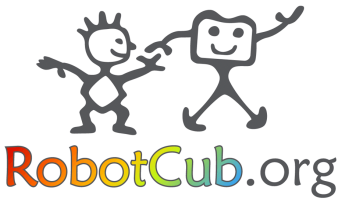


ROBotic Open-architecture Technology for
Cognition, Understanding and Behavior

Project no. 004370

RobotCub

Development of a cognitive humanoid cub

Instrument: Integrated Project
Thematic Priority: IST – Cognitive Systems

Specifications of the electronics

Due Date:
Submission date:
DRAFT

Start date of project: **01/09/2004** Duration: **60 months**

Organisation name of lead contractor for this deliverable:

Responsible Person: Giorgio Metta

Revision: **01**

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Service)	
CO	Confidential, only for members of the consortium (including the Commission Service)	**CO**

Table of Contents

1 Introduction

This document contains the description of the electronics with details useful for the mechanical design.

2 Estimated size

Card A: 55x69x15mm: brushless amplifier (2X)
- Each card A controls two Kollmorgen motors

Card B: 48x52x25mm: DSP cards (2X) that goes with a brushless amplifier
- Each card B generates the control for two Kollmorgen motors

Card C: 50x30x5mm: DC controllers (including DSP)
- Each card controls 4 DC motors (I<0.6A)

Card D: 50x30x5mm: DC controller power supply
- Each supplies correct voltages to 3 C-type cards.

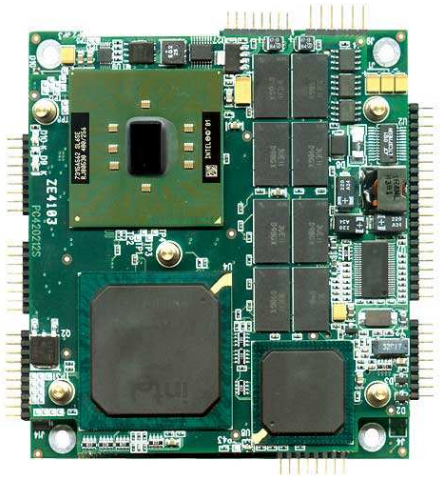
Card E: ADC 20x30x7mm
- Reads 32 channels, output on CAN bus

In addition, bypass capacitors:
- For the brushless motors: 22 diameter x 30 height, electrolytic capacitors

TSUP	Panasonic	64V	22	30	3.39 euro	2200uF	RS part no. 127-509 Pan. no. ECOS1JP222B

PC104: 90x96mmx22mm without heatsink (need to be checked) – this includes the Gbit Ethernet interface. We previously estimated 90x96x30mm but beware of connectors and of the processor heatsink. This is a PIII 800MHz processor – 15W typical power consumption (5VDC supply).

http://www.eurotech.it/main/product.asp?4M=CPU-1463
or
http://www.eurotech.it



Weight ~= 250g.

Cost: approx. 1200 Euros.
Size: see below.

- Dimensions: 90 X 96 mm (3.6”X3.8”)
  Height 18.6 mm (0.7”), pins and components on the bottom side not included

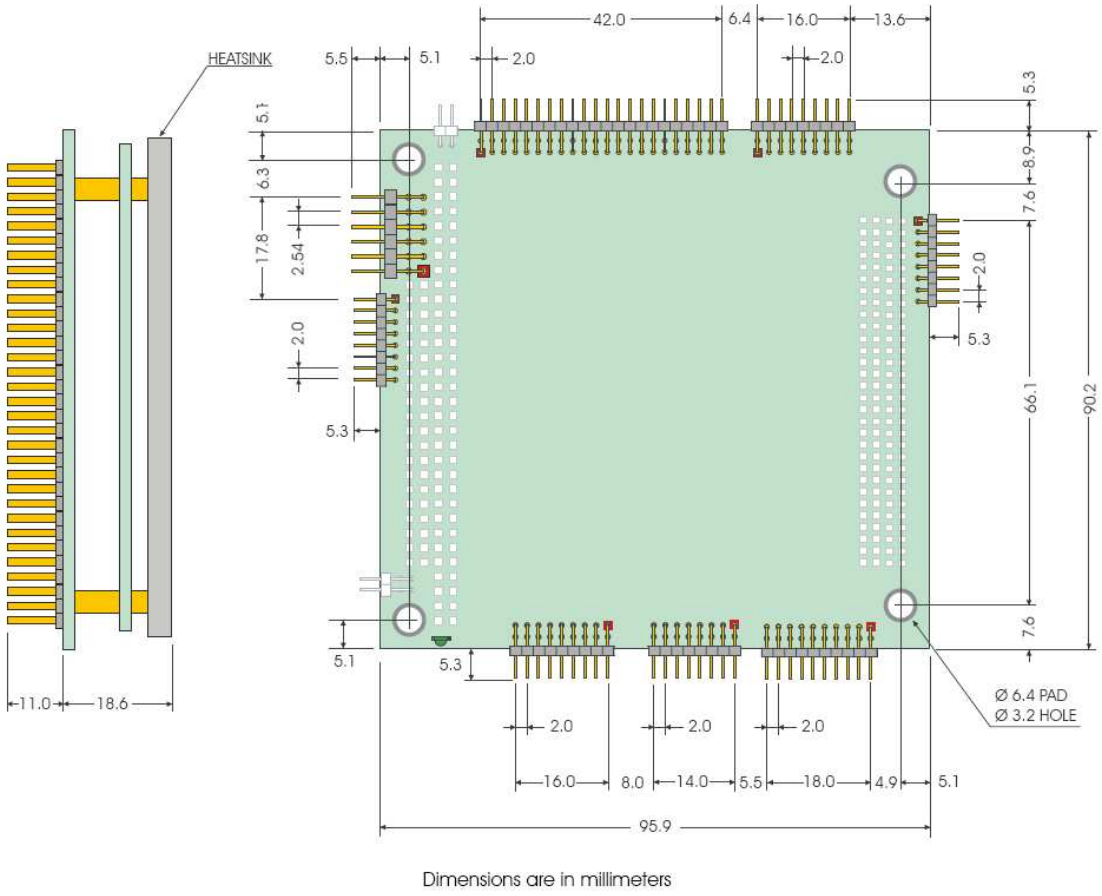


Figure 12. CPU-1453/63 Board dimensions

Alternate solution:

Pentium M 1.8GHz.
http://www.dsl-ltd.co.uk/products/pb855spec.htm

No GBit Ethernet. It requires more effort on our side. Size has to be checked (seems larger than specs).

3 Number of wires

The next sections summarize the number of wires between the robot's subsystems: i.e. where it is difficult to route the wires.

3.1 PC104 card

List of connections:

- 4 CAN bus 4 wires each connections through the neck
- 1 CAN bus for extra data: e.g. Hall-effect sensors, tactile, etc.
- Gbit Ethernet cable, standard RJ45 connector, cable going through the neck (Cat5-E)
- Speaker, 2 wires
- Microphones: 3 x 2 mic = 6 wires (power supply included)
- Gyro: serial port/USB – already included in the PC104
- Cameras: two Firewire cables: 6 wires each, twisted pair cable
- Spare DIO ports (parallel?)

To check:

- Disk on chip
- Actual size

3.2 Brushless amplifier: card A

Motor connections:

- Motor Leads: #20 AWG Teflon coated per MIL-W-22759/11, 3 leads, 152 (6.00) min lg. ea. 1-black, 1-red, 1-white. (0.1524cm each wire)
    - See: http://www.jaguarind.com/products/teflon/11.html
- Sensor Leads: #26 AWG type "ET" Teflon coated per MIL-W-16878, 5 leads, 152 (6.00) min lg. ea. 1-blue, 1-brown, 1-green, 1-orange, 1-yellow. (0.08382cm each wire)
    - See: http://www.jaguarind.com/products/teflon/etteflon.html

From the Danhaer motion catalogue.

Pin	Description
J2-1	PE (Chassis Ground) on S200 AC Input Drives BUS/CTRL GND on S200 DC Input Drives
J2-2	Motor Phase W
J2-3	Motor Phase V
J2-4	Motor Phase U

Mating Connector Information

Screw Terminal Connector
12 – 24 AWG Wire Range, Phoenix MSTB2,5/4-STF-5,08-BK
OR
Spring Cage Clamp Connector
12 – 24 AWG Wire Range, Phoenix FKC 2,5/4-SFT-5,08-BK
OR
Crimp Connector
Crimp Shell
14-20 AWG Wire Range, Phoenix MSTBC 2,5/4-STZF-5,08-BK
Crimp Contact
14-16 AWG Wire Range, Phoenix MSTBC-MT 1,5-2,5
Crimp Contact
18-20 AWG Wire Range, Phoenix MSTBC-MT 0,5-1,0

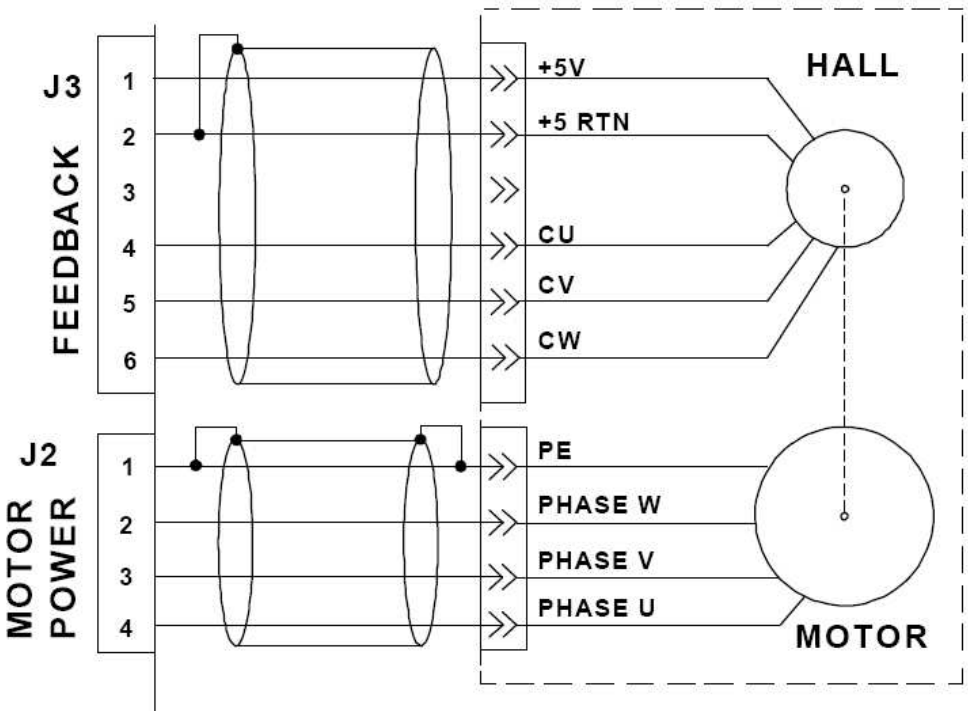
Refer to www.phoenixcon.com.

See www.phoenixcon.com for the connectors (for the S200 brushless drive). This is extra information not required for the actual iCub. During testing the S200 drive might be actually employed (connectors are provided with the S200 – need to be purchased).

Hall-effect sensor for commutation and feedback (5 wires)

- Require power (5VDC), GND: 2 wires
- Three feedback wires: relative to the U, V, and W phase

3.2.1 Connections



PE is the Protective Earth.

PWM voltage is going to be 48V. Do we need a global PE on the robot?

3.2.2 Summary: brushless amp

For each motor	# of wires
Feedback (5VDC + 3 signals)	5
Control (PE + 3 PWM)	3-4
Temperature feedback	3
	12
X2 motors, each board	**24**
To the DSP card	# of wires
PWM signals (before amp)	3x2
Feedback 3 signals (HALL)	3
5 VDC	2
Amp enable	1
Current feedback	1-3
Temperature feedback	1
GND	1
	17
X2 motors each board	**34+24**

3.3 Brushless DSP card: card B

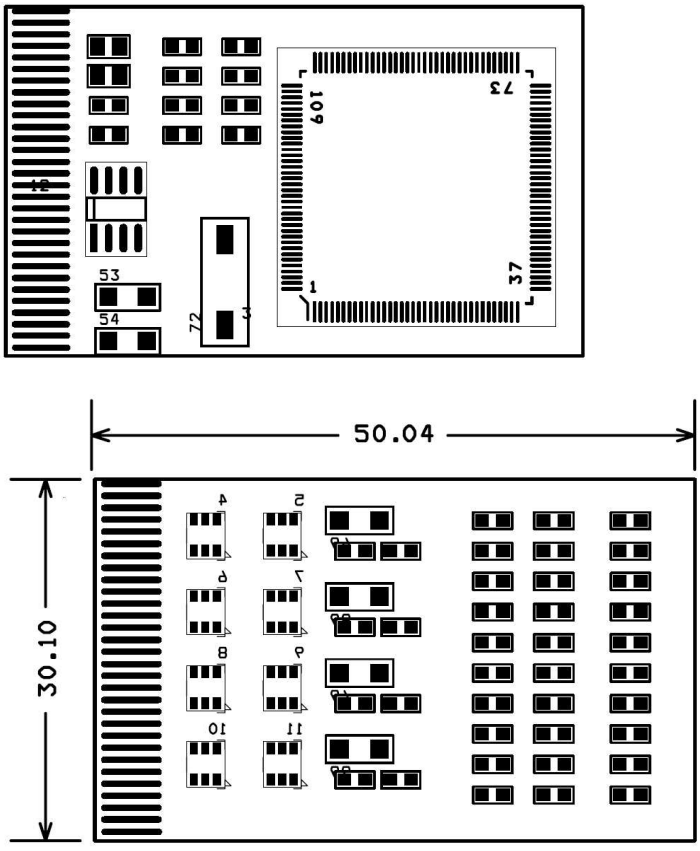
This is a DSP card.

In addition to the connections reported above connecting card A:

For each motor	# of wires
Spare ADC	2x2
Power supply 48V	2
CAN bus	4
Bypass capacitor connector	2 (if power supply is not on card B?)
Total	10

3.4 DC card: card C

Tentative:



Current estimated number of wires: 60
It should include extra AD inputs for the absolute position sensors.
Connectors to be determined (Omnetics?).

3.5 DC power supply: card D

This card receives 48V in input and returns 12, 5, and 3.3V in output.

Name	# of wires
In	2
Bypass capacitor connector	2
Out 12, 24 or both	1
Out 5	1
Out 3.3	1
GND	3
	10

3.6 ADC card: card E

Name	# of wires
Power supply 12V	2
Inputs	40 Omnetics connector
CAN bus	4
	46

4 Routing of wires

Neck:

- 4 CAN bus 4 wires each connections
- 1 CAN bus for extra data: e.g. Hall-effect sensors, tactile, etc.
- Gbit Ethernet cable, standard RJ45 connector
- Power supply: 48VDC, 2 wires, PC104~15W + control cards (please consider 0.6A max per motor)

Shoulder:

- 1 CAN bus (maybe 2?)
- 9 wires connecting feedback and control to the elbow
- 1 force/torque sensor cable: ?? wires (we are purchasing one to test it)
- Power supply: 48VDC, 2 wires (only for small control cards – type C)
- Power supply: 12VDC? Required for the ADC card

Elbow:

- 6X incremental encoders 3 wires each
- 6X AD in (feedback): 1 wire each (hall-effect sensors)

- Feedback supply 5VDC: 2 wires
- 1 CAN bus
- 12x control signals: 2 wires each (0.6A max)
- Power supply: 12VDC. Required for the ADC card

Wrist:

- 1 CAN bus
- 2X AD in: 1 wires each
- 2X control signal: 2 wires each
- Power supply: 12VDC. For the ADC card

Lower body still to be organized.
Tension sensors still to be considered for elbow and knee (important).

5 List of motors

Joint name	Motor type	I/V/other	Quantity	List of sensors
Shoulder front/back	RBE01211-A	20A peak @48V CSD-17-100-2A-GR	1+1	Absolute position (pot), temperature
Shoulder elevation	RBE01211-A		1+1	Absolute position (pot), temperature
Shoulder rotation	RBE01210-A[1]	15A peak @48V	1+1	Absolute position (pot), temperature
Elbow	RBE01210-A		1+1	Absolute position (pot), temperature
Wrist	Minimotor 1331-012SR 1331-024SR	Voltage can be chosen freely, 24V less current!	3+3	Encoder, Temperature sensor?
Fingers	Minimotor 10XX, 8XX	Peak <0.5A	8+8	Encoder, Hall effect position feedback
Eyes	Minimotor 1319024SR Gear 14/1, GR:66	Note the 24V!	3	Encoder (IE2-512)
Neck pan	Minimotor 1717024SR Gear 16/7, GR: 247	Stall current 0.337A	1	Encoder+pot (IE2-512)

[1] Need to verify whether the 1210 winding A is ok.

Neck tilt	Minimotor 2224024SR Gear 20/1, GR: 246	Stall current 0.646A but thermal limit at 0.280A[2]	1	Encoder+pot (IE2-512)
Neck roll	Minimotor 1524024SR Gear 16/7, GR: 247	Stall current 0.404A	1	Encoder+pot (IE2-512)
Waist motion	RBE01210-A	15A peak @48V	3	Absolute position, temperature
Hip	RBE01210-A		3+3	Absolute position, temperature
Knee	RBE01210-A		1+1	Absolute position, temperature
Ankle rotation	RBE00711-A	Plus CSD14, GR: 50? 12.6A peak @48V	1+1	Encoder?
Ankle flexion	RBE01210-A		1+1	Temperature?
Total			51	

To be determined: capacitors' size and physical placement: see RS catalogue: 3245307, 21x40 2200uF, 63V
Current specs, peak power consumption (start up): 17500W!
Power supply Xantrex 6KW, 60V-100A (?) 3-phase input (?) or Xantrex 2600: 2.4KW.

Sensor type	Number of wires	Type	Quantity	Notes
ATI mini 45	6?	Analog	5	Force/torque reading
Gyros XSens Mti		Digital	1	RS232, 422
Camera	Firewire	Digital	2	
Microphones	2	Analog	2	
Speaker	2	Analog	1	Output
Tactile		Analog		Reuse Toyota electronics

Interface			Quantity	Notes

[2] Can we still do it with single chip amp?

name				
Ethernet Gbit			1	
CAN bus			5-7?	

Available space

Card type	L	W	H	Notes
Small	50	30	5	Small DC motors, possibly 4?
Other	52	48	25	
Brushless controller	69	110	15	Brushless

6 Missing things

A tension/torque sensor on the elbow/knee might be required for full active-compliance control. No solution is available at the moment. Some more electronics might be required.

UGDIST and UNISAL (?) are evaluating the AS5040 and AS5043 (http://www.austiamicrosystems.com) as absolute position sensors for the main joints. A small PCB is required and needs to be developed.

The ATI-45 requires some bulky electronics in the off-the-shelf version. Actual size needs to be verified and space to be found for a custom version. This is important and requires evaluation. UGDIST is purchasing one sensor for testing, UNISAL has one already.

7 References

Further reference can be found in Deliverable 7.2, 8.1, and 8.2 that are available from the website http://www.robotcub.org following the links on “dissemination” and then “deliverables”.

Kollmorgen: http://www.danahermotion.com
Minimotor/Faulhaber: http://www.minimotor.ch
Harmonic Drive: http://www.harmonicdrive.de/en/index.htm
PC104 card: http://www.eurotech.it