

List of Sponsors & Projects for Senior Design Projects
(8/29/2002, Dr. Wei Chen, ME/IE396)

1. Sponsor: Merkle-Korff Ind., Des Plaines, IL
Contact Person: Nick Shin, Product Manager, 847-759-7215.
Project: **Design and develop ice tray for an automatic icemaker.**
2. Sponsor: UIC, Mechanical and Industrial Engineering
Contact Person: Dr. Brianno Coller, 996-8530
Project: **Design and build a vortex generator**
3. Sponsor: ASME
Contact person: see website
Project: **2003 – Moving on & up**
See <http://www.asme.org/students/Competitions/designcontest/index.html>
4. Sponsor: Abbott, Lake County, IL.
Contact Person: Michael R. Smith, (847) 937-6436
Project: **Label Presence Detection on Filled Bottles**
5. Sponsor: UIC, Mechanical and Industrial Engineering
Contact Person: Dr. Earl Foster, 996-9620
Project: **Solar Energy Evaluation for Household Usage**
6. The following projects are provided by Motorola, Schaumburg, IL.
However, none technical consultations will be available.
Project titles:
 - a. **Thermal analysis and experimentation of Power Stacks under steady-state conditions. -SL**
 - b. **Improved packaging for an Electronic Engine Controller (returnable & rebuildable). - MA**
 - c. **Develop a wirebond fatigue tester. -JM**
 - d. **Develop a package for autobody applications which is rain-proof, sans gaskets. -DK**
 - e. **Develop a solder joint/lead fatigue tester. -DK**
 - f. **Develop a machine for doing a pull test on a flip-chip. – JM**
 - g. **Develop an isolation mounting system, integral to the electronic module, for high-vibration. - LP**
 - h. **Develop assembly-line equipment to measure “buzz” from a Chime module. - DK**
 - i. **Redesign and cost-reduce a module connector and harness, i.e., replace with an integrated harness. Include the manufacturing process. - LP**
 - j. **Reduce thermal contact resistance between adhesive (3M 9460) and circuit on an engine control unit. –SL**
 - k. **Determine junction-to-board thermal resistance for various leaded devices (IC’s, etc.) –SL**

- l. Injection Pressure Sensor pressure fatigue tester. -JM**
- m. Optimize thermal resistance test bench -SL**
- n. Vibration test fixture for functional test verification. -LP**
- o. Evaluate housing screw in plastic (common screw for both aluminum and plastic). -WR**
- p. Develop test method for measuring/evaluating voiding in Aluminum castings. -WR**
Evaluate the best way/materials to bond a PCB to an aluminum plate to reduce the thermal resistance. -WR

- 7. Water Clock (Scoot Mikalaushis)
- 8. Hand Assistance Device (Kurt Rederer)
- 9. Rich-Lean Methane Burner for Combustion for FTIR Spectrometer (Bob Shanahan)
- 10. Handhold Cover (Castaneda, Hugo)

11. Venturi effect on engine compartment cooling. (CAT)

- >
- >Project will involve the study of venturi fluid flow through a large wheel loader's exhaust stack. The venturi effect will be used to help cool the engine compartment. It will be the student's responsibility to design the most efficient exhaust stack to reduce engine compartment temperatures.
- >
- >Caterpillar will provide all necessary models, and drawings to support this project.
- >
- >

12. Effect of liftarm configuration on linkage pin joints. (CAT)

- >
- >Project will involve modeling and analysis of two different liftarm systems. Analysis will be conducted on each liftarm to determine how linkage pins are loaded in the joint that attaches the liftarm to the loader frame. Pin modeling may require the use of non-linear gap type elements or equivalent. The desired result would involve an understanding of how the stiffness of the liftarm effects edge loading in the pin joint.
- >
- >Caterpillar will provide all necessary models, and drawings to support this project.
- >

1. Design and develop ice tray for an automatic icemaker.

Purpose:

Design and build an ice tray to improve freezing time of ice cube as well as improve the overall ice volume per day. Design a unique ice cube shape.

Background:

Automatic icemaker in a residential refrigerator has been around for 40 years. The general ice cube shape has not changed from the original design. The half crescent shape is utilized in most modern icemakers. The current ice cube weights around 0.50 to 0.64 oz per cube. The freezing time is between 30 to 90 minutes. The freeze time is dependent on ambient temperature, freezer temp setting and how often the compressor is on. There are design efforts being made to improve the refrigerator as well as the icemaker controls to improve the ice making process. This project is mainly focused on the ice tray. The current ice tray is made of 380-alloy aluminum. This is a common alloy used for aluminum die cast process with very good heat transfer properties.

Objective:

- Investigate different ice cube shapes that is unique or different from the current shape
- design ice tray to improve heat transfer of the tray and improve the overall ice production

Deliverable:

- 3-D computer models of the ice tray designs
- Experimental results of the freezing time and freezing process
- Aluminum prototypes of ice trays



Abbott Laboratories

Diagnostics Division
Equipment Engineering

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DATE: Tuesday, September 10, 2002

TO: Brian Garrett

RE: Label Presence Detection on Filled Bottles – UIC Project

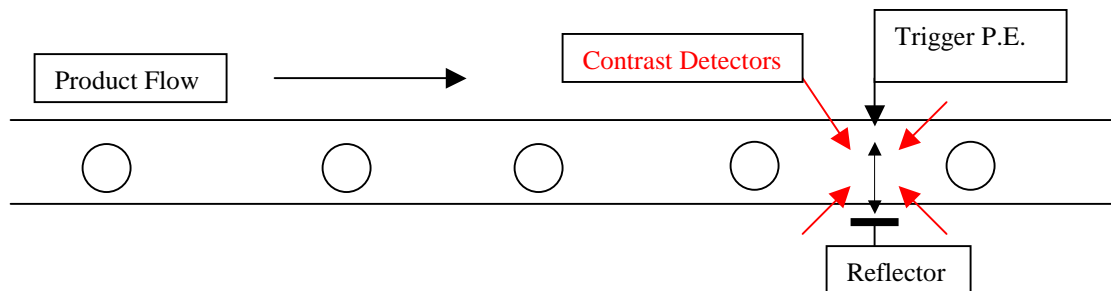
Brian,

The purpose of this project is to determine the presence of labels on bottles immediately after the labeling process.

Current Method: The current method for label detection involves the use of photo sensors to trigger the inspection and sense the label. A Banner photoeye projects across the conveyor and its output switches on when a bottle blocks the reflector. This output instructs the PLC to review the output status of 4 Omron E3S-VS5E4 contrast detectors. If any of the four contrast detectors sense a label, the bottle is allowed to proceed down the line to be packed off to shipping. Four detectors are used, as the label does not extend completely around the bottle. In some cases, the label may only extend to 1/3 of the circumference. If none of the contrast sensors detect a label, the line is stopped and an alarm is sounded. An operator is then required to remove the bottle, manually inspect for label presence, and restart the line.

Problem: These current detectors are very setup dependent. They can easily be setup incorrectly and the potential for an unlabeled bottle exiting the line is possible.

Overview of line after label application to bottles:



Objective: The objective of this project is to develop a new method of label detection.

Specifically, the system must allow for:

1. Current label configurations, including labels that only extend partially around bottles.
2. Bottle orientation can be anywhere in 360° rotation.
3. Throughput of 125 bottles per minute.
4. No contact with bottle or label.

Additional Information: This can be obtained by arranging an onsite visit or contacting me directly. I can be reached during the day and my information is provided above.

Deliverables: The goal of this project is to deliver a documented and demonstrated approach to label detection. Documentation to include: concept drawings, component assembly drawings, setup procedure, justification of selected concept, working model (to be funded by Abbott), risk analysis, and estimated costs.



MOTOROLA

*Automotive and Industrial
Electronics Group*

**9. A List of Sr. Design Projects for University
Undergraduate and Co-op Programs**

Mechanical Engineering & Packaging

Compiled by:

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Larry Poglitsch, Engineering Manager

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Rev. 7

January 15, 2001

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- 15. Evaluate housing screw in plastic (common screw for both aluminum and plastic). -WR**

16. Develop test method for measuring/evaluating voiding in Aluminum castings. -WR

17. Evaluate the best way/materials to bond a PCB to an aluminum plate to reduce the thermal resistance. -WR

Thermal Analysis & Experimentation of Various AIEG Devices & Substrates

Submitted by Steve Larson, Principal Staff Engineer.

Purpose: Motorola AIEG uses several different devices for metal oxide semiconductor, field-effect transistor (MOSFET) switching applications. Additionally, AIEG uses several types of substrate technologies to carry these devices. It would be beneficial to have a complete catalog of junction to heat sink (rigidizer) thermal resistances for most combinations of devices and substrates. It would also be beneficial to have the catalog developed through numerical and experimental modeling.

Background: AIEG has developed some catalogs of thermal resistances for various devices. However, these have not included:

- Effects of heat transfer from the top surface of the device and circuit substrate.
- Consistent circuit area from one device to another.
- Experimental verification and subsequent model modification to reflect a more realistic situation.

Objectives: Develop numerical models and determine $R_{j-rigid}$ for the matrix shown below:

Device-> Substrate	Dpak	D ² pak	Bare die
Al ₂ O ₃ on DC4107*	X	X	X
FR4 on PSA, ** no VIAS***	X	X	
FR4 on PSA, VIAS	X	X	
Polyimide on PSA, no VIAS	X	X	
Polyimide on PSA, VIAS	X	X	

*thermally conductive elastomer **pressure sensitive adhesive ***plated thru holes in FR4 (PCB)

Run the above matrix through thermal modeling. Study and achieve a correlation between numerical modeling and experimental testing.

Numerical modeling procedure: Perform three-dimensional heat transfer modeling. Existing Motorola ANSYS models may be used, or the student team may generate their own ANSYS or ICEPAK models. Effects of top surface convection and radiation should be considered.

The Motorola mentor will supply

- modeling advice and directions.
- computer time as necessary.
- assistance with some material properties.

Either establish a common circuit size OR run different circuit sizes based on the device's minimum required pitch.

Experimental modeling procedure:

1. Design a "cold plate" rigidizer to achieve an isothermal boundary condition on the bottom of the power stack.
2. Design the test circuits for the components.
3. Determine proper power supply systems.
4. Drill holes into the components with plastic packages to insert thermocouples.

5. Solder components to test circuits.
6. Fasten test circuits to the cold plate/rigidizer with pressure-sensitive adhesive.
7. Use T/C's to monitor Dpak and D²pak junction temperatures.
8. Use non-contact techniques to monitor Mega & Tritty junction temperatures.
9. Compare experiment to analytical; adjust models accordingly and rerun.

Deliverables: Report detailing procedures and results.

- Summary of numerical method procedure.
- Numerically derived junction-to-case thermal resistances for all matrix items.
- Experimental junction-to-case thermal resistances for all matrix items.
- Design documentation for the test equipment and electrical circuit.

Develop A Wire Bond Fatigue Tester.

Submitted by Jack Meagher, Section Manager.

Purpose: Design a Wire Bond Fatigue Tester to evaluate the fatigue life of different wire formulations and wire bond dimensions.

Background: A common means for interconnecting a silicon die to an electronic package leadframe is a thermosonically or ultrasonically formed wire bond. Wires vary in diameter (.001" to .020"), material (Au, Al, Al/Mg) and anneal state (std. anneal to over-anneal). The loop length, height and foot radius may also be varied. Each of these variables affects the fatigue life of the wire bond. When an electronic package with wirebonds is placed into service, changes in the ambient temperature and on/off cycles of the device cause thermal cycling of the wire bond and its anchor points. The amount of motion in the wire bond under these changing temperature conditions is determined by the coefficients of thermal expansion (CTE) of the package materials. It would be beneficial to have a mechanical means to duplicate the cyclical motion resulting from temperature variations so that high cycle fatigue studies could be completed quickly.

Objective: The objective of the Wire Bond Fatigue Tester would be to take a specimen and mechanically cycle the wire bond to failure while recording to cycles to failure. A convenient means of detecting failure is to pass a small electrical current through the wirebond until the failure results in an open circuit.

Procedure: Generate a concept of the tester displacement mechanism and computer control system that monitors the tester and shuts itself down after recording the number of cycles to failure. The tester mechanism must be able to cycle a wire bond through an adjustable displacement with as small a tolerance as possible. The displacement amplitude does not need to be recorded for each cycle but a warning should be sent if the amplitude begins to approach its tolerance limits.

Deliverables: Design Documentation for the tester and flow chart for the computer control system. A mock-up of the deflection mechanism demonstrating the accuracy of the displacement is also required.

Develop a Solder Joint/Lead Fatigue Tester

Submitted by Jeff Kotz, Section Manager.

Purpose: Design a piece of test equipment to evaluate the fatigue life of the solder joint or lead for common electronic component package styles.

Background: Solder joints are commonly used to interconnect electronic devices to printed circuit boards. The geometry of the lead and the amount and type of solder used influence the strength characteristics of the solder/lead interconnection. When an electronic system is placed into service, changes in the ambient temperature and on/off cycles of the device cause thermal cycling of component leads and the solder joints. The amount of motion in the wire bond under these changing temperature conditions is determined by the coefficients of thermal expansion (CTE) of the package materials. Additionally, electronic systems in automotive environments will typically experience high dynamic loads from vibration input such as the engine and suspension. It would be beneficial to have a mechanical means to duplicate the cyclical motion resulting from temperature and dynamic inputs so that high cycle fatigue studies could be completed quickly.

Objective: The objective of the Solder Joint Fatigue Tester would be to take a specimen and mechanically cycle either the component lead or a solder joint to failure while recording to cycles to failure. A convenient means of detecting failure is to pass a small electrical current through the wirebond until the failure results in an open circuit.

Procedure: Generate a concept of the tester displacement mechanism and computer control system that monitors the tester and shuts itself down after recording the number of cycles to failure. The tester mechanism must be able to cycle a solder joint/component lead specimen through an adjustable displacement with as small a tolerance as possible. The displacement amplitude does not need to be recorded for each cycle but a warning should be sent if the amplitude begins to approach its tolerance limits.

Deliverables: Design Documentation for the tester and flow chart for the computer control system. A mock-up of the deflection mechanism demonstrating the accuracy of the displacement is also required.

Develop a Device to Open Polybent™ Module for Failure Analysis

Submitted by Larry Poglitsch, Section Manager

Purpose: Develop a fixture to simplify the process for opening Polybent™ module.

Background: The Polybent™ design is a sealed module developed to withstand the extremes of an automotive underhood environment. A primary feature of this design is sealed construction, which provides environmental protection against entry of water, dust, and fluids commonly located with the engine compartment. The sealed construction, and folding of the substrate rigidizer, render the module difficult to open once the assembly has been completed. Opening of the module, which is required for failure or physical analysis, is a difficult and time consuming process, and commonly results in undesirable deformation of the substrate rigidizer, and damage to attached components.

Objective: The objective of this project is to develop a fixture design which allows simple and repeatable disassembly of a Polybent™ module. Specific objectives include ability to open the module without damaging components or the circuit, minimizing rigidizer deformation, and

allowing separation of the circuit and rigidizer from the housing. Additional considerations include ergonomic if a manual design is chosen, minimization of process steps required, safety of operation (e.g. no metal cutting), and flexibility to accommodate variety of package form factors.

Procedure: An on sight visit is encouraged to assess current Polybent™ module designs and to obtain related documentation. Develop a number of possible concepts for the fixture. The use of brainstorming techniques and a QFD are highly encouraged. Select a design concept and document the selection process. Develop the selected concept to the point that it is ready for fabrication.

Deliverables: Documentation of the concept generation and selection process including, but not limited to concept sketches and the justification for the selected concept. Documentation for the fixture including, but not limited to: detail component and assembly drawings; design calculations; tolerance analysis; design Failure Mode and Effect Analysis (FMEA); bill of material with cost estimates.

Develop an Vibration Isolation Mount That Doesn't Wear Out

Submitted by Larry Poglitsch, Section Manager

Purpose: Develop an isolation mounting scheme for electronics control module which does not wear out.

Background: Current trend in electronics packaging is to locate controls directly on the engine to simplify cable routing of input and output connections. While direct mounting on engine simplifies installation, it places significantly higher thermal and dynamic loads on the electronics packaging. A common method for reducing the dynamic inputs into the electronic module is to employ elastomeric based isolators which dampen and attenuate dynamic inputs. However, based on the temperature extremes in the vehicle, and exposure to fluids commonly present in the underhood environment, these systems are subject to wear, and require replacement within the service life of the control system.

Objective: Develop concept design for isolation mounting system which will not wear out within the typical operational life of the vehicle. Proposed design should have projected life greater than 10 years, or 150,000 miles in service. Cost and performance (attenuation) should be comparable with current elastomer based systems.

Procedure: Proposed approach to project is to review current applications and isolation schemes employed. Independent work to identify and assess alternatives would follow. The use of brainstorming techniques and a structured method for evaluating alternatives are highly encouraged. Select a design concept and complete calculations to project proposed system performance. Detail proposed components in sufficient detail to allow fabrication of samples for verification testing.

Deliverables: Documentation of the concept generation and selection process including, but not limited to concept sketches and the justification for the selected concept. Documentation for proposed design including, but not limited to detail component and assembly drawings, design calculations, and bill of material with cost estimates.

Development of a fatigue tester with subsequent fatigue testing for the Injection Pressure Sensor (IPS) and the Gasoline Direct Injection (GDI) sensor program

Submitted by Chris Hoyle, Group Leader

Purpose: The purpose of the project is two-fold:

The reason this work is needed is the unique construction of the GDI sensor. Typically, our sensors are micromachined silicon diaphragms in which issues such as pressure hysteresis, drift, and mechanical fatigue are negligible. Due to the high operating pressure of a GDI sensor (2000 psiG), the sensor construction is significantly different. The part utilizes a 17-4 pH Stainless Steel diaphragm crimped or brazed to a carbon steel port. A Kovar plate is welded to the SS diaphragm and the sense element is attached to the Kovar plate with frit glass. In this construction, the diaphragm now consists of 3 metals attached with welding, crimping and brazing processes, which can lead to pressure hysteresis, fatigue, or dimensional shifts.

The IPS sensor is failing due to high pressure pulses up to 2000 psi. We have been unable to simulate the failures in Northbrook due to equipment limitations. A fatigue tester is needed to test the silicon to high pressure pulses.

Background: Philip Kang and Ben Farb of Motorola have done background work to decide what is needed for a fatigue tester. The best direction has been identified as a hydraulic system which utilizes a standard valve to cycle the pressure of the hydraulic fluid. Potential sources for the hydraulics have been selected.

Procedure & Deliverables: The job for the students will be to do more analysis to define the exact equipment needed to perform the cycling testing in the shortest time possible. The project will also involve selection of all the auxiliary equipment needed to complete the system as well as the design of some unique fixtures. Validation of the equipment should be completed with actual GDI sensors with some means to determine the pressure cycling is meeting the design intent.

Philip Kang and Ben Farb will be available to give direction in this program. The program team has requested this testing and supports the development, so funding for the equipment will be available.

Develop a Package for Autobody Applications which is Rainproof, Sans Gaskets

Submitted by Declan Killarney, Program Manager

Purpose. Develop a scheme for keeping rainwater out of door and seat modules which does not require gaskets.

Background. Current module design (see Figures 1 & 2) is a simple, snap-fit enclosure with no seals. This allows rainwater to enter the enclosure. It is desirable to limit water entrance by a means other than adding rubber seals.



Figure 1.



Figure 2.

Procedure. Proposed approach to project is to review current designs and sealing techniques employed. Independent work to identify and assess alternatives would follow. The use of brainstorming techniques and a structured method for evaluating alternatives are highly encouraged. Select a design concept and complete calculations to project proposed system performance. Detail proposed components in sufficient detail to allow fabrication of samples for verification testing.

Deliverables: Documentation of the concept generation and selection process including, but not limited to concept sketches and the justification for the selected concept. Documentation for proposed design including, but not limited to detail component and assembly drawings, design calculations, and bill of material with cost estimates.

Optimize Thermal Resistance Test Bench

Submitted by Steve Larson, Principal Staff Engineer.

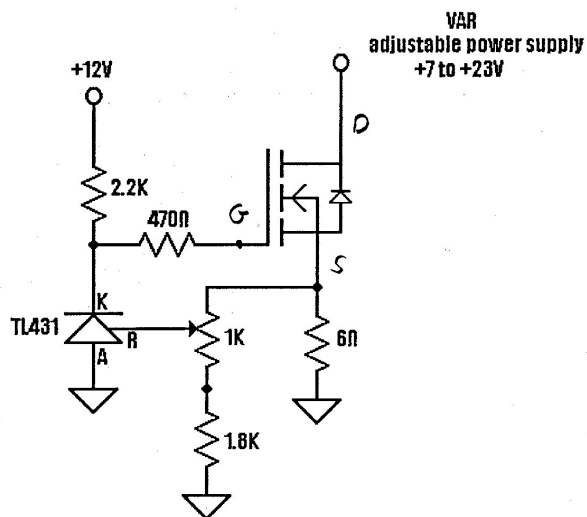
Purpose. Provide easy, reusable test board and coolant connections to devices on substrates.

Background. The thermal resistance test bench is used to measure device temperature, heat sink temperature, and device current and voltage. The circuit in Figure 3 is necessary for powering the test device (usually a field effect transistor). The existing test setup (Figures 4 and 5) requires soldering wires on each test board. The process of connecting up the circuit is tedious and can cause damage to the test board.

Procedure. Review the existing test bench. Develop an improved method of making the interconnects. Research improved coolant connection techniques. Determine improved methods for attaching the device thermocouple.

Deliverables. Documentation

Closed Loop Regulation of FET Dissipation



Set 1K pot for 3.0V at FET Source terminal. This establishes 0.5A drain current.

The Drain to Source voltage drop of the FET = VAR - 3V.

VAR volts	FET Watts
7	2
8	2.5
9	3
10	3.5
11	4
12	4.5

Figure 3 of the concept generation and selection process including, but not limited to concept sketches and the justification for the selected concept. Documentation for proposed fixture(s) including, but not limited to detail component and assembly drawings, design calculations, and bill of material with cost estimates. If completed early enough in the semester, the new bench can be fabricated in Northbrook's model shop and the design team could participate in the design verification.

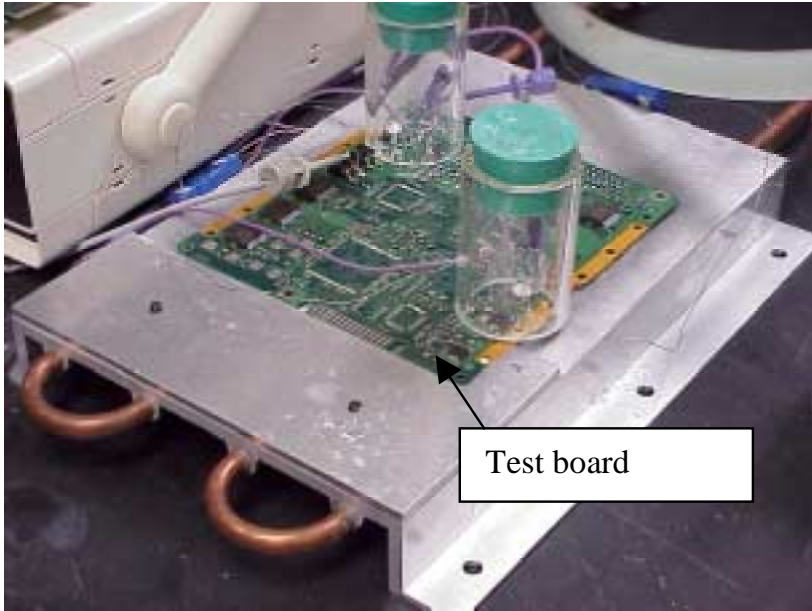


Figure 4.

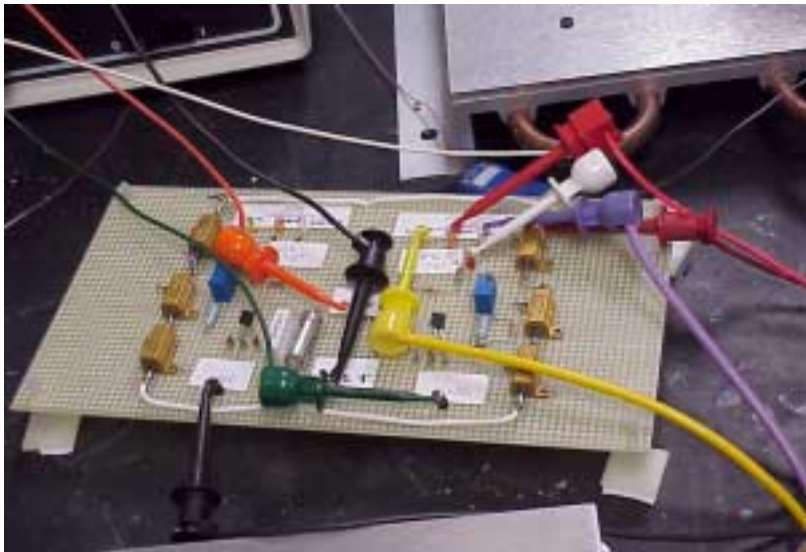


Figure 5.