V IOVDD=3.3V AVDD=2.8V CVDD=2.5V					
Total Power, play mode, LHP and RHP with 30Ω load to GBUF			120		mW
Total Power, play mode, LOUT and ROUT with 10kΩ load			120		mW
UART player application VCC=6.0V, IOVDD=2.7V AVDD=2.6V CVDD=2.2V					
Total Power, pause mode			10		mW
Total Power, play mode, LHP and RHP with 30Ω load to GBUF			80		mW
Total Power, play mode, LOUT and ROUT with 10kΩ load			80		mW
UART player application VCC=4.0V, IOVDD=2.7V AVDD=2.6V CVDD=2.2V					
Total Power, pause mode			10		mW
Total Power, play mode, LHP and RHP with 30Ω load to GBUF			80		mW
Total Power, play mode, LOUT and ROUT with 10kΩ load			80		mW

5.9 Digital Characteristics

Parameter	Symbol	Min	Typ	Max	Unit
High-Level Input Voltage		0.7×IOVDD		IOVDD+0.3	V
Low-Level Input Voltage		-0.2		0.3×IOVDD	V
High-Level Output Voltage, -1.0 mA load [1]		0.7×IOVDD			V
Low-Level Output Voltage, 1.0 mA load [1]				0.3×IOVDD	V
XTALO high-level output voltage, -0.1 mA load		0.7×IOVDD			V
XTALO low-level output voltage, 0.1 mA load				0.3×IOVDD	V
Input leakage current		-1.0		1.0	µA
Rise time of all output pins, load = 30 pF [1]				50	ns

[1] Pins GPIO0_[14:0], GPIO1_[5:0].

6 Component Layout

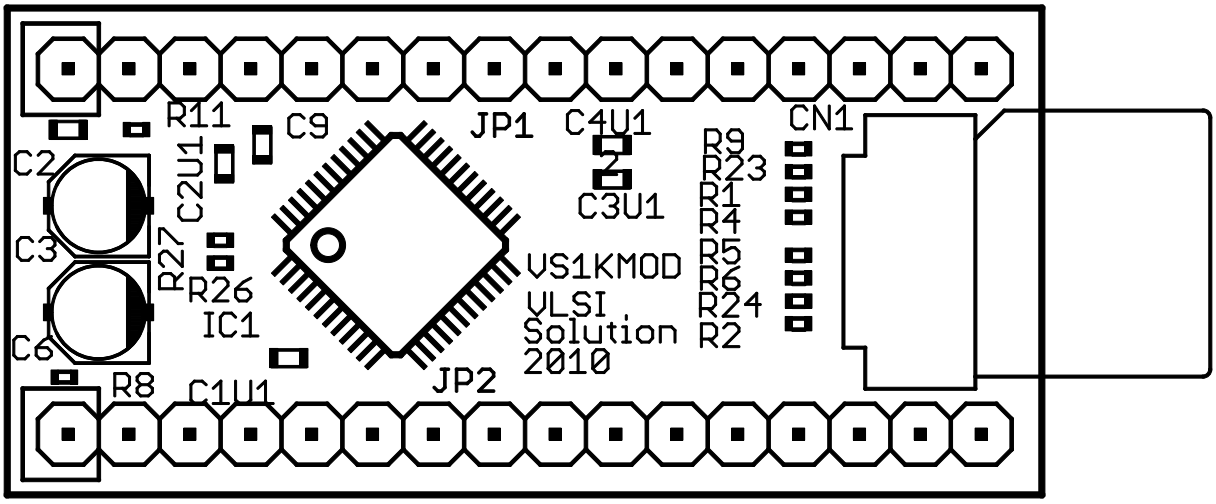


Figure 4: Top silkscreen of the PCB (Top view)

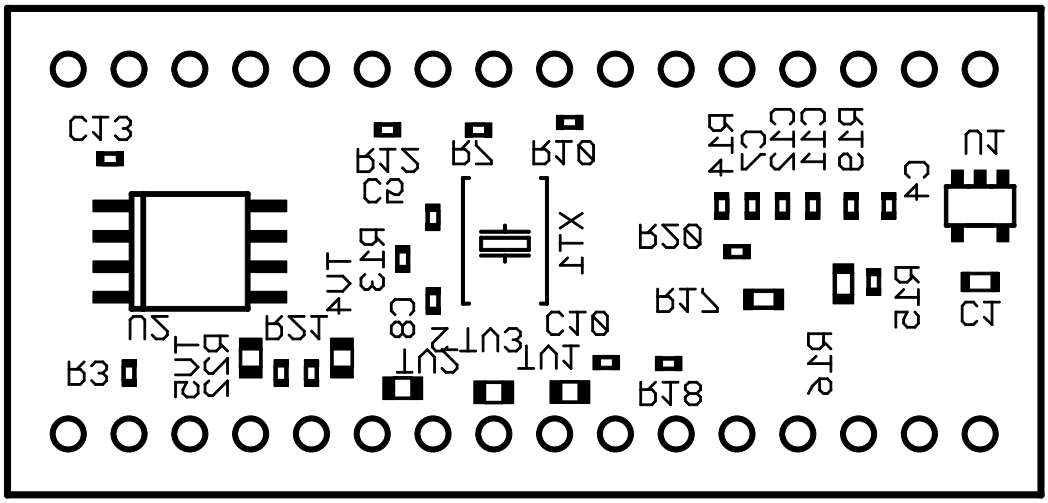


Figure 5: Bottom silkscreen of the PCB (Top view)

Note: Upto and including document version 0.3 component C3 was incorrectly marked as C4, and C4 was marked as C3. Figure 4 shows the correct component names.

7 PCB Layout

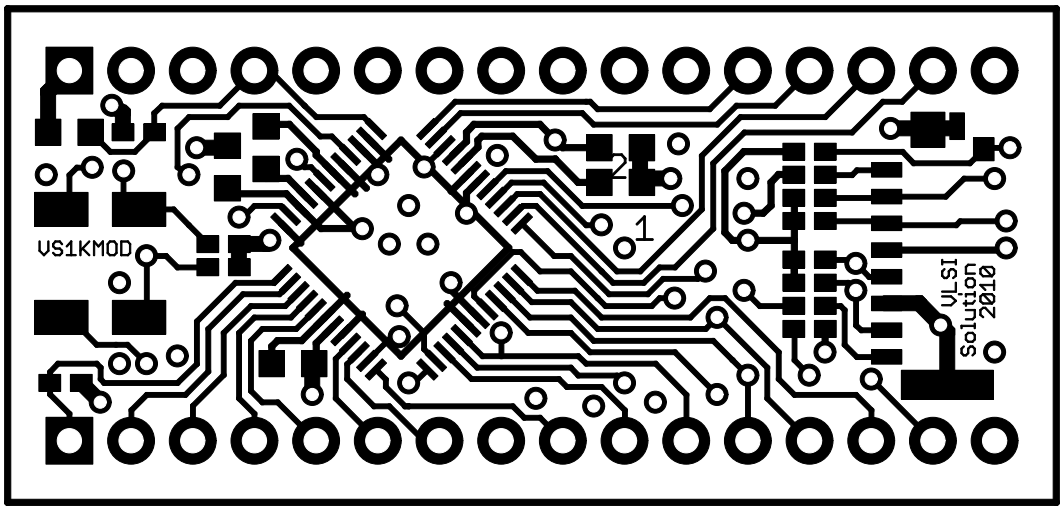


Figure 6: Top layer of the PCB layout (Top view)

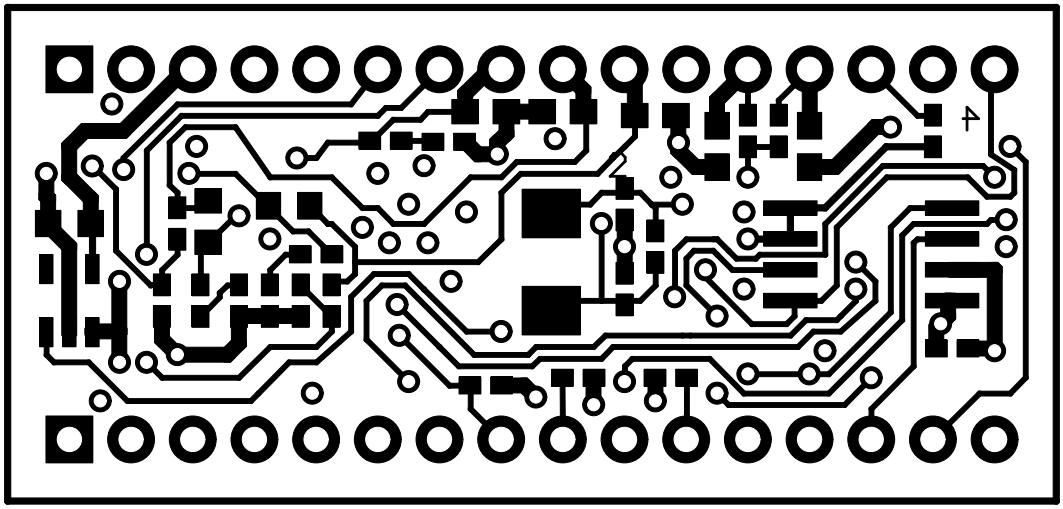


Figure 7: Bottom layer the PCB layout (Top view)

8 PCB Schematics

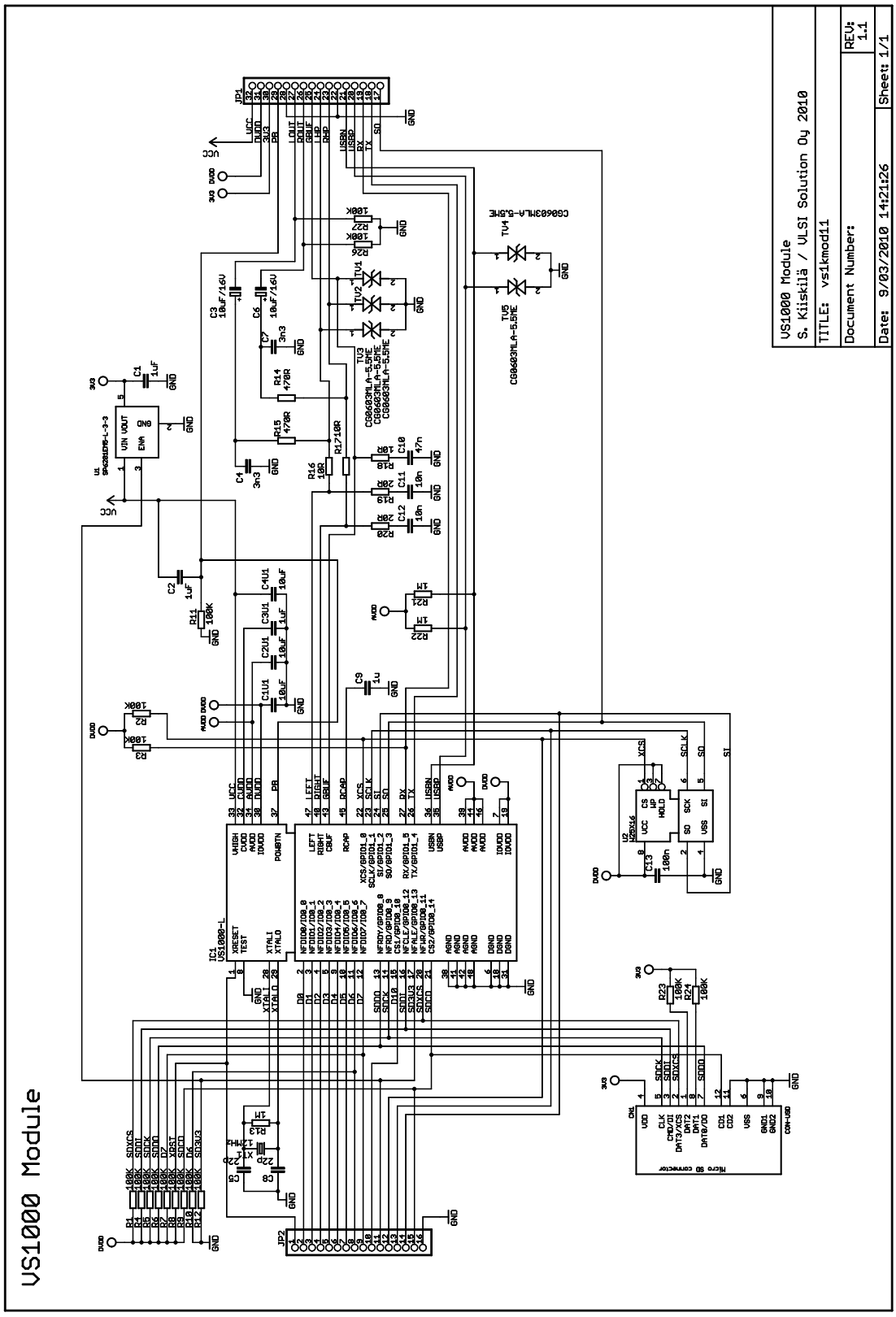


Figure 8: Schematic of the VS1000 Module.

8.1 Notes about the Schematic

- Line outputs have a first order RC low-pass filter that removes some of the DA converter quantization noise. Useful when connecting to a limited bandwidth amplifier.
- Line outputs are ac coupled. Can be connected directly to an amplifier.
- Headphone outputs (including common buffer) are DC biased to 1.2V. Do not connect common buffer to the ground! Do not connect Left/Right outputs directly to an amplifier!
- Input power supply is connected to pin 1 of JP1.

9 Default Firmware (version 0.3)

The VS1000 Audio Module allows several uses in addition to audio playback. For normal audio use, the content can reside in either the SPI FLASH or external SD card. The default firmware implements UART-controller player, which plays files from the SPI FLASH.

UART speed 115200 bps is used. The module boots up in *continuous* playing mode, which plays all available files sequentially and continues until powered off. If SD/MMC card insertion is detected, files are played from SD/MMC instead (since version 0.3).

When power is applied and the firmware starts, if a valid FAT filesystem is detected, you will get the string `"fat"`, a 4-byte FAT size (most significant byte first), then a newline character (0x0a). For example `"fat", 0x00, 0x00, 0x0f, 0xc0, 0x0a`. If there is not a valid FAT disk, you will get `"nofat"` and a newline (0x0a).

Then the string `"files"` is sent, followed by a two-byte value containing the number of playable files (for example 0x00, 0x04 for 4 files), and a newline (0x0a).

When a file has been located and starts playing, you will get the string `"play"` and a two-byte file number, then a 8.3-character filename (for example `"ADAMAN~1OGG"` and a newline (0x0a). After a file is finished playing (or interrupted), you will get `"done"` and a newline (0x0a). If the player is in the *continuous* playing mode, a new file will be automatically selected and played.

The *continuous* playing mode understands the following single-byte commands:

- `f` - switch to *file* play mode
- `c` - switch to *continuous* play mode
- `C` - cancel play, return to play loop, responds with `c`
- `+` - volume up, responds with two-byte current volume level
- `-` - volume down, responds with two-byte current volume level
- = - pause on, responds with =
- > - play (normal speed), responds with >
- ≫ `(0xbb)` - faster play, responds with the new play speed
- `n` - next song, responds with `n`
- `p` - previous song, responds with `p`
- `?` - info, returns play seconds (4 bytes, high byte first), and one-byte file left indicator (255 to 0).

In *file* play mode files are not played automatically. To change into *file* play mode, send `f`, then you can send `C` to cancel playback.

The *file* play mode commands are single-line commands ending with the newline character (0x0a). The following commands are currently implemented:

- `OFF\n` - powers down
- `c\n` - switch to *continuous* play mode
- `L\n` - list files
- `P`*FILENAMEOGG*`\n` - play file by name, must be 8.3-character uppercase name without the "." .
- `p`*number*`\n` - play file by number

Continuous play mode commands are available during the playing of the song.

If SD card is inserted during SPI FLASH playback, `"SD"` and newline (0x0a) are sent, and the SD/MMC player program is loaded. It will send FAT (or no-FAT) and file number information in the same way as the SPI FLASH player program before starting playback.

If SD card is removed during SD playback, `"!SD"` and newline (0x0a) are sent and the SPI FLASH player program is loaded.

If USB attach is detected during play mode, USB mass storage mode is started. `"USB Attach"` and newline (0x0a) is displayed before going into mass storage mode, and `"USB Detach"` and newline when returning to play mode.

The selected play mode is preserved when switching between SPI FLASH and SD/MMC player programs, but is reset to continuous play mode when USB Mass Storage is used with SPI FLASH. The same applies to volume setting.

Updating

Since version 0.3 SD/MMC card can be used for firmware update. If a program named `"SDUPDATE.PRG"` is found on the SD/MMC card, it is automatically executed. The program can then for example open another file on the SD card and program the contents to SPI FLASH.

Both the boot firmware and audio content can be programmed in this way.

Source Code

If you look at the source code, the software now consists of three parts:

1. usbmass, which is executed after power-on and handles USB Mass Storage for SPI FLASH, and loads spiplayer or sdplayer depeding on the SD/MMC insertion switch.
2. spiplayer, which plays SPI FLASH content, loads sdplayer if SD/MMC insertion switch is triggered, and loads usbmass (using watchdog reset) if USB attachment is detected.
3. sdplayer, which plays from SD/MMC, and also handles USB Mass Storage, and loads spiplayer if SD/MMC insertion switch is triggered.

The parts are compiled and linked separately (usbmass.bin, spiplayer.bin, and sdplayer.bin), and SPI boot images are generated from them. Then the three boot images are combined into one image file (spiall.spi) that is programmed into SPI FLASH.

The starting offsets are specified in Makefile and passed as preprocessor definitions to programs.

10 Application Examples

10.1 Headphone Connection

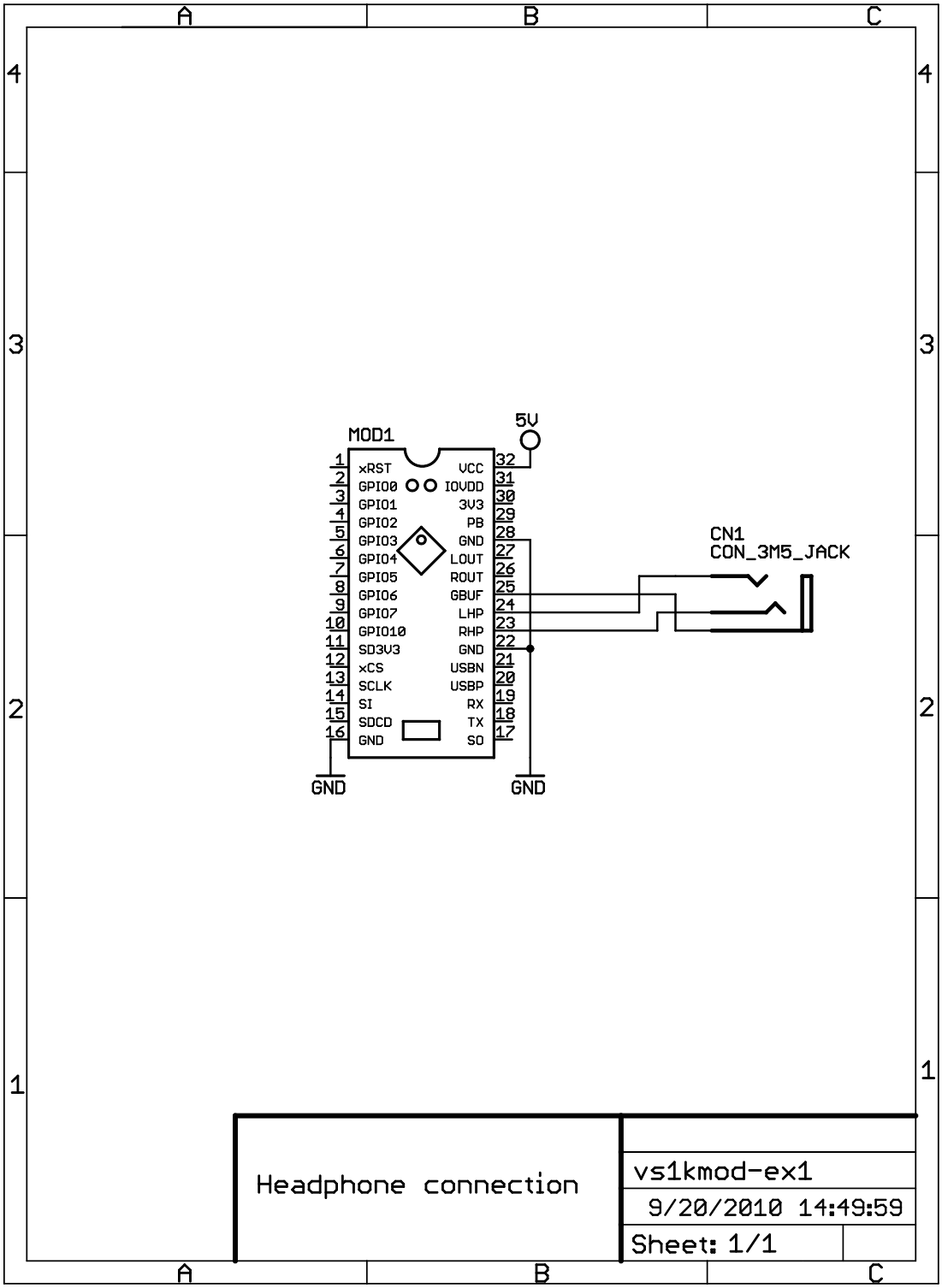


Figure 9: Headphone Connection.

10.2 Line Out Connection

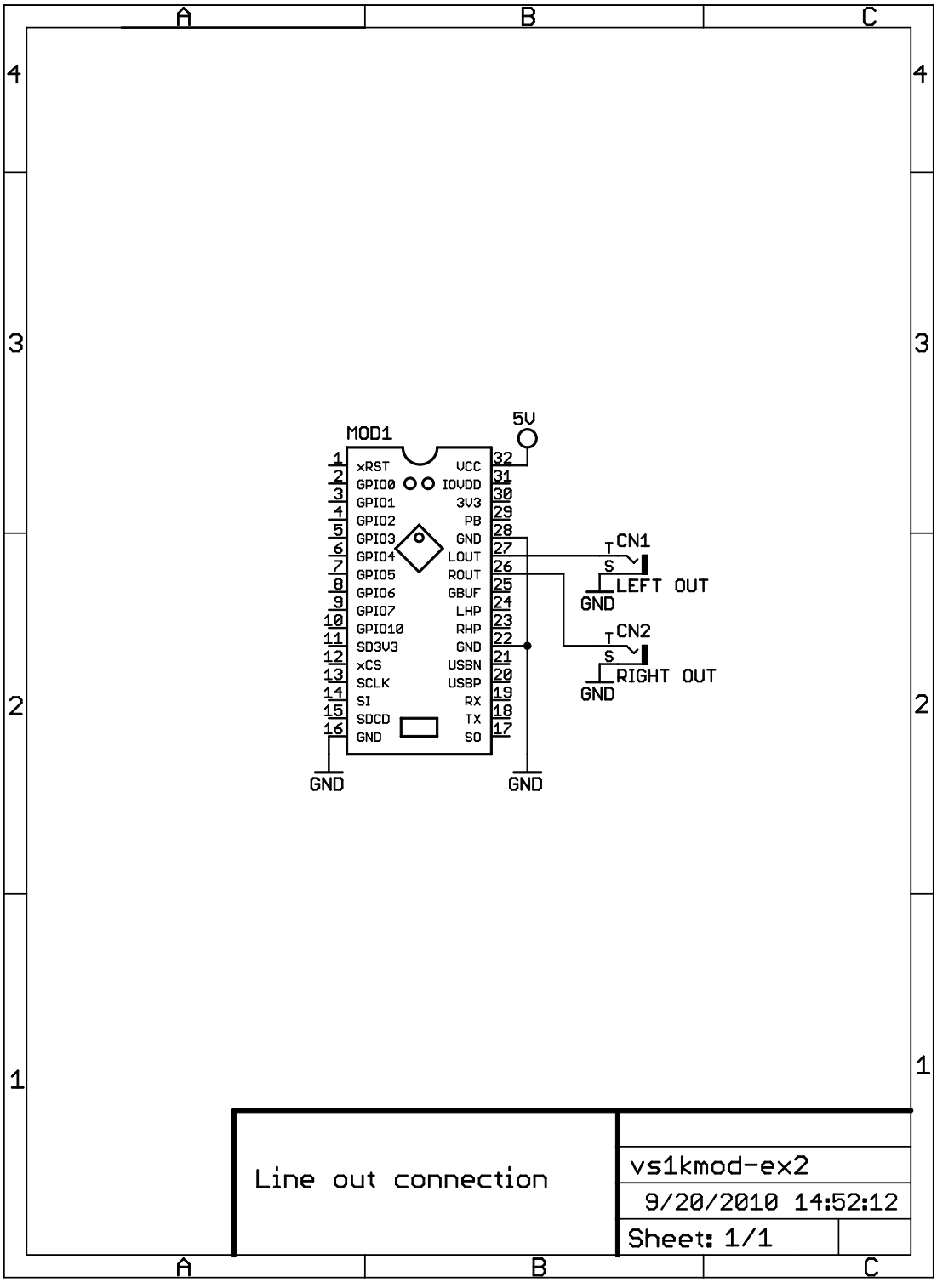


Figure 10: Line Out Connection.

10.3 USB Controlled and Powered Device with Headphone Output

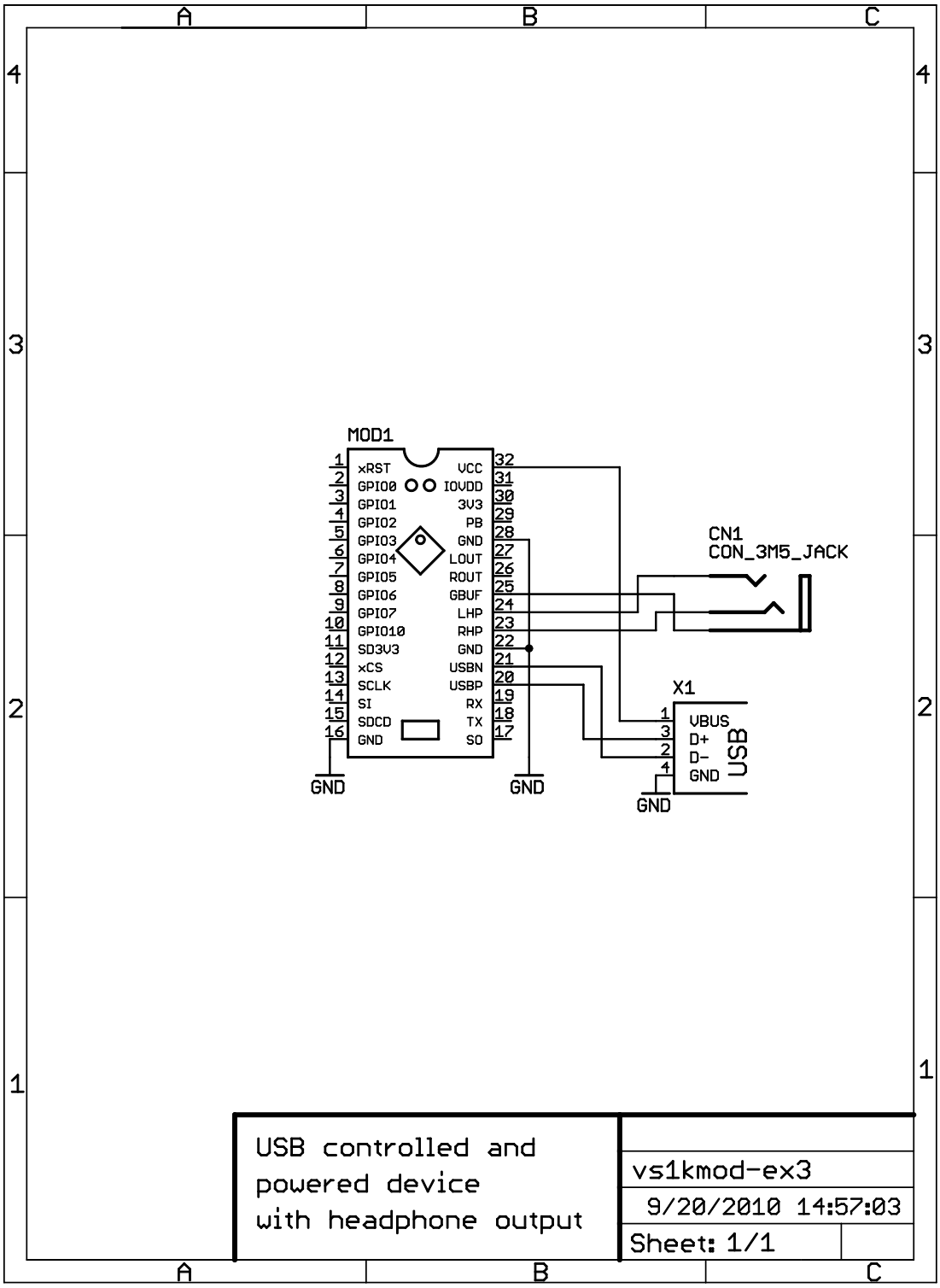


Figure 11: USB Controlled and Powered Device with Headphone Output.

10.4 RS232 Control

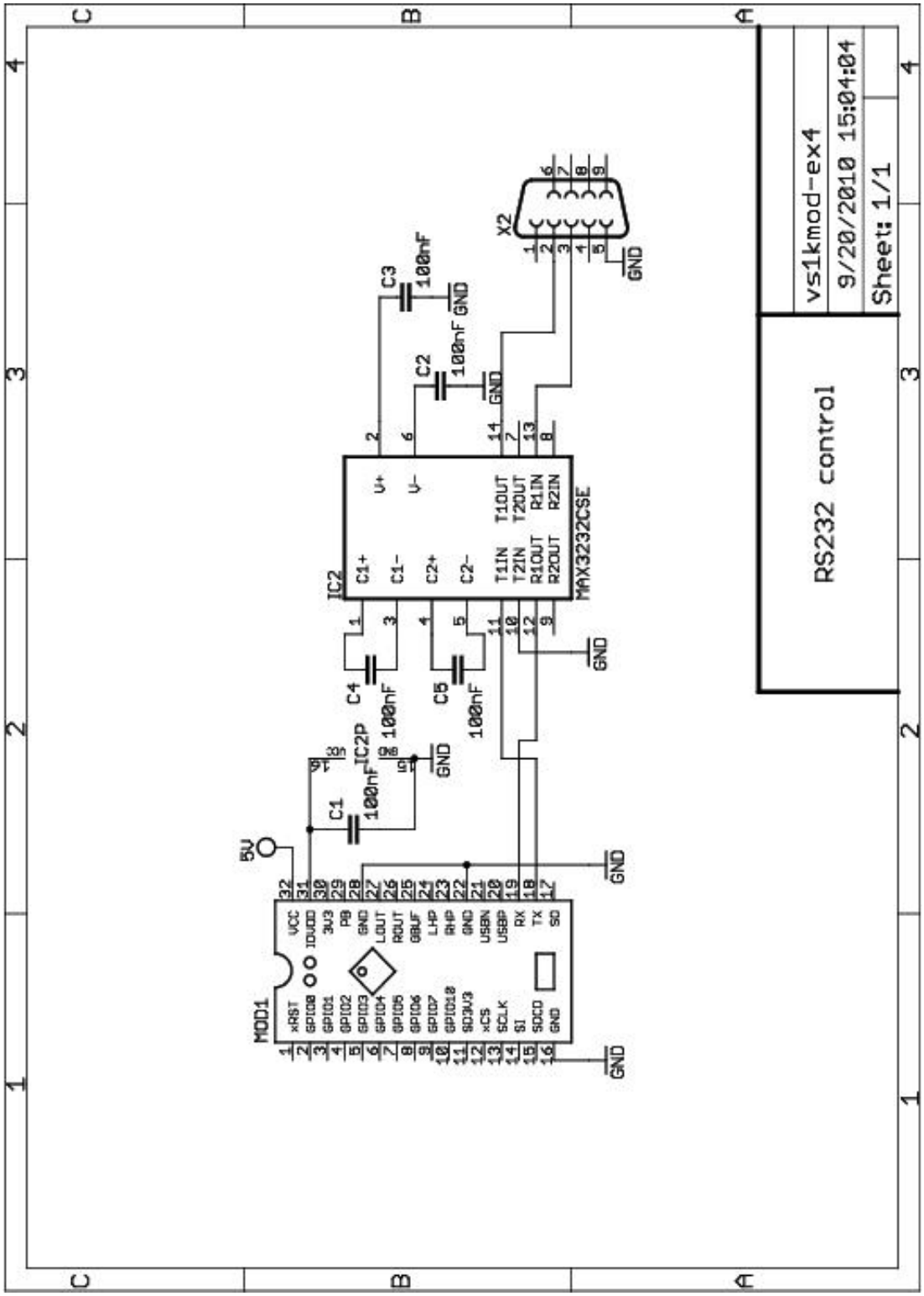


Figure 12: RS232 Control.

10.5 Button Controlled Player

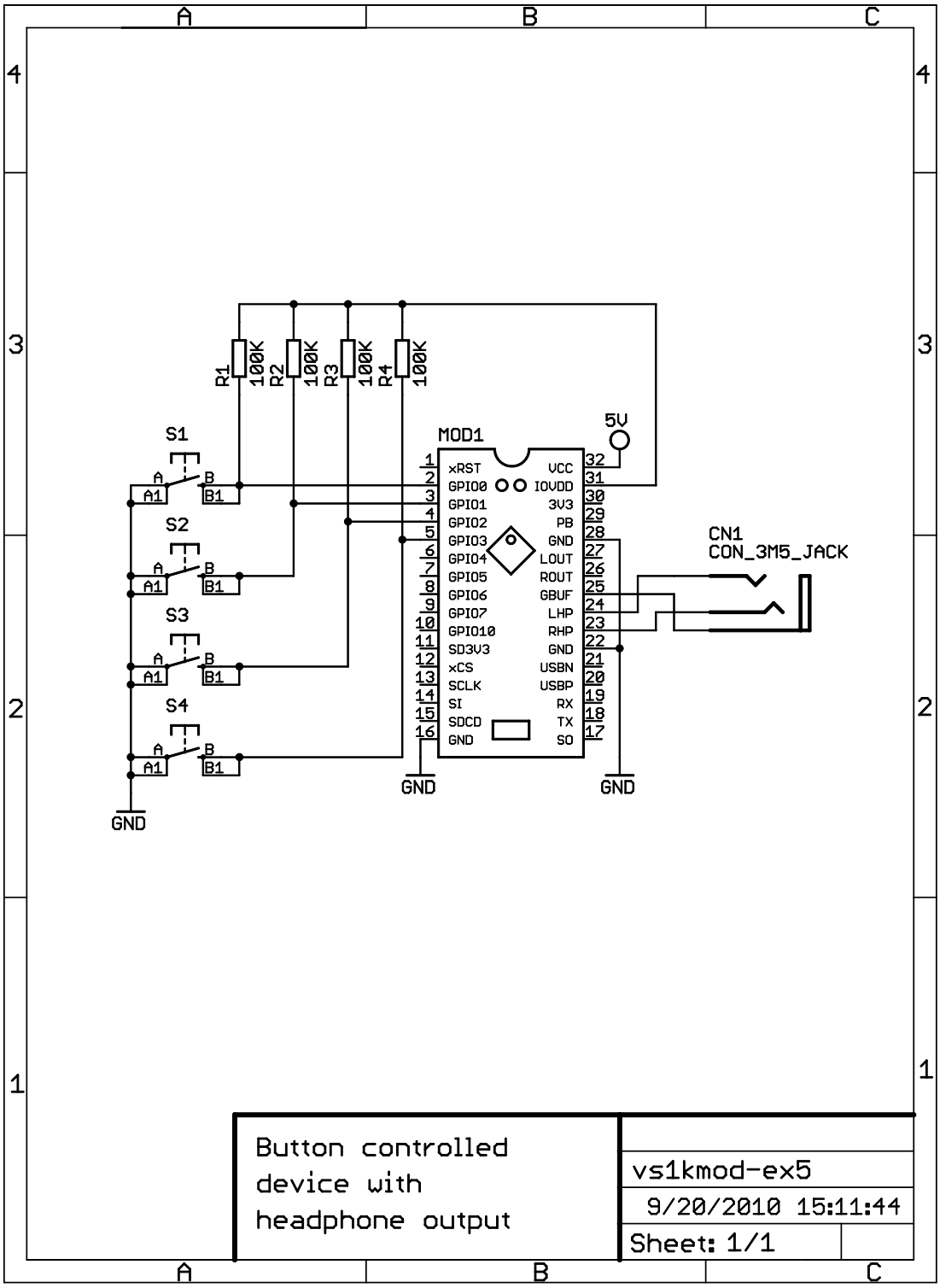


Figure 13: Button Controlled Player.

10.6 USB controlled LEDs and Relays

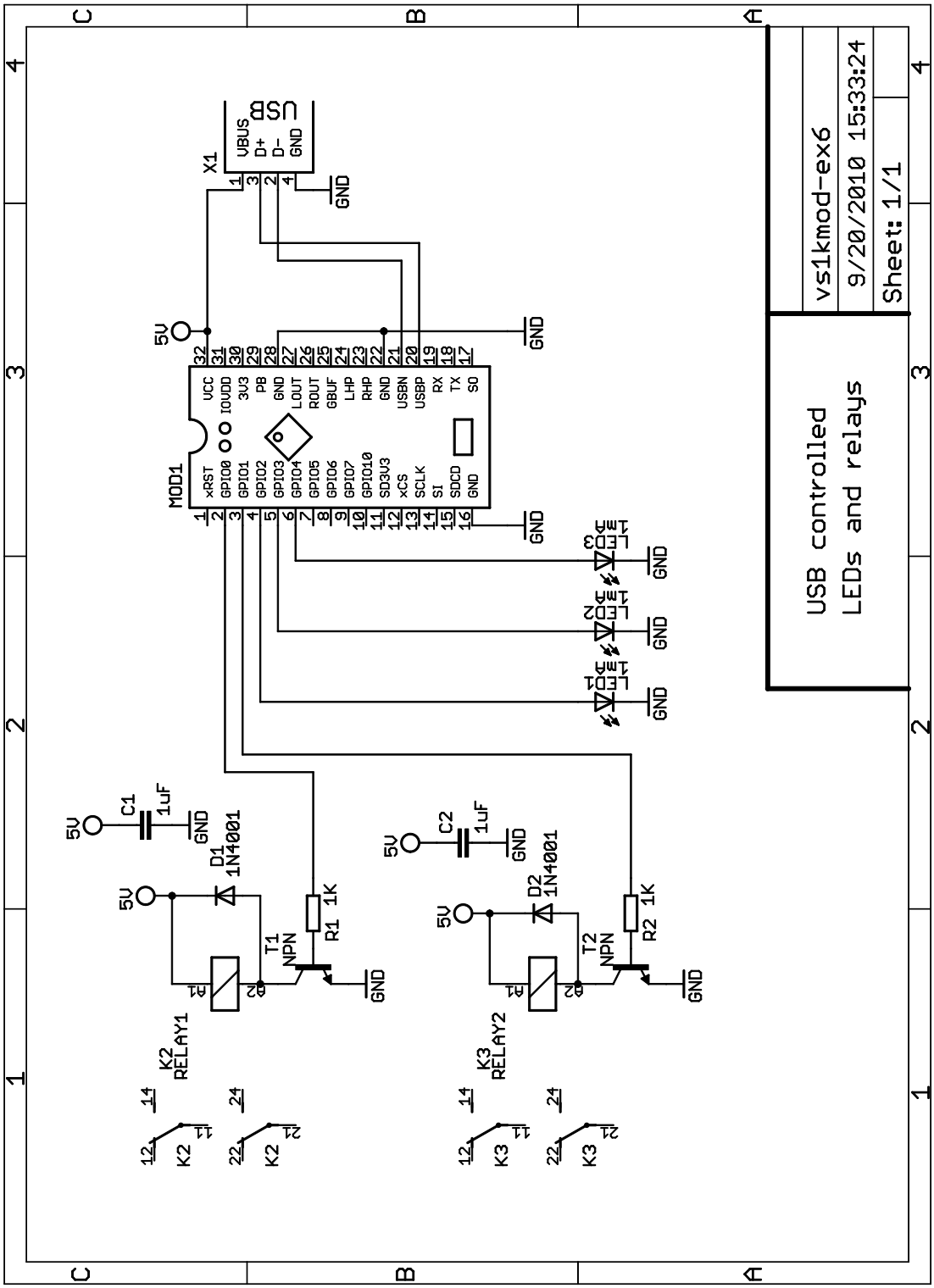


Figure 14: USB Controlled LEDs and Relays.

11 Document Version Changes

This chapter describes the most important changes to this document.

Version 0.41, 2010-11-09

- Corrected image placement.

Version 0.4, 2010-11-04

- Clarified FLASH / EEPROM storage.
- Corrected component names in Chapter 6, Component Layout.

Version 0.3, 2010-10-28

- Revised the default firmware description to correspond to version 0.3.

Version 0.2, 2010-10-12

- Added default firmware description.

Version 0.1, 2010-09-21

- Preliminary datasheet.

12 Contact Information

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