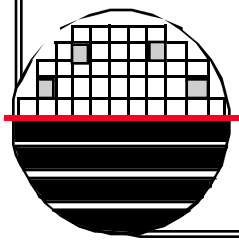
ROCHESTER INSTITUTE OF TECHNOLOGY
MICROELECTRONIC ENGINEERING

Microsystem, PCB and Protoboard Components

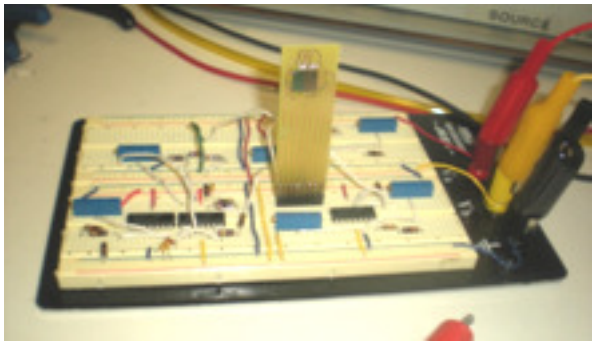
Dr. Lynn Fuller

Webpage: http://people.rit.edu/lffeee
Microelectronic Engineering
Rochester Institute of Technology
82 Lomb Memorial Drive
Rochester, NY 14623-5604
Tel (585) 475-2035
Fax (585) 475-5041
Email: Lynn.Fuller@rit.edu
Department webpage: http://www.microe.rit.edu

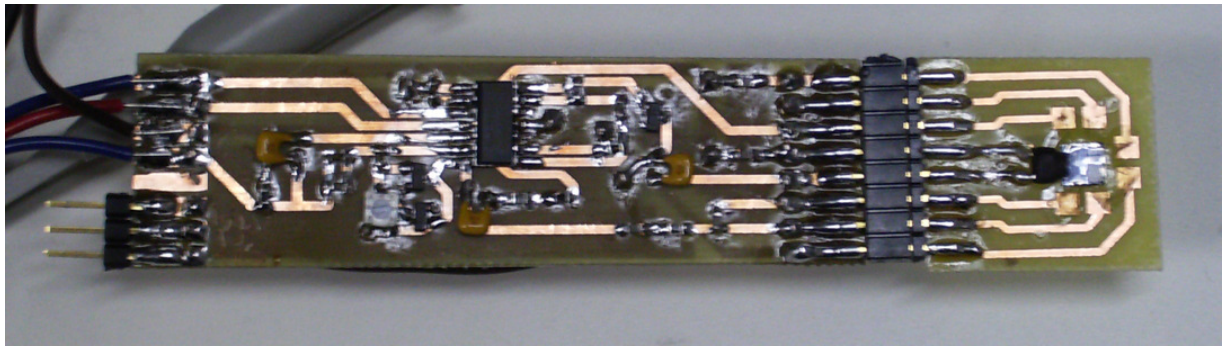


INTRODUCTION

The design of microsystems involves the integration of MEMS, on chip custom integrated circuits, off chip electronics such as power supply chips, microcontrollers and communication components. The integration is often done at the printed circuit board (PCB) level. This document will illustrate some of the various components used at the prototype, PCB and System level.



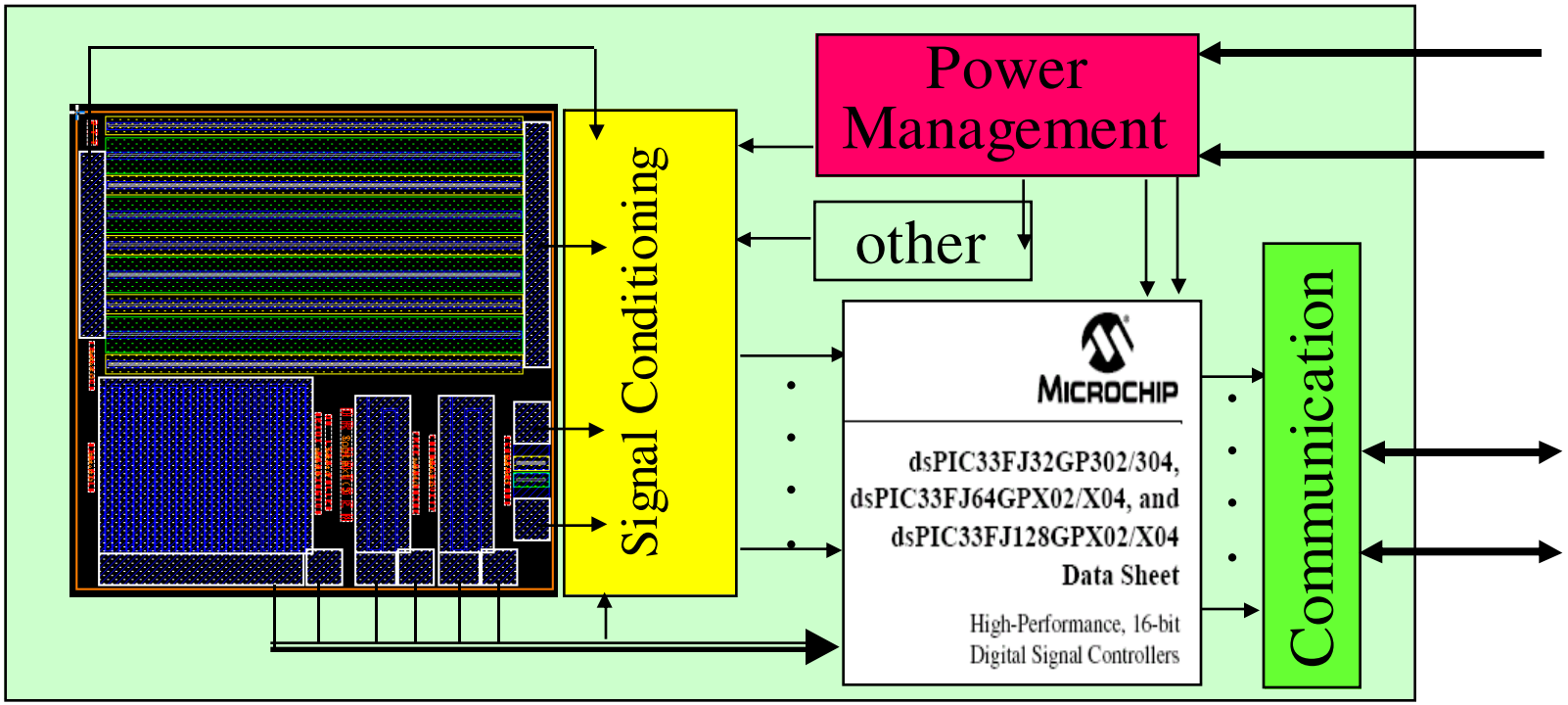
Protoboard



PCB, MEMS

MICROSYSTEM DESIGN

Multi-Sensor MEMs Chip

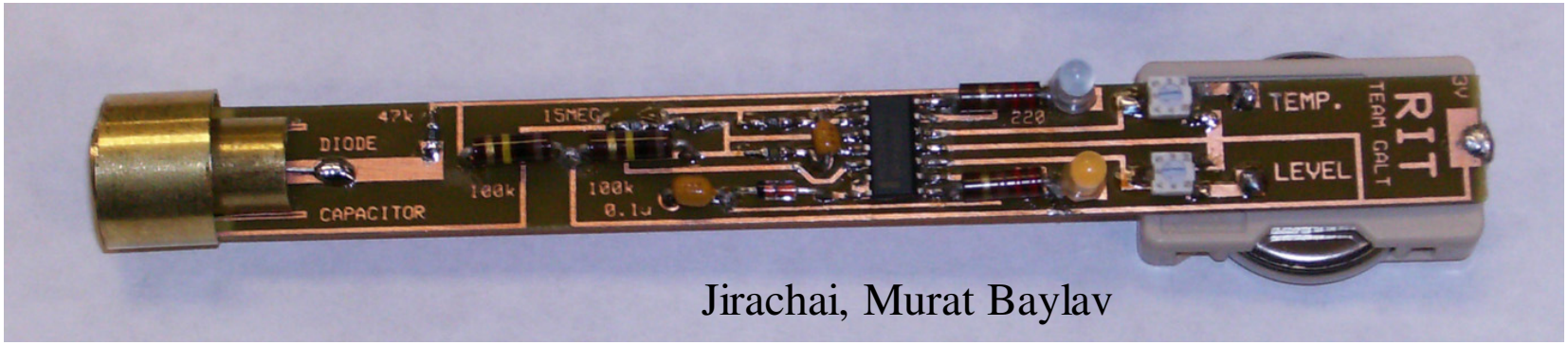


Micro Controller

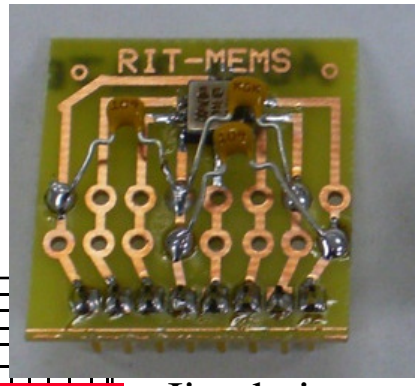
Signal Conditioning Electronics

PCB PROTOTYPE

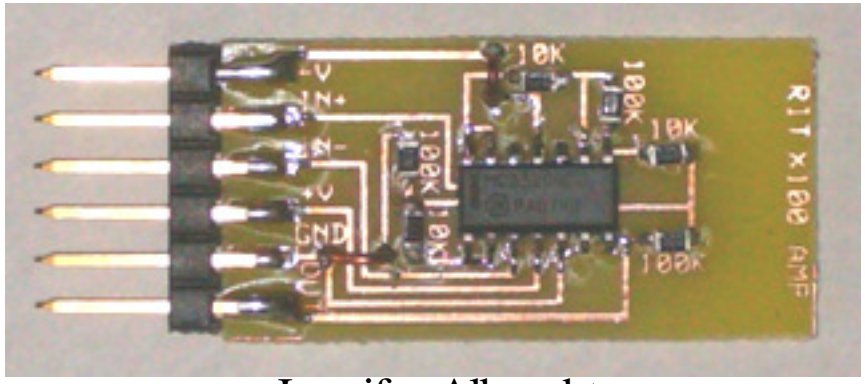
Prototype evaluation: breadboard sensors and signal processing electronics at the PCB level to evaluate different approaches for realizing microsystems.



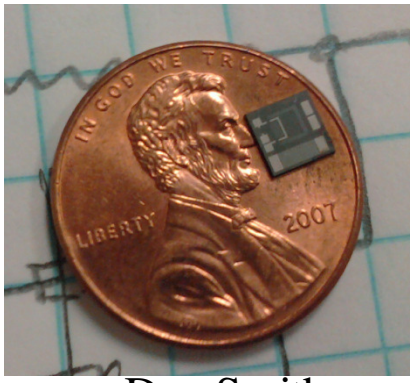
Jirachai, Murat Baylav



Jirachai



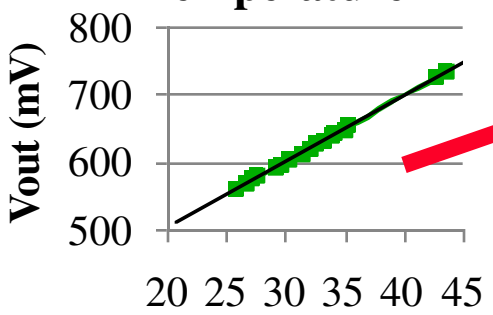
Jennifer Albrecht



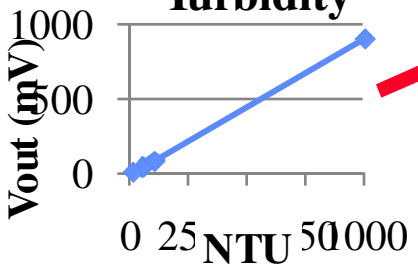
Dan Smith

MEMS Universal Fluid Interrogation Sensor (MUFINS)

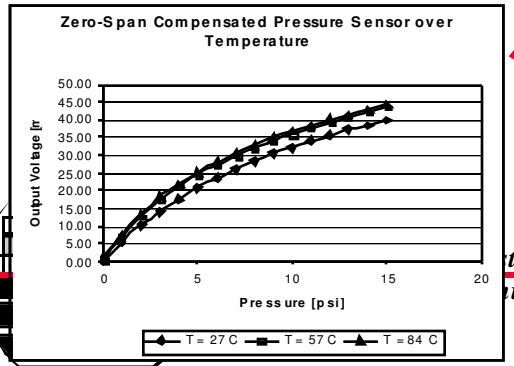
Temperature



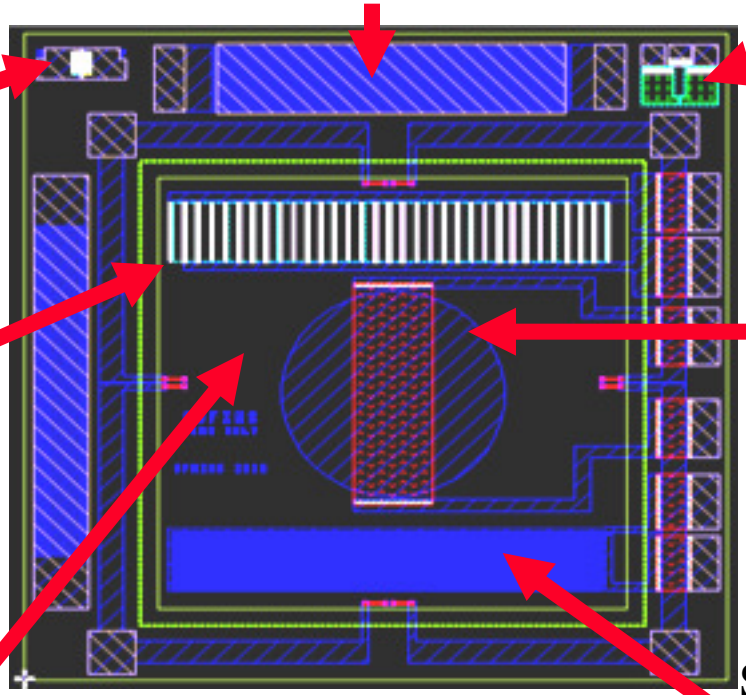
Turbidity



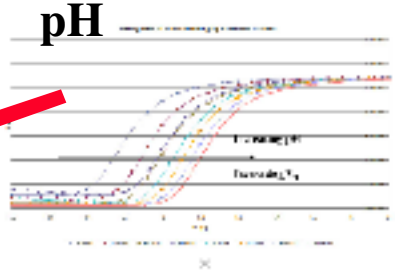
Pressure



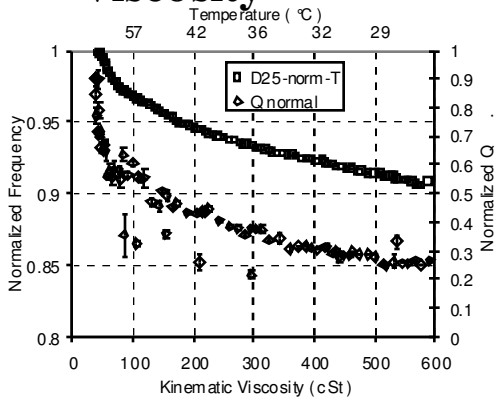
Fluid Level and Conductivity



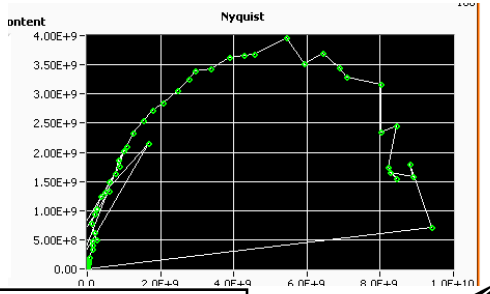
pH



Viscosity



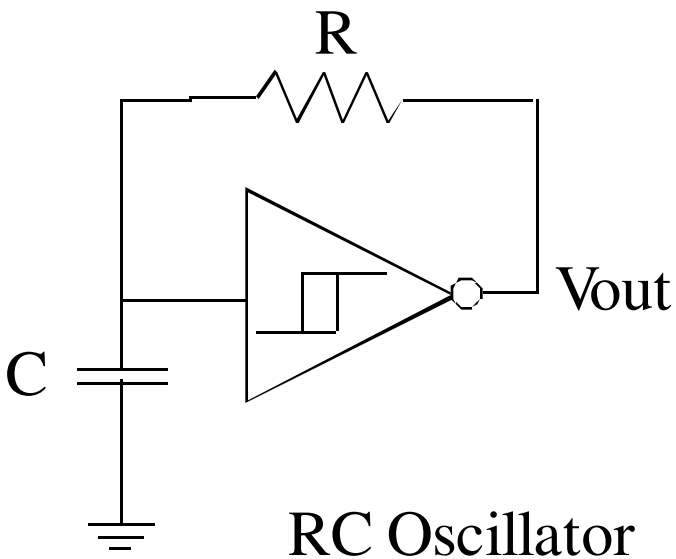
Spectroscopic impedance



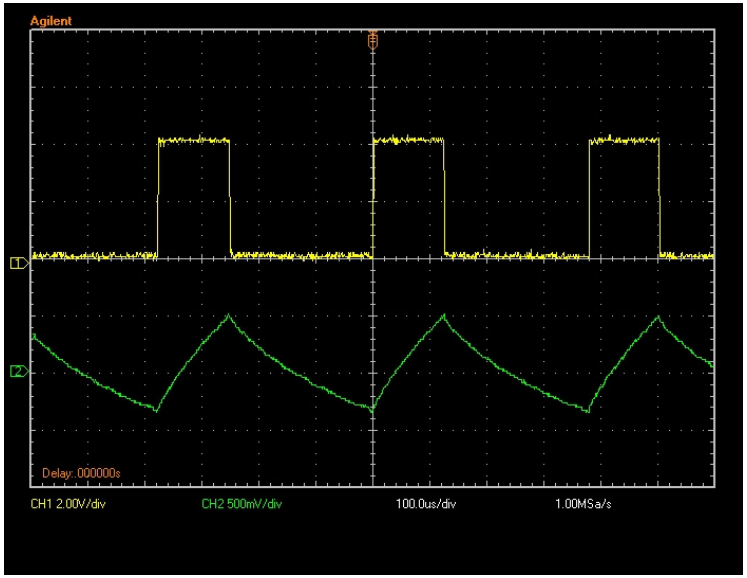
Applications:

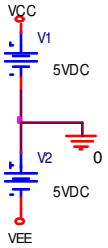
- Drinking water
- Automobile engine oil
- Industrial Fluids

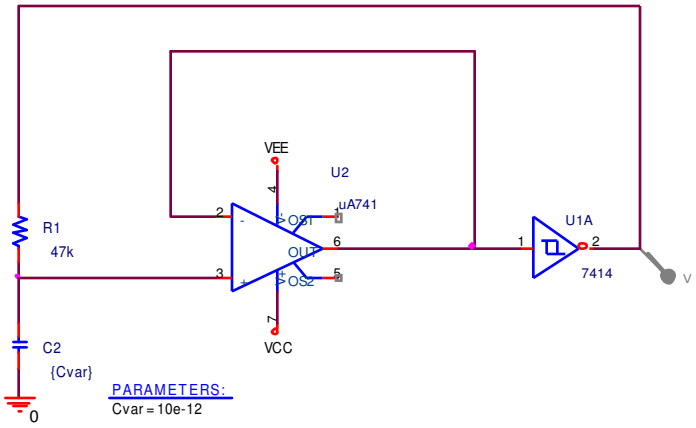
GATE LEVEL DESIGN AND SIMULATION

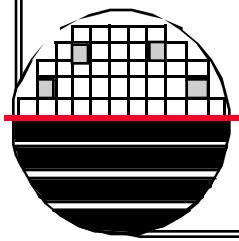


RC Oscillator





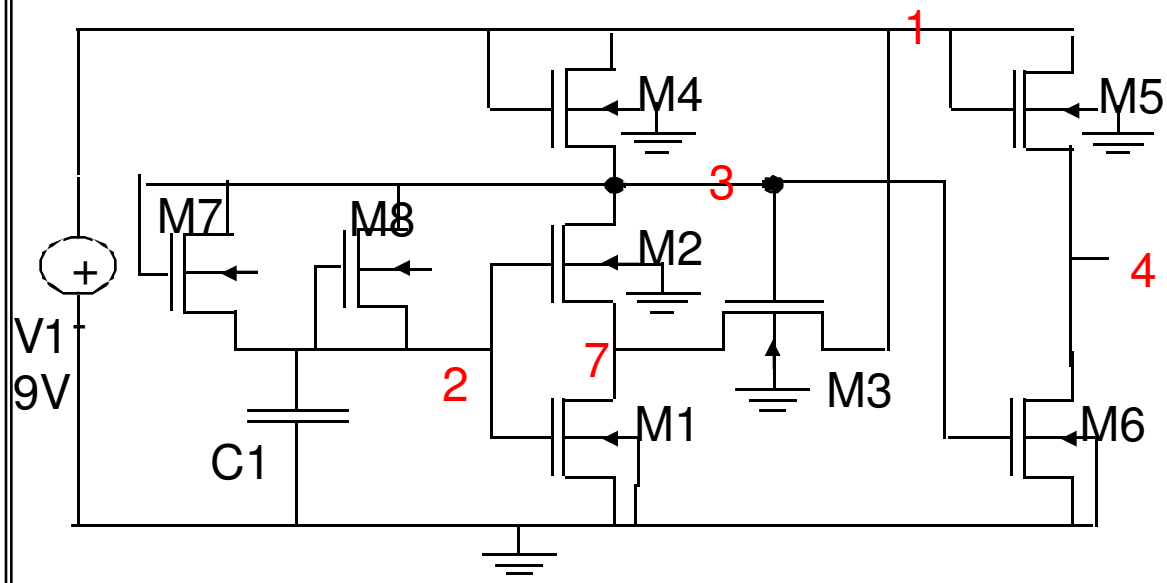


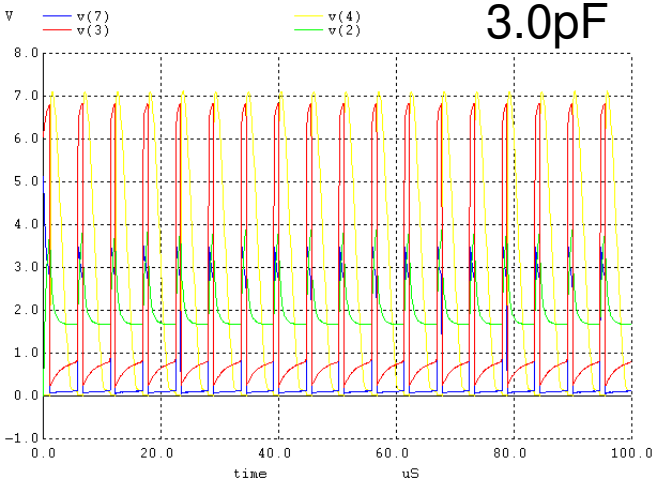


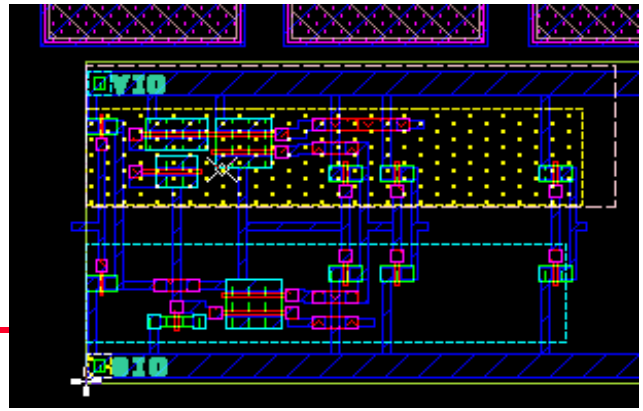
Rochester Institute of Technology
Microelectronic Engineering

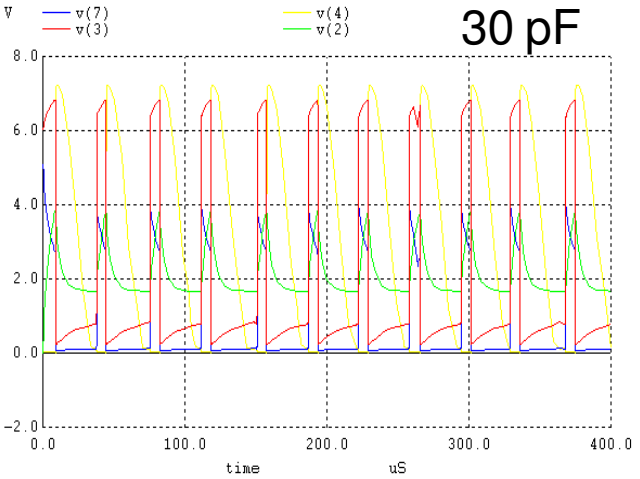
TRANSISTOR LEVEL CIRCUIT DESIGN AND SIMULATION

RC_OSCILLATOR.TXT

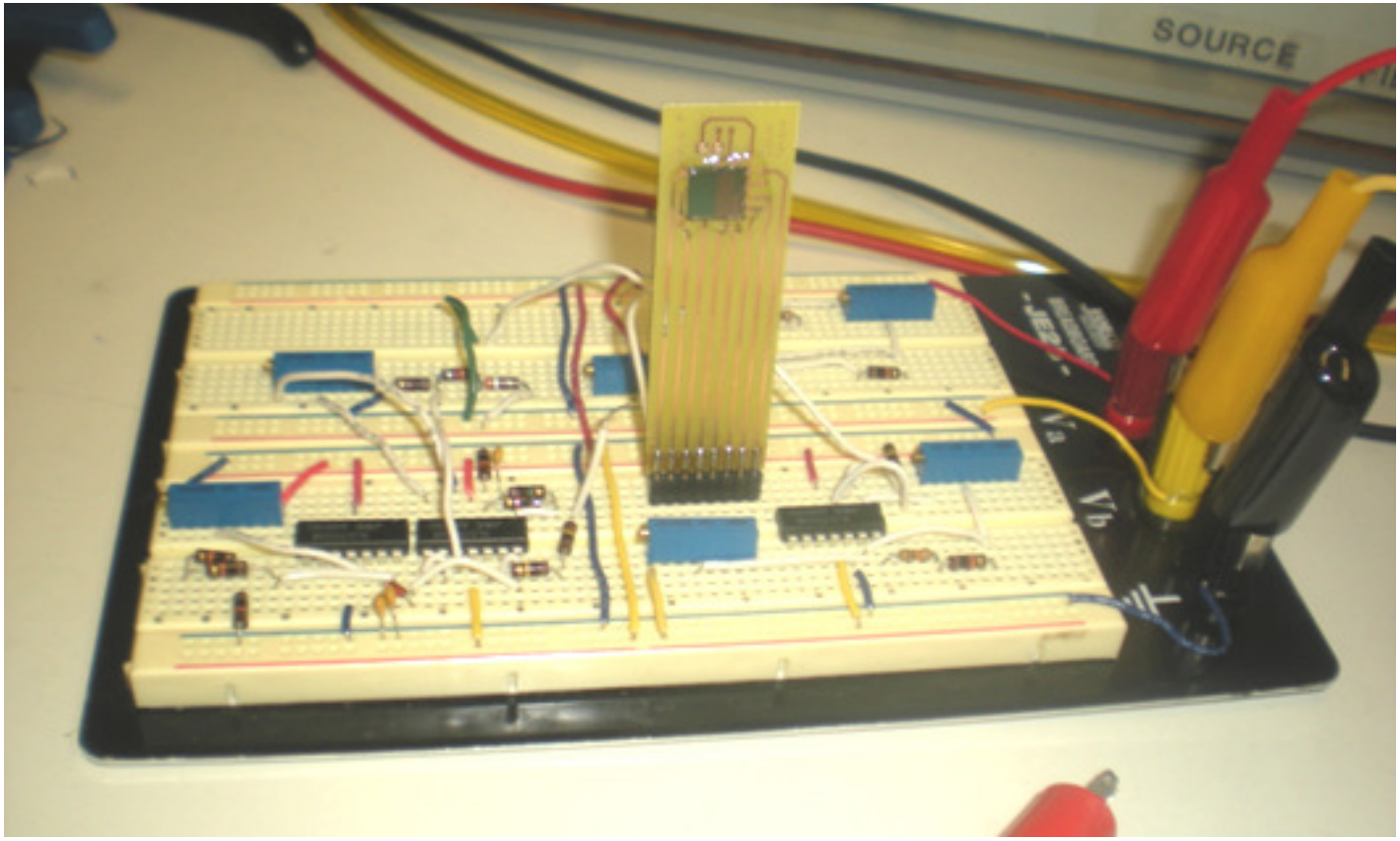








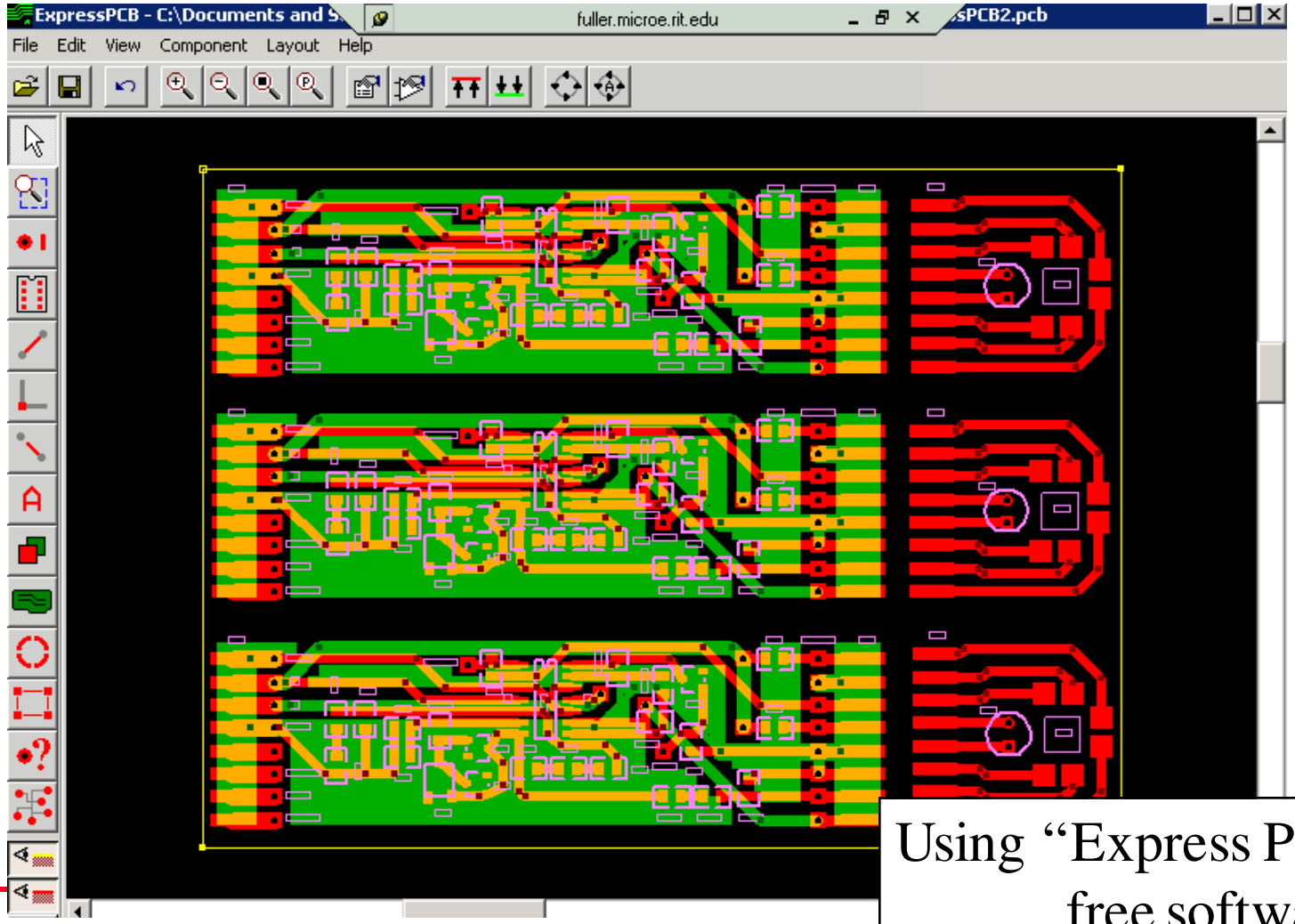
PROTOBOARD REALIZATION



Heidi Purrington

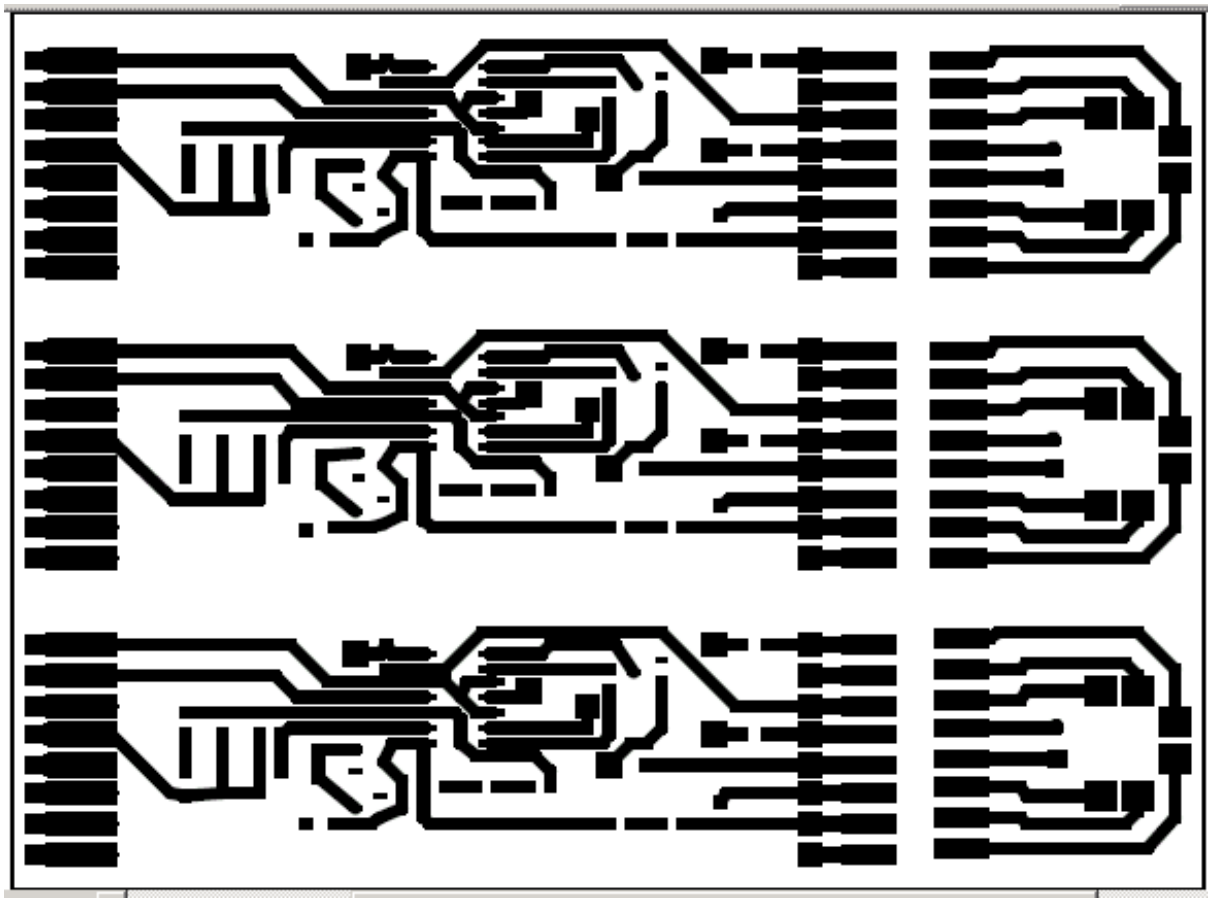
Rochester Institute of Technology
Microelectronic Engineering

EXPRESS PCB – FREE SOFTWARE FOR PCB DESIGN



Using "Express PCB" free software

ARTWORK GENERATION



Print using a laser printer onto a transparency

MAKE COPPER PCB BOARD

1. Cut two sided copper board (6”x 9”) into smaller size that can be spin coated with photoresist (3”x 3”). Use shear in machine shop.
2. Clean Board with 400 grit sand paper or very fine steel wool followed by using Soap, Water and Blow Dry.
3. Spin coat with photoresist (HPR504) at 1500 rpm, 60 sec.
4. Bake in Oven 100°C, 4 min. (gray oven near ion implanter)
5. Place Transparency on Board and Flatten with Glass Plate
6. Flood Expose, (10 sec = ~ 100mj/cm2) on Karl Suss MA150
7. Develop in CD-26 Developer (~1 min), inspect
8. Repeat 2 to 5 for other side of two sided board
9. Test with drop of etch mixture on bare copper area, rinse, dry
10. Hard bake in Oven 140°C 15 min
11. Etch in Mixture of Water, H2O2, HCl (3:2:1)
12. Strip Resist in Acetone, Rinse in Water
13. Drill holes.
14. Cut Board into Individual Packages Using Shear in Machine Shop.

MAKE COPPER PCB BOARD

2-sided copper PCB
1/32” x 6”x9”
473-1011-ND $8.82

Shear

Small Shear

MAKE COPPER PCB BOARD

SCS Spin Coater

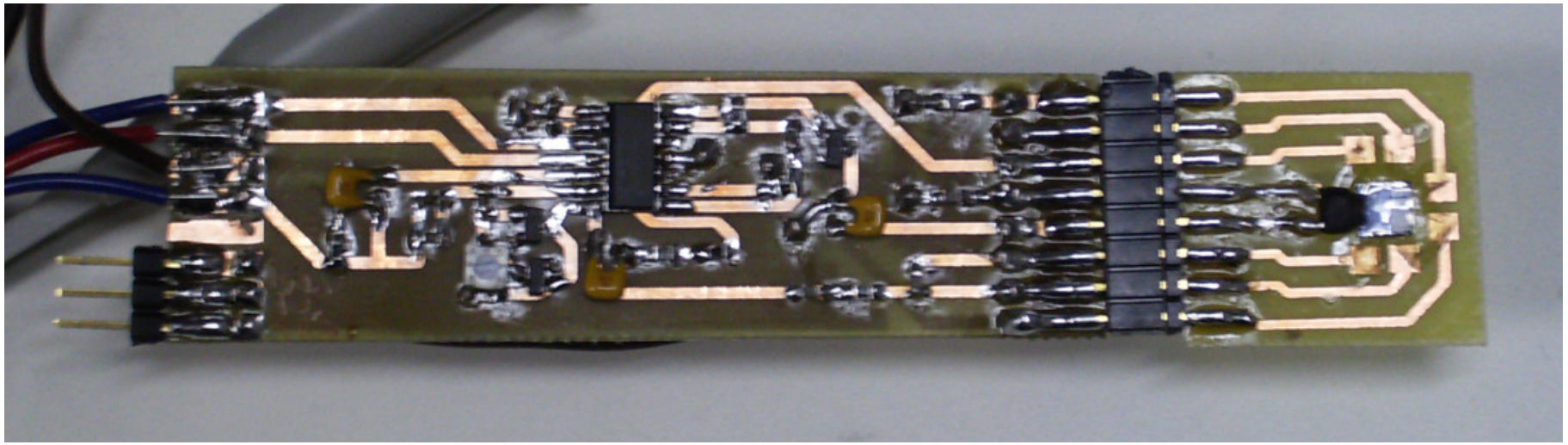
Oven

MAKE COPPER PCB BOARD

Flood Expose
(10 sec = ~ 100mj/cm2)
Karl Suss MA150

PCB

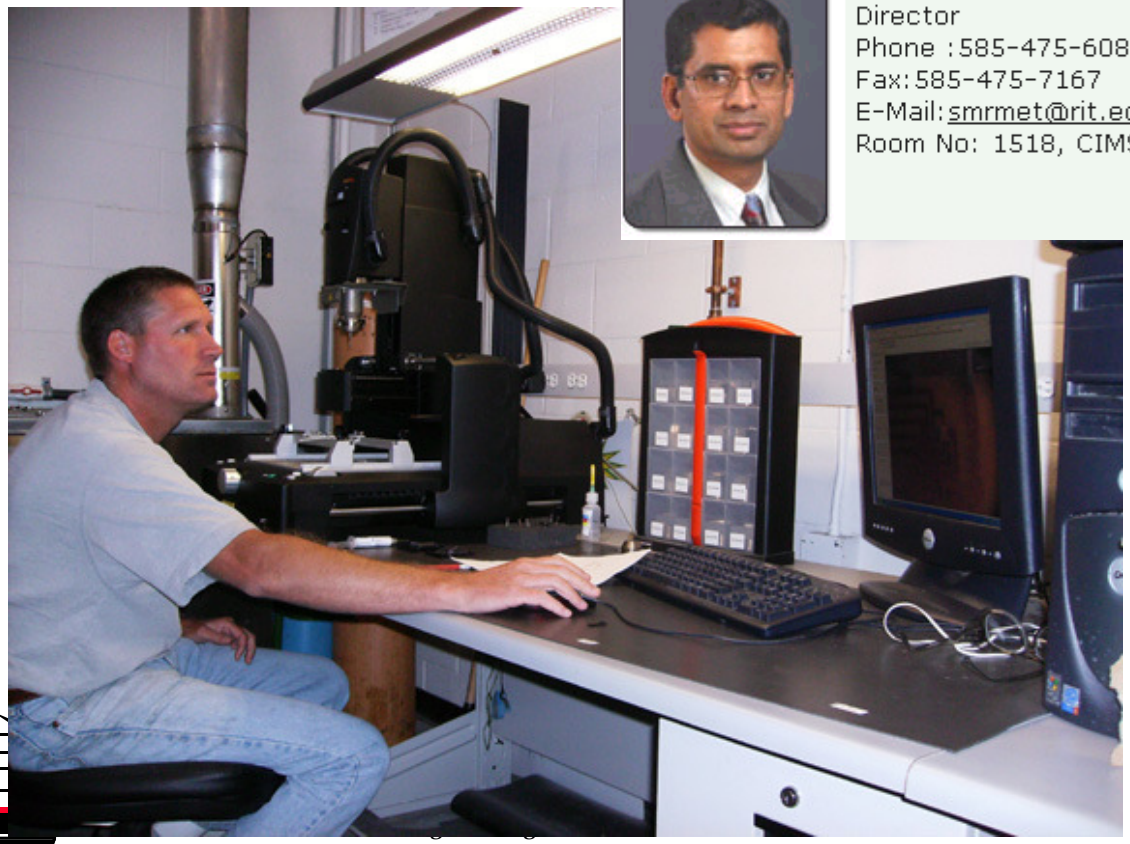
Drinking Water Sensor



Heidi Purrington, 2009

PICK, PLACE AND SOLDER TOOL

CEMA – Center for Electronics Manufacturing and Assembly



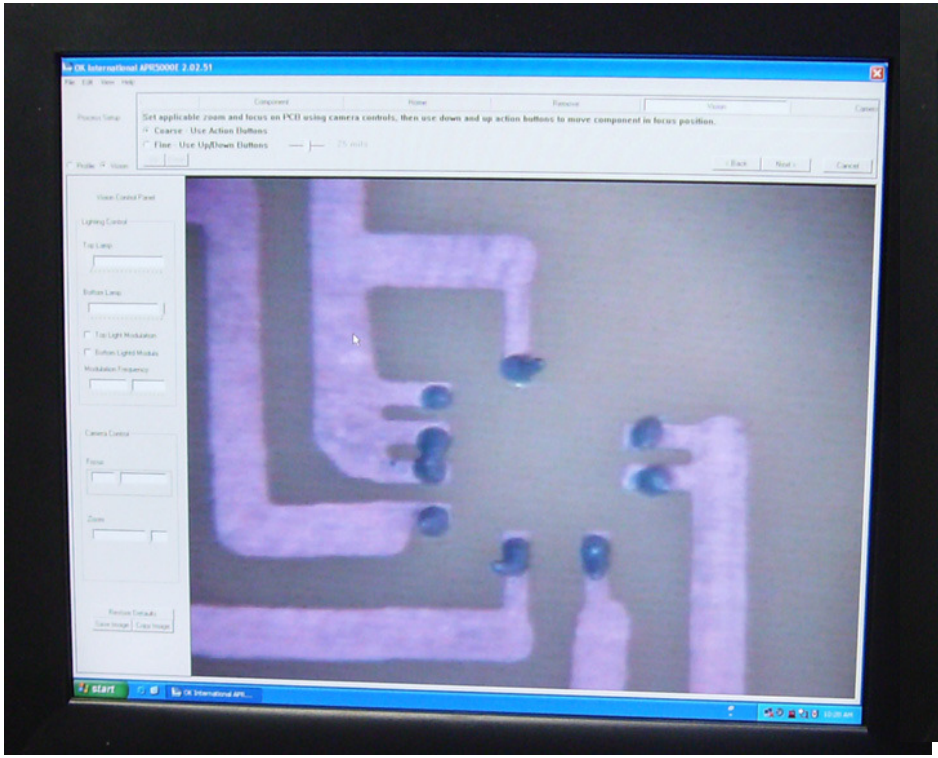
Dr. Ramkumar, Ph.D.
Director
Phone :585-475-6081
Fax:585-475-7167
E-Mail:smrmet@rit.edu
Room No: 1518, CIMS

Address:

CEMA
Room 1518
78 Lomb Memorial Dr
Rochester, NY
14623

Jeff Lonneville
jglasp@rit.edu
78-1552

ADXL325 ALIGNMENT IMAGES



Copper Traces with Solder Paste

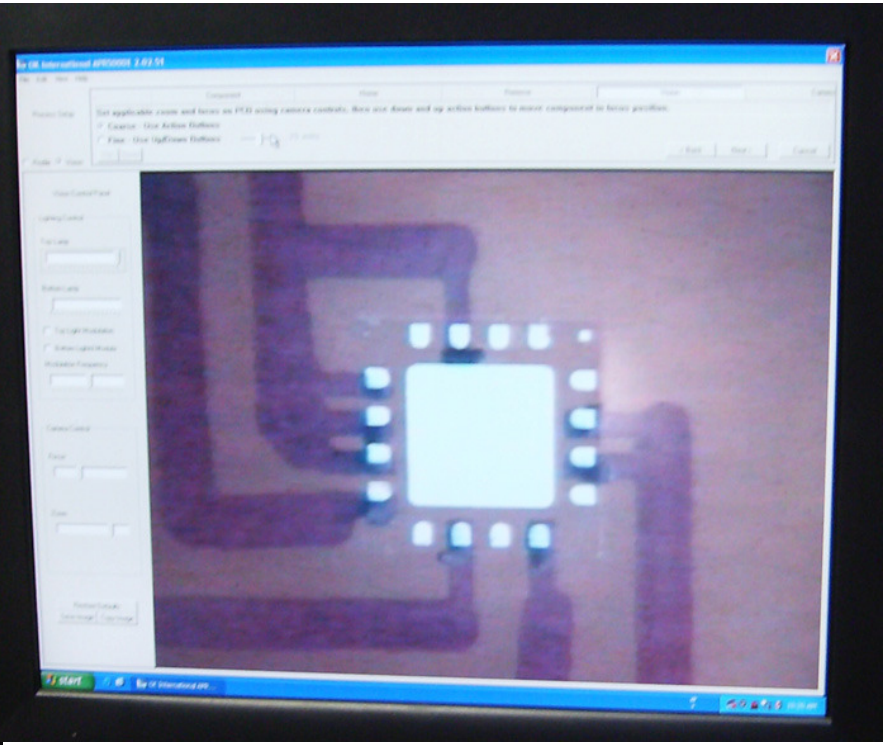
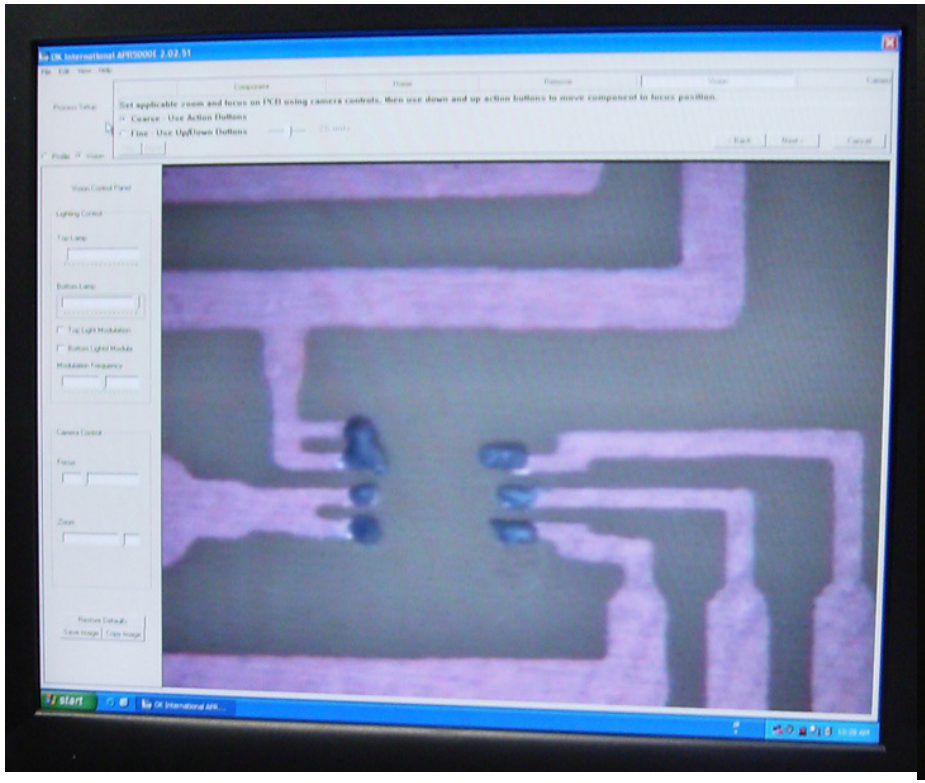


Image of bottom of ADXL325 Superimposed on Copper Traces

BMA140 ALIGNMENT IMAGES



Copper Traces with Solder Paste

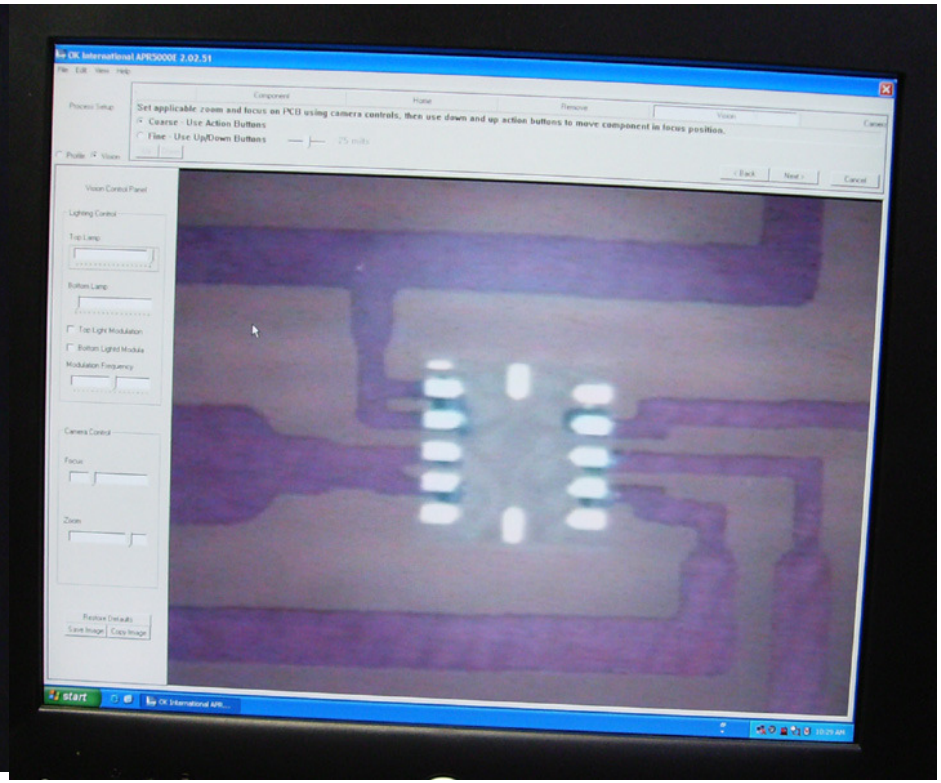
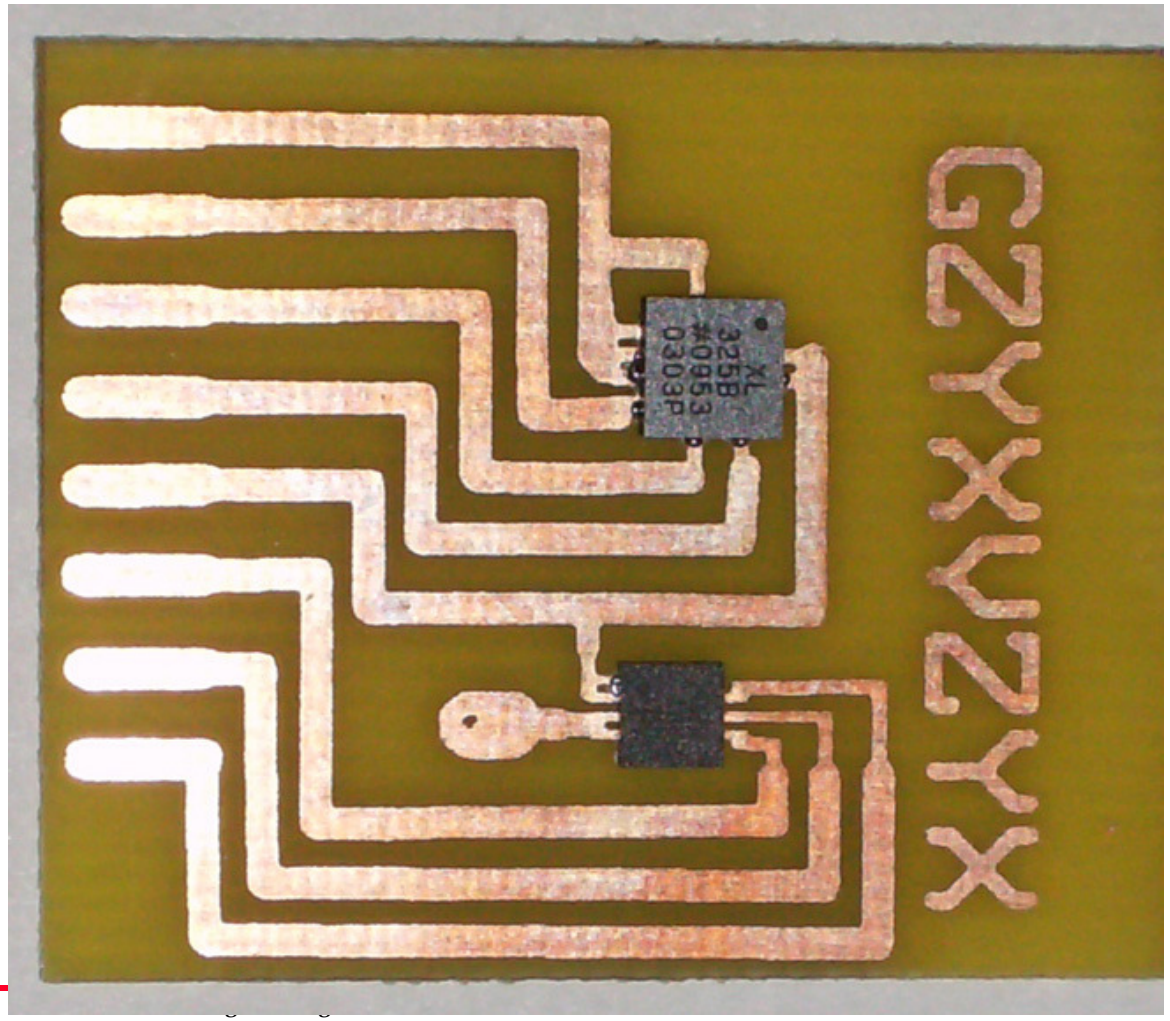


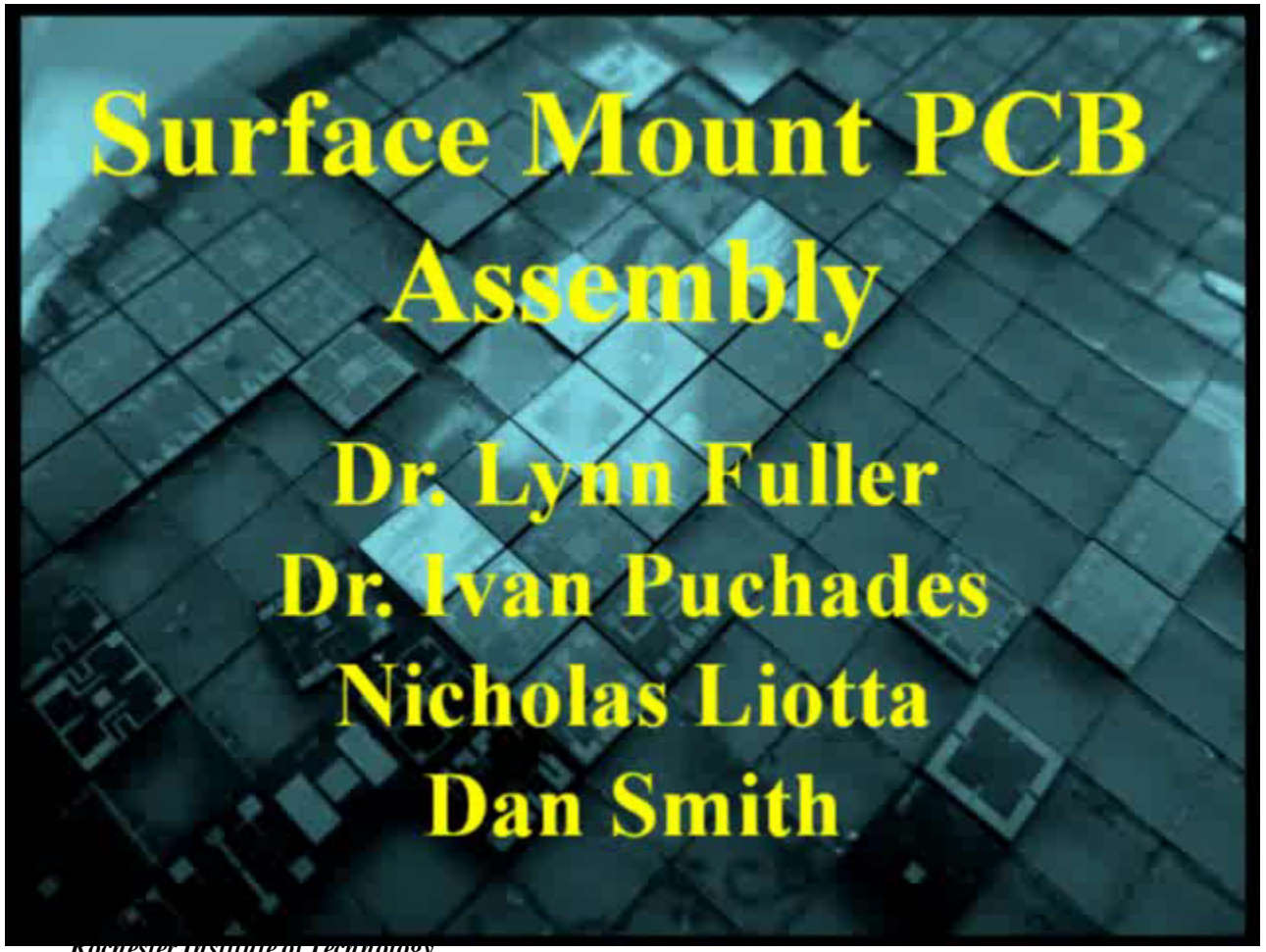
Image of bottom of BMA140 Superimposed on Copper Traces

TEMPERATURE RAMP DURING SOLDERING

COMPLETED BOARD WITH SOLDERED COMPONENTS

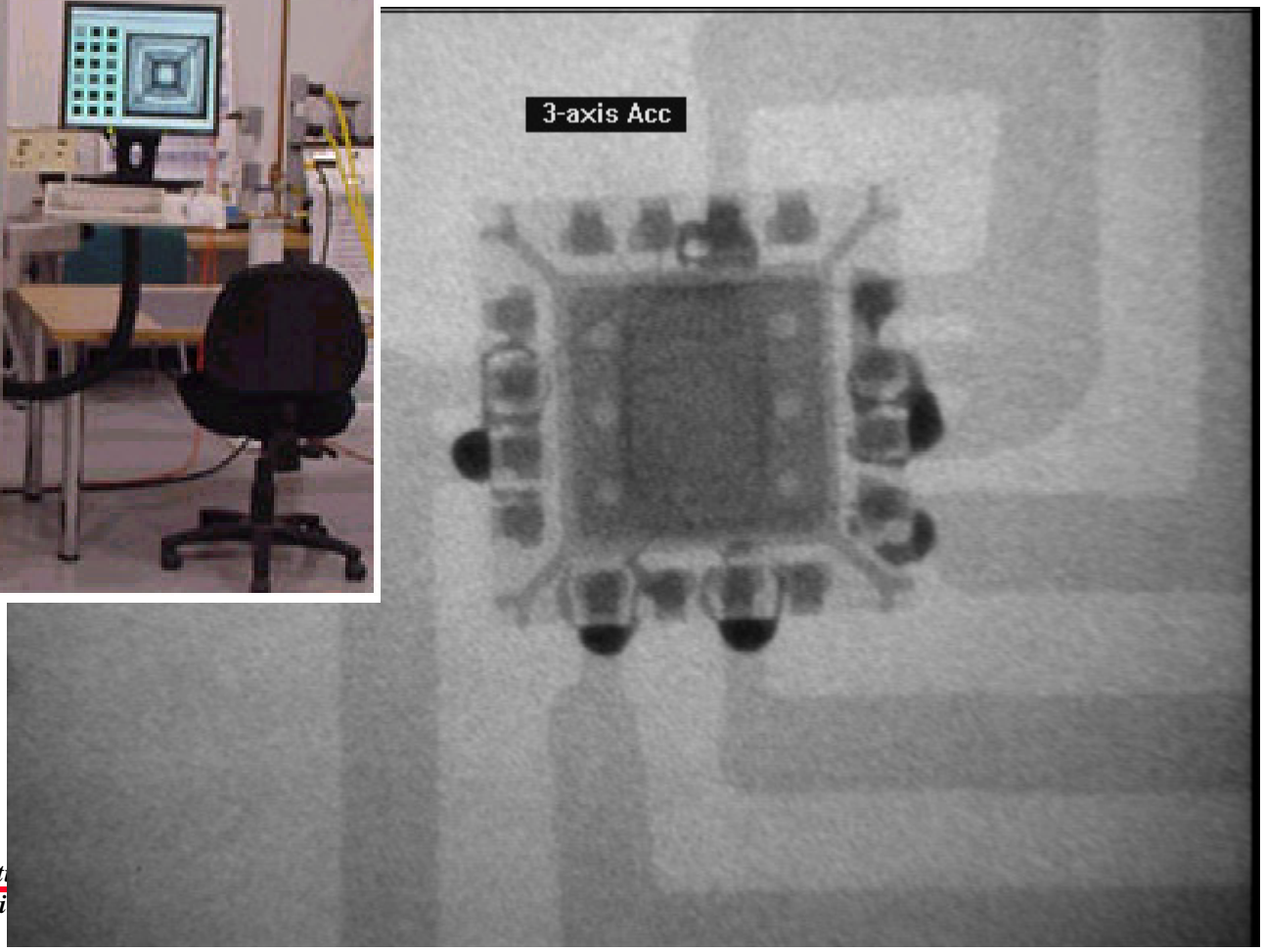


SURFACE MOUNT

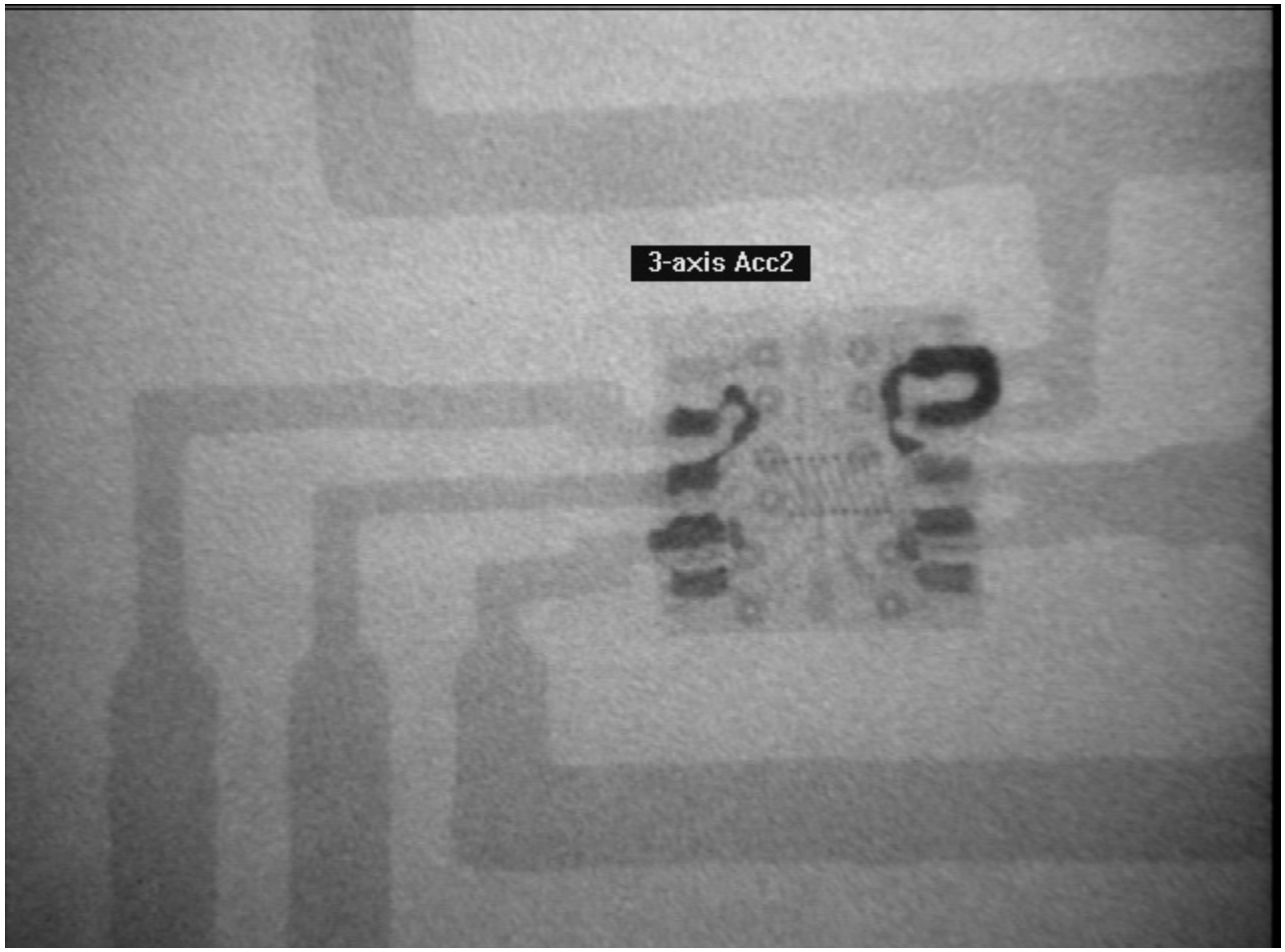


XRAY IMAGE OF ADXL325 SOLDER JOINTS

Glenbrook X-Ray Inspection



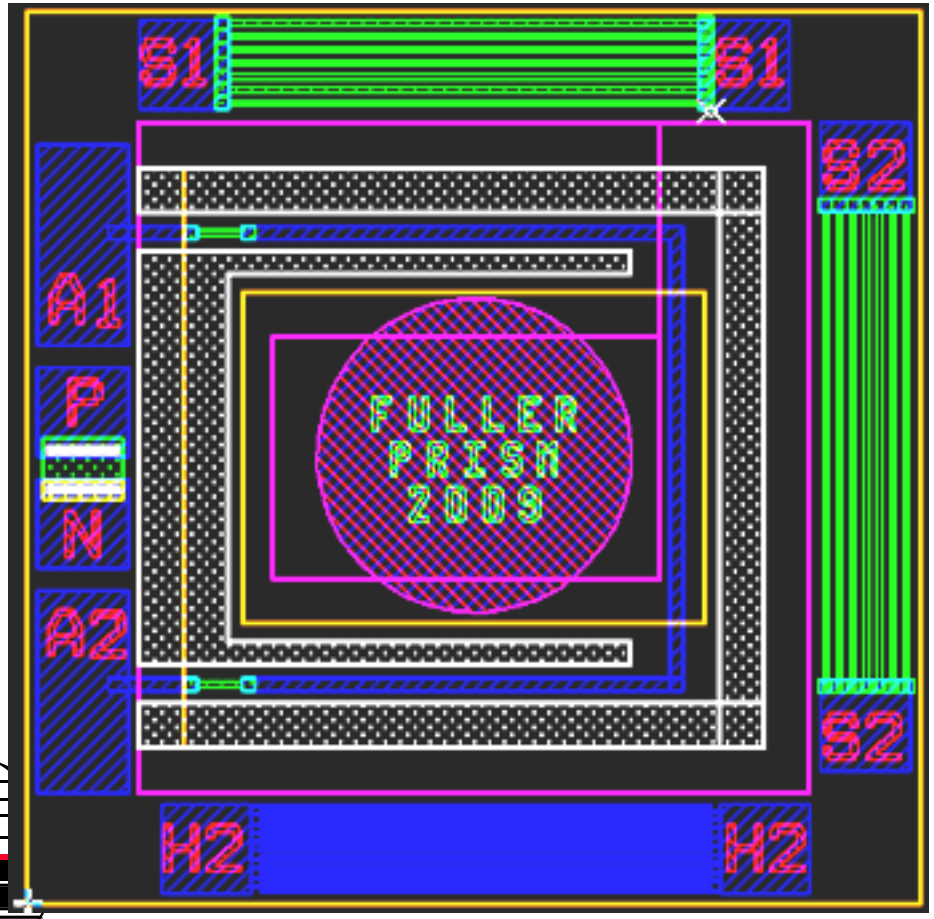
XRAY IMAGE OF BMA140 SOLDER JOINTS



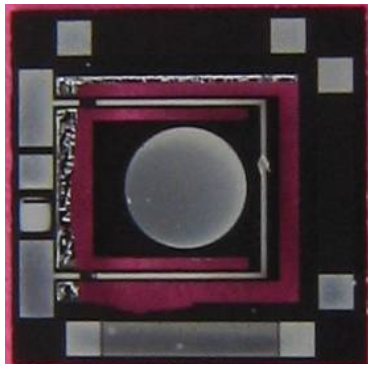
Shows Possible Problem with Y and Z outputs shorted together

MEMS MULTI-SENSOR CHIP's

Prognostic Integrated Sensory MEMS (PRISM)



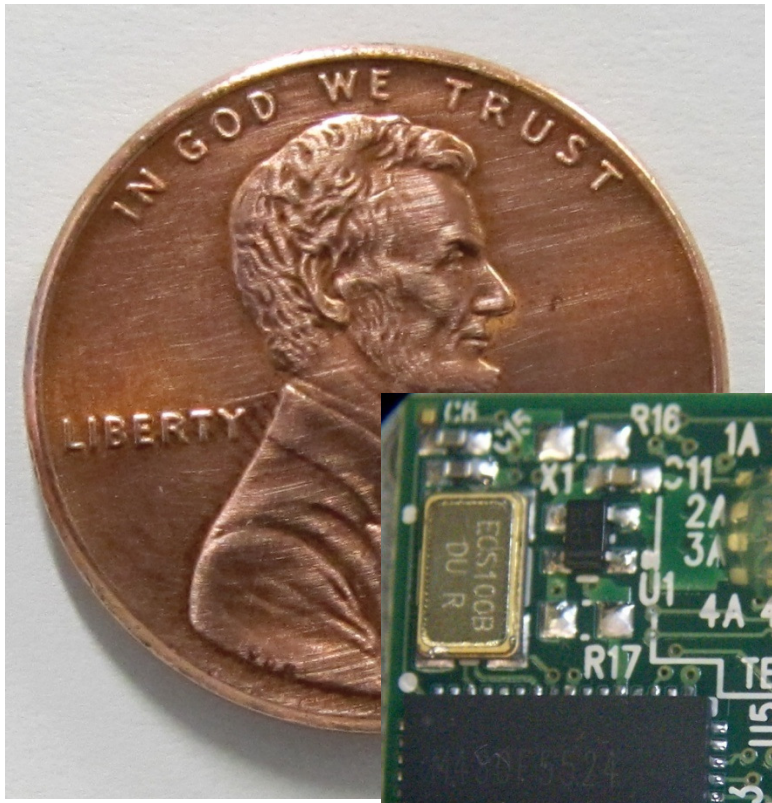
1-AxisAccelerometer
Temperature Sensor
Humidity Sensor
X & Y Strain Sensor

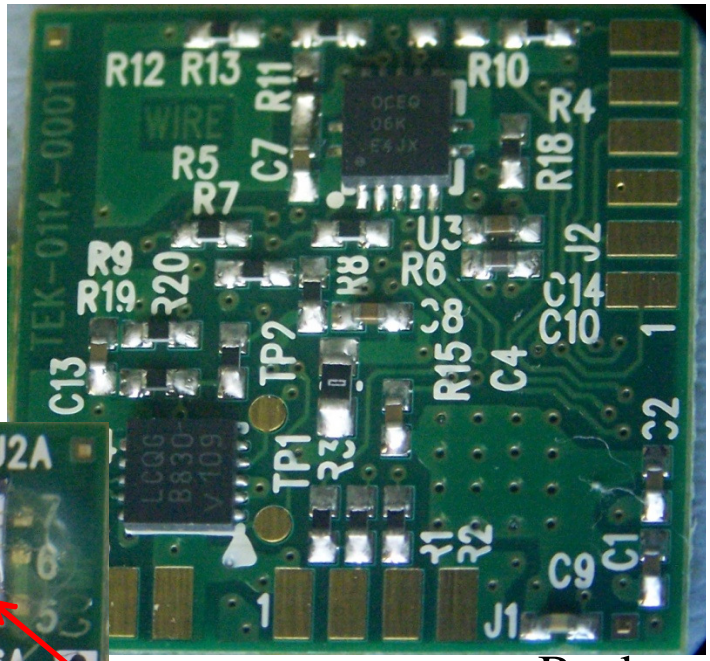


4mm x 4mm Chip

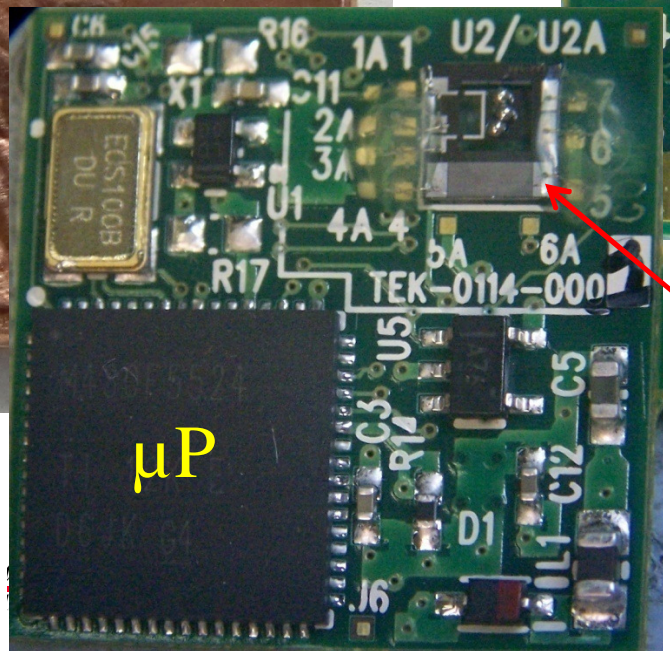
Health Management Solution to Predict Equipment Performance and Readiness

MULTISENSOR MICROSYSTEM





Back



Front

MEMS Multisensor Chip
Acceleration (shock)
Temperature, Humidity

PARTIAL LIST OF PROTOTYPE COMPONENTS

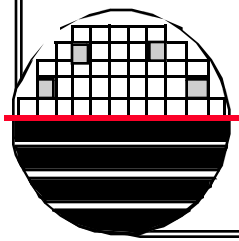
Power Conditioning Components:
NEG Lin Regulator; Voltage Converter CMOS SW-CAP; POS Lin Regulator; 3.3V Regulator;

Integrated Circuits:
Schmitt Inverter; Op Amp Lo Voltage MOS; Microcontroller; Counter/Shift Register, Instrumentation Amplifier, Multiplier, Waveform Generator

Passive: 100Kohm, 10Kohm, 1Kohm Trimpot; SMD Resistors many values from 100ohm to 10 MEG ohm; Axial Lead Resistors ¼ watt, all values; Chip Capacitors 0.001uF, 0.1uF, 1.0uF, 10uF, more;

Other:
LEDs IR, Red, Green, Blue, White, Yellow; Diodes, MOSFETs N and P; Bluetooth Radio

Hardware: Connector for Pin Strip Header, Pin Strip Header, 2-sided copper PCB

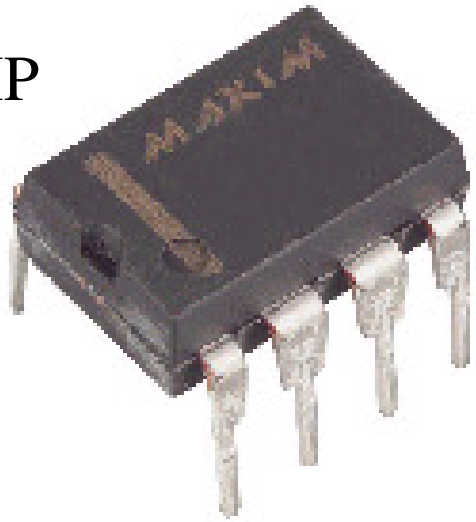


PROTOTYPE AND PCB PARTS

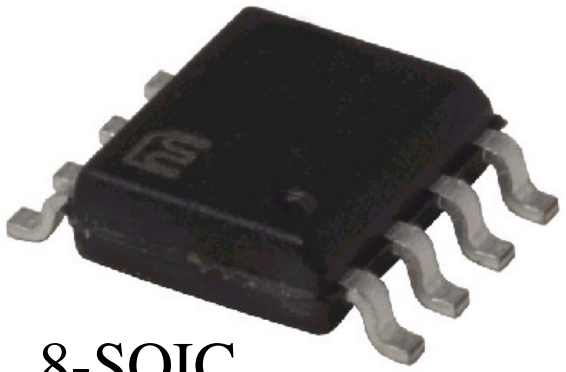
POWER CONDITIONING COMPONENTS

Description	Digikey Part Number	Package	~Price
POS Lin Regulator Variable	LM317MBSTT3GOS CT-ND	SOT-223	$0.72
POS Lin Regulator 3.3 Volt	576-1151-ND	8-SOIC	$1.11
Voltage Converter CMOS SW-CAP	MAX1044CPA+-ND	8-DIP	$2.68
Voltage Converter CMOS SW-CAP	MAX1044CSA+-ND	8-SOIC	$3.26
NEG Lin Regulator	296-11417-5-ND	8-SOIC	$5.60

8-DIP



SOT-223

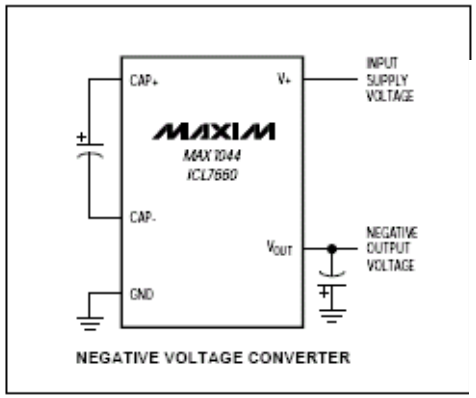


8-SOIC

SWITCHED CAPACITOR VOLTAGE CONVERTER

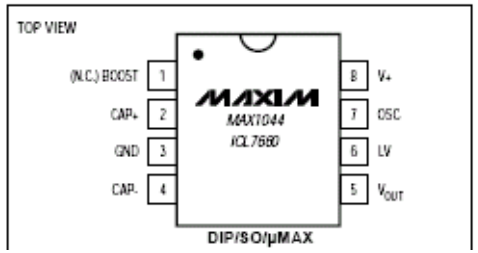
Portable Telephones
Op-Amp Power Supplies
EIA/TIA-232E and EIA/TIA-562 Power Supplies
Data-Acquisition Systems
Hand-Held Instruments
Panel Meters

Typical Operating Circuit



NEGATIVE VOLTAGE CONVERTER

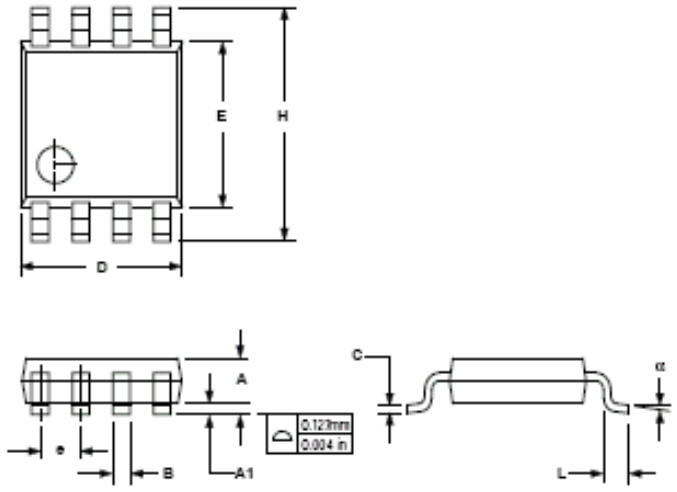
Pin Configurations



DIP/SO/µMAX

MAX1044CSA+-ND
CMOS
1.5-10 Volt Supply

Package Information



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.036	0.044	0.91	1.11
A1	0.004	0.008	0.10	0.20
B	0.010	0.014	0.25	0.36
C	0.005	0.007	0.13	0.18
D	0.116	0.120	2.95	3.05
E	0.116	0.120	2.95	3.05
e	0.0256		0.65	
H	0.188	0.198	4.78	5.03
L	0.016	0.026	0.41	0.66
α	0°	6°	0°	6°

21-0036

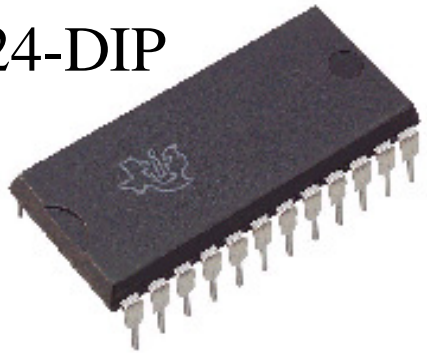
8-PIN µMAX PACKAGE

INTEGRATED CIRCUITS

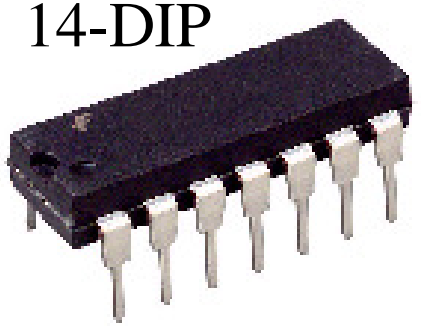
Description	Digikey Part Number	Package	~Price
Hex Schmitt Inverter	CD40106BCN-ND	14-DIP	$0.40
Hex Schmitt Inverter	CD40106BCMXCT-ND	14-SOIC	$0.32
Quad Op Amp Lo Voltage MOS	NJU7034D-ND	14-DIP	$1.43
Dual Op Amp Lo Voltage MOS	NJU7032M#-ND	8-DMP	$0.83
Quad Bipolar Op Amp 1.8to12V	MC33204DGOS-ND	14-SOIC	$1.46
PIC33 Microcontroller	DSPIC33FJ64MC804-E/PT-ND	44-TQFP	$7.26
CD4034B 8-Stage Counter/Shift	296-14237-ND	24-DIP	$1.88

44-TQFP -

24-DIP

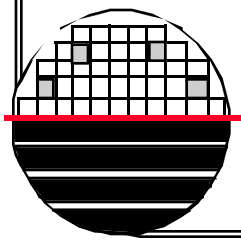


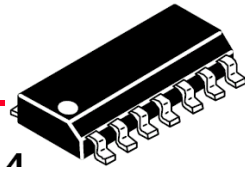
14-DIP



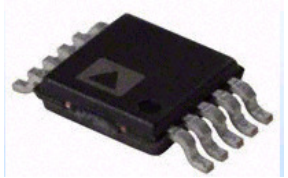
INTEGRATED CIRCUITS

Description	Digikey Part Number	Package	~Price
AD9833 Waveform Generator	MAX038CWP+-ND	10-MSOP	$8.20
AD534 Analog Multiplier	AD534JDZ-ND	14-CDIP	$31.58
Instrumentation Amplifier	INA101HP-ND	14-DIP	$19.13

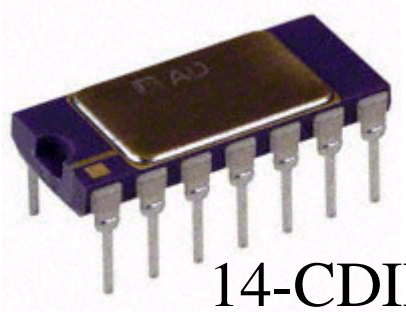




14-SOIC



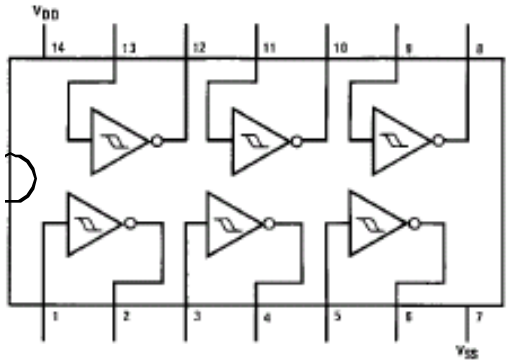
10-MSOP



14-CDIP

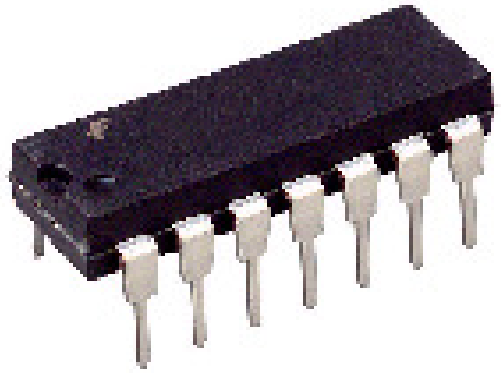
HEX INVERTER WITH HYSTERESIS

Connection Diagram

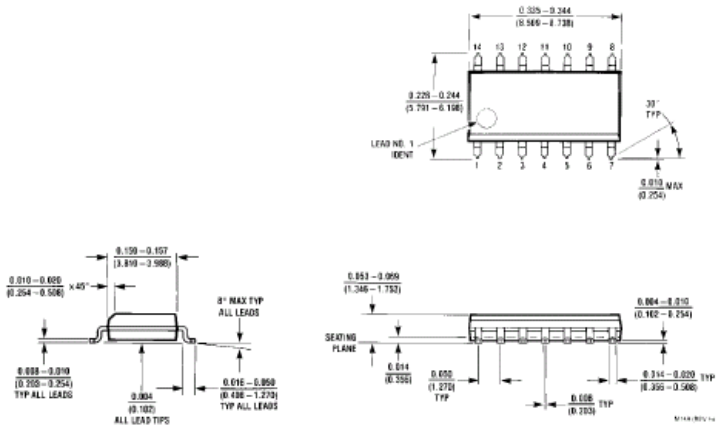


Top View

CD40106
CMOS
3-15 Volt Supply

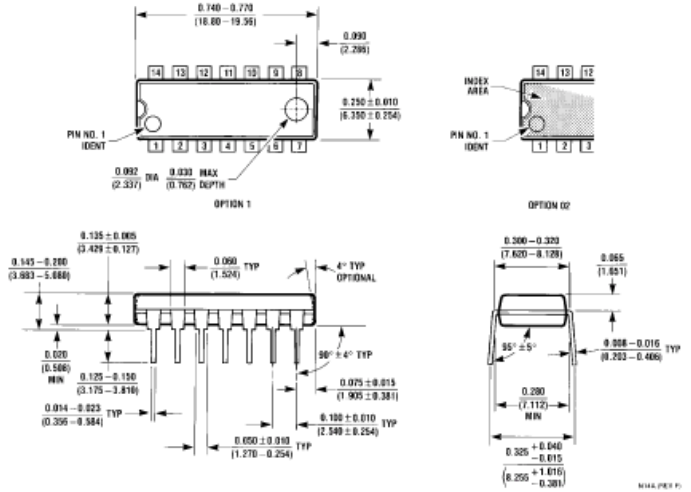


Physical Dimensions inches (millimeters) unless otherwise noted



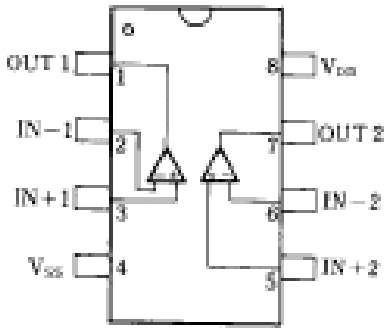
14-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-012, 0.150" Narrow
Package Number M14A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

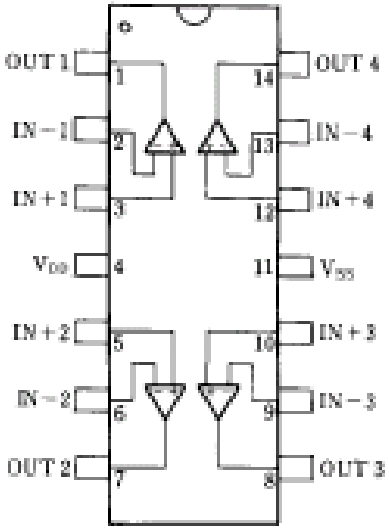


14-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide
Package Number N14A

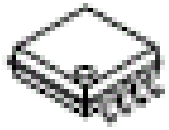
LOW VOLTAGE CMOS OP AMP



NJU7032D
NJU7032M



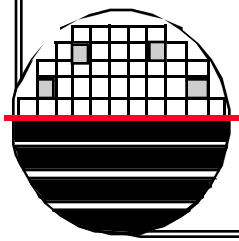
NJU7034D
NJU7034M
NJU7034V



NJM7031M

NJU7032M

NJU7032M
CMOS
3-16 Volt Supply

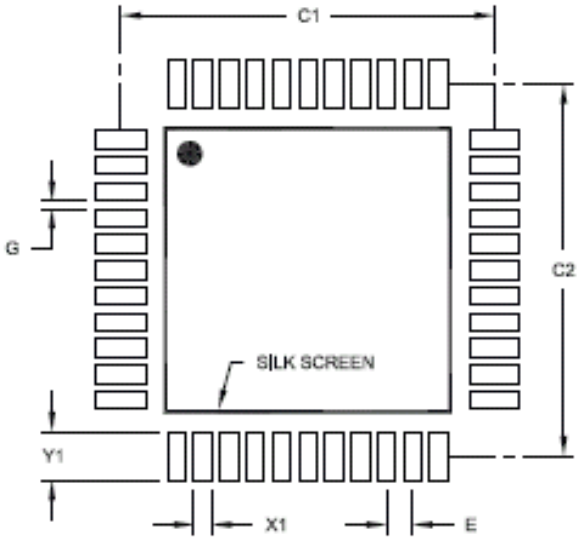


MICRO-CONTROLLER (μP)

MICROCHIP

dsPIC33FJ32GP302/304, dsPIC33FJ64GPX02/X04, and dsPIC33FJ128GPX02/X04 Data Sheet

High-Performance, 16-bit Digital Signal Controllers



RECOMMENDED LAND PATTERN

3 to 3.6 Volt Supply
-40 to 85°C
13 Analog Input Channels, 10 Bit
DAC Output 15 Bit, 100Ksps
Serial Communication Port
More

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		0.80 BSC	
Contact Pad Spacing	C1		11.40	
Contact Pad Spacing	C2		11.40	
Contact Pad Width (X44)	X1			0.55
Contact Pad Length (X44)	Y1			1.50
Distance Between Pads	G	0.25		

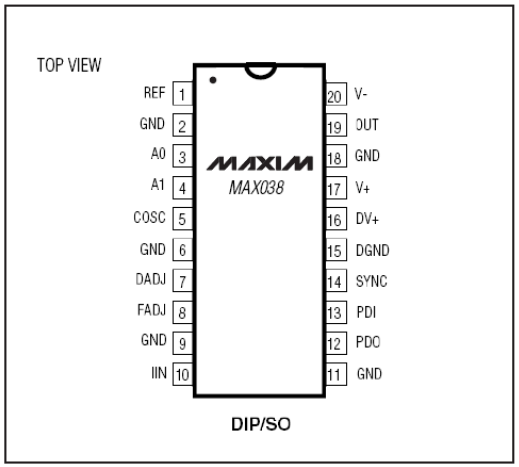
Proposed Sine Wave Generator Chip

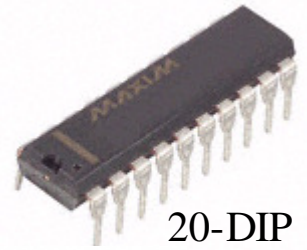
§ MAX038 / MAX038CWP Waveform Generator

- § V_{SUPPLY} = ±5 V ~40mA each
- § V_{SINE} = ±1 V
- § f_{SINE} = 4 MHz

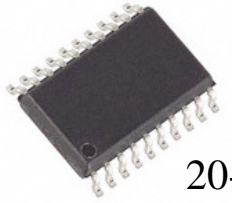
- ♦ 0.1Hz to 20MHz Operating Frequency Range
- ♦ Triangle, Sawtooth, Sine, Square, and Pulse Waveforms
- ♦ Independent Frequency and Duty-Cycle Adjustments
- ♦ 350 to 1 Frequency Sweep Range
- ♦ 15% to 85% Variable Duty Cycle
- ♦ Low-Impedance Output Buffer: 0.1Ω
- ♦ Low 200ppm/°C Temperature Drift

AC signals used in the test circuitry must be sine waves because high frequency components of square waves were coupling to other sensors on the chip.





20-DIP



20-SOIC

PASSIVE COMPONENTS

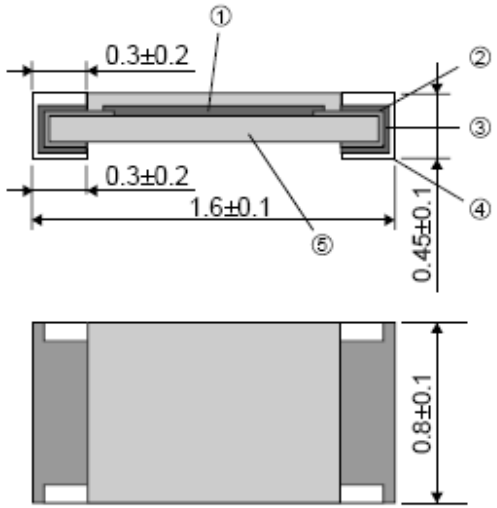
Description	Digikey Part Number	Package	~Price
1/10 watt, Thick Film Chip Resistors, 10M, 2M, 1M, 200K, 100K, 20K, 10K, 6.04K, 2K, 1K, 604, 200, 100	RHMxxxyHCT-ND*	0603SMD	$0.08
Chip Capacitors, 16-50V,100pf, 1000pf, 0.1uF, 1.0uF, 10uF	399-xxxx-1-ND	SMD	$0.05 - $0.55
100K ohm potentiometer	3006-104LF-ND	3-lead	$1.70
10K ohm potentiometer	3006Y-103LF-ND	3-lead	$1.70
1K ohm potentiometer	3006Y-102LF-ND	3-lead	$1.70
100K ohm 3mm Trimpot	3313J-104ECT-ND	SMD	$1.50
10K ohm 3mm Trimpot	3313J-103ECT-ND	SMD	$1.50
1K ohm 3mm Trimpot	3313J-102ECT-ND	SMD	$1.50

* RHM = Rohm Semiconductor, xxx= 2 or 3 digits for resistance value, y = power of 10 multiplier, H = 1%, CT=cut tape, Example RHM12.0KHCT-ND is 12.0 Kohm

PASSIVE COMPONENTS - RESISTORS

Chip Resistors

●**Dimensions** (Unit : mm)



No.	Material
①	Resistive element (Oxide metal thick film)
②	Silver thick film electrode
③	Nickel electrode
④	Sn electrode
⑤	Alumina substrate
⑥	Overcoating (Resin)

PASSIVE COMPONENTS - CAPACITORS

Digi-Key Part Number	399-1121-1-ND
Quantity Available	Available
Manufacturer	Kemet
Manufacturer Part Number	C0805C101K5GACTU
Description	CAP CERAMIC 100PF 50V NP0 0805
Lead Free Status / RoHS Status	Lead free / RoHS compliant

Price Break	Unit Price	Extended Price
10	0.05000	0.50
100	0.02930	2.93
500	0.01688	8.44

All prices are in US dollars.

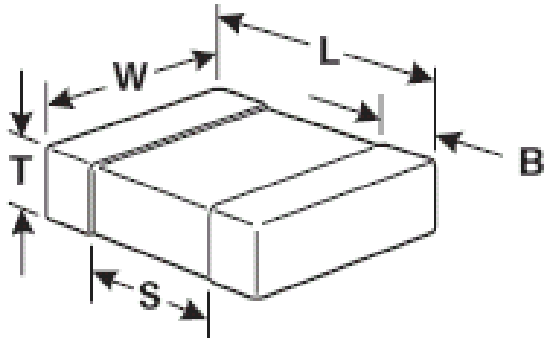
Digi-Key Part Number	399-3525-1-ND
Quantity Available	Available
Manufacturer	Kemet
Manufacturer Part Number	C1206C106K4RACTU
Description	CAP CERAMIC 10UF 16V X7R 1206
Lead Free Status / RoHS Status	Lead free / RoHS compliant

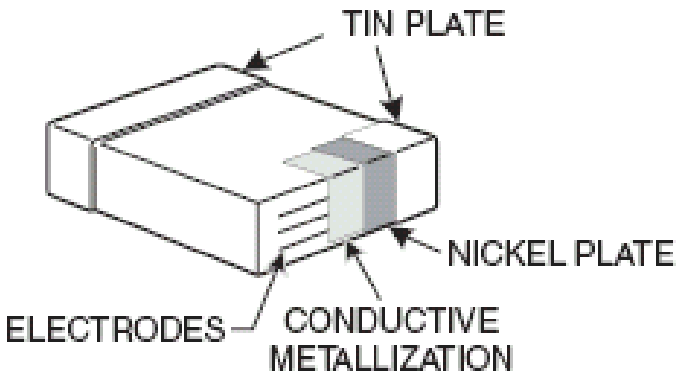
Price Break	Unit Price	Extended Price
10	0.55000	5.50
100	0.32500	32.50
500	0.18750	93.75
1,000	0.13000	130.00

All prices are in US dollars.

Size see next page

CHIP CAPACITORS





L x W = 2mm x 1.25mm

DIMENSIONS—MILLIMETERS AND (INCHES)

EIA SIZE CODE	METRIC SIZE CODE	L - LENGTH	W - WIDTH	T THICKNESS	B - BANDWIDTH	S SEPARATION minimum	MOUNTING TECHNIQUE
0201*	0603	0.6 (.024) ± .03 (.001)	0.3 ± (.012) ± .03 (.001)	See page 78 for thickness dimensions.	0.15 (.006) ± .05 (.002)	N/A	Solder Reflow
0402*	1005	1.0 (.04) ± .05 (.002)	0.5 (.02) ± .05 (.002)		0.20 (.008) -.40 (.016)	0.3 (.012)	
0603	1608	1.6 (.063) ± .15 (.006)	0.8 (.032) ± .15 (.006)		0.35 (.014) ± .15 (.006)	0.7 (.028)	Solder Wave + or Solder Reflow
0805*	2012	2.0 (.079) ± .20 (.008)	1.25 (.049) ± .20 (.008)		0.50 (.02) ± .25 (.010)	0.75 (.030)	
1206*	3216	3.2 (.126) ± .20 (.008)	1.6 (.063) ± .20 (.008)		0.50 (.02) ± .25 (.010)	N/A	
1210*	3225	3.2 (.126) ± .20 (.008)	2.5 (.098) ± .20 (.008)		0.50 (.02) ± .25 (.010)	N/A	
1808	4520	4.5 (.177) ± .30 (.012)	2.0 (.079) ± .20 (.008)		0.60 (.024) ± .35 (.014)	N/A	Solder Reflow
1812	4532	4.5 (.177) ± .30 (.012)	3.2 (.126) ± .30 (.012)		0.60 (.024) ± .35 (.014)	N/A	
1825*	4564	4.5 (.177) ± .30 (.012)	6.4 (.252) ± .40 (.016)		0.60 (.024) ± .35 (.014)	N/A	
2220	5650	5.6 (.220) ± .40 (.016)	5.0 (.197) ± .40 (.016)		0.60 (.024) ± .35 (.014)	N/A	
2225	5664	5.6 (.220) ± .40 (.016)	6.3 (.248) ± .40 (.016)		0.60 (.024) ± .35 (.014)	N/A	

PASSIVE COMPONENTS - TRIMPOT

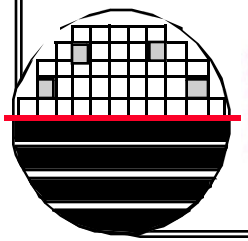
Digi-Key Part Number	3313J-102ECT-ND
Quantity Available	Available
Manufacturer	Bourns Inc.
Manufacturer Part Number	3313J-1-102E
Description	TRIMPOT 1K OHM 3MM CERMET SMD
Lead Free Status / RoHS Status	Lead free / RoHS compliant
All prices are in US dollars.	

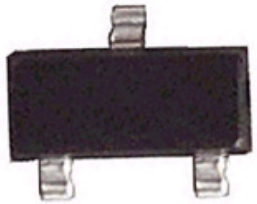
Price Break	Unit Price	Extended Price
1	1.80000	1.80
10	1.50000	15.00
100	1.38000	138.00
500	1.20000	600.00

10 plus 2 more zeros = 1000 ohms

OTHER COMPONENTS

Description	Digikey Part Number	Package	~Price
NMOSFET BS107P 200V 3.3A	IRF610PBF	TO-220	$0.68
PMOSFET 100V 230ma Vth~-2.5	ZVP2110A-ND	TO92-3	$1.13
NMOSFET 100V 320ma Vth~2.5	ZVN2110A-ND	TO92-3	$0.81
PMOSFET 100V 75ma Vth~-2.5	ZVP3310FCT-ND	SOT23-3	$0.83
NMOSFET 100V 100ma Vth~2.5	ZVN3310FCT-ND	SOT23-3	$0.70
MOSFETs Matching N and P in same package	UP0497900LCT-ND	6-SSMINI	$0.71
Surface Mount NPN BJT	MMBT3904LT3GOSCT	SOT23-3	$0.07
Surface Mount PNP BJT	MMBT4403LT1GOSCT	SOT23-3	$0.07





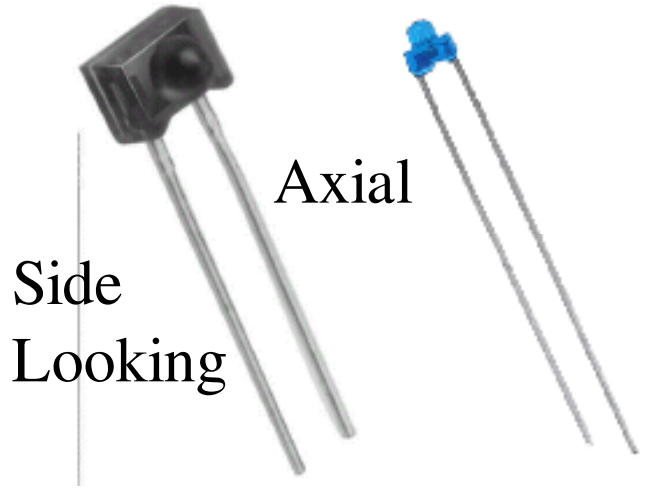
SOT23-3

TO92

TO-220

OTHER COMPONENTS

Description	Digikey Part Number	Package	~Price
IR LEDs	751-1027-ND	Axial	$0.50
1N4448 Diode	1N4448CT-ND	Axial	$0.062
1N4448 Diode BAS-16	BAS16FSCT-ND	SOT23-3	$0.031
SFH4110 IR Diode Side Look – 950nm	475-1087-ND	Axial	$0.31
SEP8736 IR Diode Side Look – 880 nm	480-1969-ND	Axial	$1.38
CSD01060A SiC Schottky Diode	CSD01060A-ND	TO220-2	$1.38



1N4448 DIODE

Digi-Key Part Number	1N4448CT-ND
Quantity Available	Available
Manufacturer	Fairchild Semiconductor
Manufacturer Part Number	1N4448TR
Description	DIODE SGL JUNC 100V 4.0NS DO-35
Lead Free Status / RoHS Status	Lead free / RoHS compliant

Price Break	Unit Price	Extended Price
1	0.06000	0.06
10	0.04300	0.43
100	0.03120	3.12
1,000	0.01296	12.96

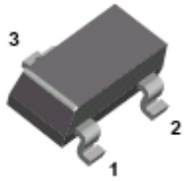
All prices are in US dollars.

Digi-Key Part Number	BAS16FSCT-ND
Quantity Available	Available
Manufacturer	Fairchild Semiconductor
Manufacturer Part Number	BAS16
Description	DIODE ULTRAFAST HI COND SOT-23
Lead Free Status / RoHS Status	Lead free / RoHS compliant

Price Break	Unit Price	Extended Price
1	0.11000	0.11
10	0.08600	0.86
100	0.06180	6.18
1,000	0.02565	25.65

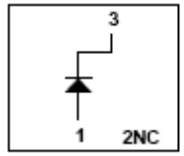
All prices are in US dollars.

BAS16



SOT-23

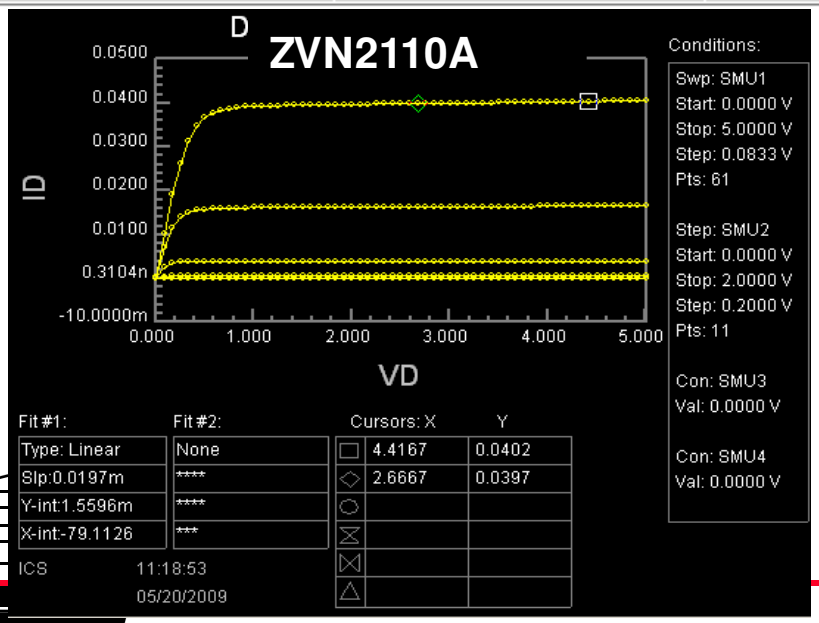
Connection Diagram

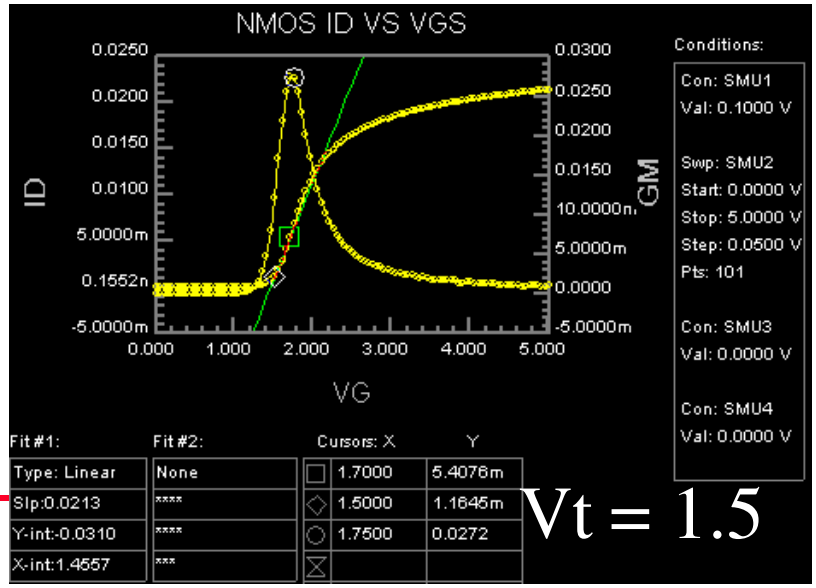


DISCRETE MOS TRANSISTORS

Digi-Key Part Number	ZVN2110A-ND
Quantity Available	3,489
Manufacturer	Zetex Inc
Manufacturer Part Number	ZVN2110A
Description	MOSFET N-CH 100V 320MA TO92-3
Lead Free Status / RoHS Status	Lead free / RoHS compliant

Price Break	Unit Price	Extended Price
1	1.08000	1.08
10	0.81000	8.10
100	0.48600	48.60
500	0.37800	189.00
1,000	0.30600	306.00
2,500	0.27000	675.00
5,000	0.23400	1,170.00
10,000	0.22500	2,250.00



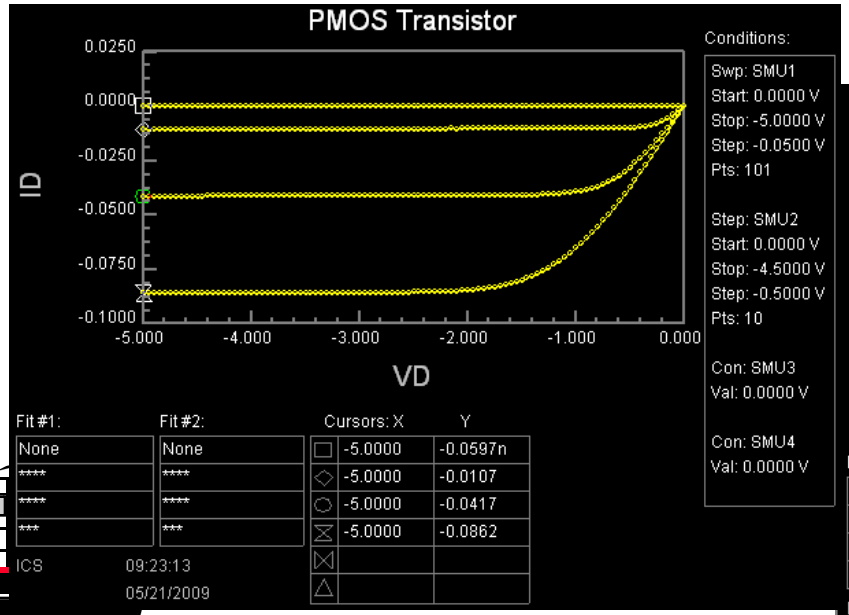


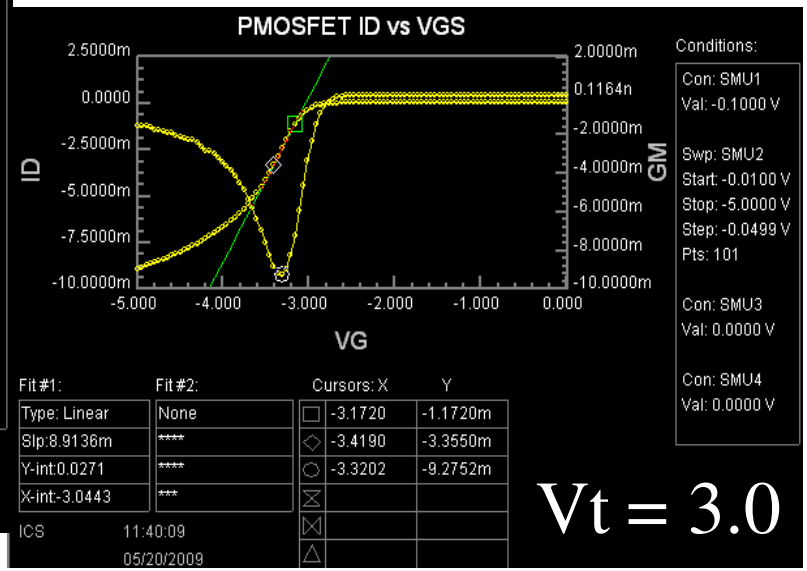
DISCRETE MOS TRANSISTORS

Digi-Key Part Number	ZVP2110A-ND
Quantity Available	3,793
Manufacturer	Zetex Inc
Manufacturer Part Number	ZVP2110A
Description	MOSFET P-CH 100V 230MA TO92-3
Lead Free Status / RoHS Status	Lead free / RoHS compliant

Price Break	Unit Price	Extended Price
1	1.50000	1.50
10	1.12500	11.25
100	0.67500	67.50
500	0.52500	262.50
1,000	0.42500	425.00
2,500	0.37500	937.50

All prices are in US dollars.





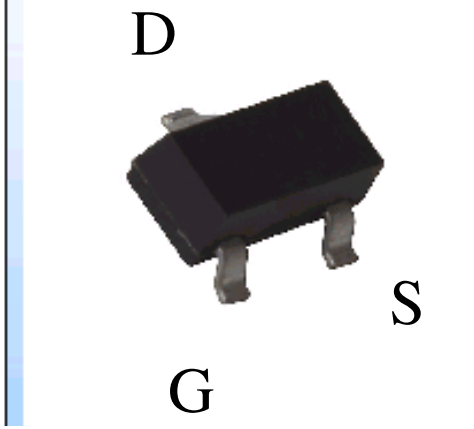
DISCRETE MOS TRANSISTORS – SURFACE MOUNT

Digi-Key Part Number	ZVN3310FCT-ND
Quantity Available	Available
Manufacturer	Zetex Inc
Manufacturer Part Number	ZVN3310FTA
Description	MOSFET N-CH 100V .1A SOT23-3
Lead Free Status / RoHS Status	Lead free / RoHS compliant
All prices are in US dollars.	

Price Break	Unit Price	Extended Price
1	0.93000	0.93
10	0.69800	6.98
100	0.41850	41.85
500	0.32550	162.75
1,000	0.26350	263.50

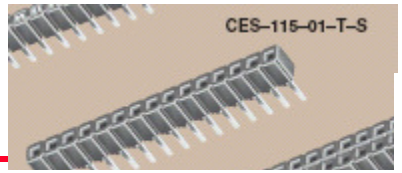
Digi-Key Part Number	ZVP3310FCT-ND
Quantity Available	Available
Manufacturer	Zetex Inc
Manufacturer Part Number	ZVP3310FTA
Description	MOSFET P-CH 100V 75MA SOT23-3
Lead Free Status / RoHS Status	Lead free / RoHS compliant
All prices are in US dollars.	

Price Break	Unit Price	Extended Price
1	1.11000	1.11
10	0.83300	8.33
100	0.49950	49.95
500	0.38850	194.25
1,000	0.31450	314.50



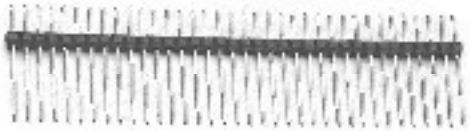
OTHER

Description	Digikey Part Number	Qty	~Price
Receptacle for Pin Strip Header	929850E-01-36-ND	36 pin row	$3.31
Pin Strip Header, Breakable	929450-01-36-ND	36 pin row	$4.85
14 DIP Socket	ED60001-ND	each	$1.09
2-sided copper PCB 6"x9"	473-1011-PCB-ND	Each	$10.38
Prototype boards	From Computer Eng	Each	$10.00
Wire for Prototype boards	C2004x-100-ND White, Red, BLue, BroWn		$16.24
Solder RMA Flux, 25AWG,63/37	KE1201-ND		$40.25
Solder Iron 25 Watt	WP25-ND		$38.92
Solder Iron Tips	ST5-ND		$3.44



Receptacle

Pin Strip Header 0.1" Single Row of 36 pins, break in any length, Straight, Gold Plated



REFERENCES

1. WWW.digikey.com
2. www.Newark.com
3. Data sheets for all the components.
4. RIT_Package.pdf contains information on how to make PCBs at RIT. See http://people.rit.edu/~lffeee/labnotes.htm