Qwerk Hardware Guide

Version 1.0, September 1, 2006

Introduction

Qwerk is a powerful embedded computer system with an I/O feature set specifically targeted for robotics and mechatronics applications. Qwerk has a powerful CPU that can run a modern OS such as Linux or Windows CE and is capable of hosting sophisticated applications that require high-level programming, multitasking, Internet connectivity and networking. This guide details the hardware features, connector pinouts, and peripheral specifications of Qwerk.

A quick overview of Qwerk's hardware features:

- 200 MHz ARM9 RISC processor with MMU and hardware floating point unit
- 32 Mbytes SDRAM, 8 Mbytes flash memory
- 4 closed-loop 2.0 Amp motor controllers (supports quadrature encoder and back-EMF "sensorless" position feedback as well as current sensing)
- 16 RC-servo controllers
- 16 programmable digital I/Os
- 8 12-bit analog inputs
- 2 RS-232 ports
- I^2C ports
- 2 USB 2.0 host ports for connecting standard USB PC peripherals
- 10/100BT Ethernet port
- Built-in audio amplifier with MP3, PCM and WAV audio support
- 4 Amp switching power supply, 90% efficient, 7 to 30 Volt input range
- Rugged aluminum enclosure
- 5.1" x 5.8" x 1.3", 12.8 ounces

Back-EMF motion feedback

Permanent-magnet motors, the most common DC motors, generate a voltage when they rotate. This voltage, or "back-EMF" voltage, is directly proportional to the motor velocity. A motor controller that can accurately sense the back-EMF voltage can determine the motor's velocity. And if the back-EMF voltage is integrated over time, the motor's position can be determined as well.

Qwerk's motor controller determines both the motor position and velocity in this manner, which makes closed-loop motor control possible. Qwerk can determine the position, velocity and torque of up to 4 independent motors simultaneously. In general, you can take a properly rated permanent magnet motor, plug it into one of the Qwerk's 4 motor ports and accurately control the motor's position, velocity, or torque. This makes it easy to build robots with Qwerk using readily available parts and motors.

Another advantage of back-EMF motion feedback is that it does not require any additional mechanical complexity such as optical/mechanical encoders. The same two wires that supply power to the motors are used for back-EMF sensing. One disadvantage of back-EMF motion feedback, however, is the position estimate tends to drift over time because of noise in the back-EMF measurements. For applications that need more accuracy, Qwerk supports quadrature encoders as well.

Onboard FPGA

As shown in the block diagram in **Figure 1**, Qwerk uses a Field Programmable Gate Array (FPGA) tightly coupled to the main CPU. The FPGA provides much of Qwerk's I/O capabilities including back-EMF motor control, RC-servo control, digital I/O and digital to analog conversion for Qwerk's audio. The FPGA provides much needed flexibility if new I/O capabilities are required for a specific sensor or actuator. Particularly, the FPGA brings dedicated hardware to bear where it is needed.

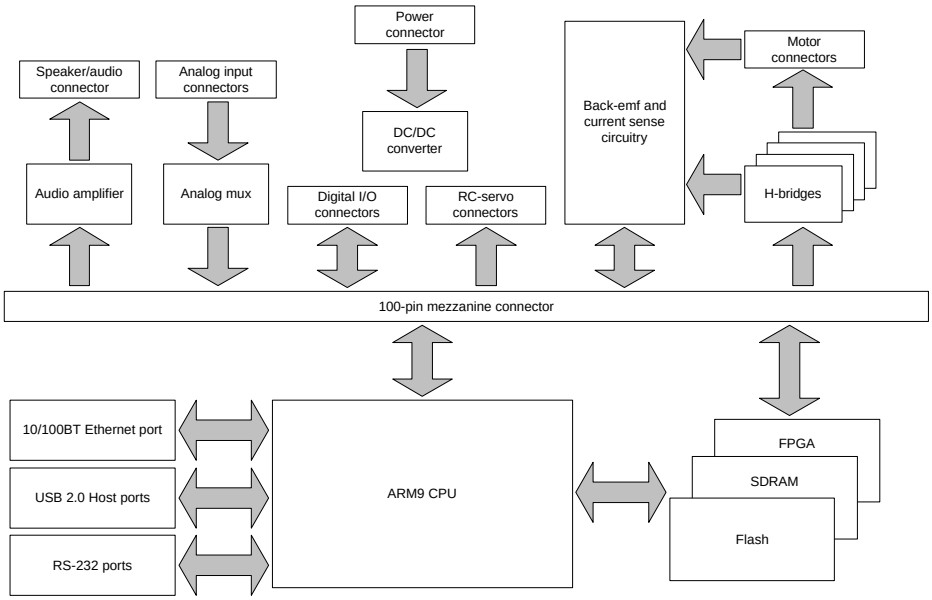


Figure 1: Qwerk Block Diagram

Overview

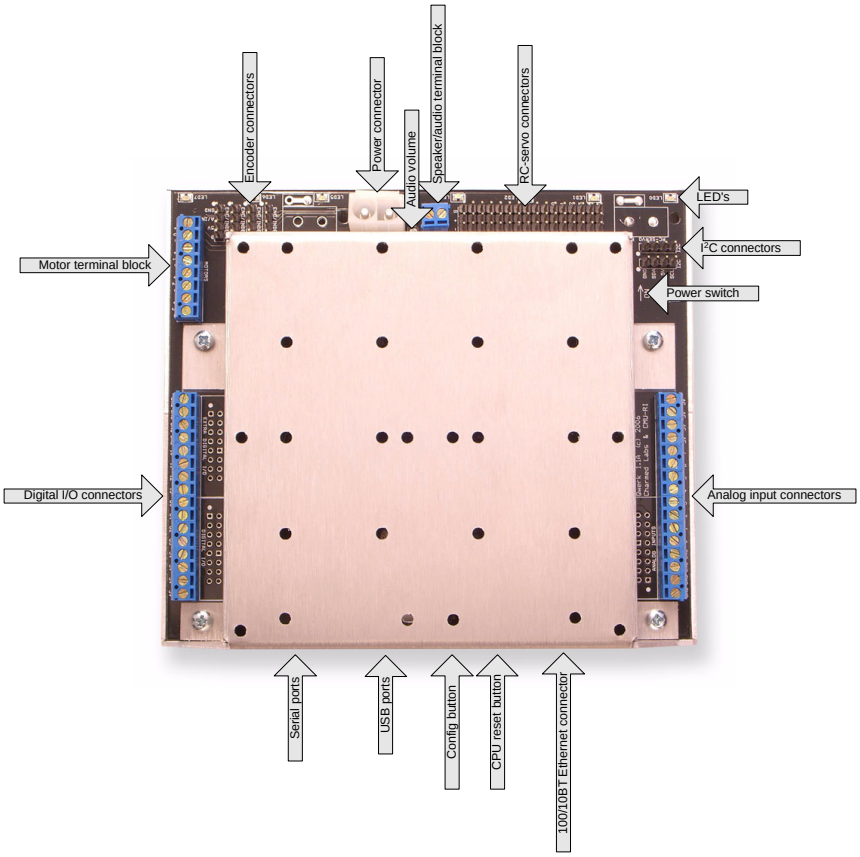


Figure 2: Qwerk top view

LED's

The 8 LED's provide simple feedback to the user. They have no permanently assigned meaning.

Audio volume

The audio volume adjusts the amplitude/volume of the speaker/audio output.

USB 2.0 ports

There are 2 USB host ports for hooking up standard PC peripherals such as webcams, thumb drives and wireless networking devices.

Config button

This button is typically used to place the Qwerk CPU in configuration mode upon power-up.

CPU Reset button

This button resets the Qwerk CPU.

10/100BT Ethernet

The Qwerk CPU has built-in Ethernet networking. The Ethernet port has automatic duplex detection, so if you wish to connect Qwerk directly to your PC (no hub), a normal Ethernet cable can be used instead of a crossover cable.

Analog input connectors

The analog inputs are used to measure voltages of analog signals.

Terminal block pinouts

Pin	Signal	I/O	Description
1	GND	Power	0.0V (ground)
2	GND	Power	0.0V (ground)
3	GND	Power	0.0V (ground)
4	GND	Power	0.0V (ground)
5	A0	Input	Analog input 0
6	A1	Input	Analog input 1
7	A2	Input	Analog input 2
8	A3	Input	Analog input 3
9	A4	Input	Analog input 4
10	A5	Input	Analog input 5
11	A6	Input	Analog input 6
12	A7	Input	Analog input 7
13	5V	Power	5.0V
14	5V	Power	5.0V
15	5V	Power	5.0V

16	5V	Power	5.0V

Dual-row connector pinouts

Pin	Signal	I/O	Description
1	GND	Power	0.0V (ground)
2	A0	Input	Digital input 4
3	GND	Power	0.0V (ground)
4	A1	Input	Digital input 5
5	GND	Power	0.0V (ground)
6	A2	Input	Digital input 6
7	GND	Power	0.0V (ground)
8	A3	Input	Digital input 7
9	5V	Power	5.0V power
10	A4	Output	Digital output 4
11	5V	Power	5.0V power
12	A5	Output	Digital output 5
13	5V	Power	5.0V power
14	A6	Output	Digital output 6
15	5V	Power	5.0V
16	A7	Output	Digital output 7

Electrical specifications

- Maximum input voltage range: -1.0V to 28.8V
- Maximum current draw per power pin: 1.0A
- Active input voltage range: 0.0V to 5.0V
- Note, maximum voltage range can exceed the active range. Voltages above or below the active range will be clipped internally.
- Voltages beyond maximum range may permanently damage Qwerk.

I^2C connectors

The I^2C connectors support I^2C communications.

Pinouts

As indicated by the silkscreen.

Pin	Signal	I/O	Description
1	GND	power	0.0V (ground)
2	SDA	input/output	I2C data
3	5V	Power	5.0V power
4	SCL	output	I2C clock

Electrical specifications

- Maximum voltage range of SDA and SCL: -1.0V to 6.0V
- Maximum current draw for each SDA and SCL: 100mA
- Maximum current draw per power pin: 150mA
- Active voltage range of SDA, SCL: 0.0V to 5.0V
- SDA and SCL each use a 2.2K pull-up resistor.
- Note, exceeding maximum ratings may permanently damage Qwerk.

RC-servo connectors

There are 16 RC-servo connectors arranged n a 16x3 header.

Pinouts

As indicated by the silkscreen.

Pin	Signal	I/O	Description
1	-	power	0.0V (ground)
2	+	power	5.0V power
3	S	output	control signal

Electrical specifications

- Maximum current draw of all RC-servos combined: 4.0A if 8.4V battery or above is used, 2.0A if 7.2V battery is used.
- Active voltage range of control signal: 0.0V to 3.3V
- The RC-servos use the regulated 5.0V supply.
- Note, exceeding maximum ratings may permanently damage Qwerk.

Speaker/audio terminal block

The speaker/audio terminal block is intended for hooking up a 3, 4, or 8 ohm speaker, but it can also be used as in input into a high impedance device like amplified speakers. The volume control is located just to the side of the audio/speaker terminal block.

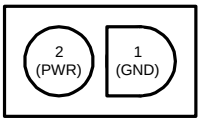
Electrical specifications

- Maximum output power with 3 ohm speaker: 3W
- Maximum output power with 4 ohm speaker: 2.5W
- Maximum output power with 8 ohm speaker: 1.5W

Power connector

The power connector is where Qwerk receives its power.

Pinouts



Pin	Signal	I/O	Description
1	GND	power	0.0V (ground), negative battery terminal
2	Power	power	Positive battery terminal

Electrical specifications

- Maximum voltage input: 34.0V
- Minimum voltage input: 7.0V

- Note, exceeding maximum ratings may permanently damage Qwerk.

Quadrature encoder connectors

There are 4 quadrature encoder connectors numbered 0 through 3, which correspond to the 4 motor controllers. The encoder connectors can be used to plug in quadrature encoders for position feedback of the motors.

Pinouts

As indicated by the silkscreen.

Pin	Signal	I/O	Description
1	GND	power	0.0V (ground)
2	A/Index	input	Encoder channel A
3	5V	Power	5.0V power
4	B	Input	Encoder channel B

Electrical specifications

- Maximum current draw per power pin: 150mA
- Maximum voltage range for A and B inputs: -1.0V to 28.8V
- Active voltage range for A and B inputs: 0.0V to 3.3V
- Note, exceeding maximum ratings may permanently damage Qwerk.

Motor terminal block

There are 4 motor control outputs for control of up to 4 independent motors. Each motor control channel has back-EMF sensing, current sensing, and thermal shutdown protection. The unregulated battery voltage is used to power the motor channels.

Pinouts

As indicated by the silkscreen. Note, "+" and "-" only indicate convention. All motor channels are bidirectional.

Pin	Signal	I/O	Description
1	+ 0	output	Motor 0 positive
2	0 -	output	Motor 0 negative
3	+ 1	output	Motor 1 positive
4	1 -	output	Motor 1 negative
5	+ 2	output	Motor 2 positive
6	2 -	output	Motor 2 negative
7	+ 3	output	Motor 3 positive
8	3 -	output	Motor 3 negative

Electrical specifications

- Maximum instantaneous current draw per channel: 2.8A
- Maximum sustained current draw per channel: 1.5A
- Note, exceeding maximum ratings may permanently damage Qwerk.

Digital I/O connectors

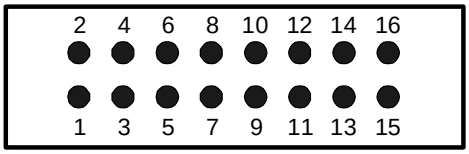
The digital I/O terminal block provides 4 digital outputs and 4 digital inputs. More digital I/O is available through the "Extra digital I/O connector".

Terminal block pinouts

As indicated by the silkscreen.

Pin	Signal	I/O	Description
1	GND	power	0.0V (ground)
2	GND	power	0.0V (ground)
3	GND	power	0.0V (ground)
4	GND	power	0.0V (ground)
5	I0	input	Digital input 0
6	I1	input	Digital input 1
7	I2	input	Digital input 2
8	I3	input	Digital input 3
9	O0	output	Digital output 0
10	O1	output	Digital output 1
11	O2	output	Digital output 2
12	O3	output	Digital output 3
13	5V	power	5.0V
14	5V	power	5.0V
15	5V	power	5.0V
16	5V	power	5.0V

Dual-row connector pinouts



Pin	Signal	I/O	Description
1	GND	Power	0.0V (ground)
2	I0	Input	Digital input 0
3	GND	Power	0.0V (ground)
4	I1	Input	Digital input 1
5	GND	Power	0.0V (ground)
6	I2	Input	Digital input 2
7	GND	Power	0.0V (ground)
8	I3	Input	Digital input 3
9	5V	Power	5.0V power
10	O0	Output	Digital output 0
11	5V	Power	5.0V power
12	O1	Output	Digital output 1
13	5V	Power	5.0V power
14	O2	Output	Digital output 2
15	5V	Power	5.0V
16	O3	Output	Digital output 3

Extra I/O dual-row connector pinouts

Pin	Signal	I/O	Description
1	GND	power	0.0V (ground)

2	I4	input	Digital input 4
3	GND	power	0.0V (ground)
4	I5	input	Digital input 5
5	GND	power	0.0V (ground)
6	I6	input	Digital input 6
7	GND	power	0.0V (ground)
8	I7	input	Digital input 7
9	5V	power	5.0V power
10	O4	output	Digital output 4
11	5V	power	5.0V power
12	O5	output	Digital output 5
13	5V	power	5.0V power
14	O6	output	Digital output 6
15	5V	power	5.0V
16	O7	output	Digital output 7

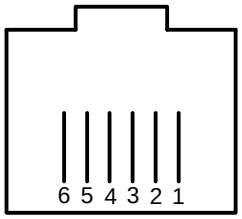
Electrical specifications

- Maximum current draw per power pin: 1.0A
- Maximum voltage range per input: -1.0V to 28.8V
- Maximum current source/sink per output: +/-15mA
- Active voltage range for outputs: 0.0V to 3.3V
- Note, maximum voltage range can exceed the active range. Voltages above or below the active range will be clipped internally.
- Exceeding maximum ratings may permanently damage Qwerk.

Serial ports 1 and 2

The serial ports can be used as standard RS-232 ports by using the supplied modular cables and DB-9 adapters or they can be used as LVTTL serial ports. Power is also provided through the serial port connectors.

Pinouts



Pin	Signal	I/O	Description
1	TXD	output	LVTTL transmit
2	GND	power	0.0V (ground)
3	TXC	output	RS232 transmit
4	RXC	input	RS232 receive
5	5V	power	5.0V
6	RXD	input	LVTTL receive

Electrical specifications

- Maximum current draw per power pin: 150mA
- Maximum current source/sink per LVTTL output: +/-7mA
- Maximum voltage range per LVTTL input: -0.7V to 4.0V

- Active voltage range per LVTTL input: 0.0V to 3.3V
- Note, exceeding maximum ratings may permanently damage Qwerk.

Hooking up a terminal

It is possible to interact with the Linux console on Qwerk via serial port 1 and the supplied RS-232 cable. Take the supplied modular cable and plug it into the serial port labeled "UART1". Then take the opposite end of the modular cable and plug it into the supplied female DB-9 adapter. The DB-9 adapter can then plug into your computer's serial port. By default the console is configured at 57.6Kbaud, 8 data bits, 1 stop bit, no parity, no flow control.

Removing the cover

Removing the cover entails unscrewing the 4 Phillips fasteners near the corners of the top piece of the aluminum enclosure. After removing these fasteners, the top piece of the aluminum enclosure lifts off easily exposing the top PC board.

Contacting Us

We are interested in hearing from you! Please send you bug reports, questions and suggestions to support@charmedlabs.com.