Ethernet-Enabled Thermocouple Readout

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1 Introduction

Capabilities:

1. 8 multiplexed thermocouple inputs.
2. Support for J-type thermocouples, easy conversion to K-type by changing thermocouple connectors and switching to AD595.
3. 12-bit ADC over 5 V range for nominal 0-480°C range and 0.1°C resolution; noise rejection will be done in software if necessary by multiple sampling.
4. 100 base-T Ethernet connection for http temperature readout or telnet readout of temperature and network reprogramming of device.
5. 20x2 LCD character display for temperature readout, with software-selectable LED backlight.

2 Hardware Notes

3 Configuration

1. Set up a method for communicating via a terminal over a DB-9 serial connection from your computer. I used minicom v. 2.1, which can be compiled under OS X and run under Terminal.app. Another freeware terminal application that should work without much effort is MacTNC. For the serial port connection, I used the Keyspan High Speed USB Serial Adaptor (USA-19HS); under minicom I configured the connection to use /dev/tty.USA19H191P1.1 (look in /dev once the device is plugged in to see what the proper setting should be).
2. Follow the instructions in the Ethernut Hardware Manual to test the Ethernut board via the serial port and configure its network settings using the BaseMon program.
3. Install binutils (under OS X 10.3.3, I used v. 2.14). As root, the procedure would be something like `tar xvzf binutils-2.14.tar.gz; cd binutils-2.14; ./configure --target=avr; make; make install`. Additional information is available at http://www.mit.edu/people/mseeman/resources/macmicro.html.
4. Install avr-gcc (under OS X 10.3.3, I used v. 3.3.2). As root, the procedure would be something like `tar xvzf gcc-core-3.3.2.tar.gz; cd gcc-3.3.2; ./configure --target=avr --enable-languages=c; make CC="cc -no-cpp-precomp"; make install`. Additional information is available at http://www.mit.edu/people/mseeman/resour

Table 1. Parts list used for sample assembly of thermocouple readout. Prices in USD are current as of April 2004.

Manufacturer	Part Number	Description	Vendor	Vendor P/N	Unit	Qty
egnite Software GMBH	Ethernut 2.0 Rev. A	microcontroller with ethernet interface	ImageCraft	Ethernut Bulk V2	$160	1
Omega	PCC-SMP-J	PC mount miniature J type thermocouple connector	Newark	01H0904	$2.55	8
Omega	SMP-J-M	J type thermocouple male connector	Omega	SMP-J-M	$1.75	8
Omega	GG-J-20-25	J type thermocouple wire, 20 AWG, glass braid insulation, 25' spool, 482°C max temp	Omega	GG-J-20-25	$19	1
Analog Devices	AD594AQ	thermocouple amplifier with cold junction compensation	Digi-Key	AD594AQ-ND	$10.43	1
Vishay Siliconix	DG407DW	8 channel differential multiplexer, SOIC-28 wide package	Newark	13C1167	$7.96	1
Vishay Siliconix	DG412LDY	quad NO SPST analog switch, SOIC-16 narrow package	Newark	25C5739	$1.11	1
National Semiconductor	ADC12130CIWM	12 bit ADC, self-calibrating, SOIC-16	Digi-Key	ADC12130CIWM-ND	$7.18	1
National Semiconductor	LM4040BIM3-5.0	5V micropower shunt voltage reference, 0.2% tolerance, 100ppm/°C temperature coefficient, SOT-23	Digi-Key	LM4040BIM3-5.0CT-ND	$1.58	1
ECS Inc.	ECS-100A-050	TTL oscillator, 5.000 MHz	Digi-Key	X109-ND	$1.88	1
Optrex	DMC20261NY-LY-AXE	LCD character display, 20x2, yellow LED backlight	Digi-Key	73-1057-ND	$20.93	1
PRD Plastics	6303020	bezel for LCD character display	Digi-Key	PRD360LPW-ND	$4.10	1
Magnecraft	W107DIP-1	SPST DIP relay, 5V coil	Newark	47F1106	$3.06	1
APS	AD-715U-1090	9V, 2.6A regulated switching power supply	All Electronics	PS-926	$8.50	1
Qualtek	761-18/003	power entry module, SPST switch, fuse	Digi-Key	Q300-ND	$7.85	1
Kobiconn	-	DC power cable, right angle, 2.1 mm locking plug, 6" 24 AWG	Mouser	172-1016	$1.32	1
Kobiconn	-	DC power jack, PC mount, 2.1 mm, right angle	Mouser	163-5004	$0.63	1
3M	1M-1010-064-3365-006.0-00-AB-00-0	ribbon cable assy, 0.1" contact spacing, 64 conductor, 6" 28 AWG	Mouser	517-1M-1010-064-6	$7.33	1
3M	1M-1010-014-3365-012.0-00-AB-00-0	ribbon cable assy, 0.1" contact spacing, 14 conductor, 12" 28 AWG	Mouser	517-1M-1010-014-12	$3.07	1

Table 1. (continued)

Manufacturer	Part Number	Description	Vendor	Vendor P/N	Unit	Qty
3M	929665-09-36-I	72 pin double row 0.1" low-profile header	Digi-Key	929665-09-36-ND	$3.60	2
Molex	39870-0102	pluggable terminal block, 2 position, 5 mm spacing	Digi-Key	WM5862-ND	$2.07	2
Molex	39870-0702	straight header receptacle for 39870-0102 terminal block	Digi-Key	WM5872-ND	$0.78	2
Diodes Inc.	DF15005S-T	1.5 A rectifier bridge, DF-S case	Newark	DF15005SDICT-ND	$0.84	1
National Semiconductor	LM1086CS-ADJ	1.5 A adjustible voltage regulator, TO-263	Newark	74C3882	$1.32	1
Littelfuse Inc.	P6KE15CA	15 V, 600 W transient voltage suppressor	Digi-Key	P6KE15CACCCT-ND	$0.44	1
Bussmann	BK/PCS	PC-Tron fuse socket, PC mount	Digi-Key	283-2356-ND	$0.65	1
Bussmann	BK/PCC-1	PC-Tron 1 A fuse, short leads	Digi-Key	283-2120-ND	$1.73	1
Ohmite	TA205PA8R20J	8.2 Ω, 5 W thick-film chip resistor	Newark	13B825	$1.50	1
Xicon	271-121	121 Ω, 1/4 W, 1% metal-film resistor	Mouser	271-121	$0.09	1
Xicon	271-330	330 Ω, 1/4 W, 1% metal-film resistor	Mouser	271-330	$0.09	1
Xicon	271-1K	1 kΩ, 1/4 W, 1% metal-film resistor	Mouser	271-1K	$0.09	1
Xicon	271-20K	20 kΩ, 1/4 W, 1% metal-film resistor	Mouser	271-20K	$0.09	1
Bourns	3296W-101	100 Ω, 25 turn cermet trim pot	Digi-Key	3296W-101-ND	$2.50	1
Bourns	3296W-203	20 kΩ, 25 turn cermet trim pot	Digi-Key	3296W-203-ND	$2.50	1
Vishay/Sprague	199D106X9016C1V1	10 μF, 16 V tantalum radial capacitor	Mouser	74-199D16V10	$0.65	5
Vishay/Sprague	199D226X9016D1V1	22 μF, 16 V tantalum radial capacitor	Mouser	74-199D16V22	$0.81	3
Vishay	1C10Z5U103M050B	0.01 μF, 50 V monolithic ceramic radial capacitor, 20% tolerance	Mouser	75-1C10Z5U103M050B	$0.13	5
Vishay	1C10Z5U104M050B	0.1 μF, 50 V monolithic ceramic radial capacitor, 20% tolerance	Mouser	75-1C10Z5U104M050B	$0.13	6
Hammond	1598JSGY	Styrene 2-piece plastic instrument case, 11" × 7.9" × 3"	Digi-Key	HM253-ND	$15.38	1
Keystone Electronics	2203	Aluminum hex standoff, 4-40 thread, 0.5" length	Digi-Key	2203K-ND	$0.26	8

5. Install avr-libc (under OS X 10.3.3, I used v. 1.0.4). As root, the procedure would be something like `tar xvzf avr-libc-1.0.4.tar.gz; cd avr-libc-1.0.4; ./doconf; ./domake; ./domake install`. Additional information is available at http://www.mit.edu/people/mseeman/resources/macmicro.html.

6. Compile the ethernut software (included in the Ethernut Starter Kit cd). I used v. 3.4.2. The procedure here is: `bunzip2 ethernut-3.4.2.tar.bz2; tar xvf ethernut-3.4.2.tar`. Then `cd ethernut/nut`, modify the `configure script` and comment out the `exit 1` statement near the beginnning of the file. Then `./configure` and select atmega128 and STK-500 options. Then `make; mkdir -p lib/gcc/atmega128; make install`. To build the crurom tool, `make -C tools/crurom/; mkdir -p tools/linux; ln tools/crurom/cruro tools/linux/`. Then build the sample applications: `mkdir -p bin/atmega128; make apps apps-install`.

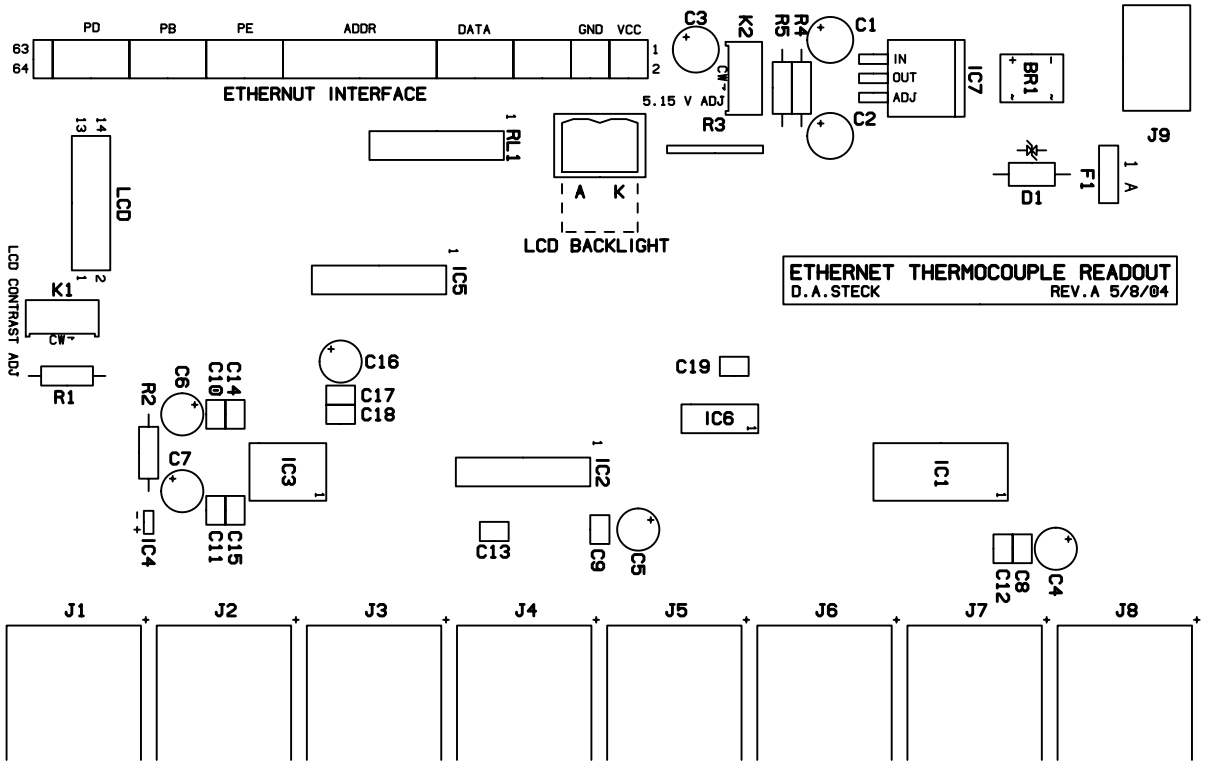

Figure 1: Top PCB silk layer.

4 PC Board

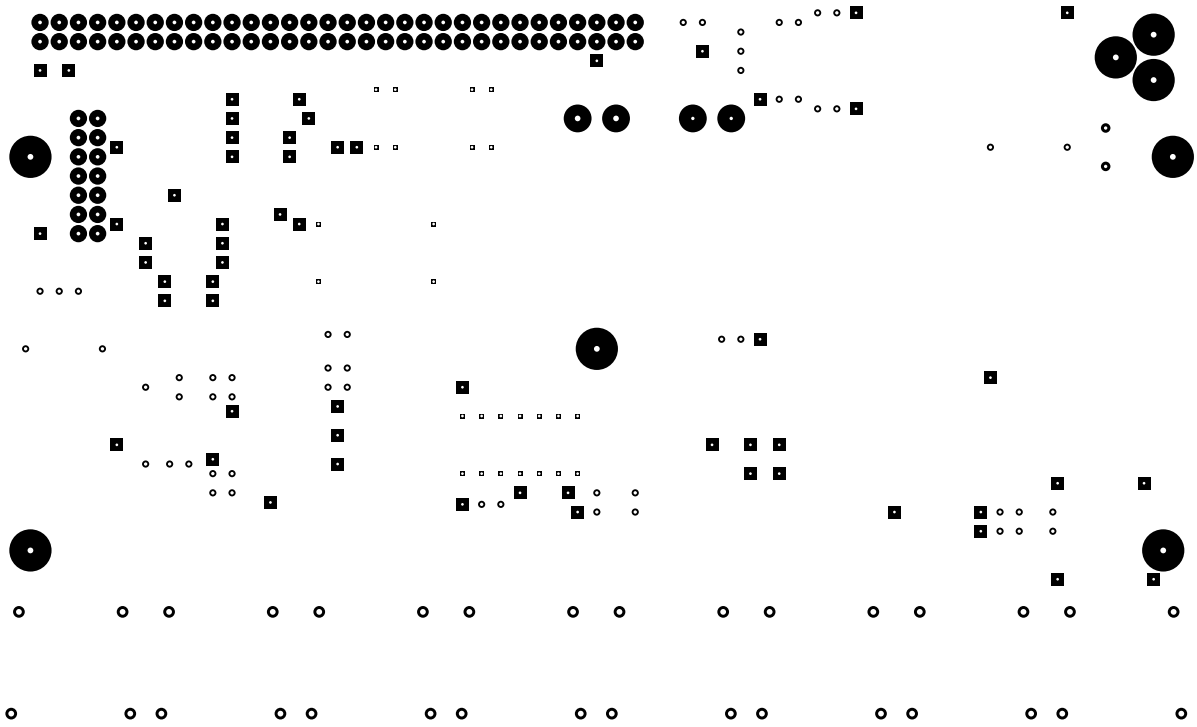

Figure 2: Top PCB solder mask layer.

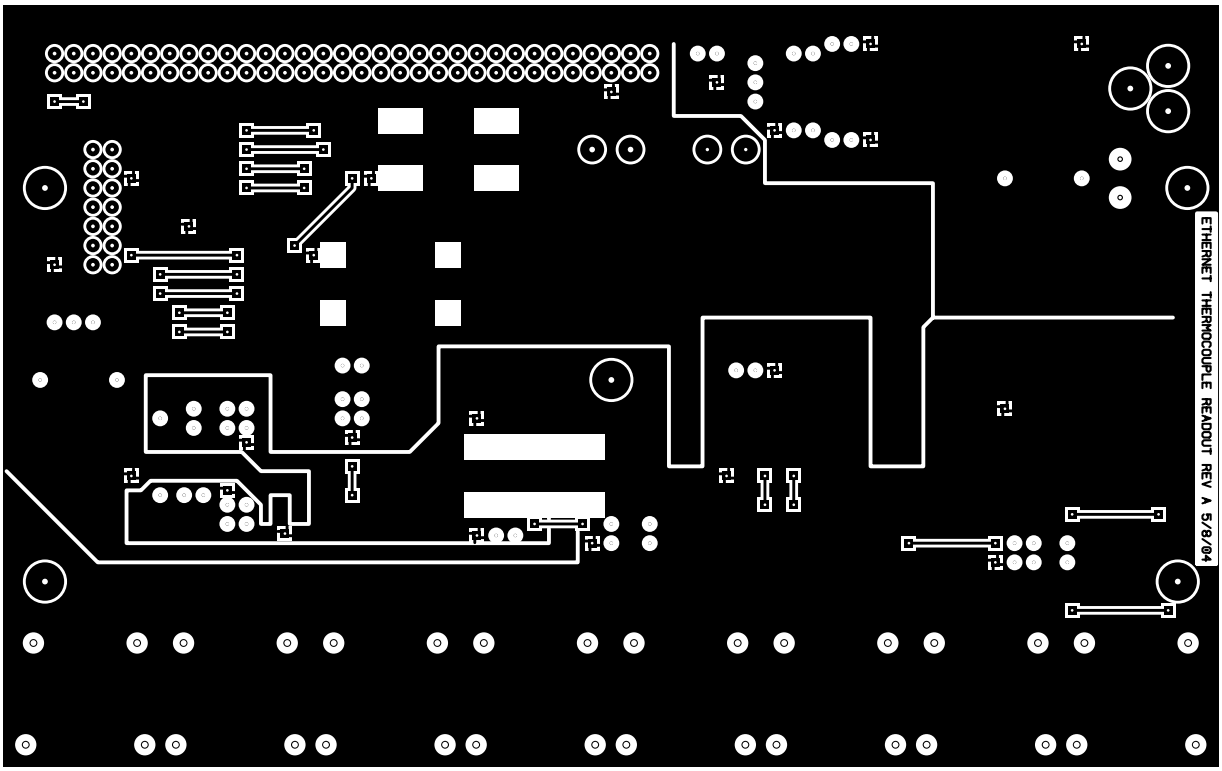

Figure 3: Top PCB copper layer.

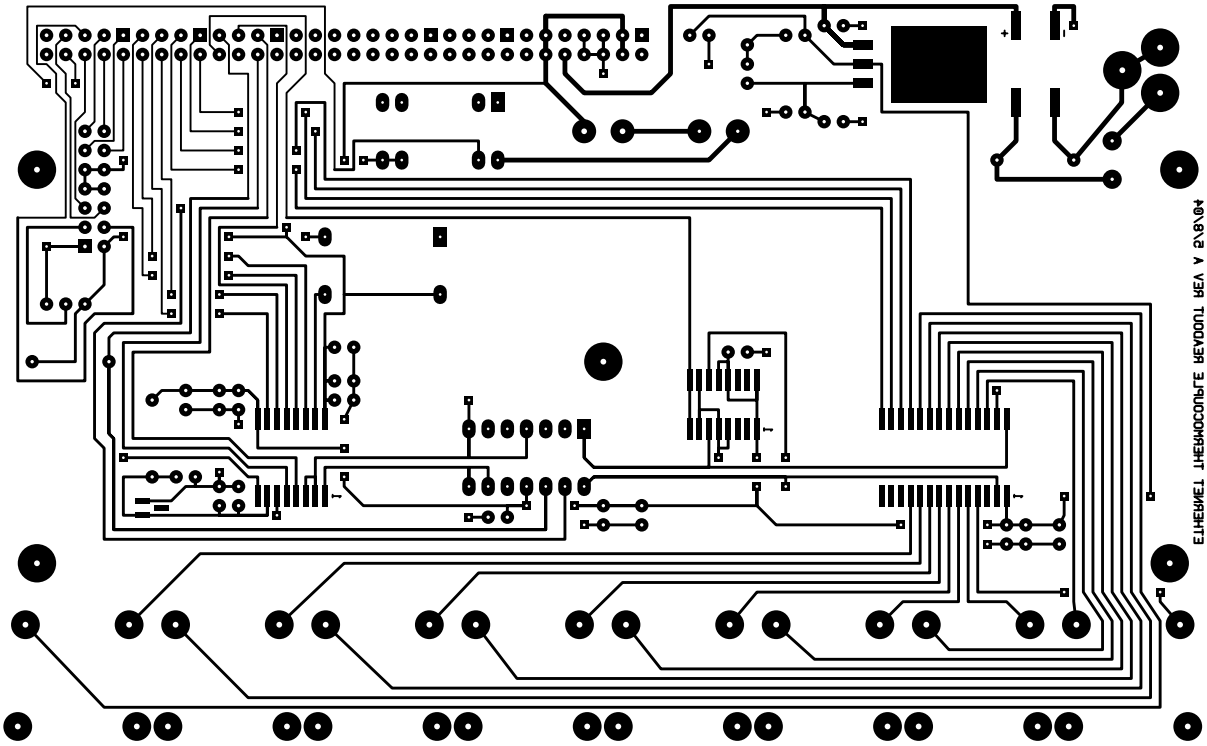

Figure 4: Bottom PCB copper layer (view from top of board).

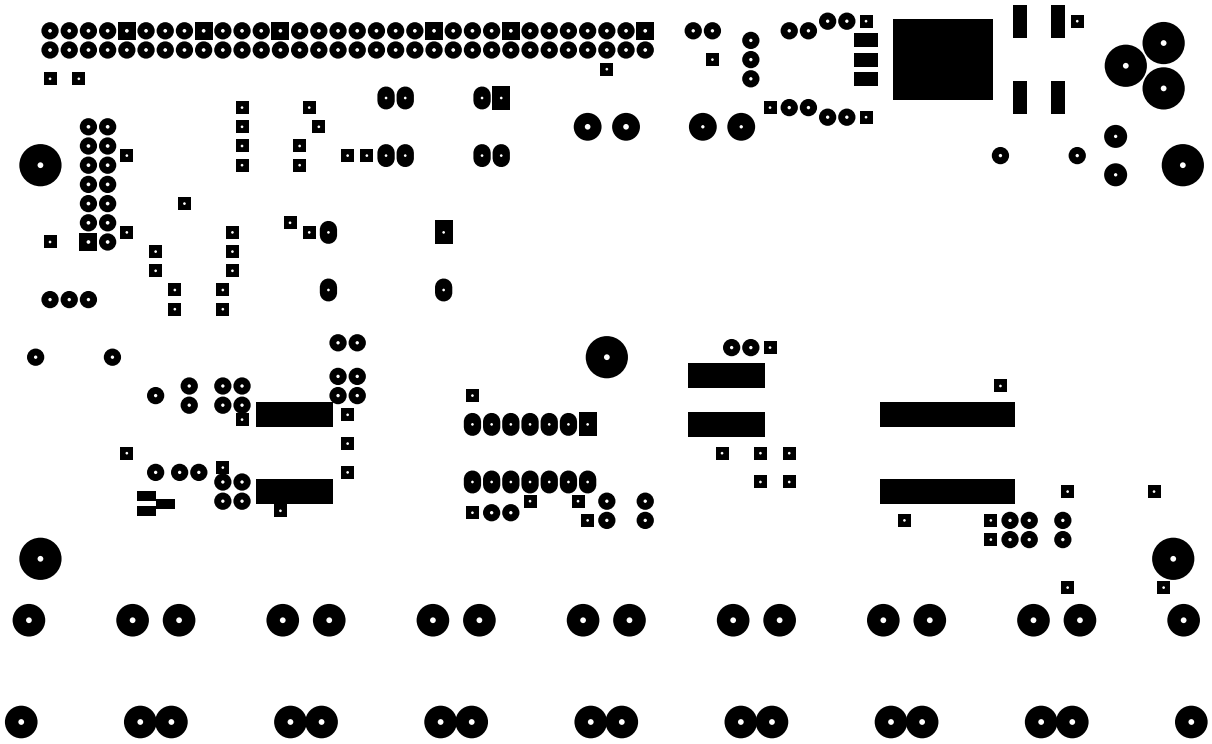

Figure 5: Bottom PCB solder mask layer (view from top of board).