SpinWarrior28

Incremental Encoder Controller for USB

Code Mercenaries

1. Features
- USB interface
- USB V1.1/2.0 compliant low speed device
- USB HID 1.1 compliance
- To be used with electromechanic or electrooptic quadrature encoders
- 3 encoders plus 6 inputs (SW28A3)
- 4 encoders plus 7 switches (SW28R4)
- 6 encoders plus 3 switches (SW28R6)
- Encoder signal frequencies up to 60 kHz (SW28A3) or 25 kHz (SW28R4, SW28R6)
- For motion tracking or human input
- Enable line for encoders to reduce power consumption in sleep mode
- Single +3.3 V power supply (5V for some modules)
- Available in QFN28 package or as modules

1.1 Variants
SpinWarrior28 is available in three variants. Custom modifications are possible for production volumes.

SpinWarrior28A3
- 3 encoders plus 6 digital inputs
- 16 bit absolute position tracking
- Index inputs for reset of position
- max. 60 kHz encoder signal frequency for ca. 250,000 steps per second

SpinWarrior28R4
- 4 encoders plus 7 switches
- 8 bit relative position tracking
- Up to 25 kHz encoder signal frequency for up to 100,000 steps per second

SpinWarrior28R6
- 6 encoders plus 3 switches
- 8 bit relative position tracking
- Up to 25 kHz encoder signal frequency for up to 100,000 steps per second

1.2 Custom variants
Custom variants are possible on request.

1.3 Obsolete variants
The SpinWarrior28 family replaces the obsolete SpinWarrior24 family. Use the following products to replace the legacy products:
SW24A3   - use SW28A3
SW24R4   - use SW28R4
SW24R6   - use SW28R6

SpinWarrior28 are functionally very close to the SpinWarrior24 parts they replace. The main differences are:
3.3 V operation instead of 5 V.
Full Speed USB instead of Low Speed.
Performance improved by an order of magnitude.
Lower current sinking capability of /En pin.

2. Functional overview
SpinWarrior is a USB HID device of the generic type. This means it will be handled by the HID driver on almost all recent operating systems, but no higher level driver (like a mouse driver) will grab the device and block the direct access.
SpinWarrior reports the axes as standard HID axes and the buttons as standard HID buttons. So higher level functions can preprocess the data without problems.

SpinWarrior28

2.1 Product selection matrix

Type	Encoders	Switches	Abs/Rel	Index Impulse	max. Freq.	QFN28	SOIC-Module
SpinWarrior28A3	3	6 (no debounce)	Abs	√	>60 kHz	√	√
SpinWarrior28R4	4	7	Rel	-	25 kHz	√	√
SpinWarrior28R6	6	3	Rel	-	25 kHz	√	√

2.2 Package types

The standard package for SpinWarrior28 is a QFN28 SMD package. For simpler handling in small volumes a DIL28 module is available too. A SOIC24 module to directly replace SpinWarrior24 chips in some applications is available.

2.3 DIL28 module

The DIL28 package is intended for easier handling in small volumes. Mechanically it fits on the same footprint as a DIL28 chip package with 300 mil row spacing.

In addition to the SpinWarrior28 chip the module already contains the 100 nF power filter capacitors for the supply power. Aside from that no additional circuitry is on the module. The electrical properties are identical with the QFN28 chips.

The DIL28 module must not be soldered in a reflow process as components may desolder and fall off the module.

2.4 SOIC24 module

A module that fits on the SOIC24 footprint is available to simplify the transition of designs from the old chips.

The SW28xx-S24 module replicates the function of the SW24xx-S chips as close as possible.

A 3.3 V regulator is contained on the module so it can accept 5 V power. No redesign of the board should be necessary in most cases.

Differences are as follows:

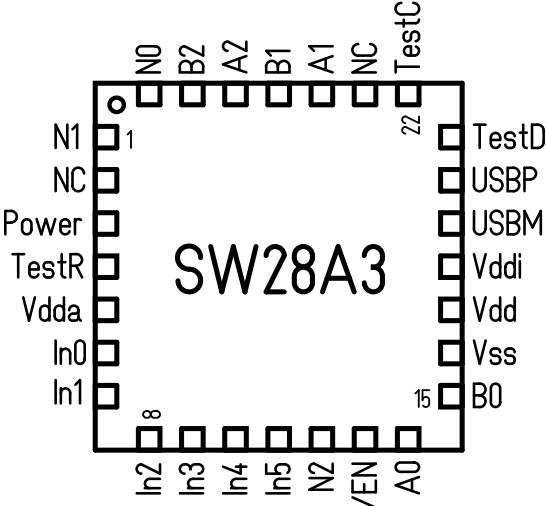USB is running at full speed instead of low speed.

The Vreg pin, which drives the USB pull up resistor for SW24xx, is not connected. SW28xx has an internal pull up resistor on the USB and does not need the external resistor. There is no need to remove the resistor on your legacy board.

All pins aside from the /Power pin are only 3.3 V tolerant. Since the /Power pin is 5 V tolerant it may be pulled up to 5 V like with the SW24xx.
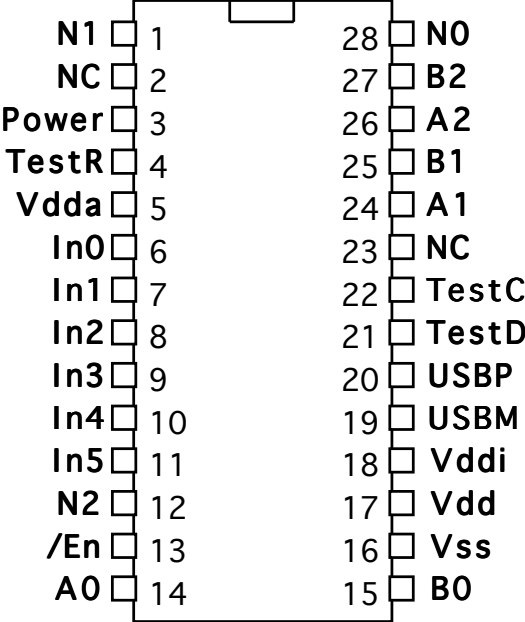
SpinWarrior28

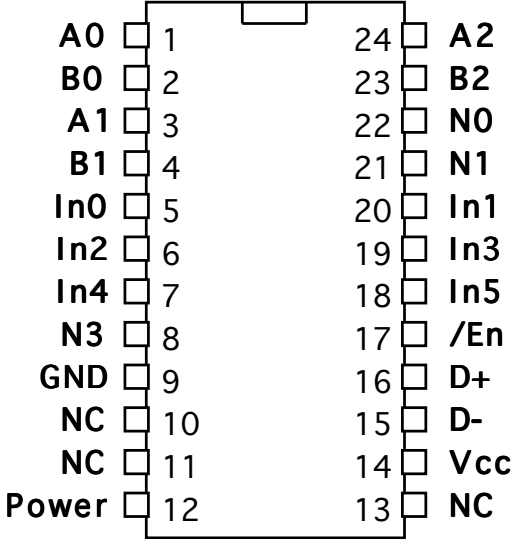## 3.0 Pin Configurations

SpinWarrior28A3-Q28
28 Pin QFN

Pins (QFN, SW28A3):
- Left side, top to bottom: N1 (1), NC, Power, TestR, Vdda, In0, In1
- Bottom, left to right: In2 (8), In3, In4, In5, N2, /EN, A0
- Right side, bottom to top: B0 (15), Vss, Vdd, Vddi, USBM, USBP, TestD
- Top, left to right: N0, B2, A2, B1, A1, NC, TestC (22)

SpinWarrior28A3-DIL28
28 Pin DIL module

Left	#	#	Right
N1	1	28	N0
NC	2	27	B2
Power	3	26	A2
TestR	4	25	B1
Vdda	5	24	A1
In0	6	23	NC
In1	7	22	TestC
In2	8	21	TestD
In3	9	20	USBP
In4	10	19	USBM
In5	11	18	Vddi
N2	12	17	Vdd
/En	13	16	Vss
A0	14	15	B0

All drawings: TOP VIEW!

SpinWarrior28A3-S24
24 Pin SOIC replacement module

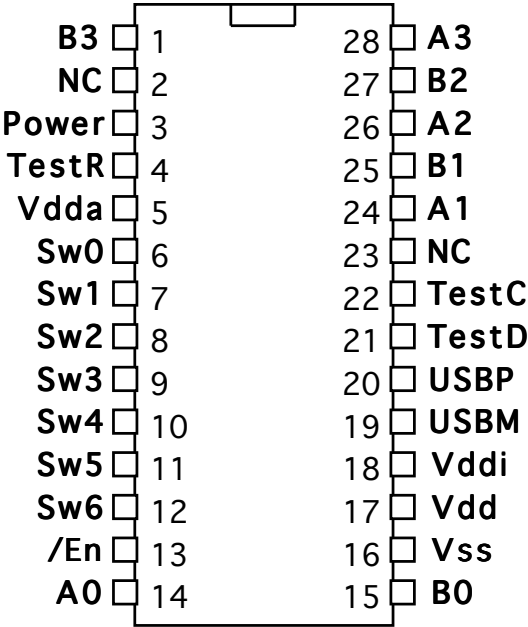| Left	#	#	Right
A0	1	24	A2
B0	2	23	B2
A1	3	22	N0
B1	4	21	N1
In0	5	20	In1
In2	6	19	In3
In4	7	18	In5
N3	8	17	/En
GND	9	16	D+
NC	10	15	D-
NC	11	14	Vcc
Power	12	13	NC

NC pins on SW28A3-S24 have no internal connection, so it does not matter if they are connected

SpinWarrior28R4-Q28
28 Pin QFN

SW28R4

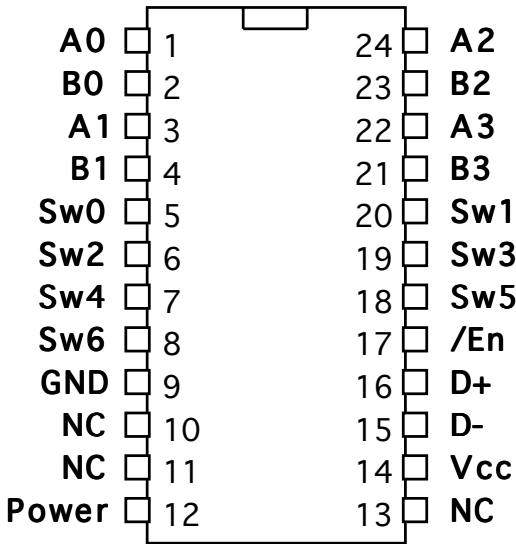| Top pins (left to right) | A3 B2 A2 B1 A1 NC TestC |
Left pins (top to bottom)	B3 (1), NC, Power, TestR, Vdda, Sw0, Sw1
Bottom pins (left to right)	Sw2 (8), Sw3, Sw4, Sw5, Sw6, /EN, A0
Right pins (top to bottom)	TestD (22), USBP, USBM, Vddi, Vdd, Vss, B0 (15)
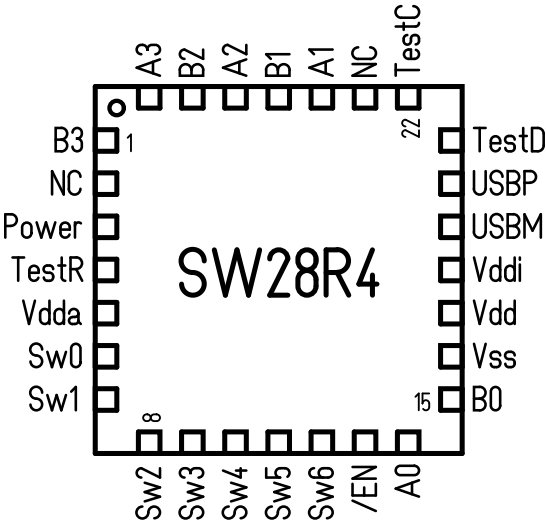
SpinWarrior28R4-DIL28
28 Pin DIL module

Pin	Signal		Pin	Signal
1	B3		28	A3
2	NC		27	B2
3	Power		26	A2
4	TestR		25	B1
5	Vdda		24	A1
6	Sw0		23	NC
7	Sw1		22	TestC
8	Sw2		21	TestD
9	Sw3		20	USBP
10	Sw4		19	USBM
11	Sw5		18	Vddi
12	Sw6		17	Vdd
13	/En		16	Vss
14	A0		15	B0

All drawings: TOP VIEW!

SpinWarrior28R4-S24
24 Pin SOIC replacement module

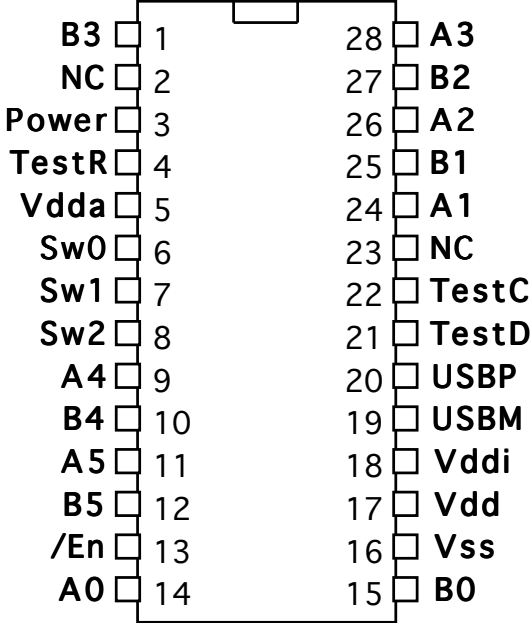| Pin	Signal		Pin	Signal
1	A0		24	A2
2	B0		23	B2
3	A1		22	A3
4	B1		21	B3
5	Sw0		20	Sw1
6	Sw2		19	Sw3
7	Sw4		18	Sw5
8	Sw6		17	/En
9	GND		16	D+
10	NC		15	D-
11	NC		14	Vcc
12	Power		13	NC

NC pins on SW28R4-S24 have no internal connection, so it does not matter if they are connected

SpinWarrior 28R6-Q28
28 Pin QFN

SW28R6
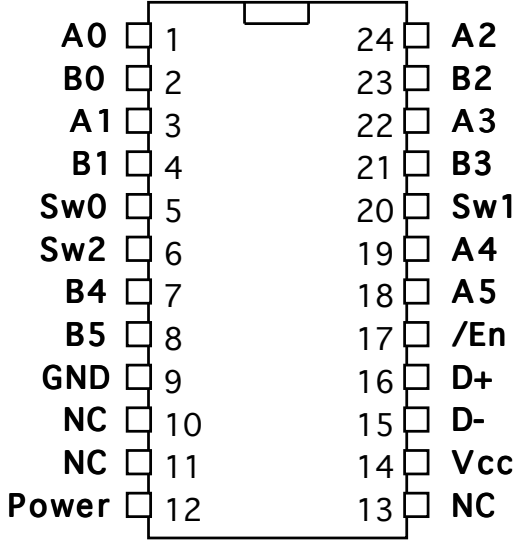
Top pins (left to right): A3, B2, A2, B1, A1, NC, TestC

Left pins (top to bottom): B3 (1), NC, Power, TestR, Vdda, Sw0, Sw1

Right pins (top to bottom): TestD (22), USBP, USBM, Vddi, Vdd, Vss, B0 (15)

Bottom pins (left to right): Sw2 (8), A4, B4, A5, B5, /EN, A0
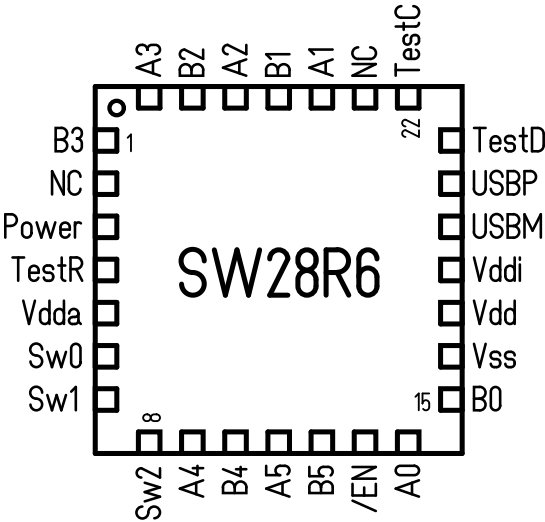
SpinWarrior28R6-DIL28
28 Pin DIL module

Left	Pin	Pin	Right
B3	1	28	A3
NC	2	27	B2
Power	3	26	A2
TestR	4	25	B1
Vdda	5	24	A1
Sw0	6	23	NC
Sw1	7	22	TestC
Sw2	8	21	TestD
A4	9	20	USBP
B4	10	19	USBM
A5	11	18	Vddi
B5	12	17	Vdd
/En	13	16	Vss
A0	14	15	B0

All drawings: TOP VIEW!

SpinWarrior28R6-S24
24 Pin SOIC replacement module

Left	Pin	Pin	Right
A0	1	24	A2
B0	2	23	B2
A1	3	22	A3
B1	4	21	B3
Sw0	5	20	Sw1
Sw2	6	19	A4
B4	7	18	A5
B5	8	17	/En
GND	9	16	D+
NC	10	15	D-
NC	11	14	Vcc
Power	12	13	NC

NC pins on SW28R6-S24 have no internal connection, so it does not matter if they are connected

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4.0 Pin Descriptions SpinWarrior28A3-Q28/-DIL28

Name	I/O	Type	Pins	Description
USBP, USBM	I/O	special	20, 19	USB differential data lines
A0, B0	I	Input, internal pullup	14, 15	Quadrature signals for X axis encoder
A1, B1	I	Input, internal pullup	24, 25	Quadrature signals for Y axis encoder
A2, B2	I	Input, internal pullup	26, 27	Quadrature signals for Z axis encoder
N0, N1, N2	I	Input, internal pullup	28, 1, 12	Index inputs for the encoders
In0, In1, In2, In3, In4, In5	I	Input, internal pullup	6, 7, 8, 9, 10, 11	Digital inputs, active low
/En	O	OpenDrain, internal pullup	13	Enable signal for encoders. Encoders can draw power when this signal is low
Power	I	Input, internal pull down	3	Used to set high or low power mode, pull to Vdd for 500 mA
TestR, TestD, TestC		special	4, 21, 22	Used during manufacturing, do not connect
Vss		Power supply	16	Ground
Vdd, Vdda, Vddi		Power supply	17, 5, 18	Supply voltage, connect to 3.3 V
NC	-		2, 23	do not connect

4.1 Pin Descriptions SpinWarrior28A3-S24

Name	I/O	Type	Pins	Description
D+, D-	I/O	special	16, 15	USB differential data lines
A0, B0	I	Input, internal pullup	1, 2	Quadrature signals for X axis encoder
A1, B1	I	Input, internal pullup	3, 4	Quadrature signals for Y axis encoder
A2, B2	I	Input, internal pullup	24, 23	Quadrature signals for Z axis encoder
N0, N1, N2	I	Input, internal pullup	22, 21, 8	Index inputs for the encoders
In0, In1, In2, In3, In4, In5	I	Input, internal pullup	5, 20, 6, 19, 7, 18	Digital inputs, active low
/En	O	OpenDrain, internal pullup	17	Enable signal for encoders. Encoders can draw power when this signal is low
Power	I	Input, internal pull down	12	Used to set high or low power mode, pull to Vcc for 500 mA
GND		Power supply	9	Ground
Vcc		Power supply	14	Supply voltage, connect to max. 5 V
NC	-		10, 11, 13	do not connect

SpinWarrior28

4.2 Pin Descriptions SpinWarrior28R4-Q28/-DIL28

Name	I/O	Type	Pins	Description
USBP, USBM	I/O	special	20, 19	USB differential data lines
A0, B0	I	Input, internal pullup	14, 15	Quadrature signals for X axis encoder
A1, B1	I	Input, internal pullup	24, 25	Quadrature signals for Y axis encoder
A2, B2	I	Input, internal pullup	26, 27	Quadrature signals for Z axis encoder
A3, B3	I	Input, internal pullup	28, 1	Quadrature signals for Rx axis encoder
Sw0, Sw1, Sw2, Sw3, Sw4, Sw5, Sw6	I	Input, internal pullup	6, 7, 8, 9, 10, 11, 12	Switch inputs, contacts must close to ground
/En	O	OpenDrain, internal pullup	13	Enable signal for encoders. Encoders can draw power when this signal is low
Power	I	Input, internal pull down	3	Used to set high or low power mode, pull to Vdd for 500 mA
TestR, TestD, TestC		special	4, 21, 22	Used during manufacturing, do not connect
Vss		Power supply	16	Ground
Vdd, Vdda, Vddi		Power supply	17, 5, 18	Supply voltage, connect to 3.3 V
NC	-		2, 23	do not connect

4.3 Pin Descriptions SpinWarrior28R4-S24

Name	I/O	Type	Pins	Description
D+, D-	I/O	special	16, 15	USB differential data lines
A0, B0	I	Input, internal pullup	1, 2	Quadrature signals for X axis encoder
A1, B1	I	Input, internal pullup	3, 4	Quadrature signals for Y axis encoder
A2, B2	I	Input, internal pullup	24, 23	Quadrature signals for Z axis encoder
A3, B3	I	Input, internal pullup	22, 21	Quadrature signals for rX axis encoder
Sw0, Sw1, Sw2, Sw3, Sw4, Sw5, Sw6	I	Input, internal pullup	5, 20, 6, 19, 7, 18, 8	Digital inputs, active low
/En	O	OpenDrain, internal pullup	17	Enable signal for encoders. Encoders can draw power when this signal is low
Power	I	Input, internal pull down	12	Used to set high or low power mode, pull to Vcc for 500 mA
GND		Power supply	9	Ground
Vcc		Power supply	14	Supply voltage, connect to max. 5 V
NC	-		10, 11, 13	do not connect

4.4 Pin Descriptions SpinWarrior28R6-Q28/-DIL28

Name	I/O	Type	Pins	Description
USBP, USBM	I/O	special	20, 19	USB differential data lines
A0, B0	I	Input, internal pullup	14, 15	Quadrature signals for X axis encoder
A1, B1	I	Input, internal pullup	24, 25	Quadrature signals for Y axis encoder
A2, B2	I	Input, internal pullup	26, 27	Quadrature signals for Z axis encoder
A3, B3	I	Input, internal pullup	28, 1	Quadrature signals for Rx axis encoder
A4, B4	I	Input, internal pullup	9, 10	Quadrature signals for Ry axis encoder
A5, B5	I	Input, internal pullup	11, 12	Quadrature signals for Rz axis encoder
Sw0, Sw1, Sw2	I	Input, internal pullup	6, 7, 8	Switch inputs, contacts must close to ground
/En	O	OpenDrain, internal pullup	13	Enable signal for encoders. Encoders can draw power when this signal is low
Power	I	Input, internal pull down	3	Used to set high or low power mode, pull to Vdd for 500 mA
TestR, TestD, TestC		special	4, 21, 22	Used during manufacturing, do not connect
Vss		Power supply	16	Ground
Vdd, Vdda, Vddi		Power supply	17, 5, 18	Supply voltage, connect to 3.3 V
NC	-		2, 23	do not connect

4.5 Pin Descriptions SpinWarrior28R6-S24

Name	I/O	Type	Pins	Description
D+, D-	I/O	special	16, 15	USB differential data lines
A0, B0	I	Input, internal pullup	1, 2	Quadrature signals for X axis encoder
A1, B1	I	Input, internal pullup	3, 4	Quadrature signals for Y axis encoder
A2, B2	I	Input, internal pullup	24, 23	Quadrature signals for Z axis encoder
A3, B3	I	Input, internal pullup	22, 21	Quadrature signals for rX axis encoder
A4, B4	I	Input, internal pullup	19, 7	Quadrature signals for rX axis encoder
A5, B5	I	Input, internal pullup	18, 8	Quadrature signals for rX axis encoder
Sw0, Sw1, Sw2	I	Input, internal pullup	5, 20, 6	Digital inputs, active low
/En	O	OpenDrain, internal pullup	17	Enable signal for encoders. Encoders can draw power when this signal is low
Power	I	Input, internal pull down	12	Used to set high or low power mode, pull to Vcc for 500 mA
GND		Power supply	9	Ground
Vcc		Power supply	14	Supply voltage, connect to max. 5 V
NC	-		10, 11, 13	do not connect

SpinWarrior28

4.6 Pin descriptions

USBP, USBM
Differential data lines of USB. Connect these signals direct to a USB cable.
For a PCB layout make sure to run these two signals next to each other. USB data is a differential signal that produces best signal quality and lowest RF emission if the two lines are close to each other.

A0, B0
Quadrature inputs for the first axis. An encoder that generates two digital signals with ±90° offset must be connected to these inputs.
If channel A leads channel B by 90° the pulses reported by SpinWarrior will be positive.
The first encoder is reported as X axis.
Inputs with internal pullup resistor.

A1, B1
Quadrature inputs for the second axis.
The second encoder is reported as Y axis.
Inputs with internal pullup resistor.

A2, B2
Quadrature inputs for the third axis.
The third encoder is reported as Z axis.
Inputs with internal pullup resistor.

A3, B3 (SW28R4 and SW28R6 only)
Quadrature inputs for the fourth axis.
The fourth encoder is reported as Rx axis (rotational X).
Inputs with internal pullup resistor.

A4, B4 (SW28R6 only)
Quadrature inputs for the fifth axis.
The fifth encoder is reported as Ry axis (rotational Y).
Inputs with internal pullup resistor.

A5, B5 (SW28R6 only)
Quadrature inputs for the sixt axis.
The sixth encoder is reported as Rz axis (rotational Z).
Inputs with internal pullup resistor.

N0, N1, N3 (SW28A3)
Inputs for the index signals from the three encoders. A low to high edge on the Nx input resets the internal counter for that channel to zero.
Inputs with internal pull up resistor.
Leave open if not used.

Sw0..Sw6 (SW28R4)
Sw0..Sw2 (SW28R6)
Inputs for switches closing to ground.
Pulling a switch input low does signal an active switch. The switches are reported as HID buttons.
Inputs with internal pull up resistor.

In0..In5 (SW28A3)
Digital inputs active low.
Pulling one of these inputs low does signal an active status being reported via USB. The signals are not internally debounced, so care must be taken when switches are connected to these inputs.
Inputs with internal pull up resistor.
Leave open if not used.

Vss
Power supply ground.

Vdd, Vdda, Vddi
Supply voltage inputs
A 100nF ceramic capacitor is required to be connected directly to the power supply pins. Use one capacitor for each power input

Power
Input to set the power mode. The status of the pin is checked only at power up and bus reset. Pulling this pin to high sets high power mode, this means the SpinWarrior28 will report as a high power, bus powered device drawing up to 500 mA. Pulling Power low on reset sets the low power mode specifying 100 mA maximum power draw.
When using electromechanical encoders the Power pin can be tied low since the current will definitely stay below 100mA. For optical encoders the data sheet of the parts used should be checked for the current draw of these parts and the Power pin set accordingly. Keep in mind that the SpinWarrior requires operating current too.

/En
To meet the USB suspend mode current limit it is necessary, that the encoders draw no current while the USB is suspended.
The /En pin is low when current may be drawn. When using mechancial encoders their common connector may be connected direct to the /En pin. For optical encoders check their data sheets to determine if the /En pin can sink sufficient current or if a driver is necessary. In any case a low side driver is recommended. Otherwise the SpinWarrior inputs may be pulled low through the encoders internal protection diodes which results in a unwanted current draw during suspend state.

5. Device Operation

Due to the fact that all current operating systems offer an especially easy access to devices in the HID class, SpinWarrior was designed as a generic HID device.

By identifying as a generic HID class device SpinWarrior avoids being controlled by any of the higher level system drivers, which makes it possible to access SpinWarrior from application level.

5.1 Accessing SpinWarrior

A common misconception with people new to the USB is that they think they can "talk to the USB port". The truth is that you do that as likely as you are going to directly talk to your Ethernet port or PCI bus.

Communication on the USB is always with a specific device attached to the USB. The USB itself is only the medium through which you communicate.

To get access to a certain device you have to look for the VendorID and ProductID of that device. The specific mechanism for doing so depends on the individual operating system.

For details refer to our sample code.

5.2 Movement direction

If channel A leads channel B by 90° the pulses reported by SpinWarrior will be positive.

5.3 Tracking accuracy

When using encoders with a clean signal that has no ringing or bouncing SpinWarrior will report the exact number of pulses it receives as long as the maximum edge rate for the encoder signal is not exceeded.

Exceeding the maximum edge rate can result in lost impulses.

Performance of SpinWarrior28 has been significantly improved over its predecessors. The tracking of the encoder signals is no longer influenced by USB activity.

Since SpinWarrior is using quadrant tracking it will report an impulse for each falling or rising edge on either signal A or B. This results in a resolution four times higher than that achieved by using A as the clock and B as the direction signal.

Reversing the movement direction can result in some pulses not getting reported. If the last pulses have not been transmitted before the direction changes subsequent pulses will be substracted from the stored pulses.

This means the pulses seen by the computer for a given movement in one direction and then back will be the exact same, though it can happen that the maximum position does not get reported due to the direction reversal.

5.4 Using mechanical encoders

The use of electro mechanical encoders (i.e. encoders that use switches to generate the quadrature signals) should be limited to human input applications. It is not recommended to use electromechanical encoders or switches with SW28A3 at all.

Switches bounce, that means a contact closure is not immediate and final, the contact will close and open several times for a few milliseconds before becoming stable.

Usually this is compensated by a debounce logic either in hardware or software. But adding such a debounce logic would restrict the rotation speed that can be tracked to a level that feels uncomfortable.

SpinWarrior does not implement such a debounce logic for the encoders to allow maximum tracking speed. Though this also means some additional spurious pulses may be detected.

Due to the quadrant tracking used by SpinWarrior such false pulses usually are compensated. Though testing shows that some pulses may actually be added by mechanical encoders. This makes them unsuitable for exact tracking like in motion control.

5.5 Power supply

USB does allow a device to be "Bus Powered". This means the device does get its power off the USB port. To avoid overloading on the USB ports devices need to advertise their power requirements.

There are two power classes for devices: Low power and high power. Low power devices may draw up to 100mA off the USB, high power devices up to 500mA.

Likewise there are high power and low power ports. Usually high power ports are those on the motherboard and on hubs with external power supply or hubs in a monitor. Low power ports are typically on hubs that get their power off the USB, like hubs in keyboards.

If the system decides that there is not sufficient power to supply a high power decive that device does not get enabled.

SpinWarrior can operate either as a high power or low power device. Pulling the Power pin high or low at reset sets the desired power rating.

This allows to configure SpinWarrior optimally for supporting the encoders used.

5.6 Suspend

All devices on USB need to support the suspended state. When the host computer stops to periodically access the USB, like when it goes to sleep, all devices need to enter the suspended state and drop their power draw to less than 500μA for low power devices or less than 2.5mA for high power devices. When entering suspended state SpinWarrior pulls the /En pin high. Care must be taken in designing the external circuit so that it will draw no more than the allowed suspend power rating while /En is high.

5.7 Remote Wakeup

SpinWarrior chips support the remote wakeup feature. They are able to wake the host computer from sleep state if the host operating system has enabled this feature.

Remote wakeup is initiated by SpinWarrior if any of the switch inputs is pulled low while the chip is in suspended state.

5.8 Data Report Format

SpinWarrior28A3 keeps a 16 bit count for each encoder position and reports this as an absolute position. The count gets reset to zero on a low to high going edge of the N input of that encoder channel.

SpinWarrior28R4 and SpinWarrior28R6 keep an 8 bit count of encoder impulses received since the last data transmission. To measure an absolute positon with them it is necessary to sum up all received data packets on the controlling computer.

SpinWarrior28A3 sends reports with 7 byte length:
Byte0 - X LSB
Byte1 - X MSB
Byte2 - Y LSB
Byte3 - Y MSB
Byte4 - Z LSB
Byte5 - Z MSB
Byte6 - Switches

SpinWarrior28R4 sends reports with 5 byte length:
Byte0 - X
Byte1 - Y
Byte2 - Z
Byte3 - rX
Byte4 - Switches

SpinWarrior28R6 sends reports with 7 byte length:
Byte0 - X
Byte1 - Y
Byte2 - Z
Byte3 - rX
Byte4 - rY
Byte5 - rZ
Byte6 - Switches

SpinWarrior28

6. Absolute Maximum Ratings

Storage Temperature ....-65°C to +150°C
Ambient Temperature, operating...-0°C to +70°C
Supply voltage on Vcc relative to Gnd ....-0.5V to +7V
DC input voltage...-0.5V to Vcc+0.5V
Maximum current into all ports...70mA
Power Dissipation..300mW
Static discharge voltage..>2000V
Latch-up current ....>200mA

6.1 DC Characteristics

	Parameter	Min	Max	Units	Remarks
V_{cc}	Operating Voltage	2.0	3.6	V	typ. 3.3 V
I_{cc}	Operating Supply Current		25	mA	
I_{sb}	Suspend mode current		350	μA	internally active
I_{ol}	Sink current on interface pins		25	mA	max. combined all pins 80 mA
I_{olen}	Sink current on /En pin		25	mA	max. combined all pins 80 mA
V_{ol8}	Output low voltage		0.4	V	I = 8 mA
V_{oh8}	Output high voltage	V_{ddi}-0.4		V	I = 8 mA
V_{ol20}	Output low voltage		1.3	V	I =20 mA
V_{oh20}	Output high voltage	V_{ddi}-1.3		V	I =20 mA
R_{up}	Pull up/down resistors	25	55	kΩ	typ. 40 kΩ
V_{ith}	Input Threshold Voltage	0.7 x V_{ddi}		V	

6.2 Encoder Timing
Minimum timing for the encoders is specified as the time from edge to edge on any of the two signals for each encoder. The time from any edge on signal A to an edge on signal B, or vice versa, or any two edges on either signal A or B must not be shorter than what is specified as tmin.

6.2.1 Encoder Timing SW28A3
tmin = 4μs, fmax = 62,500Hz
Timing does not change if all encoders are operating.

6.2.2 Encoder Timing SW28R4 and SW28R6
tmin = 10μs, fmax = 25,000Hz
Timing does not change if all encoders are operating.

7. Ordering information

The chips listed here are standard products. Customized chips are available on request.

Partname	Order Code	Description	Package
SpinWarrior28A3	SW28A3-Q28	Rotary encoder controller for 3 encoders, absolute	QFN28
SpinWarrior28A3	SW28A3-DIL28	Rotary encoder controller for 3 encoders, absolute	DIL28 Mod
SpinWarrior28A3	SW28A3-S24	Rotary encoder controller for 3 encoders, absolute	SOIC24 Mod
SpinWarrior28R4	SW28R4-Q28	Rotary encoder controller for 4 encoders, relative	QFN28
SpinWarrior28R4	SW28R4-DIL28	Rotary encoder controller for 4 encoders, relative	DIL28 Mod
SpinWarrior28R4	SW28R4-S24	Rotary encoder controller for 4 encoders, relative	SOIC24 Mod
SpinWarrior28R6	SW28R6-Q28	Rotary encoder controller for 6 encoders, relative	QFN28
SpinWarrior28R6	SW28R6-DIL28	Rotary encoder controller for 6 encoders, relative	DIL28 Mod
SpinWarrior28R6	SW28R6-S24	Rotary encoder controller for 6 encoders, relative	SOIC24 Mod

7.1 Packaging info
QFN28 chips come in trays - TBD
DIP28 modules - TBD
SOIC24 repalcement module - TBD

7.2 USB VendorID and ProductID
By default all SpinWarrior chips are shipped with the USB VendorID of Code Mercenaries ($7C0 or decimal 1984) and a fixed ProductID.
On request chips can be equipped with the customers VendorID and ProductID. VendorIDs can be obtained from the USB Implementers Forum <www.usb.org>
Customized chips may be subject to minimum order quantities, contact <sales@codemercs.com> for details.

7.3 Serial numbers
SpinWarrior chips do have unique serial numbers in their device descriptors. These serial numbers can be used to simplify programming for multiple SpinWarriors connected to a single computer.

The serial numbers are factory programmed and can not be changed. Serial numbers are 8 digit hexadecimal numbers. No two chips of a type will be produced with identical serial numbers. Though it can be that a SW28R4 has the same serial number as a SW28R6 or SW28A3 chip.
It is not possible to order chips with a specific serial number unless they are ordered as custom chips which are subject to minimum order volumes and setup charges.

7.4 Product IDs, Versions and Production Status
Following is the current status for all SpinWarrior variants and the Product ID information. ProductIDs are independent of the package type.

| Partname	Product ID	Current Shipping Version	Status
SpinWarrior28A3	$1208	V1.0.0.0	shipping
SpinWarrior28R4	$1209	V1.0.0.0	shipping
SpinWarrior28R6	$120A	V1.0.0.0	shipping
SpinWarrior24A3	$1200	V1.1.0.0	discontinued, available for maintenance only
SpinWarrior24R4	$1201	V1.1.0.0	discontinued, available for maintenance only
SpinWarrior24R6	$1202	V1.1.0.0	discontinued, available for maintenance only

SpinWarrior28

8. SpinWarrior28R4 with optical encoders
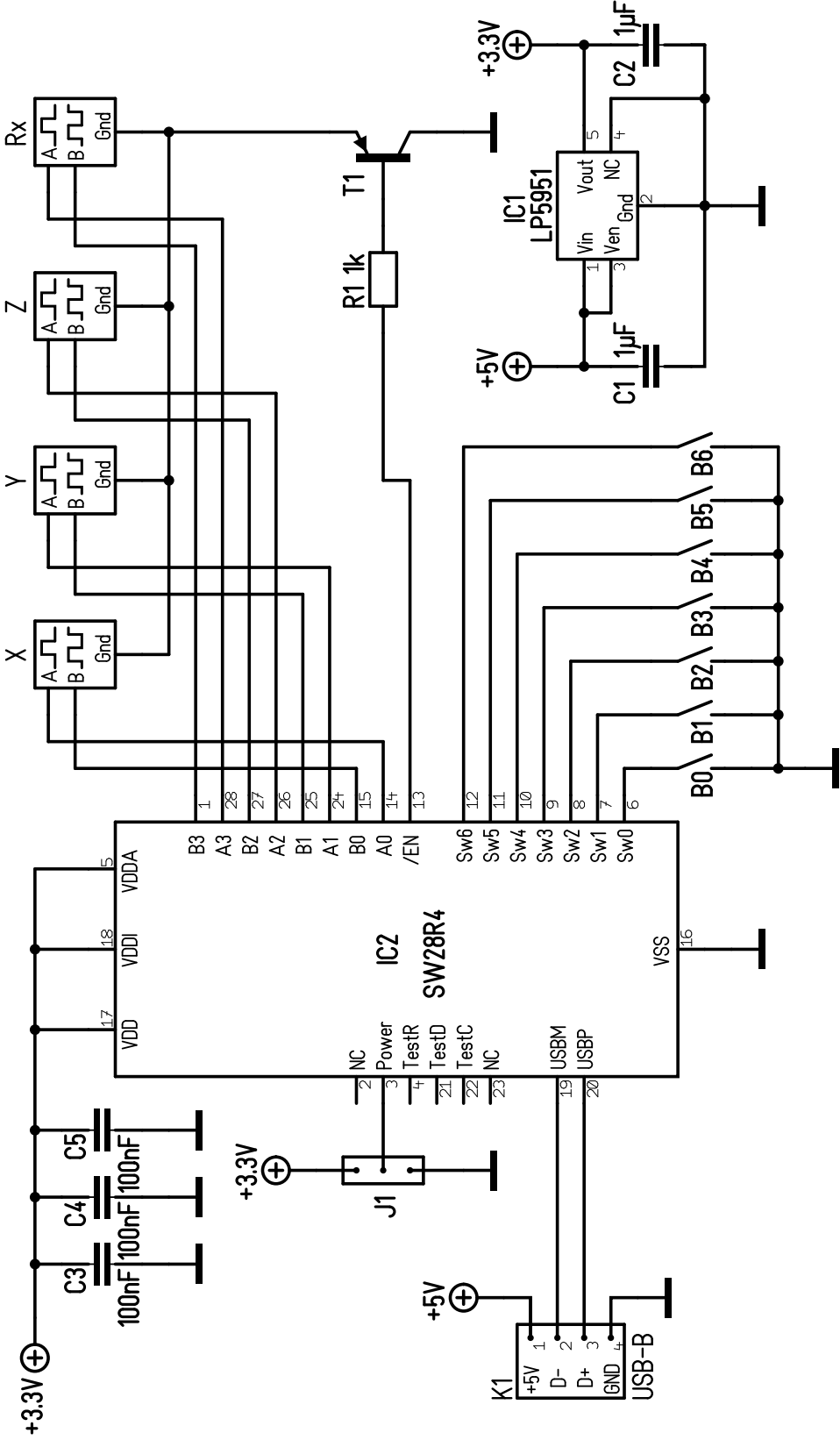
The low side driver circuit for the power supply of the encoders is just an example. Actual driver circuits should be designed to fit the requirements of the encoders used.
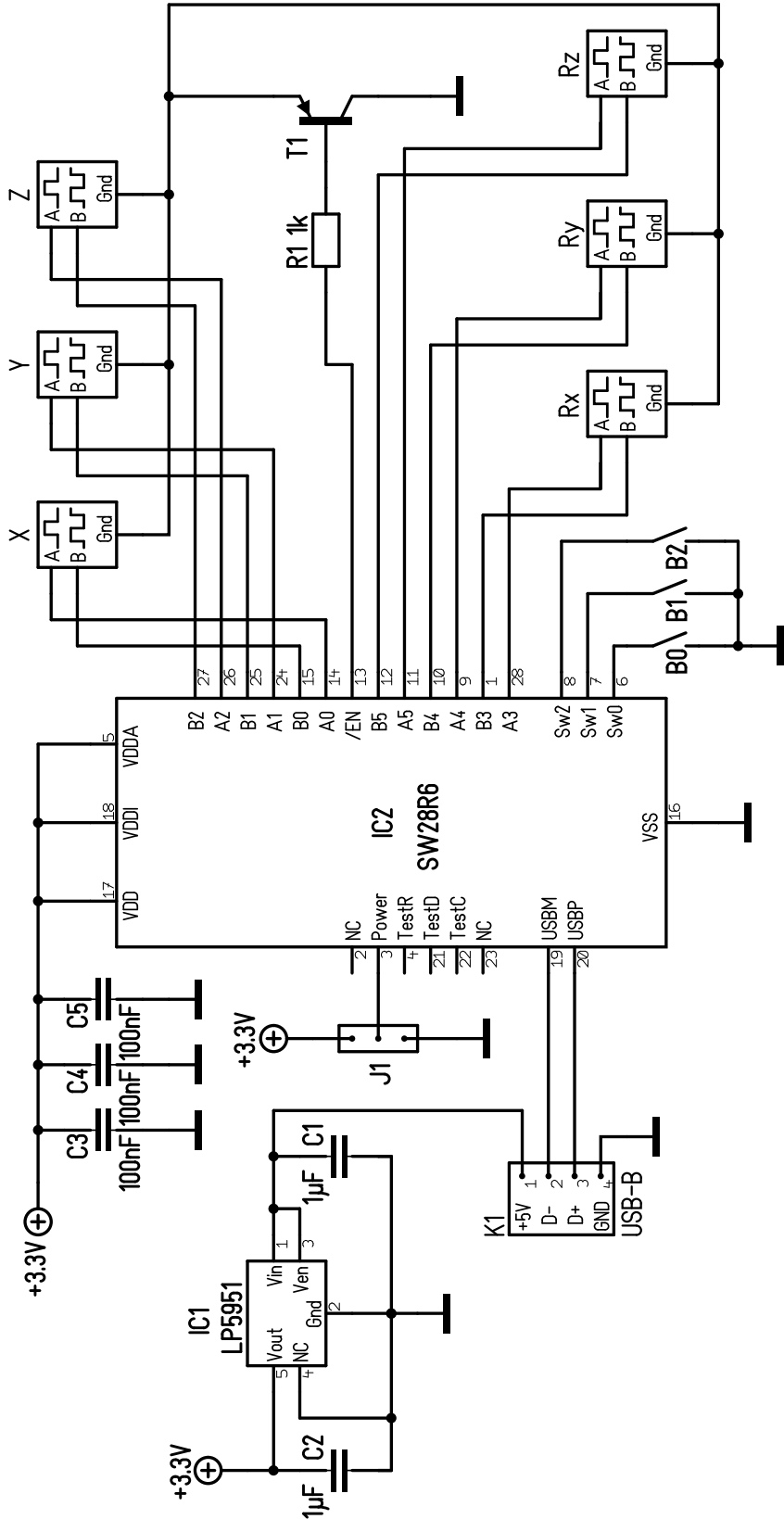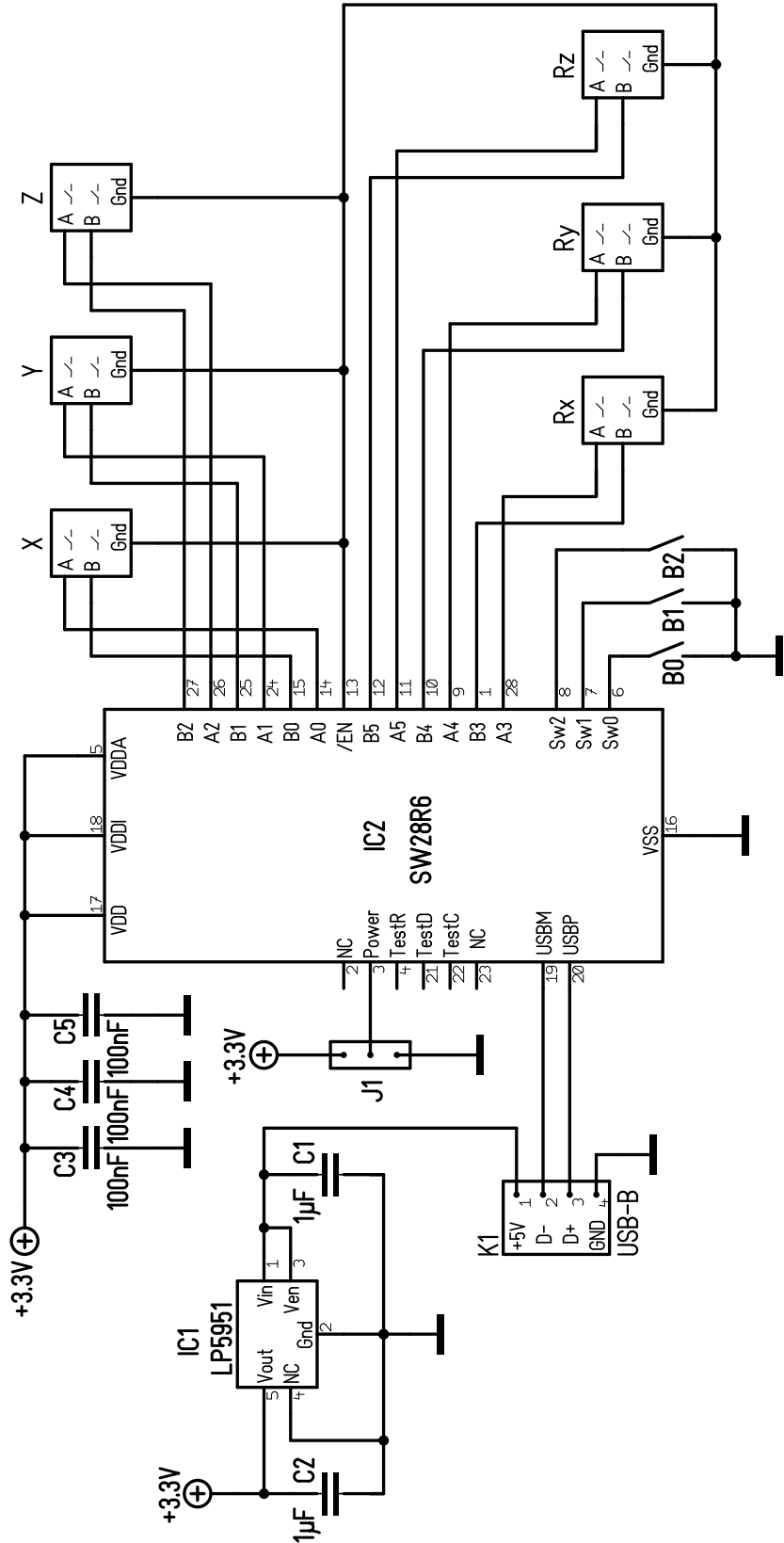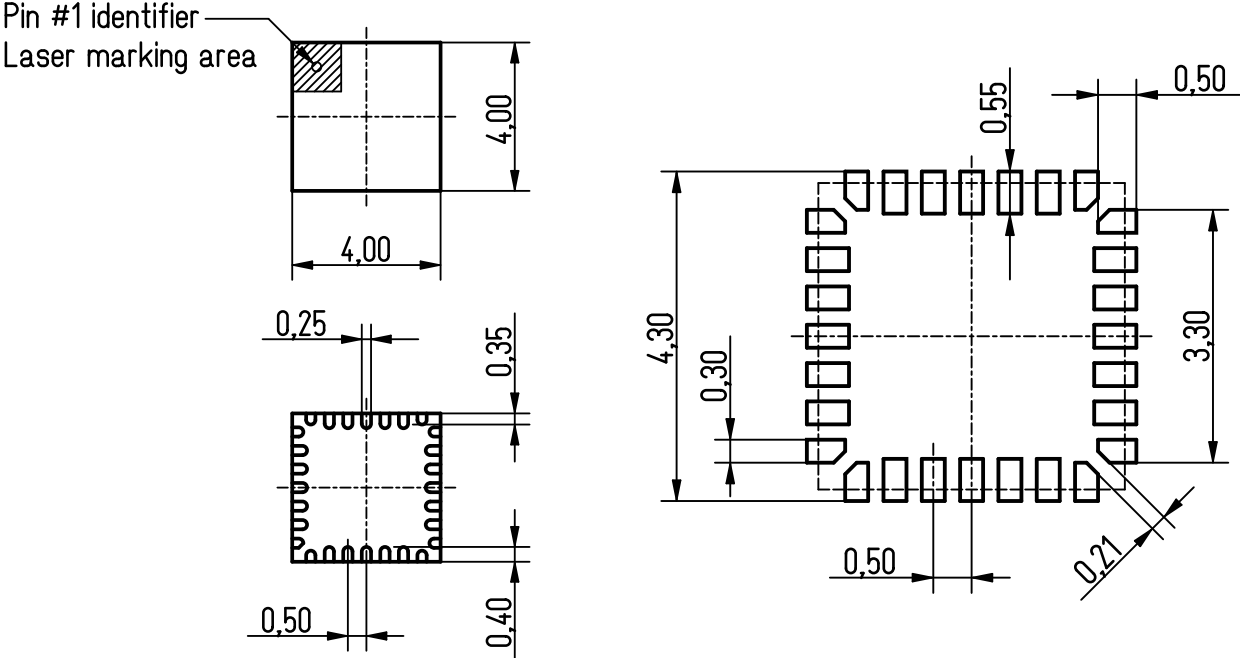
SpinWarrior28

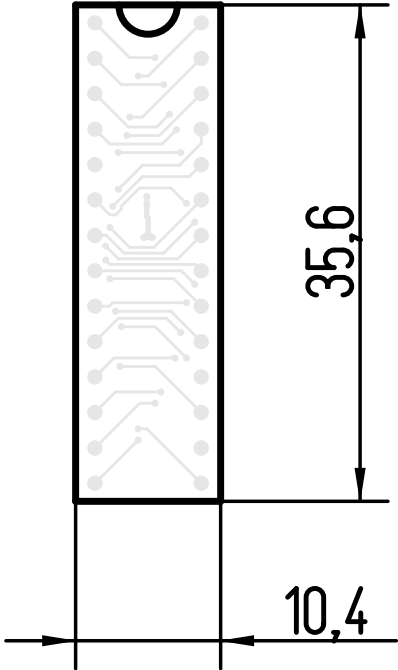**8.1 SpinWarrior 28R4 with mechanical encoders**
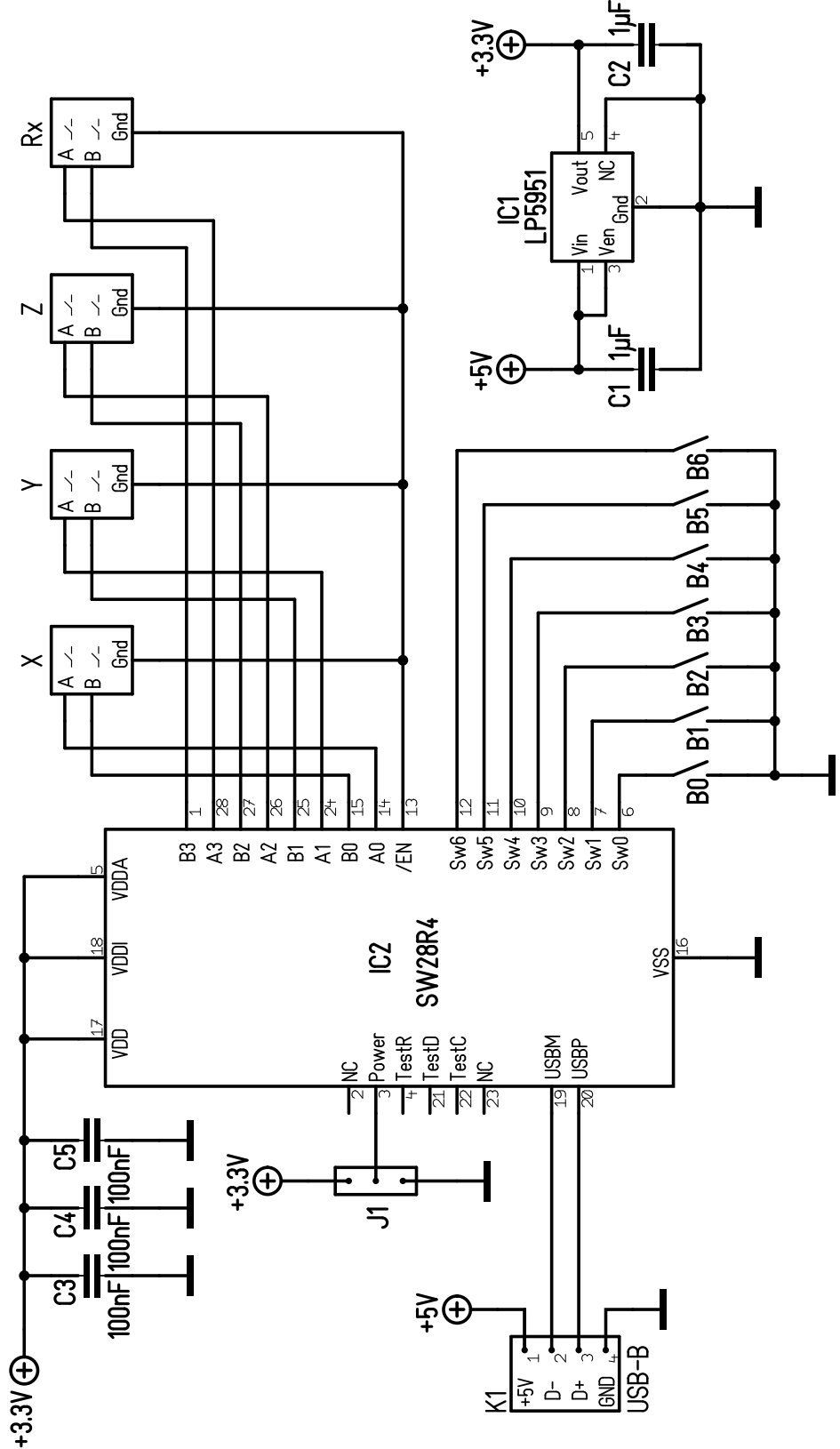
The common connectors of the mechanical encoders should be connected to /En and not to ground. This ensures that the encoders do not drain current through the internal pull up resistors of the SpinWarrior while in suspend mode.

SpinWarrior28

8.2 SpinWarrior28R6 with optical encoders

The low side driver circuit for the power supply of the encoders is just an example. Actual driver circuits should be designed to fit the requirements of the encoders used.

SpinWarrior28

8.3 SpinWarrior 28R6 with mechanical encoders

The common connectors of the mechanical encoders should be connected to /En and not to ground. This ensures that the encoders do not drain current through the internal pull up resistors of the SpinWarrior while in suspend mode.

8.4 SpinWarrior 28A3

SpinWarrior28

9. Package Dimensions
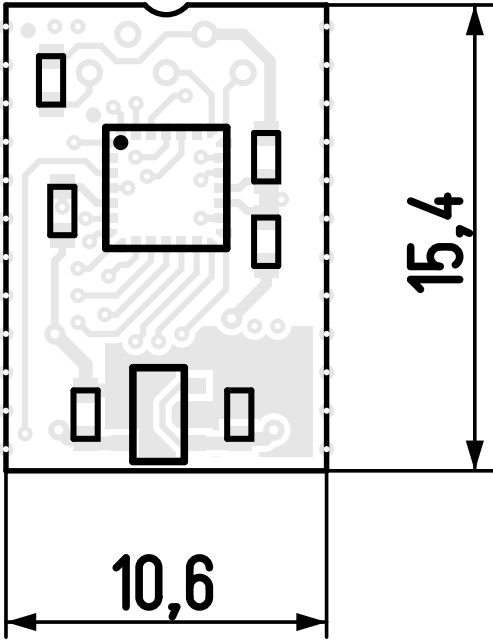**28 Pin QFN - UQFPN28 - 4x4 mm with 0.5 mm pitch**
and recommended footprint

Pin #1 identifier
Laser marking area

4,00

4,00

0,25

0,35

0,50

0,40

0,55

0,50

4,30

3,30

0,30

0,50

0,21

28 Pin DIL module

35,6

10,4

SpinWarrior28

24 Pin SO24 Replacement Module

15,4

10,6

Height at thickest point: max. 2.2 mm

10. ESD Considerations

SpinWarrior has an internal ESD protection to withstand discharges of more than 2000V without permanent damage. However ESD may disrupt normal operation of the chip and cause it to exhibit erratic behaviour.

For the typical office environment the 2000V protection is normally sufficient. Though for industrial use additional measures may be necessary.

When adding ESD protection to the signals special care must be taken on the USB signal lines. The USB has very low tolerance for additional resistance or capacitance introduced on the USB differential signals.

10.1 EMC Considerations

SpinWarrior uses relatively low power levels and so it causes few EMC problems. The most important issue is to provide a very clean layout for the power supply. SpinWarrior runs at 12MHz internal clock rate, this can cause current spikes if the supply lines are not carefully layed out.

To avoid any EMC problems the following rules should be followed:
- Keep the PCB traces from the resonator to the chip pins as short as possible.
- Put the 100nF ceramic capacitors right next to the power supply pins of the chip and make sure the PCB traces between the chips power pins and the capacitor are as short as possible.
- Run the power supply lines first to the capacitor, then to the chip.
- Keep the two USB signal lines close to each other, route no other signal between them. USB uses differential signalling so the best signal quality with lowest RF emission is achieved by putting these lines very close to each other.

11. Revision History

The current shipping version of SpinWarrior28R4 and SpinWarrior28R6 is V1.0.1.6. for SpinWarrior28A3 the shipping version is V1.0.1.C.

V1.0.1.C - Fixed a problem on SW28A3 that prevented a continuos stream of status reports, mostly that was a problem for reading the initial status and in case of single lost reports. It now sends the current status every millisecond.

V1.0.1.6 - Fixed a problem with USB that could lead to the device not properly enumerating.

V1.0.0.3 - Fixed a problem that could cause an error leading to an "unknown device" on Windows system start.

1.0.0.0 - This is the inital release version of SpinWarrior28.

11.1 Document Revision History

26.07.2023 - Version info for SW28A3 V1.0.1.C
16.06.2022 - Added version info for V1.0.1.6
12.11.2018 - Added version notes for versions up to V1.0.0.3

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