RICE RESEARCH

ENVIRONMENTAL LASER SENSOR

OPTICAL “NOSE”

Laser Science Group

RICE

Sensing the World Around Us

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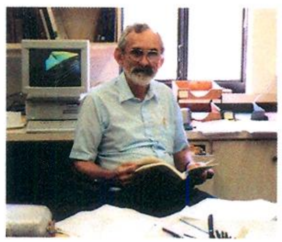	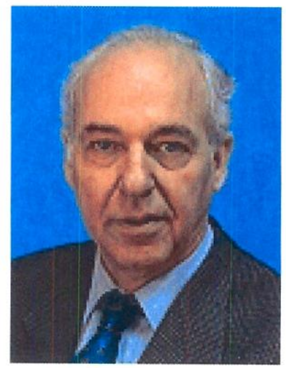	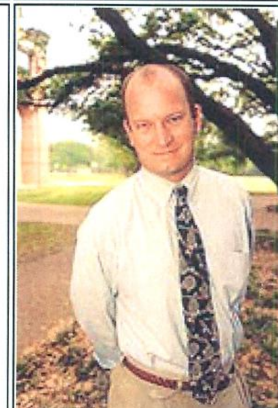
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	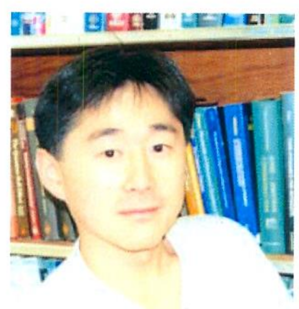	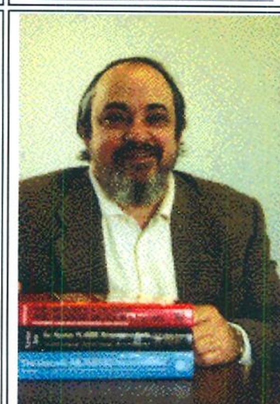

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		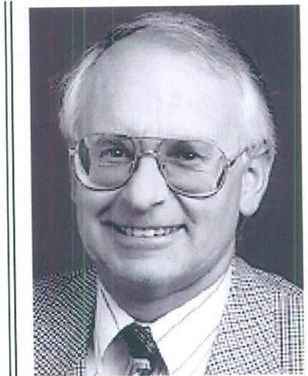
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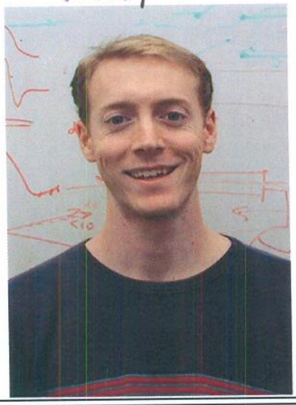

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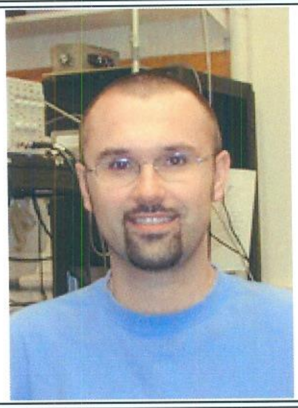
Rafal Lewicki



Laser Science Group
Sensing the World Around Us

Diode Laser Based Mid-IR Gas Sensors (1997 - 2000)

Mid-infrared laser absorption spectroscopy, offers high speed, high precision, immunity to interference, and remote sensing capabilities for detection of numerous trace gas species. Tunable near-infrared diode laser sources are mixed and frequency converted to longer wavelengths using state of the art nonlinear optical crystals such as periodically poled lithium niobate.

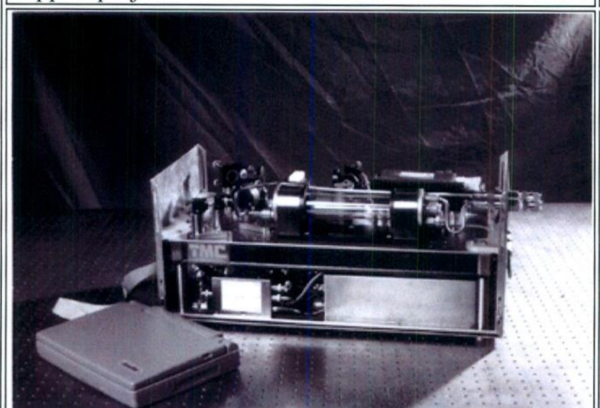
Prototype #1 (1996-1997):

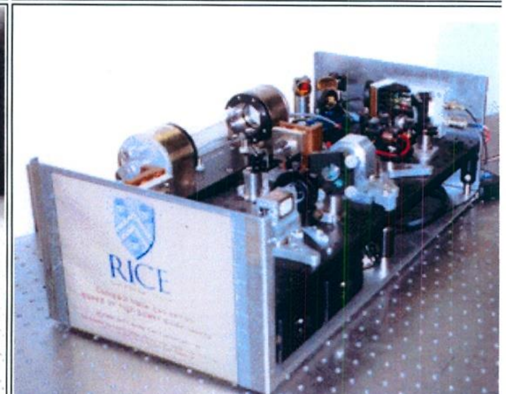
- Diode and solid state laser pumped
- Discrete optics
- Detection of CO, H2CO and CH4

- NASA Phase II-III Lunar Mars Life Support project: Detection of CO & H2CO

Prototype#2 (1997):

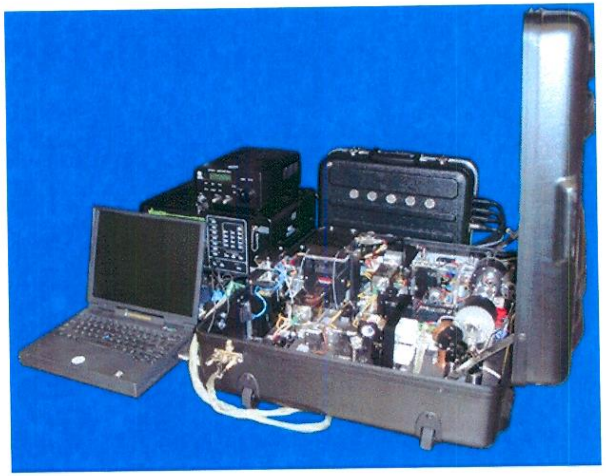
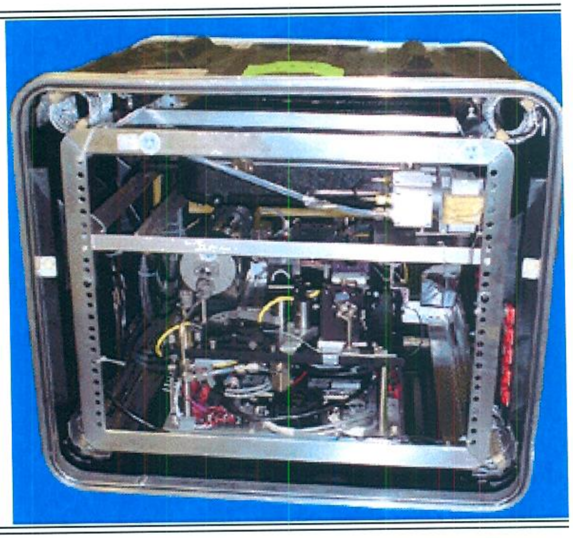
- Diode laser pumped
- Discrete optics
- Low cost
- Detection of CH4 and H2O





Prototype #3 (1998-2000):

Prototype #4 (1999-2000)

- Diode laser pumped - Widely tunable: 3.3 - 4.4 microns - Fiber coupled optics - Fully automated tuning and longterm operation - 12 different species detected *Field tests & Applications:* - H_2CO detection in a Trace Contaminant Control System at TDA Inc., Denver, CO - Detection of SO_2, HCl, CO_2, CH_4, H_2O at Masaya volcano, Nicaragua	- Telecom diode laser pumped - Fiber amplified - Fiber coupled optics - Longterm operation (weeks) - shock-mounted *Field tests & Applications:* - CH_4 detection in Tokyo, Japan - Detection of CH_4 and HCl at Masaya volcano, Nicaragua
	
Prototype #5 (1999-2000): *Features:* - Telecom diode laser pumped - High power fiber amplifiers - Dual beam / 2f detection *Field tests & Applications:* - Sub-ppb detection of atmospheric H_2CO	**Prototype #6 (1999-2000):** *Features:* - Quantum Cascade Laser - High power (mW's) - Room temperature operation (Pulsed) *Field tests & Applications:* - Detection of CH_4 and N_2O

Rice Research

OPTICAL NOSE

OPTICAL NOSE?

Development of Quantum-Cascade Laser Based Biosensor Technology

Thomas L. Harman [UHCL] / Frank K. Tittel [Rice U] / John C. Graf [NASA-JSC] / Yury Bakhirkin [UHCL]

Master’s Thesis UHCL

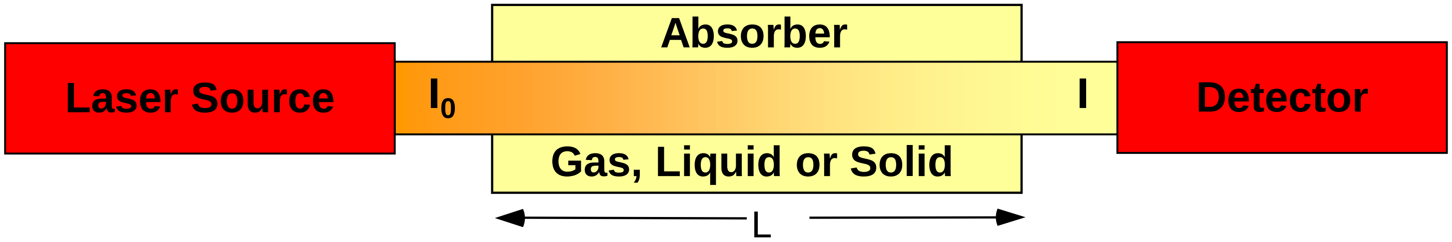
RICE UNIVERSITY

NOVEL LASER-BASED GAS SENSORS FOR TRACE GAS DETECTION IN A SPACECRAFT HABITAT
BY

DARRIN PAUL LELEUX

DOCTOR OF PHILOSOPHY
HOUSTON, TX
APRIL, 2002

Direct Laser Absorption Spectroscopy



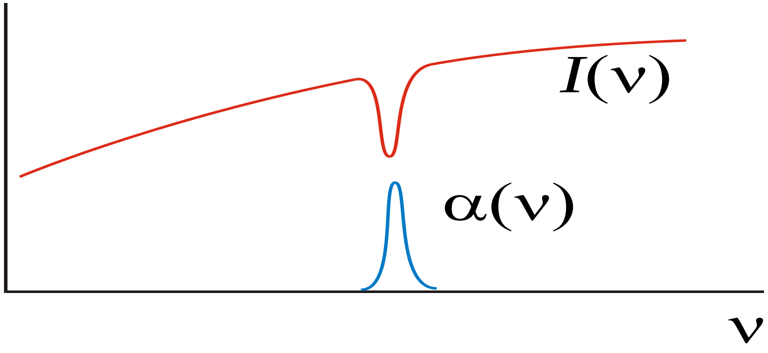
Beer-Lambert's Law of Linear Absorption

$$I(\nu) = I_0 \cdot e^{-\alpha(\nu) \cdot P_a L}$$

$\alpha(\nu)$ - absorption coefficient [cm^{-1} atm^{-1}]; L – path length [cm]

ν - frequency [cm^{-1}]; P_a- partial pressure [atm]

$$\alpha(\nu) = C \cdot S(T) \cdot g(\nu - \nu_0)$$



C - total number of molecules of absorbing gas/atm/cm^3 [molecule$\cdot cm^{-3}$ $\cdot atm^{1}$]

S - molecular line intensity [cm $\cdot$molecule^{-1}]

$g(\nu - \nu_0)$ - normalized lineshape function [cm], (Gaussian, Lorentzian, Voigt)

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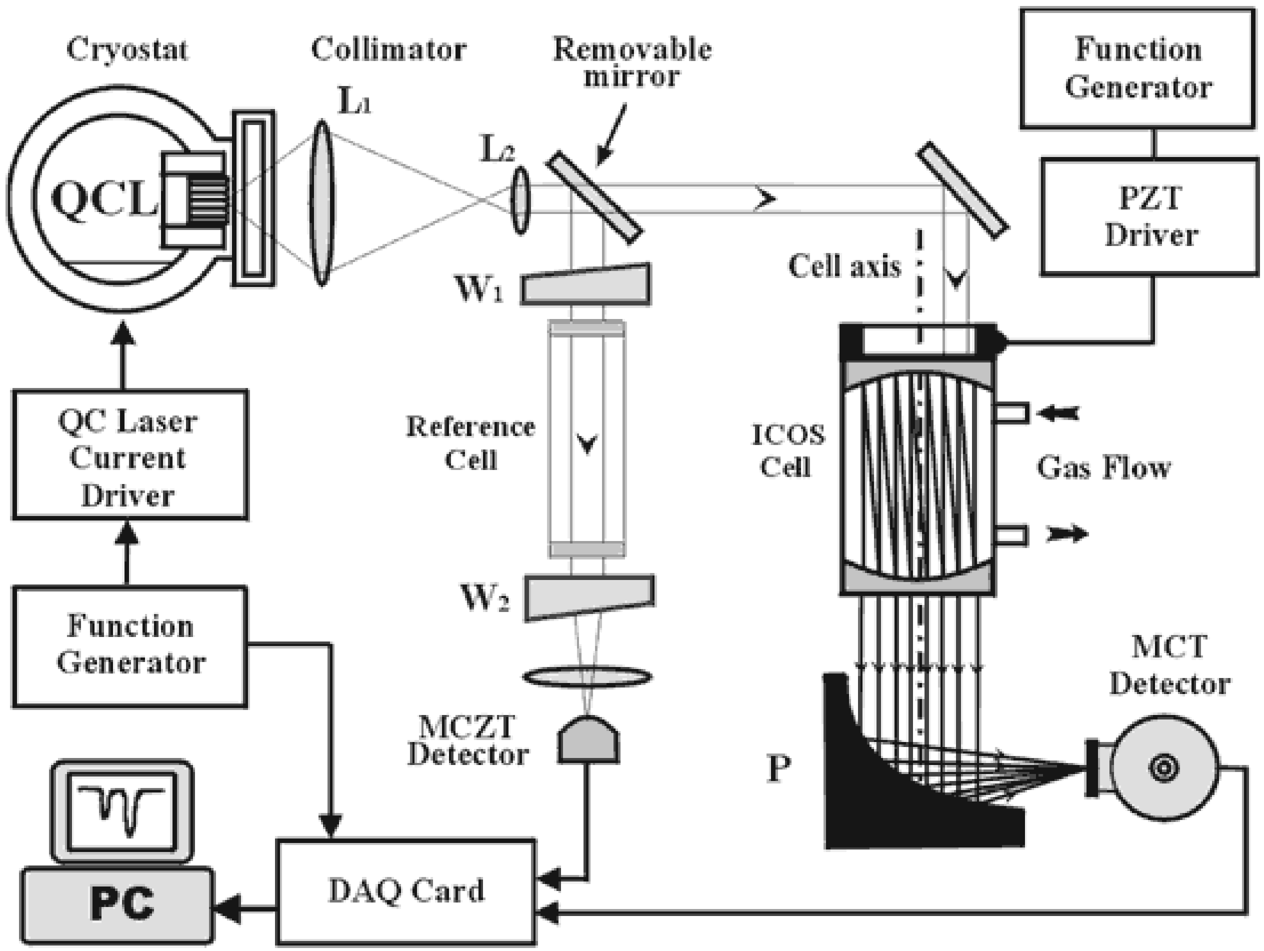
EXPERIMENTAL SETUP



Target Gases – 1

Molecule	Formula	Trace Concentration in Breath (ppb)	Biological/Pathology Indication
Nitric Oxide	NO	6 - 100	Inflammatory and immune responses (e.g., asthma) and vascular smooth muscle response
Carbon Monoxide	CO	400 - 3000	Smoking response, CO poisoning, vascular smooth muscle response, platelet aggregation
Hydrogen Peroxide	H_2O_2	1 - 5	Airway Inflammation, Oxidative stress
Carbonyl Sulfide	OCS	100 – 1000	Liver disease and acute allograft rejection in lung transplant recipients
Formaldehyde	$HCHO$	400 - 1500	Cancerous tumors, breast cancer

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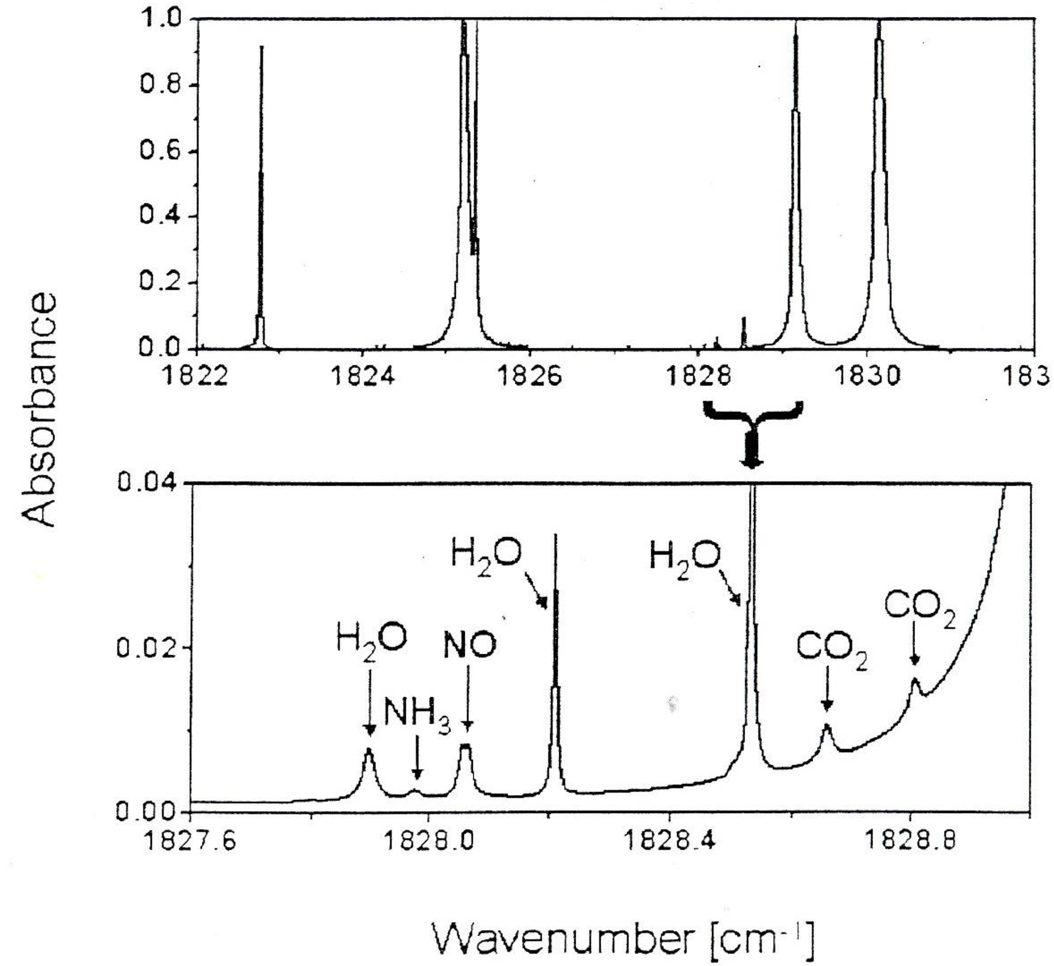
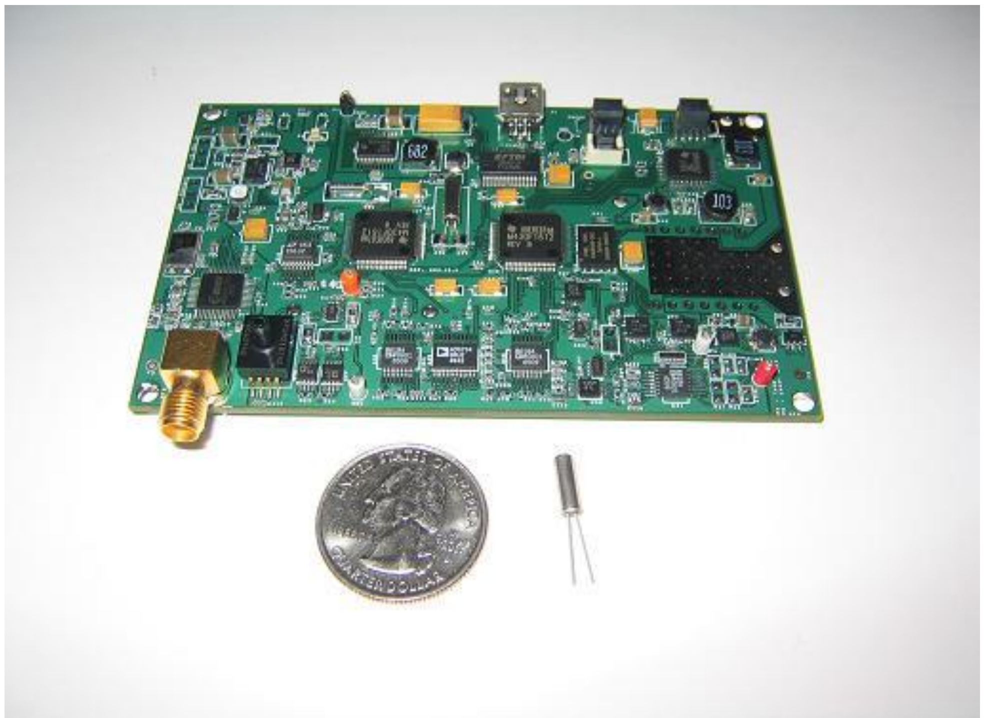
Molecule	Formula	Trace Concentration in Breath (ppb)	Biological/ Pathology Indication
Pentane	$CH_3(CH_2)_3CH_3$	4 - 20	Lipid peroxidation, oxidative stress associated with inflammatory diseases, immune responses, transplant rejection, breast and lung cancer
Ethane	C_2H_6	3 - 100	Lipid peroxidation and oxidative stress
Carbon Dioxide isotope ratio	$^{13}CO_2/^{12}CO_2$	$4 - 5 \times 10^5$	Marker for Helicobacter pylori infection associated with peptic ulcers and gastric cancer, drug clearances rates
Methane	CH_4	1000 - 8000	Digestive function, colonic fermentation
Ammonia	NH_3	100 - 500	Hepatic encephalopathy, liver cirrhosis, fasting response
Acetone	C_3H_6O	1000 - 5000	Fasting response, diabetes mellitus response, ketosis

Example Scan for Exhaled Breath-
Detection of Asthma and Respiratory Problems



Rice System 2002

New Circuit Board 2008 with Stephen So

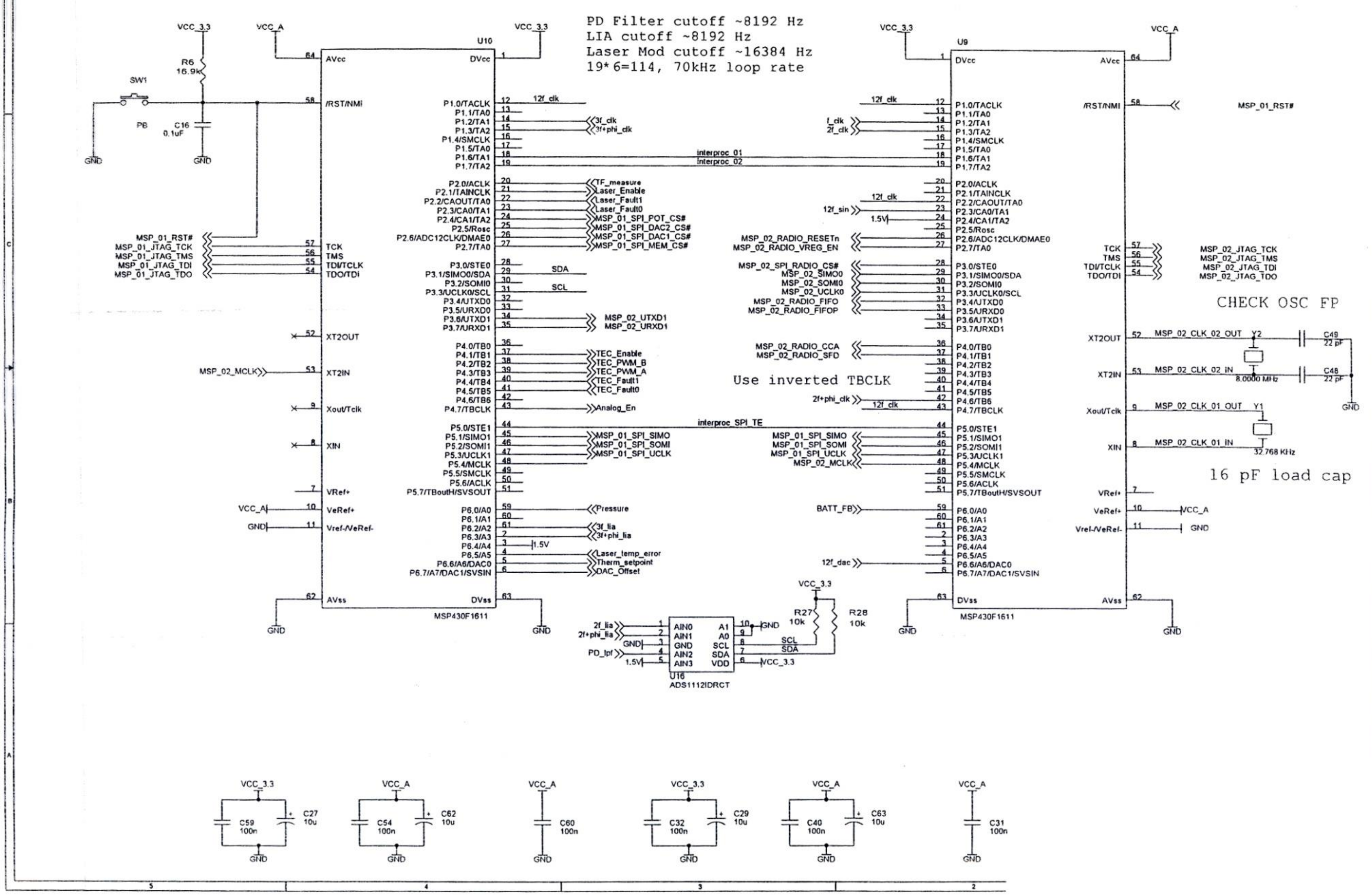


Design at Rice for handheld spectrometer

MSP430F1611 Processor (MSP 01)

Use a multiple of 19 for timer loop length!
PWM loop rate = measurement loop rate!

MSP430F1611 Processor (MSP 02)



EARLIER WORK

Embedded Control and Data Acquisition for a Compact Difference-Frequency Generation (DFG) Laser Spectrometer

Darrin P. Leleux and Dr. Thomas L. Harman,
University of Houston at Clear Lake
A Joint Research Project with the
Rice Laser Science Group, Dr. Frank K. Tittel

Research Objective

Design and implement an embedded data acquisition and control system for the Rice Laser Science Group's Difference-Frequency Generation Laser Spectrometer utilizing the Motorola MC68HC16Z1EVB Microcontroller

- Simplify environmental field measurements
- Decrease physical size, weight and cost
- Replace DACQ card and function generator

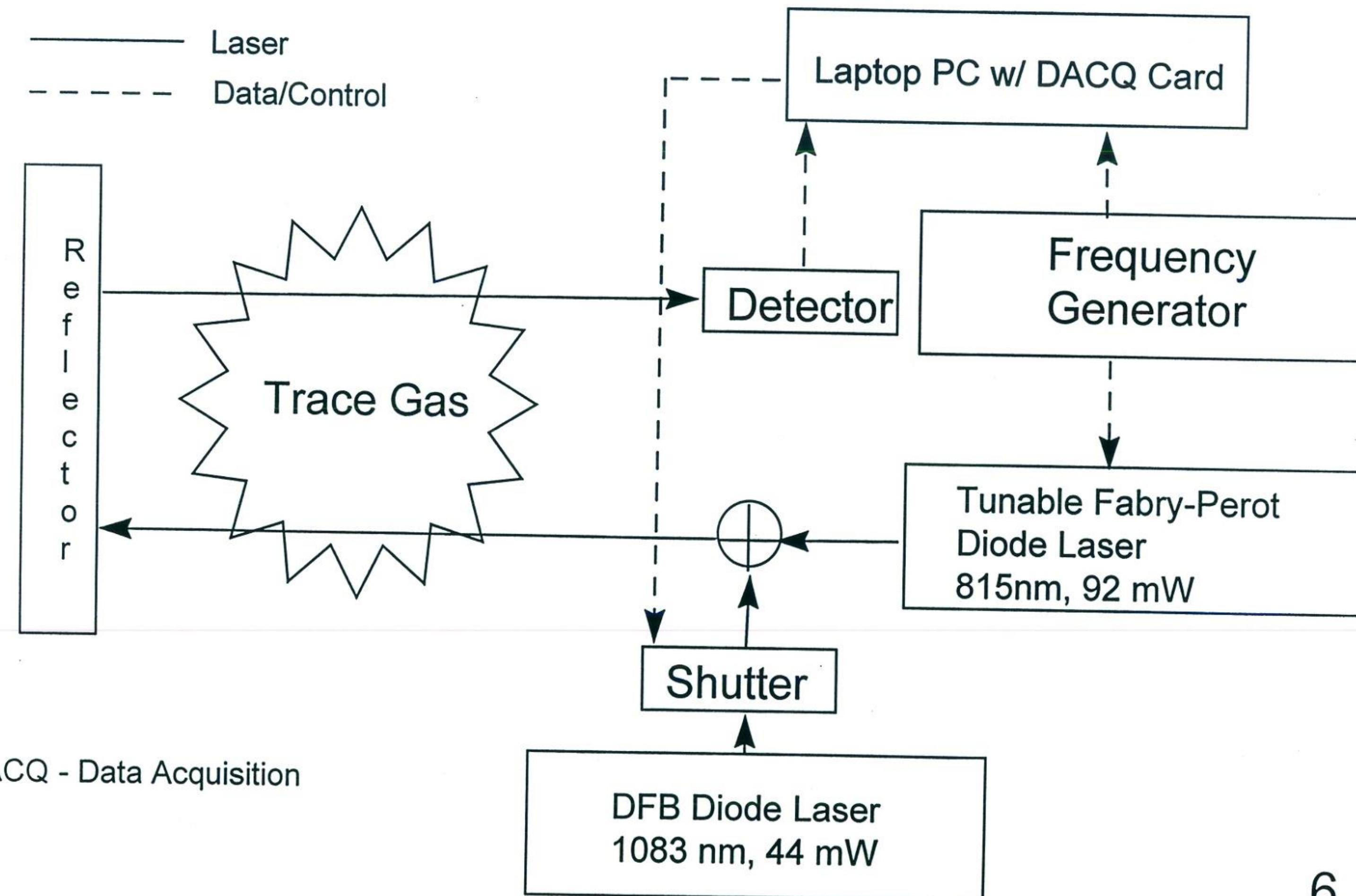
Advantages of Digital versus Analog Processing

- Data and Control samples are easier to manipulate with software
- More flexible, deterministic and robust
- Unaffected by temperature and age
- More reliable than analog components
- Ability to modify laser control real-time to compensate for laser temperature biases
- Dual-channel analog to digital conversion for differential data acquisition ensuring low noise spectroscopy

Motorola MC68HC16Z1 Microcontroller

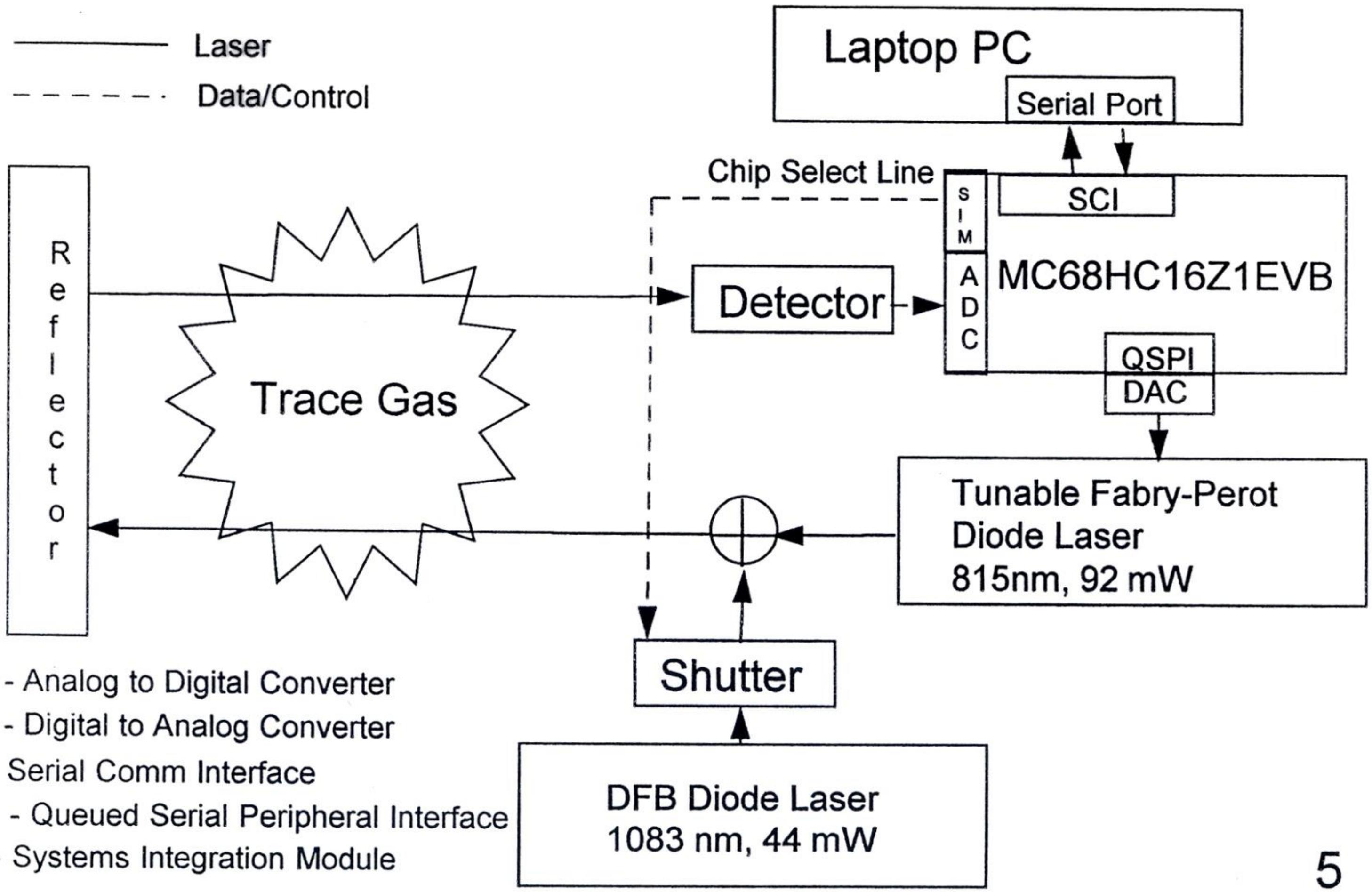
- 16-bit Central Processing Unit
- 16.78 MHz System Clock
- 8 or 10-bit Analog to Digital Conversion
- 1024-byte on-board Random Access Memory
- Queued Serial Peripheral Interface
  - Communicate with Digital to Analog Converter which is used to control laser
- Serial Communication Interface
  - Communicate with Laptop PC through standard RS-232 interface

Current DFG Based Gas Sensor



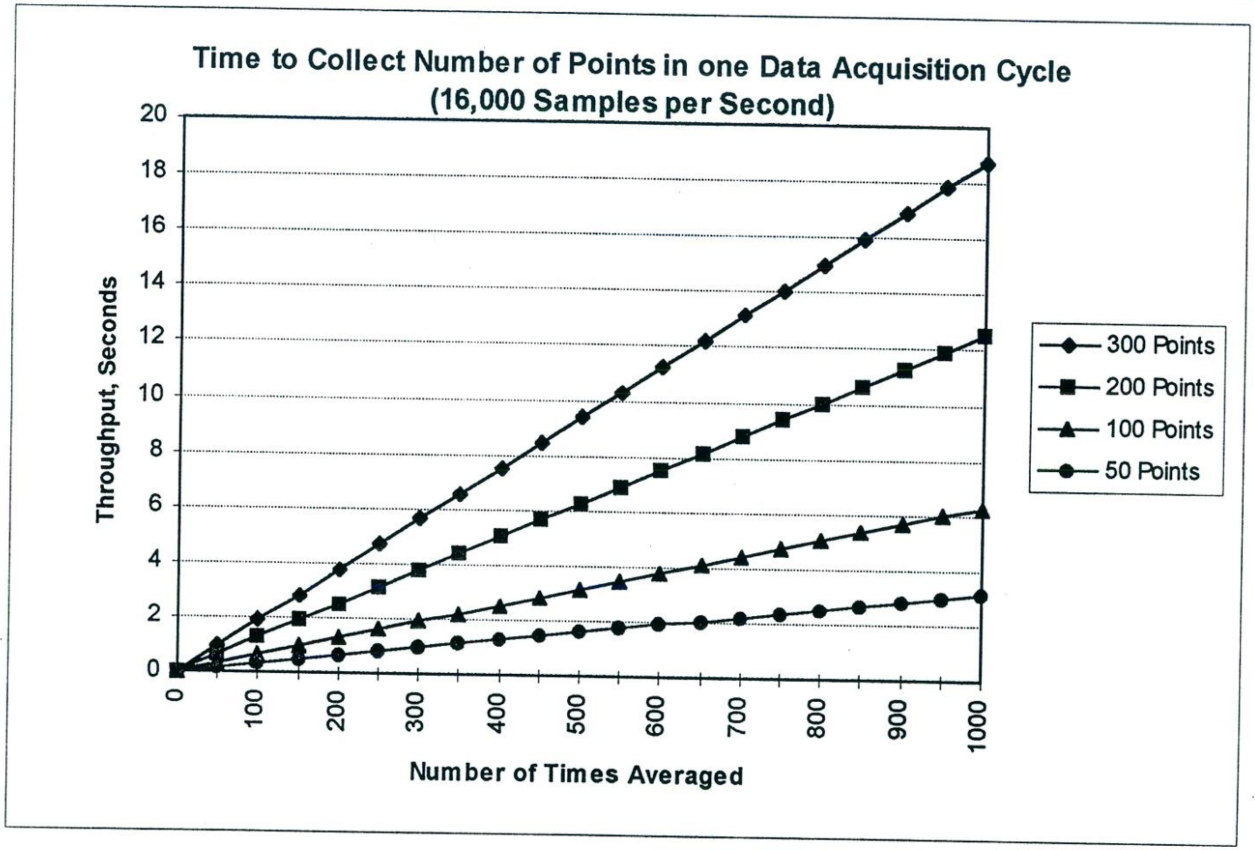
DACQ - Data Acquisition

Proposed DFG Based Gas Sensor

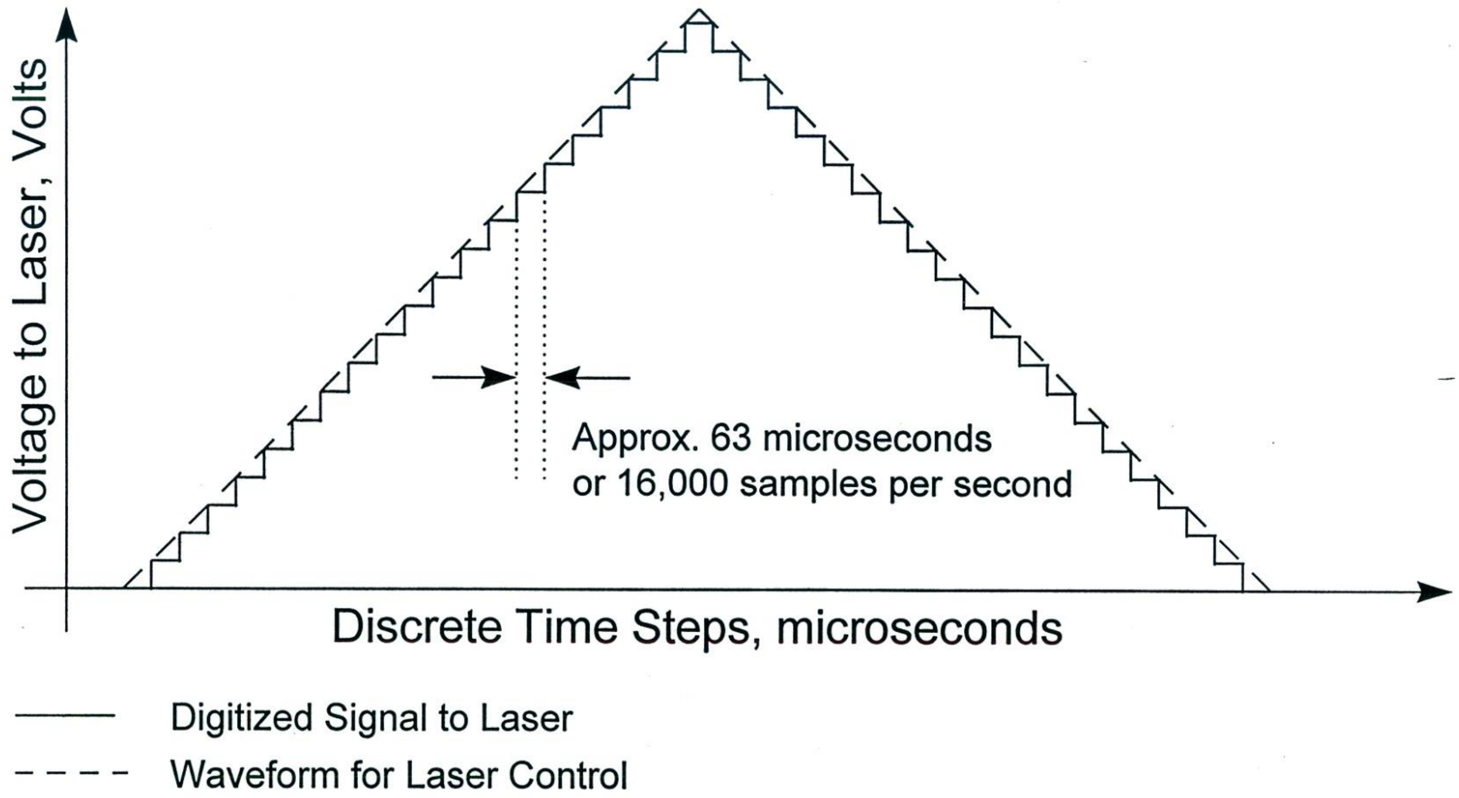


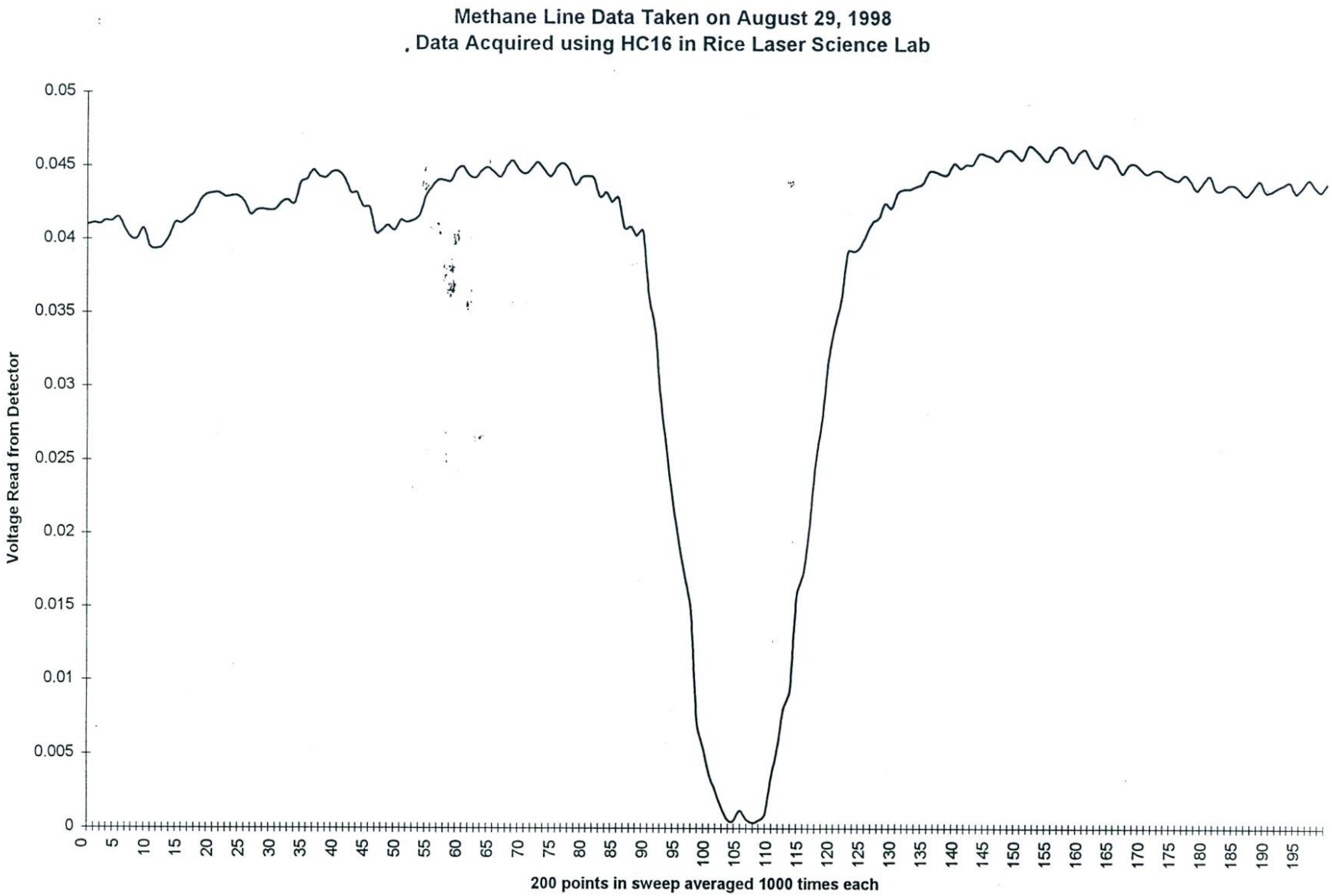
ADC - Analog to Digital Converter
DAC - Digital to Analog Converter
SCI - Serial Comm Interface
QSPI - Queued Serial Peripheral Interface
SIM - Systems Integration Module

Data Acquisition Performance



Digital Laser Control




Methane Line Data Taken on August 29, 1998
. Data Acquired using HC16 in Rice Laser Science Lab
Voltage Read from Detector
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195
200 points in sweep averaged 1000 times each

Future Studies

- 16-bit Dual-Channel Analog to Digital Conversion
  - Possibly using Burr-Brown DSP102
- Faster CPU (possibly using Texas Instruments Digital Signal Processors)
  - Incorporate DSP algorithms in addition to control and data acquisition logic plus display logic
- Greater on-chip Random Access Memory
  - Reduce memory latency

END OF RICE RESEARCH

End in Slides but not in Practice

Shuttle Camera Controller

Done with Alan Clapp – our student

Combining Microcontroller Units and PLDs for Best System Design

Microcontroller timer units and programmable logic devices both can create complex system timing functions. Using the Motorola time processor unit available on the MC68332 and MC68HC16Y1 microcontrollers and PLDs from Altera, we compared the performance and flexibility of these devices in applications that require various timing functions. These investigations show that in certain systems the combination of a microcontroller timer and a PLD provides the most efficient design.

Alan E. Clapp

Marquette Electronics, Inc.

Thomas L. Harman

University of Houston at Clear Lake

The complexity of modern microcontrollers allows designers to incorporate numerous peripheral hardware functions on a single chip. In addition to the central processor unit, the microcontroller often includes modules for communication, data conversion, and timing functions. Among these modules is the microcontroller's programmable timer unit, which serves to measure and create timing waveforms.

In some applications, however, the microcontroller timer cannot meet the system performance requirements. For example, the timer unit might not be fast enough when monitoring a rapidly changing input signal. The designer then must choose alternatives to create or measure timing waveforms and thus add circuitry to implement a specific timing function. Programmable logic devices often afford a viable choice for implementing such functions.

To compare microcontroller timer units and PLDs, we have studied two devices used for timing tasks—Motorola's TPU and Altera's EPS464 synchronous timing generator (STG). As a practical design example of a system requiring precisely synchronized timing waveforms on multiple channels, we also built a camera control system containing both types of devices.

Programmable logic

The term *programmable logic* generally encompasses devices that can be programmed to perform various digital logic functions. This broad definition includes devices ranging from PLDs to fully customized logic chips. PLDs are devices having structured internal architectures of logical elements with programmable interconnections. To create a specific function, the designer uses a development system to define the interconnections. At the other end of the spectrum are custom logic chips whose logic functions are specified by the designer but fabricated by a chip manufacturer.

PLD characteristics

Initially introduced in the mid 1970s to replace small-scale integration chips from the transistor-transistor logic family, PLDs now feature increased functional capabilities and speed of operation, with reduced die size and power requirements. These features give designers the flexibility to create innovative designs while maintaining a low-cost circuit implementation.

Functionally, the typical PLD consists of a number of basic logic circuits arranged in groups called macrocells. In one PLD architecture, called programmable array logic- or PAL-like devices,

0272-1732/94/$04.00 © 1994 IEEE

Motorola Contest is Music to Engineer's Ears

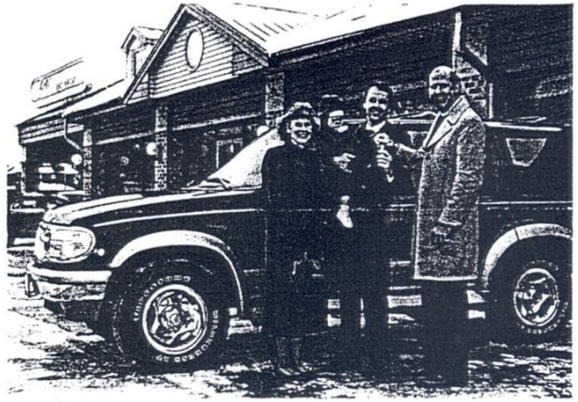
Early last summer Marquette Monitoring engineer Alan Clapp noticed an ad in *Electrical Engineering Times* about a design contest sponsored jointly by Motorola and Ford to promote interest in Motorola's lowest-cost microcontroller, the 20-pin 68HC705J1A. Ford was involved because the contest's grand prize was a 1996 Eddie Bauer Edition Ford Explorer. At this point we could just say that Alan entered the contest and that soon a Ford Explorer will be parked in his driveway, but that wouldn't be any fun. So, here are some of the details.

Motorola has a whole series of microcontrollers in what would be called the 6805 family. They range in complexity from devices with over 100 pins and many features to the low-cost 20-pin model featured in this particular contest. All together, Motorola offers over 200 derivatives in the 6805 family. To Alan's knowledge, this particular processor is not being used in any Marquette equipment, but, as Alan points out, "We could use it in any number of monitoring applications; for example, where you might want to read switches from a user interface or control a motor or a relay to turn something on or off, to mention just a couple."

It should be noted that Alan had some success in a previous Motorola contest, having won a trip for two to Hawaii back in 1994. Buoyed by this previous success, Alan decided to enter the contest.

Having made the commitment to participate in the contest and having received his "contest kit" in the mail containing all the necessary hardware and paperwork, Alan then had the challenge of designing something that really worked. Expanding on an idea he got from his wife, Lauri; Alan "invented" The Music Teacher, which in his own words, "is a low-cost battery-operated piano keyboard designed to develop a student's musical ability."

Specifically, The Music Teacher is a twelve-key, single octave keyboard with both a Play and a Learn mode. In the Play mode, the student can use The Music Teacher as he or she would use any keyboard to play music. In the Learn mode, the student uses The Music Teacher to learn "perfect pitch and the harmonic relationship between notes." In this mode, The Music Teacher generates a random note which the student has to attempt to match by playing one of the twelve keys. While the key is pressed and the tone is being generated, the student can guess whether he/she has matched the note or not. Upon releasing the key, The Music Teacher indicates a correct note by lighting a green LED and an incorrect note by lighting a red LED. In addition, The Music Teacher indicates whether the incorrect note was sharp (too high) or flat (too low).



Marquette Engineer Alan Clapp, his wife, Lauri, and daughter Sarah are presented the keys to their new 1996 Ford Explorer by Tom Marischen, World Marketing Manager, CSIC Microcontroller Division of Motorola.

Besides physically building something, Alan had to submit paperwork detailing the design process used to arrive at his device. As Alan put it, "The judges were looking for cost-saving practices, manufacturability, reliability, good EMI and ESD design practices. I got a fairly detailed explanation of what they wanted in the contest kit. They provided a self-scoring sheet which helped me to determine how many of the various design provisions I needed to include. This also helped the judges determine how cost-effective my design was and how easy it would be to manufacture."

Evidently Alan did something right. In November he was notified that he was one of 15 finalists. At that point he was asked to submit his actual working hardware and software. In early December, Alan found out his entry had won the grand prize. Asked whether the judges told him what it was about his design that won the contest for him, Alan replied, "Yes, to some extent. They said it made good use of the resources on the chip. They said they liked my presentation. They also said that they thought the device was fun; fun to work with, fun to play with."

Alan hasn't entered a lot of contests. In fact, he has only entered two (and won them both, we might add). "I find it personally satisfying to use my electrical engineering background and apply it in this way," Alan noted. "It's challenging, but also fun. I spent about 120 hours on this project. Even had I not won anything, it would have been worth it. It's one of those things. Once you get started on it, you want to do a good job and see it through. It's a personal challenge for me to see if I could get the thing to work."

Alan especially liked this contest because it was a practical exercise. "It required me to design something that really worked. So I had to do it at a low enough level that I could really learn something. The next time I need a microcontroller application in my work, I'll think about using this 6805."

Alan encourages others to enter these contests. As he pointed out, "Your chances are better than you might think." In this particular contest, Alan was told that Motorola had about 6000 requests for contest kits. Of those 6000, only 87 submitted entries. As Alan pointed out, "If you spend the time and effort to think it out and send something in, I think you have a pretty good chance." He continued, "That's how I felt about it, as I was going through the process. I didn't think I necessarily had the greatest idea or the greatest implementation, but I figured I had just as good a chance as anybody. The fact that I had won a contest before was also encouraging."

Recently, Alan and his wife and daughter were invited to Schmitt Ford in Mequon-Thiensville for a series of publicity photos. Since then, Alan and Lauri have placed an order for an Explorer with their personal choice of options. Soon it will sit in their driveway.

Alan insists that he doesn't have another contest picked out to participate in. Still, one can't help but wonder where all of this might lead. After all, anyone familiar with the history of Marquette Electronics knows it all started with the invention of an electronic musical instrument known as the T-Bass. If The Music Teacher doesn't work out, Alan can always branch out into some other field. Maybe he could invent an electronic device that turns things on and off with the clap of your hands. Yeah, yeah, that's the ticket. He could call it the Clapp-er. Or has that idea been taken already?

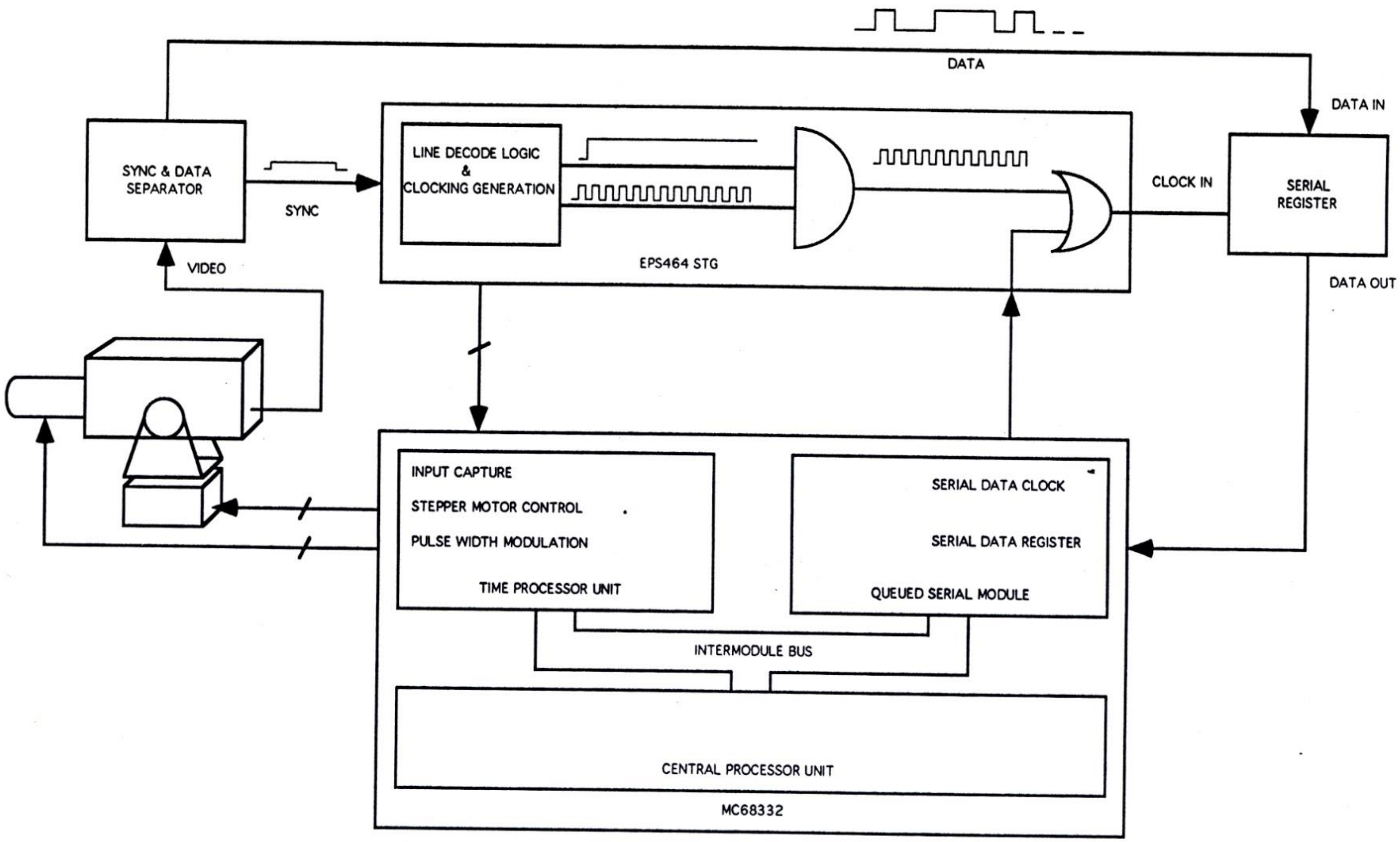


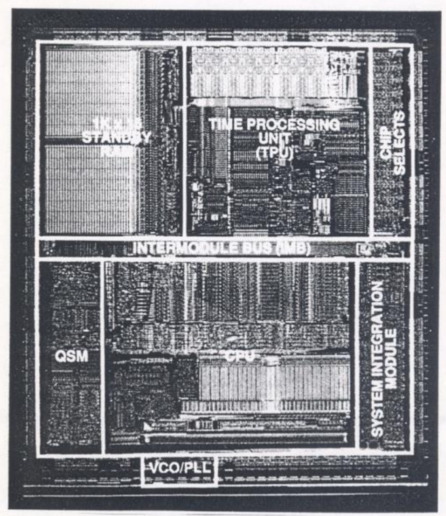
Figure 10. Data decoding system block diagram.

THE MOTOROLA MC68332 MICROCONTROLLER

Product Design, Assembly Language Programming, and Interfacing

Thomas L. Harman

School of Natural and Applied Sciences
University of Houston–Clear Lake



Prentice Hall
Englewood Cliffs, New Jersey 07632

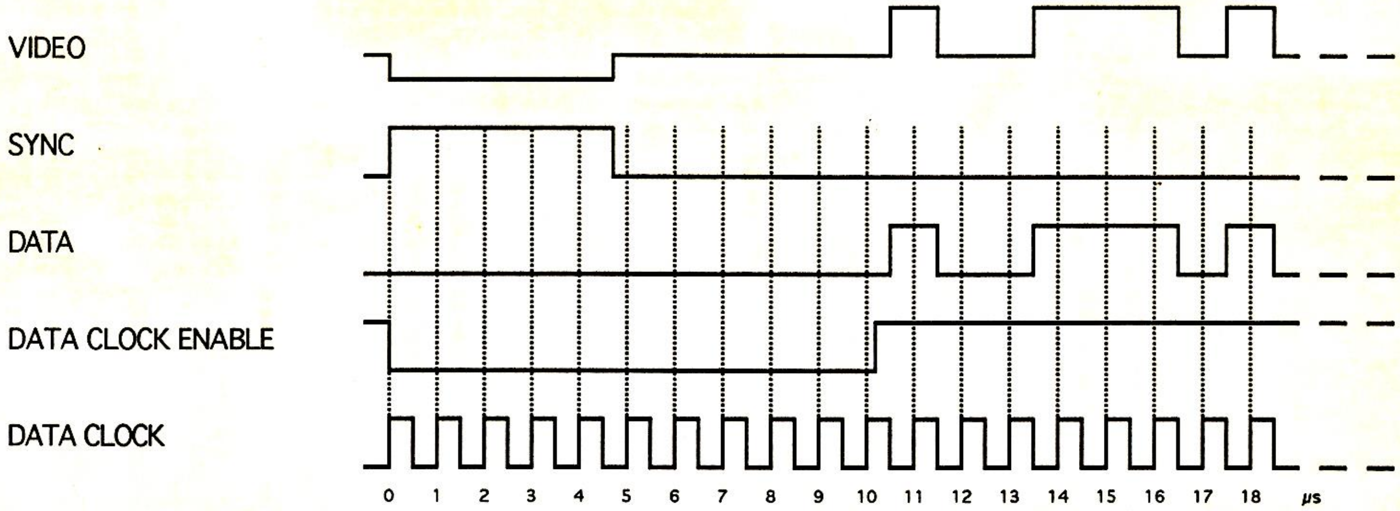


Figure 9. Data decoding timing diagram.

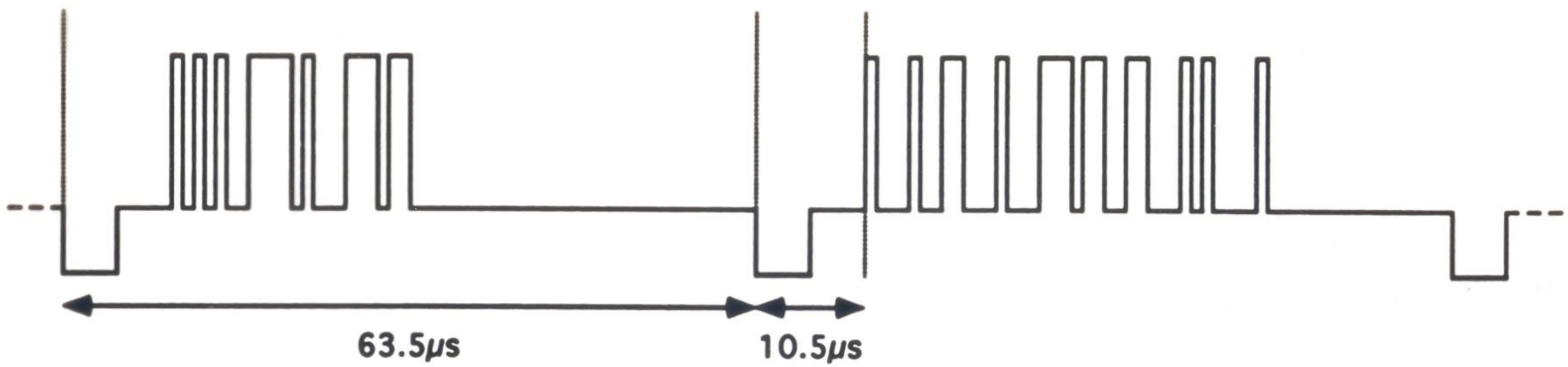


Figure 8. Data embedded on two video lines.

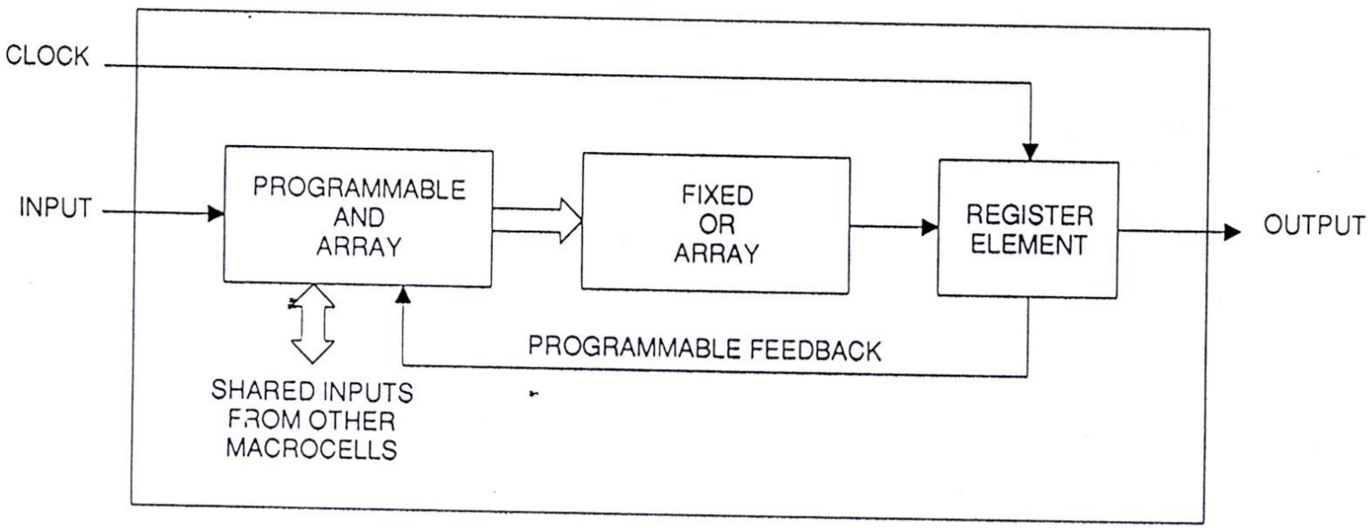


Figure 1. PLD macrocell structure.

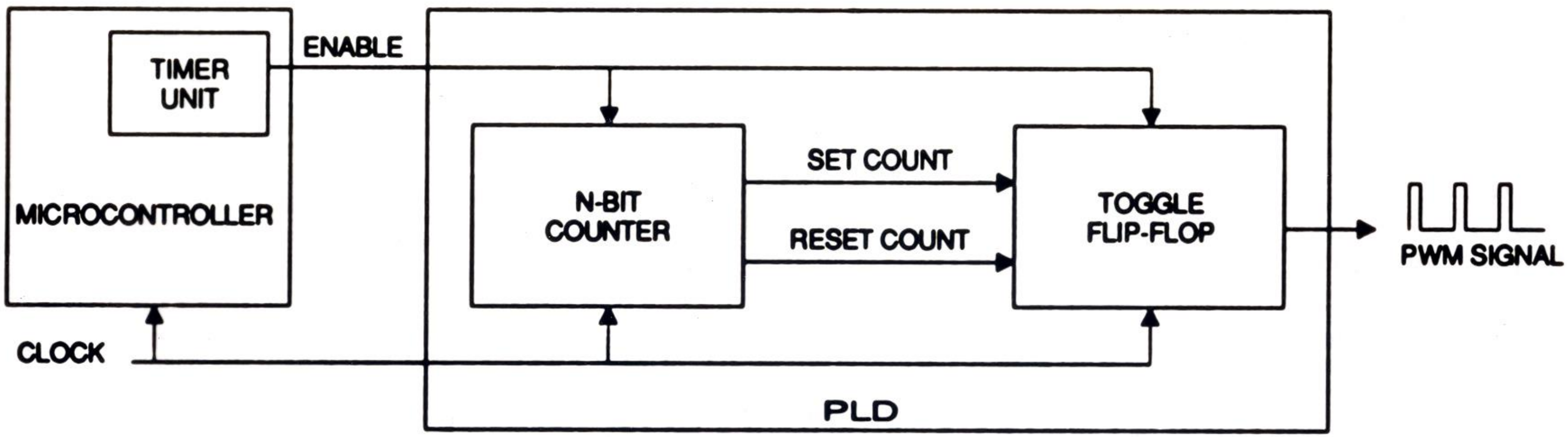


Figure 3. PWM Block Diagram

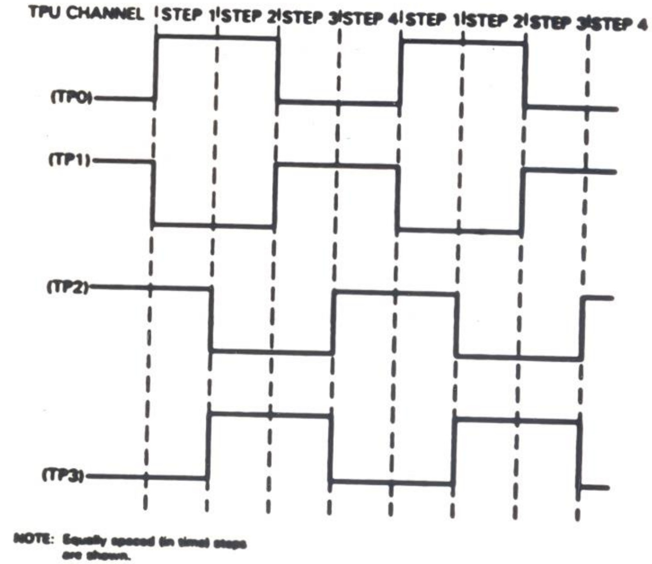
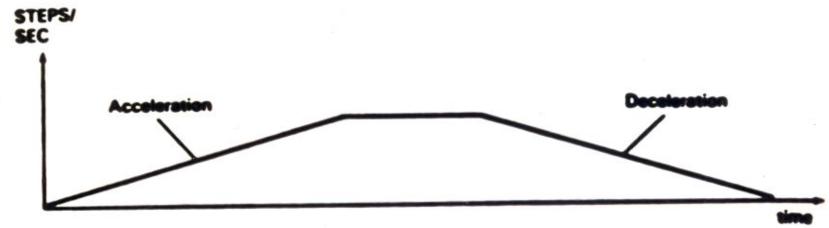


Figure 5 Stepping sequence.

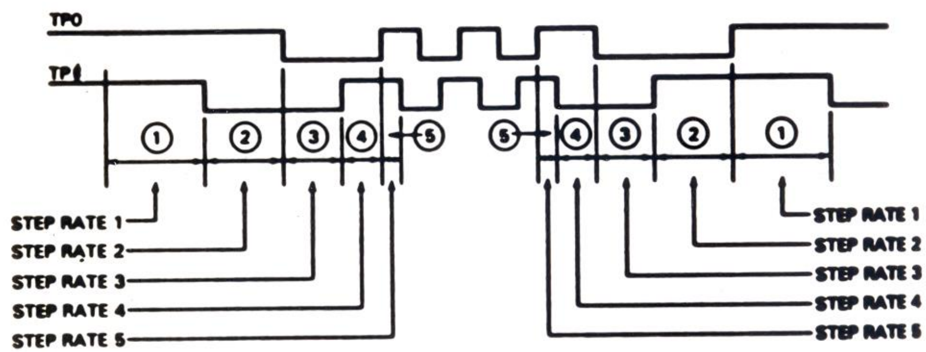
COUNTER CLOCKWISE ROTATION ↓

	TP0	TP1	TP2	TP3
STEP	Q4	Q3	Q2	Q1
1	ON	OFF	ON	OFF
2	ON	OFF	OFF	ON
3	OFF	ON	OFF	ON
4	OFF	ON	ON	OFF

CLOCKWISE ROTATION ↑



(a) Average acceleration profile



(b) Example stepping sequence with STEP_RATE_CNT = 5

Figure Stepper motor control for two-channel, full-step control.

MICROPROCESSOR CONTROLLED HOT WATER HEATER

US006246831B1

(12) **United States Patent**
Seitz et al.

(10) **Patent No.: US 6,246,831 B1**
(45) **Date of Patent: Jun. 12, 2001**

(54) **FLUID HEATING CONTROL SYSTEM**

(75) Inventors: **David E. Seitz**, Conroe; **David Paul Sharp**; **Thomas Lamson Harman**, both of Houston; **Louis J. Everett**, College Station; **Rodney H. Neumann**, The Woodlands, all of TX (US)

(73) Assignee: **David Seitz**, Houston, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/334,337**

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(51) **Int. Cl.**[7] **F24H 1/10**
(52) **U.S. Cl.** **392/486**; 219/497; 219/483; 392/466
(58) **Field of Search** 392/465, 466, 392/479, 480, 481, 484, 485, 486, 487, 488, 489; 219/483, 497

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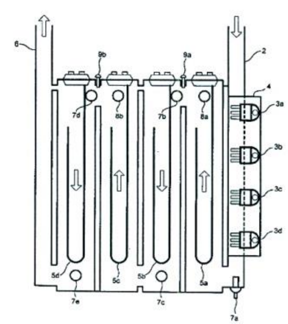
Assistant Examiner—Fadi H. Dahbour
(74) *Attorney, Agent, or Firm*—Browning Bushman

(57) **ABSTRACT**

An improved system, method and apparatus for control of an instantaneous flow-through fluid heater system is disclosed. The control incorporates a logic control method providing modulation of power in small steps to a plurality of heating elements retaining responsiveness to closed-loop control needs without inducing light flicker. Further, the life of the coils of heating circuit electromechanical relays are extended by energizing the coils with a pulse-width-modulated drive decreasing in duty cycle and thus the latent coil heat when an increase in mains voltage is sensed. The life of the contacts of same relays are extended by inhibiting heating element triac drive immediately upon sensing loss of relay coil power, such as by an over temperature limit switch opening, thus ensuring that relay contacts open with zero heating element current. In addition to the software "watch-dog timer" internal to the microcontroller, a redundant fail-safe circuit external to the microcontroller prevents a program lockup condition from leaving any heating element triac or relay drive in an energized state. A combination of control hardware and program provide self-diagnostic detection of an inoperative thermistor, stuck relay, or a failed triac or heating element. An improved means of sensing water level is disclosed incorporating a low-level, high frequency signal, allowing detection of non-conducting distilled water and the reliable detection of water in the presence of main-frequency currents as would exist in ungrounded sheathed heating elements with electrical leakage or as would exist with bare-elements.

29 Claims, 59 Drawing Sheets



Everyone Loves the Seisco

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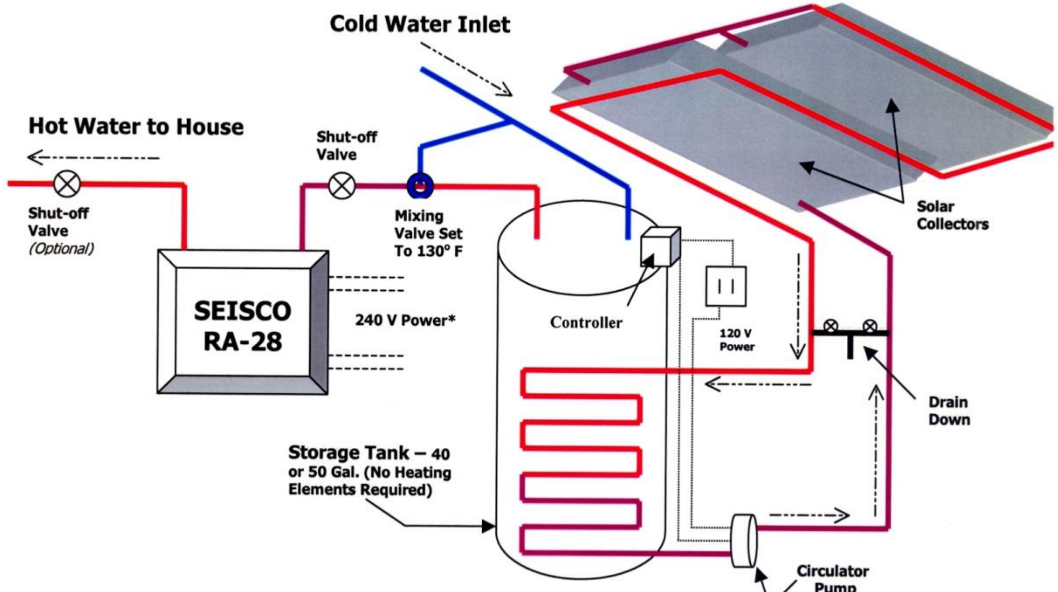
www.seisco.com
888-296-9293
223 W. Airtex Houston, Texas 77090

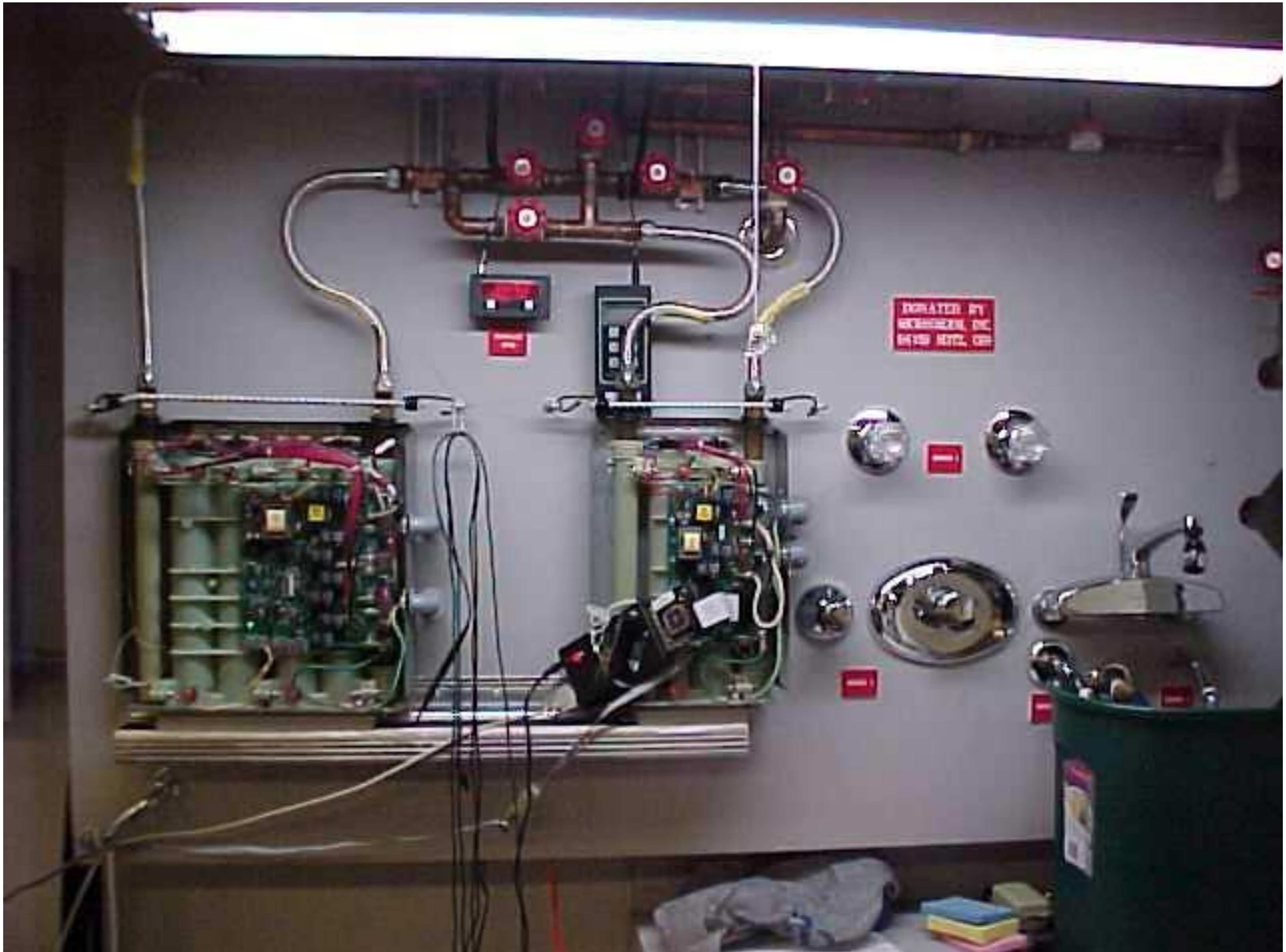
SEISCO Model RA-28
Tank-Less!! ELECTRIC
Continuous Water Heater –
Solar Water Heating Application

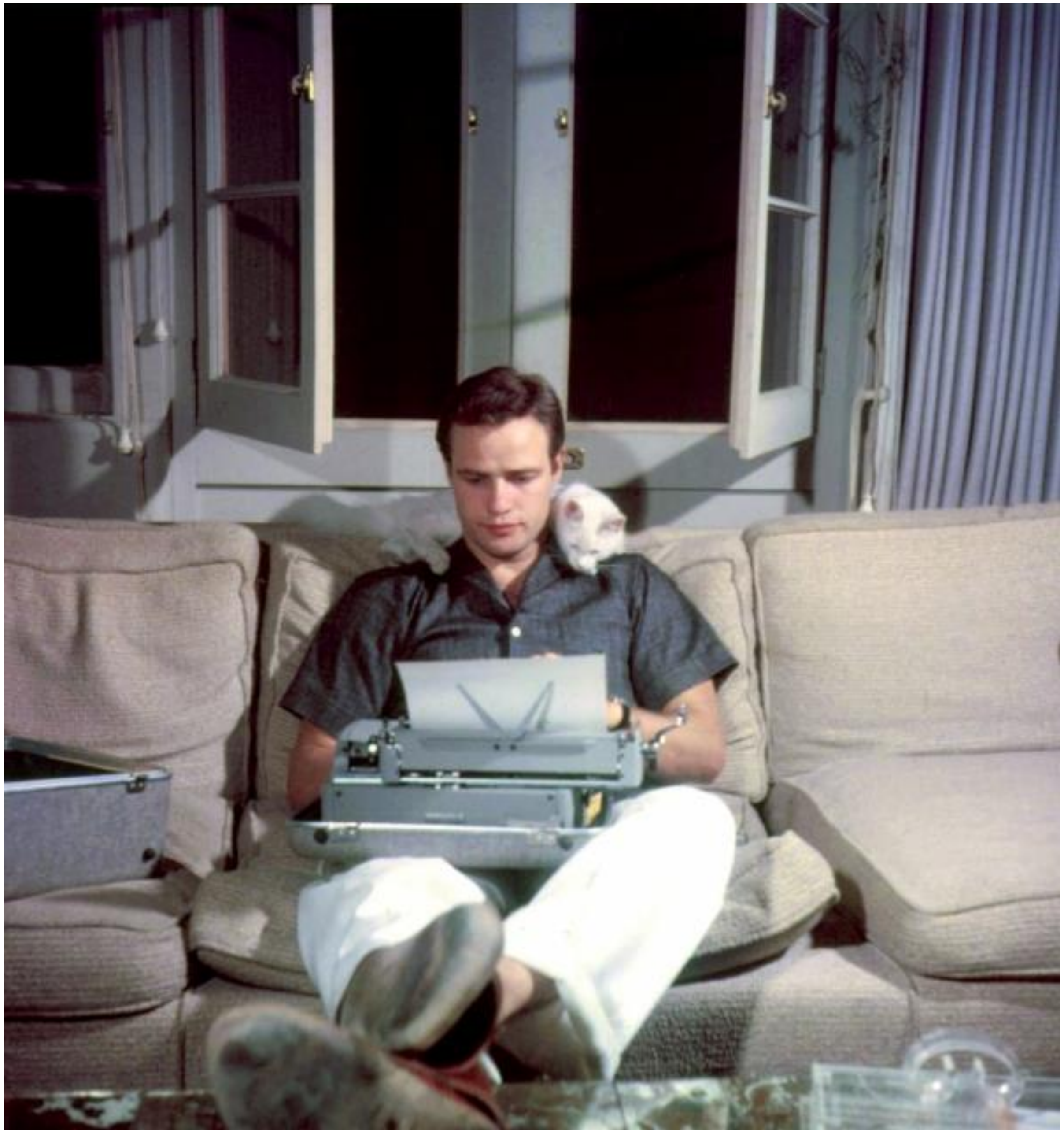
Recommended SEISCO Model RA-28 Back-up to Domestic Solar Water Heating System with Storage Tank and Closed-Loop Heat Exchanger



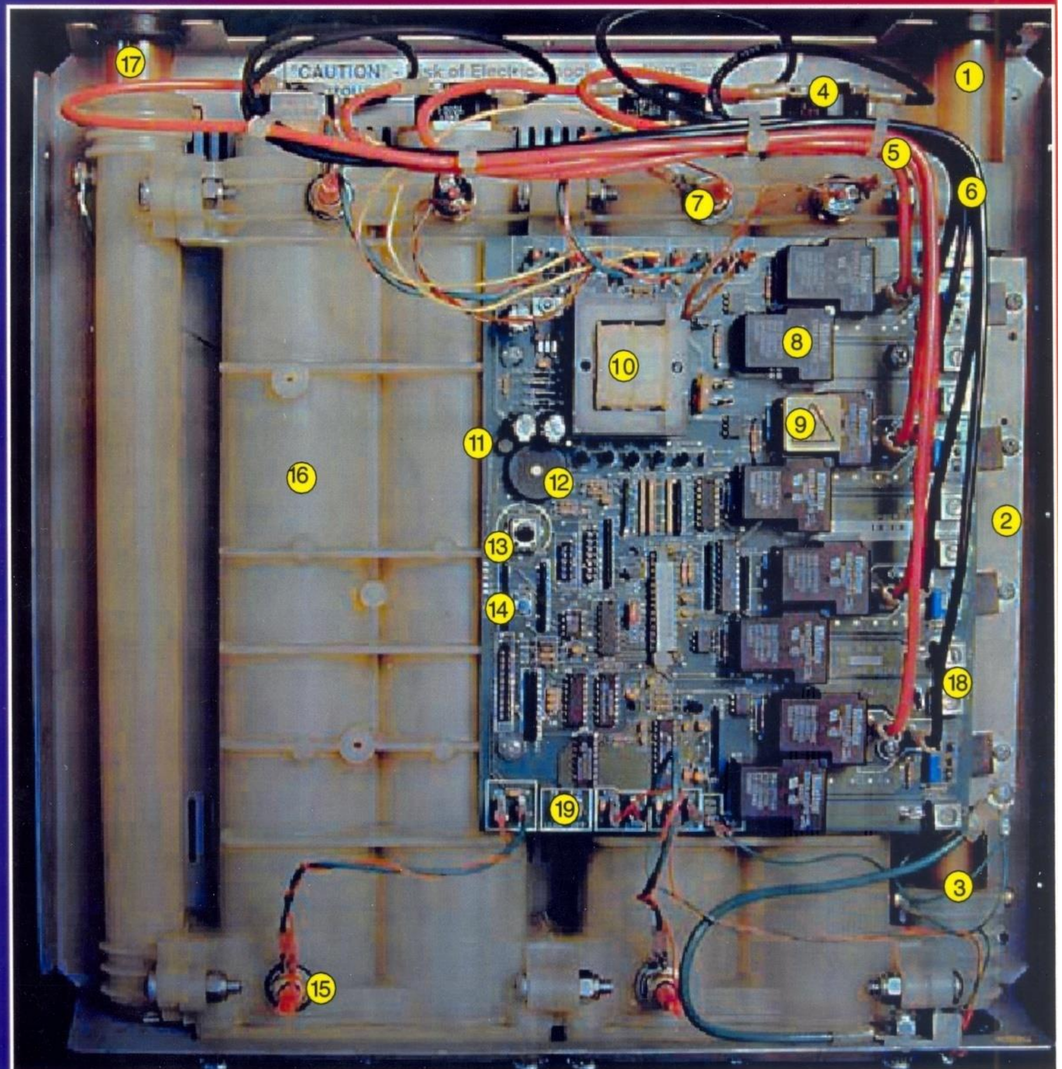
* The RA-28 Model requires **FOUR** 30 Amp, 240 Volt circuits from the main electrical panel or from an installed 120 Amp sub-panel or disconnect box.

- Temperatures from the Solar Heated Storage Tank can reach 160° F, thus requiring a mixing valve ahead of the Seisco to prevent the high temperature switch from tripping and disabling the Seisco.
- If the Storage Tank contains heating elements, they should be disconnected or the power turned off to enable the Seisco to provide the back-up heating. The Seisco should be set to turn on when the water from the Storage Tank drops below 120° F.



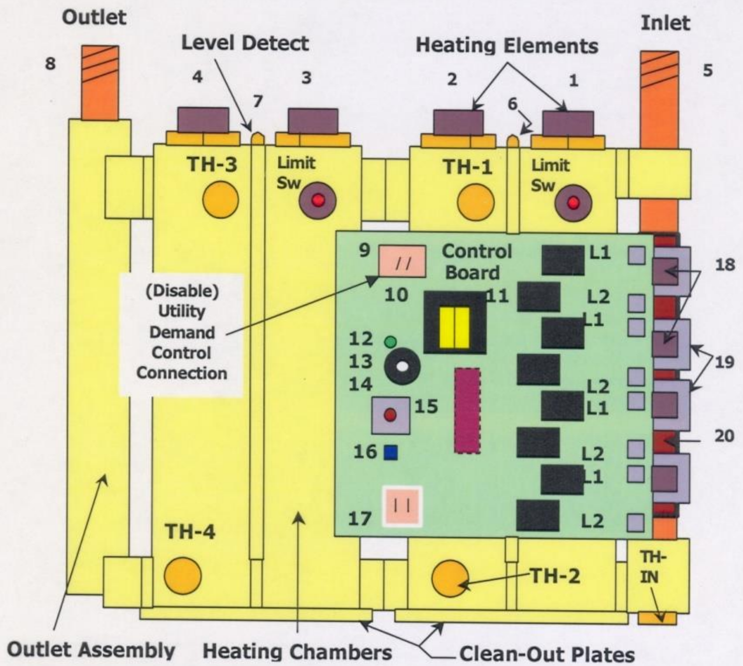


Informational guide to the inner workings of the the SEISCO water heater.



SEISCO

SEISCO® - Four Chamber Models (18, 22 & 28 KW) Internal Workings and Parts Identification



LEGEND

1 – Heating Element #1
2 – Heating Element #2
3 – Heating Element #3
4 – Heating Element #4
5 – Inlet Water Tube, ¾
6 – Water-Level Detect Screw
7 – Water-Level Detect Screw
8 – Outlet Water Tube, ¾
9 – Disable, Demand Control Switch
10 – Transformer
11 – Heating Element Relays (8 ea.)
12 – LED Light Indicator
13 – Audible Speaker
14 – Output Temperature Control

LEGEND

15 – Microprocessor Control Chip
16 - Blue Button; Manual Audible Activation
17 – Terminal Spades for Leak Detect Wires
18 – Triacs (4 each)
19 – Triac Mounting Blocks to Heat Sink (4 ea.)
20 – Copper Heat Sink Tube
L1 – Power Connection Lugs (208 – 240 VAC)
L2 – Power Connection Lugs (208 – 240 VAC)
Limit Sw : Over Temperature Limit Switches (2)
TH-IN : Inlet Temperature Sensor
TH-1 : Chamber Temperature Sensor #1
TH-2 : Chamber Temperature Sensor #2
TH-3 : Chamber Temperature Sensor #3
TH-4 : Chamber Temperature Sensor #4

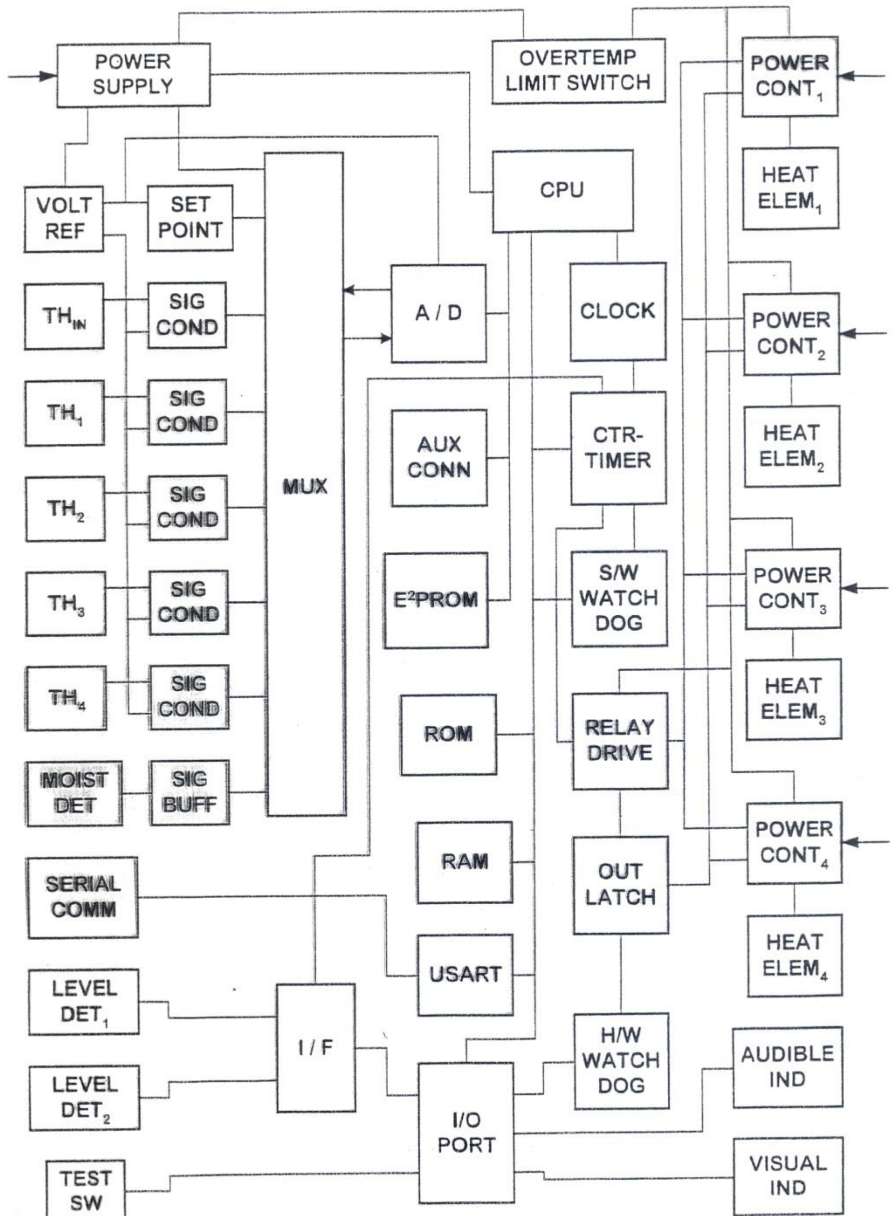
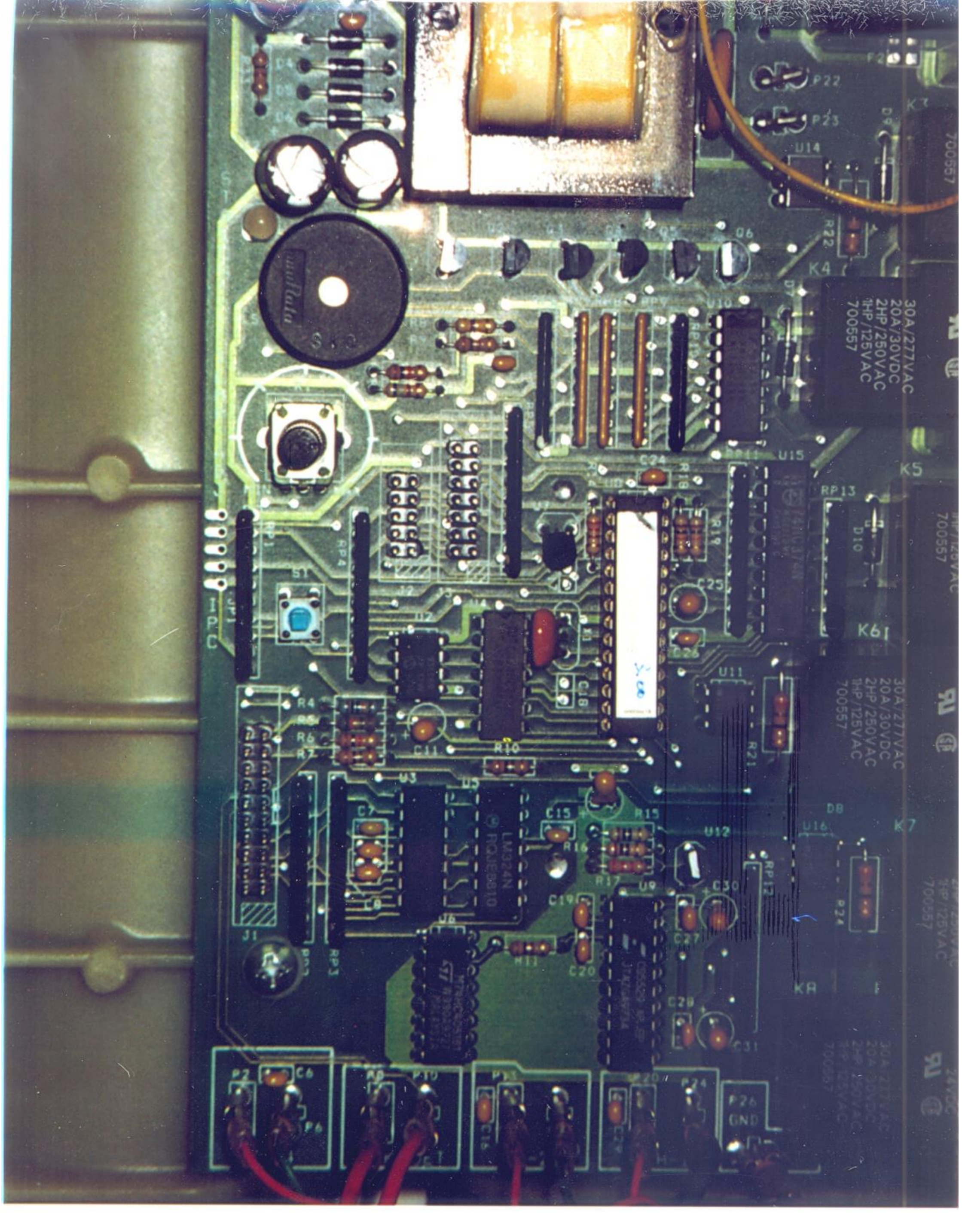
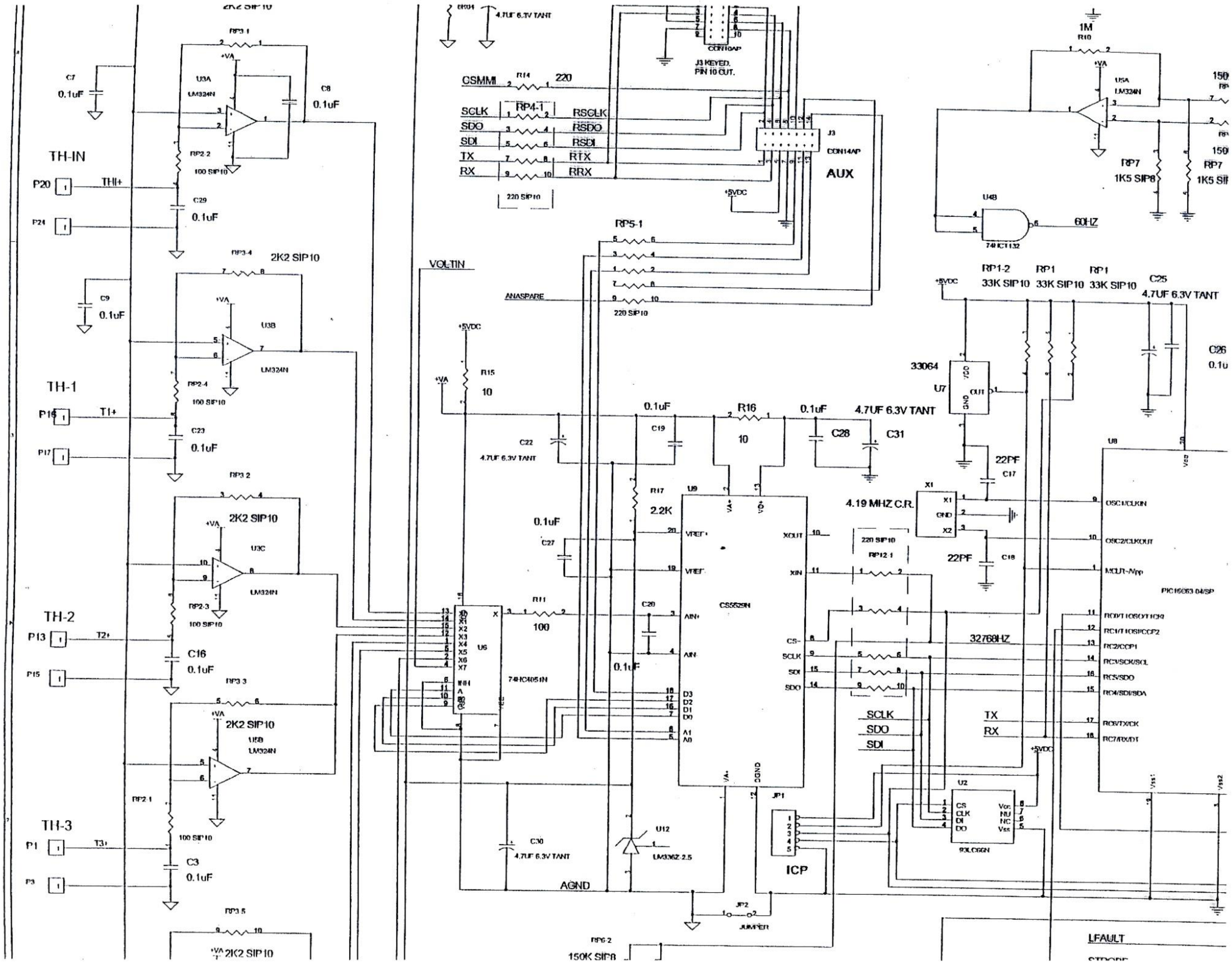
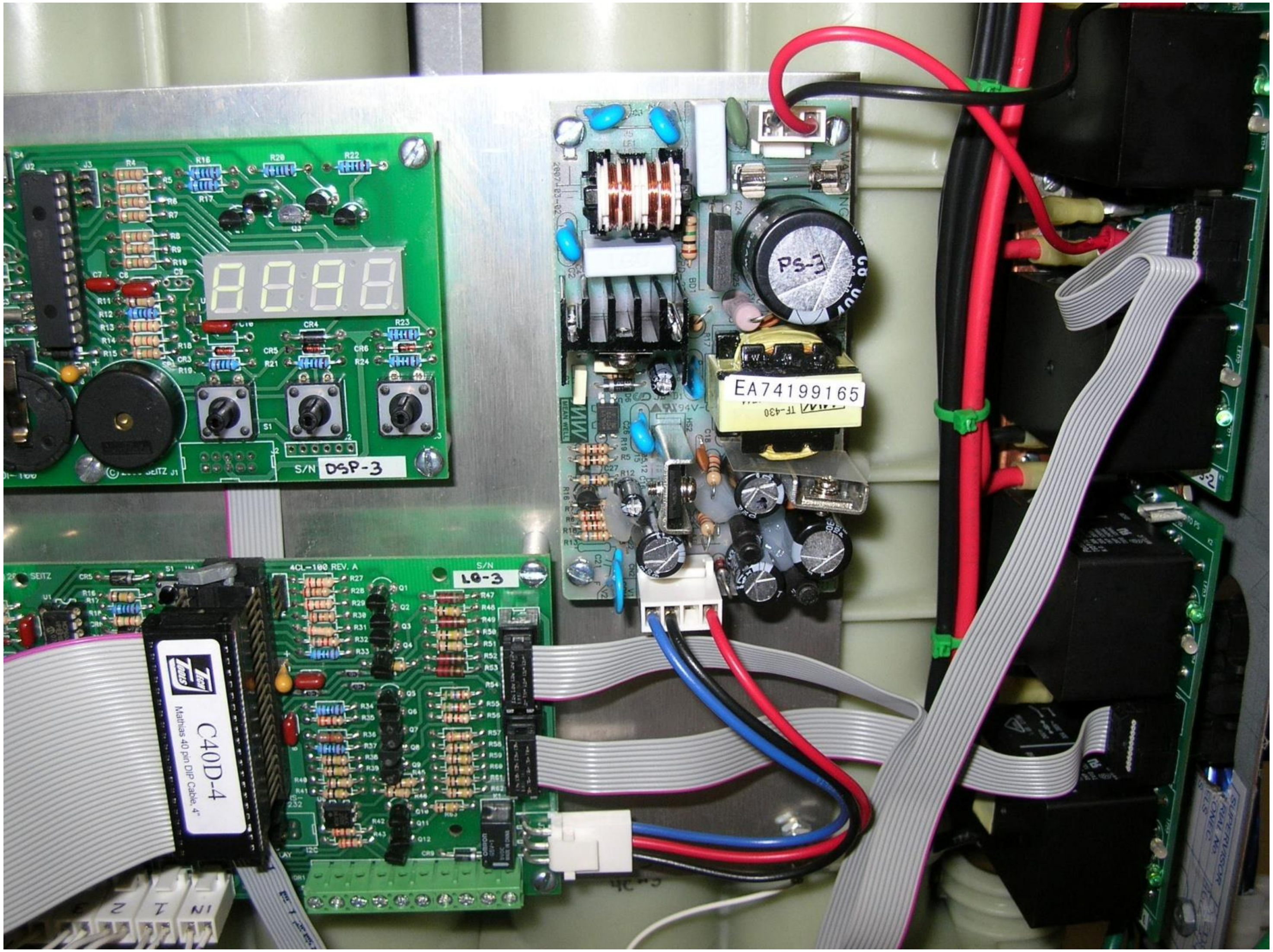

POWER SUPPLY
OVERTEMP LIMIT SWITCH
POWER CONT1
HEAT ELEM1
VOLT REF
SET POINT
CPU
MUX
A / D
CLOCK
THIN
SIG COND
TH1
SIG COND
POWER CONT2
HEAT ELEM2
AUX CONN
CTR-TIMER
TH2
SIG COND
TH3
SIG COND
E2PROM
S/W WATCH DOG
POWER CONT3
HEAT ELEM3
TH4
SIG COND
ROM
RELAY DRIVE
MOIST DET
SIG BUFF
POWER CONT4
RAM
OUT LATCH
SERIAL COMM
HEAT ELEM4
USART
LEVEL DET1
I / F
H/W WATCH DOG
AUDIBLE IND
LEVEL DET2
I/O PORT
TEST SW
VISUAL IND

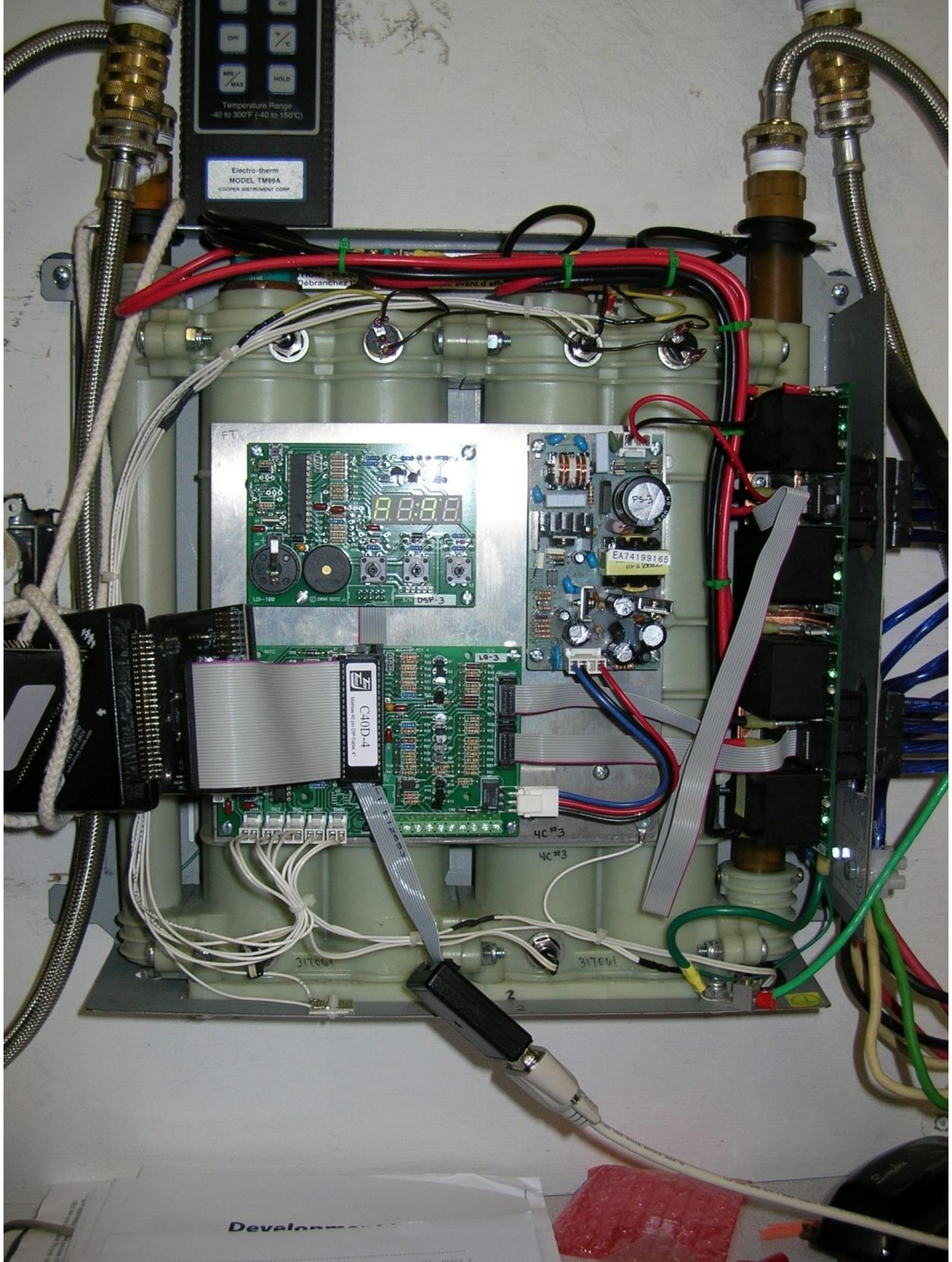
Fig. 1


30A/277VAC
20A/30VDC
2HP/250VAC
1HP/125VAC
700557
LM324N

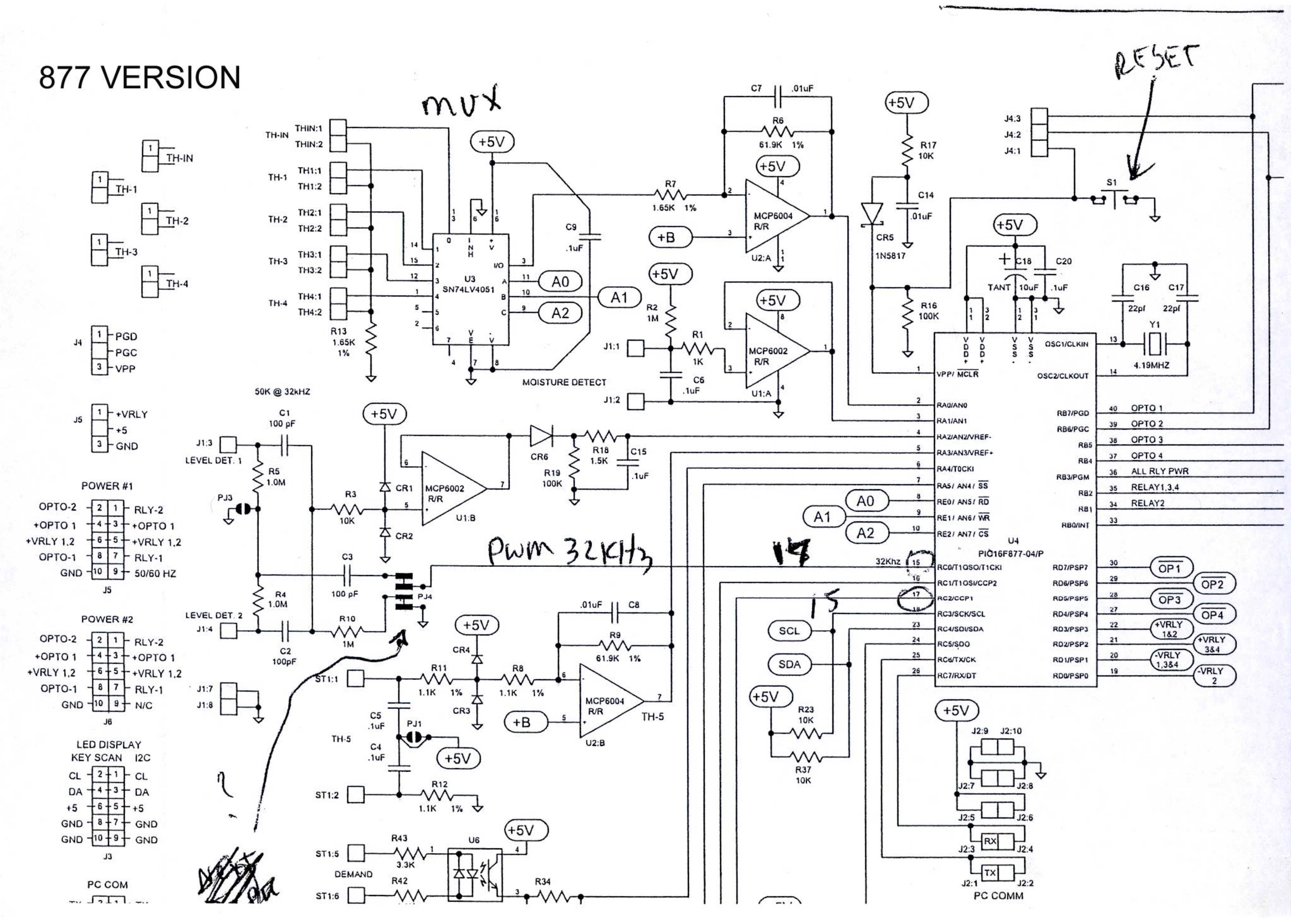


TH-IN
TH-1
TH-2
TH-3
AUX
AGND
ICP
CS5529N
74HC4051N
PIC16C63-04/SP
93LC66N
LM336Z-2.5
74HCT132
4.19 MHZ C.R.
32768HZ
60HZ
CSMMI
SCLK
SDO
SDI
TX
RX
RSCLK
RSDO
RSDI
RTX
RRX
VOLTIN
ANASPARE
LFAULT
J3 KEYED. PIN 10 CUT.
JUMPER


S/N DSP-3
PS-3
EA74199165
4CL-100 REV. A
S/N LG-3
C40D-4
Mathias 40 pin DIP Cable, 4"


OFF
MIN/MAX
HOLD
Temperature Range
-40 to 300°F (-40 to 150°C)
Electro-therm
MODEL TM99A
COOPER INSTRUMENT CORP.
DSP-3
PS-3
EA74199165
LG-3
C40D-4
4C#3
317061

877 VERSION



mux
RESET
PWM 32KHz
MOISTURE DETECT
U3
SN74LV4051
U4
PIC16F877-04/P
MCP6004
MCP6002
POWER #1
POWER #2
LED DISPLAY
KEY SCAN I2C
PC COM
PC COMM
LEVEL DET. 1
LEVEL DET. 2
DEMAND
50K @ 32kHZ
4.19MHZ
1N5817
OPTO 1
OPTO 2
OPTO 3
OPTO 4
ALL RLY PWR
RELAY1,3,4
RELAY2

MICROPROCESSOR CONTROLLED HOT WATER HEATER New Model


Coming Soon
Point of Use
Launch Date
Mid-2012
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SEISCO
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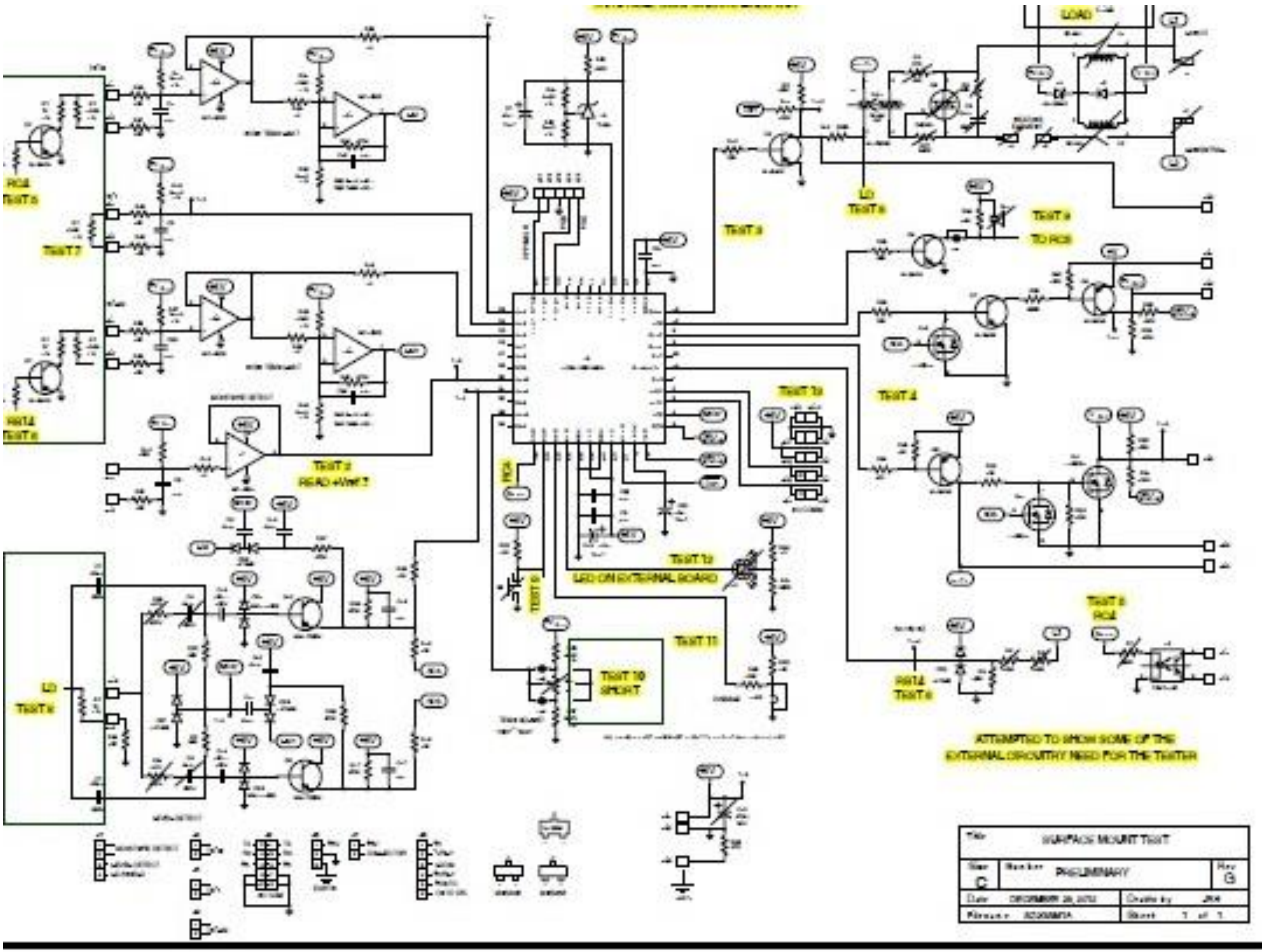
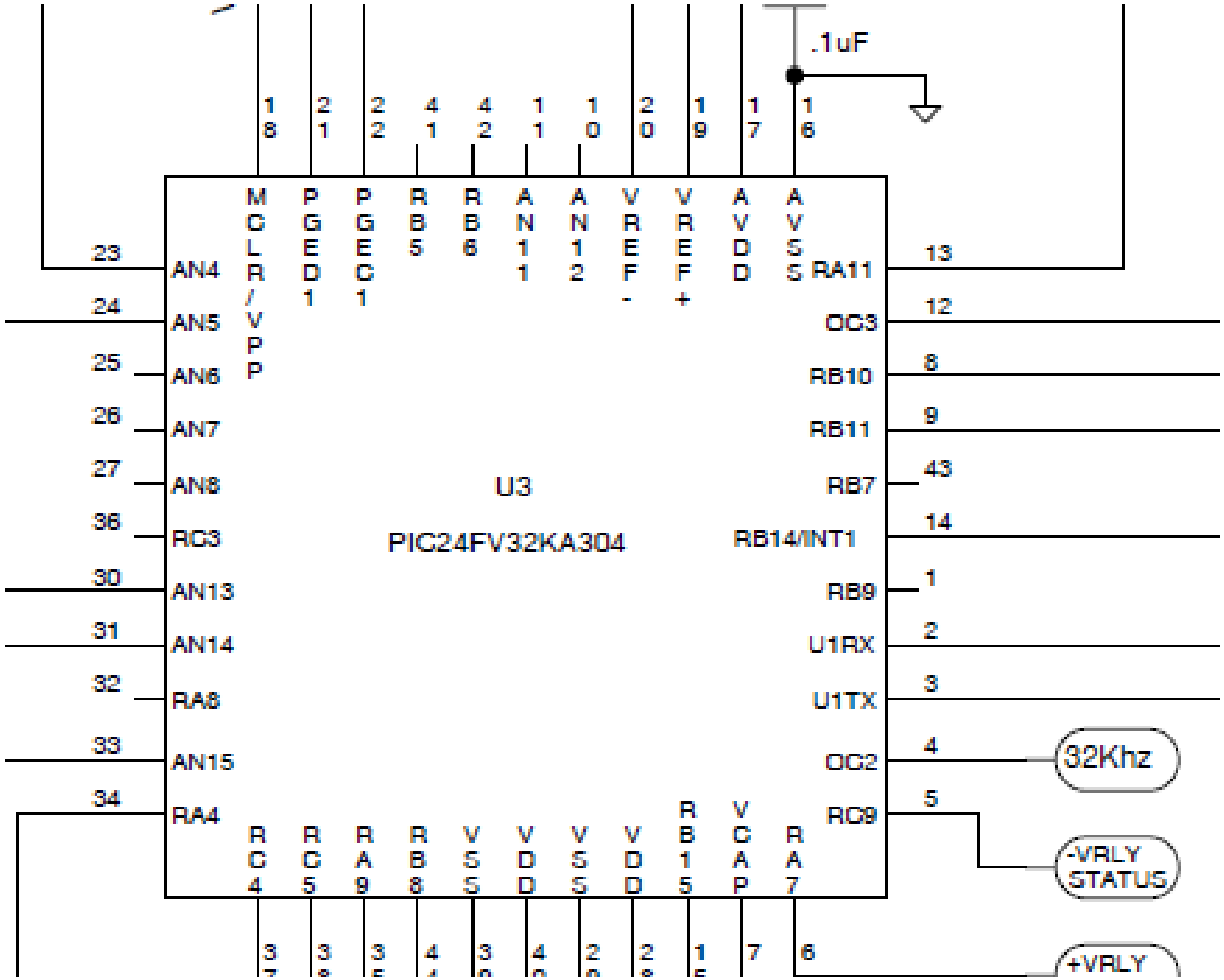
ADVANCED TANKLESS TECHNOLOGY



LOAD
TEST 7
TEST 4
LED ON EXTERNAL BOARD
TEST 10
SHORT
TEST 11
ATTEMPTED TO SHOW SOME OF THE
EXTERNAL CIRCUITRY NEED FOR THE TESTER
SURFACE MOUNT TEST
PRELIMINARY


.1uF
U3
PIC24FV32KA304
MCLR/VPP
PGED1
PGEC1
RB5
RB6
AN11
AN12
VREF-
VREF+
AVDD
AVSS
AN4
AN5
AN6
AN7
AN8
RC3
AN13
AN14
RA8
AN15
RA4
RA11
OC3
RB10
RB11
RB7
RB14/INT1
RB9
U1RX
U1TX
OC2
RC9
RC4
RC5
RA9
RB8
VSS
VDD
VSS
VDD
RB15
VCAP
RA7
32Khz
-VRLY STATUS
+VRLY