

WERC Design Contest 2014 – Task 1

CIRCUITREE DECAY DETECTOR

Design of a Hybrid and Cost-Effective System
to Measure Structural Integrity of Trees



ENVIRONMENTAL ENGINEERING FOR TREE
SAFETY CONSULTING GROUP

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OVERVIEW OF PRESENTATION



- Motivation for CircuiTree design
- Benefits/failure of trees
- Project goals
- Alternative technologies
- Design solution
- Detailed system design
- Experimentation
- Full scale implementation
- Business plan
- Outreach plan
- Conclusion

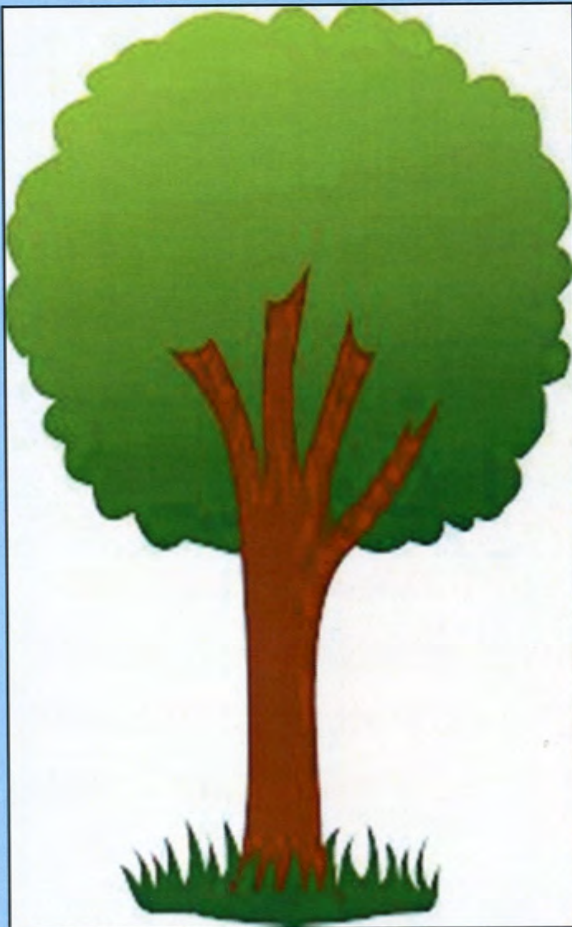


MOTIVATION FOR CIRCUITREE DESIGN

- In Hurricane Sandy, NYC alone lost approximately 20,000 trees.
- Hurricane Sandy was the third most costly catastrophic storm in 2013 dollars with total claims of over 19 billion dollars and property losses exceeding 65 billion dollars. The majority of claims were a result of falling or flying debris.
- 106 individuals died as a result of the storm with 20 individuals dying directly because of fallen trees.



THE BENEFITS OF TREES



- Each tree
 - Provides \$7 savings in annual environmental benefits
 - Produces approximately 260 pounds of oxygen per year
 - Reduces energy usage
 - Reduces noise and air pollution
 - Reduces storm water runoff
 - Increases quality of life
 - Increases property values
 - Absorbs carbon dioxide
 - Cleans the air

WHY TREES FAIL



- Two Failure Modes
 - Trunk and branch breaking due to wood decay
 - Failure due to shallow root systems
- Approximately 65% of trees fail due to trunk and branch decay, 35% because of shallow root systems.
- Wood decay starts through a wound, then insects and fungi enter the tree.



PROJECT GOALS



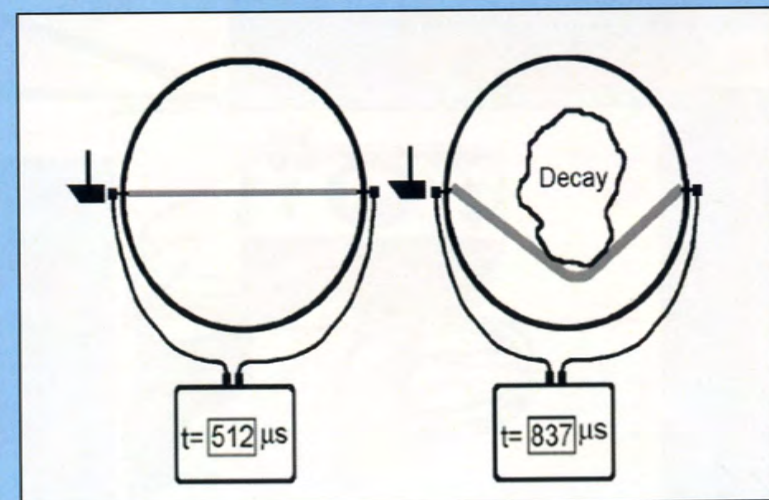
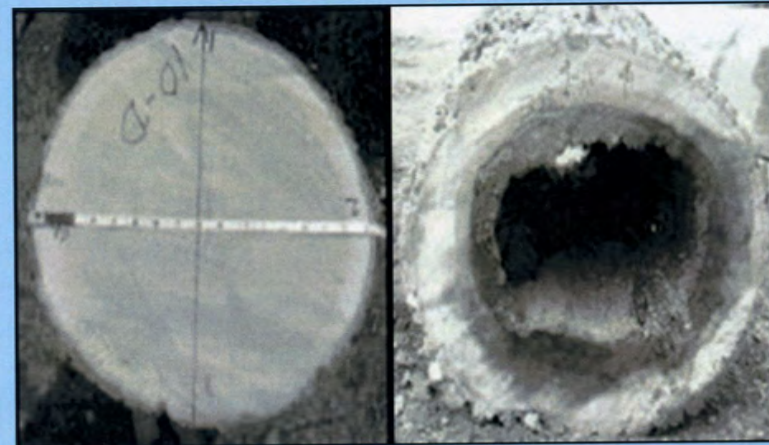
- CircuiTree is a safe, non-destructive and easy-to-use system for the homeowner and small nursery business to test the structural integrity of trees on their property.
- Using an impact mallet, accelerometer and a hand held mobile device, frequency and time of flight measurements are gathered and analyzed.



TIME OF FLIGHT AND FREQUENCY ANALYSIS

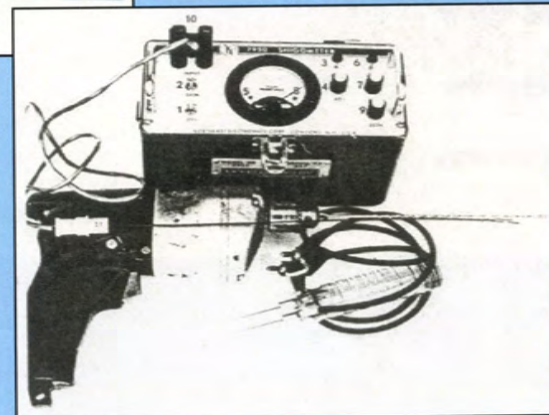
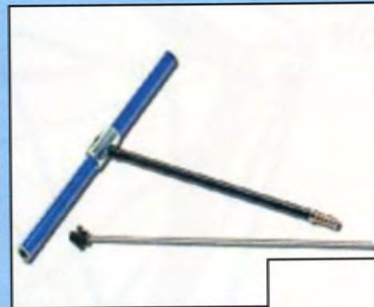
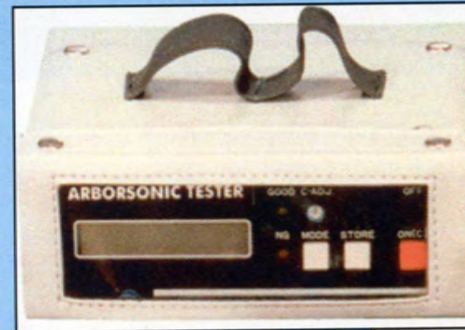


- Time of Flight analysis determines how long vibrations take to travel through the tree.
- Frequency analysis “listens” to the tree, analyzing the sound it produces.

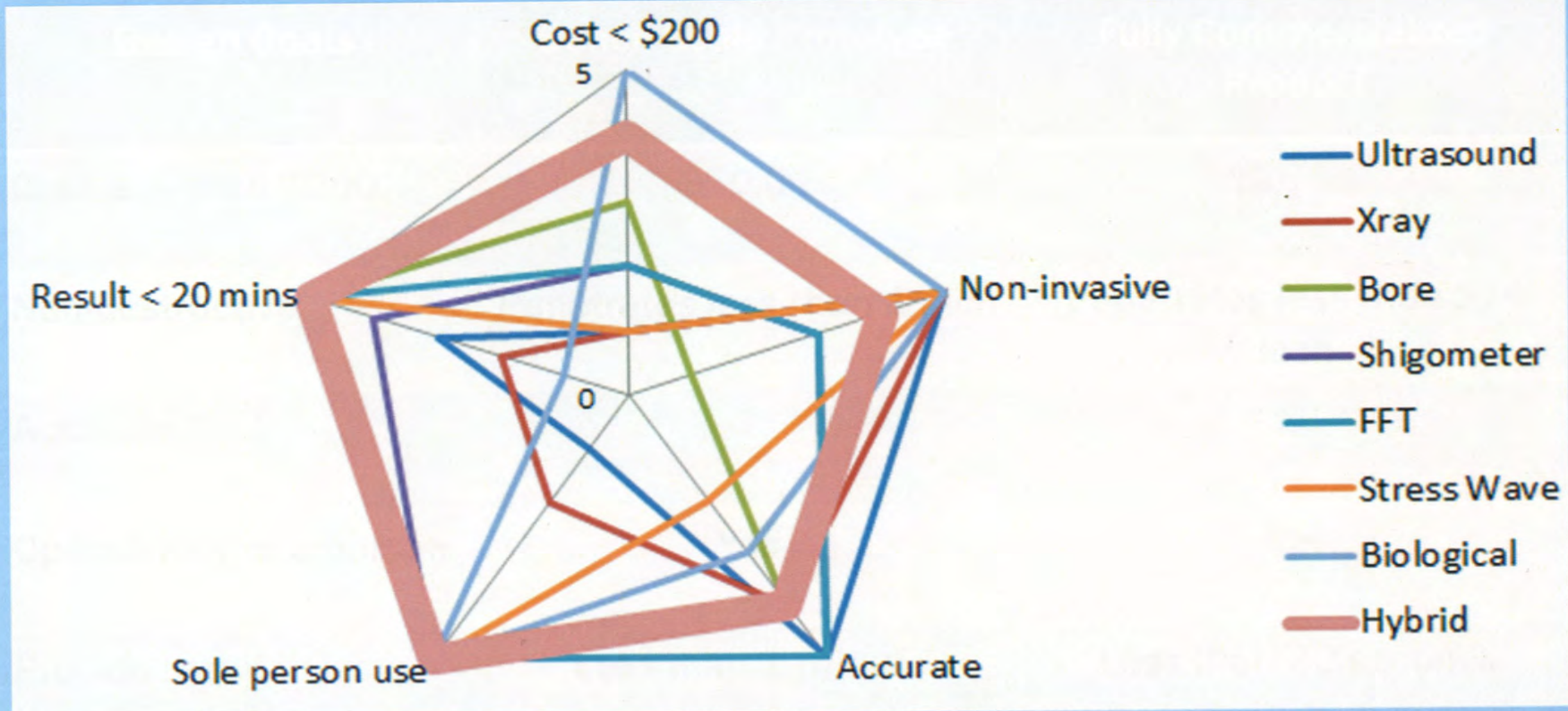


ALTERNATIVE TECHNOLOGIES RESEARCHED TO DETERMINE TREE FAILURE

- Ultrasonography
- Ground-penetrating radar (GPR)
- Increment boring
- Biological inspection
- Stress analysis



RADAR CHART COMPARING ALTERNATIVE TECHNOLOGIES

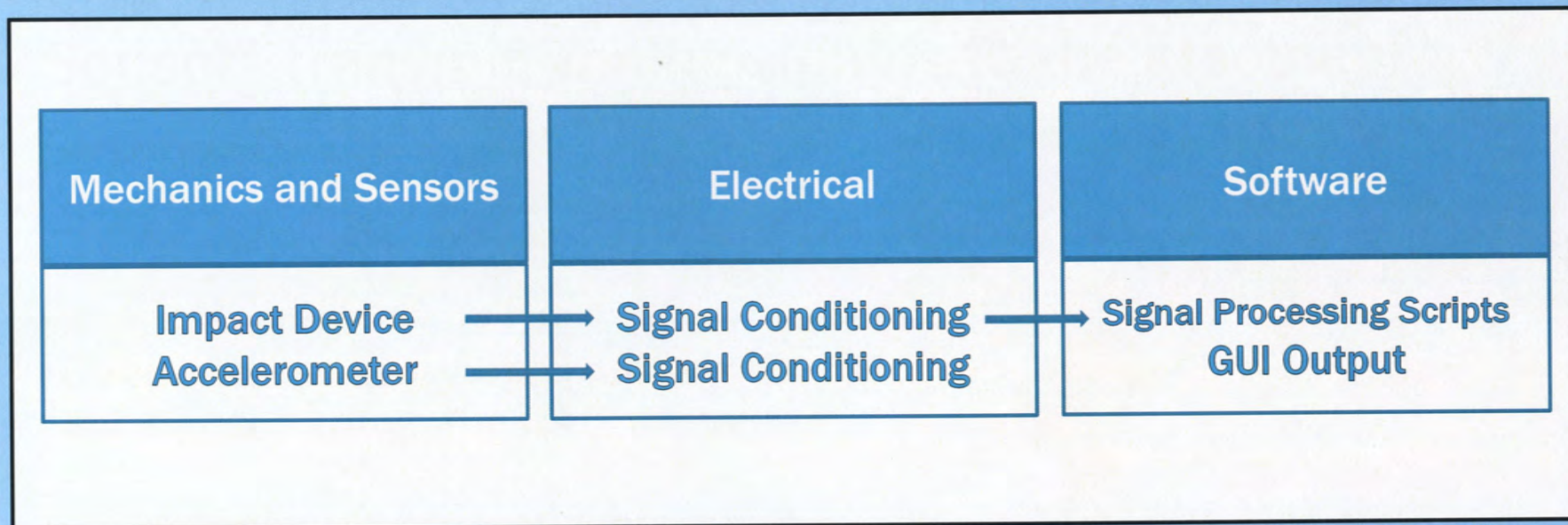


DESIGN SOLUTION



Design Goals	Bench Scale Prototype	Fully Commercialized Product
Cost less than \$200	\$50.02	\$20.01
Non-destructive	Penetrates less than 1 inch	Penetrates less than 1/4 inch
Accurate	7	10
Operable by one person	Yes	Yes
Provide result in less than 20 minutes	Less than 1 minute	Less than 30 seconds

DETAILED SYSTEM DESIGN



MECHANICS AND SENSORS



- Impact Device
- Sensors transmit analog signals to the electrical sub-system
 - Piezoelectric disc transducer on impact device

Impact Device

Strikes the tree specimen and sends the signal through the DAQ computer

Piezoelectric contact microphone is attached by epoxy to rubber top of the impact device. These are connected positively and negatively to the oscilloscope.



MECHANICS AND SENSORS



■ Accelerometer on Tree

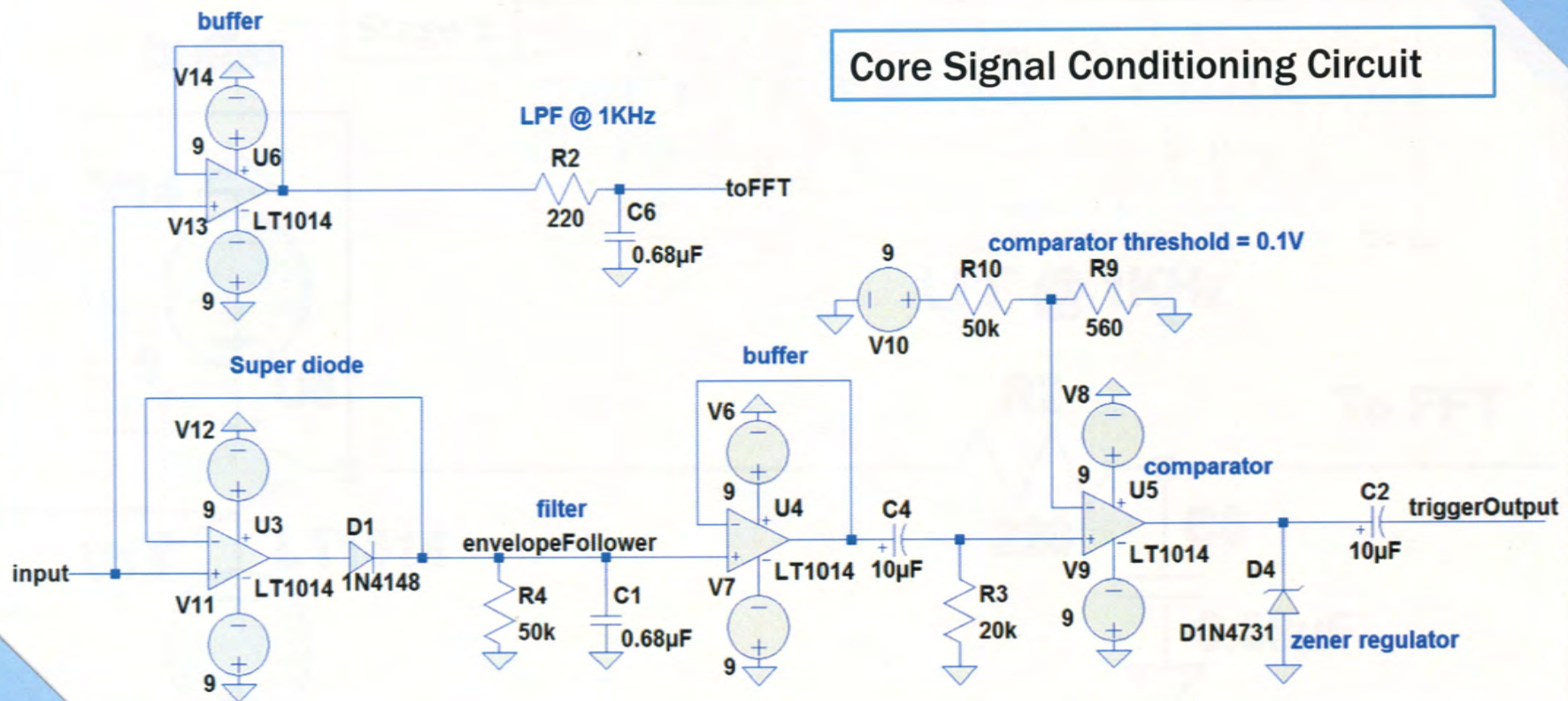


An accelerometer is epoxied to a metal plate that is affixed to each specimen. It is powered by 9 volts and connects into the DAQ computer.

ELECTRICAL



Core Signal Conditioning Circuit

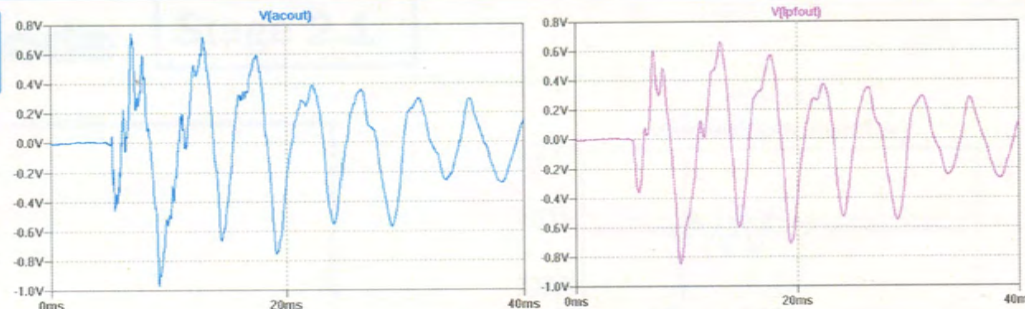


ELECTRICAL



buffer

Stage 1



LPF @ 1KHz

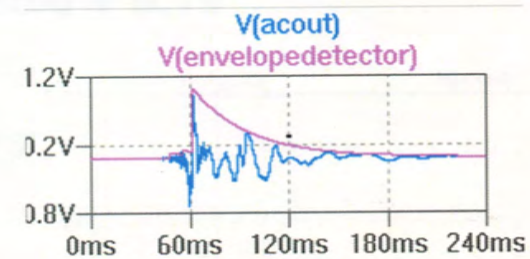
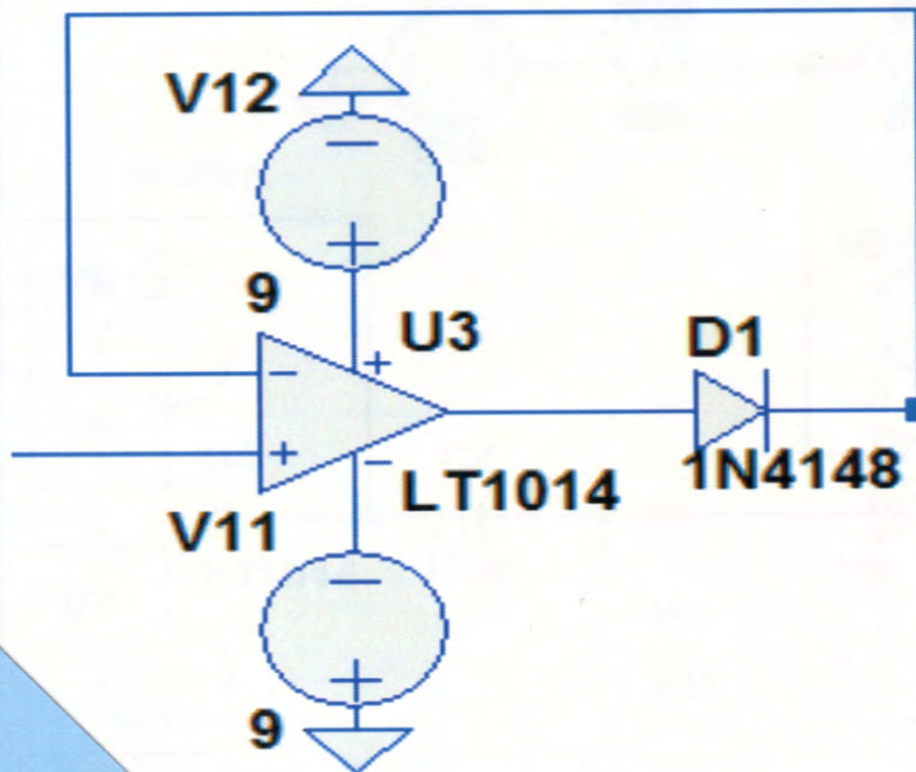


ELECTRICAL



Super diode

Stage 2.1



filter

envelopeFollower

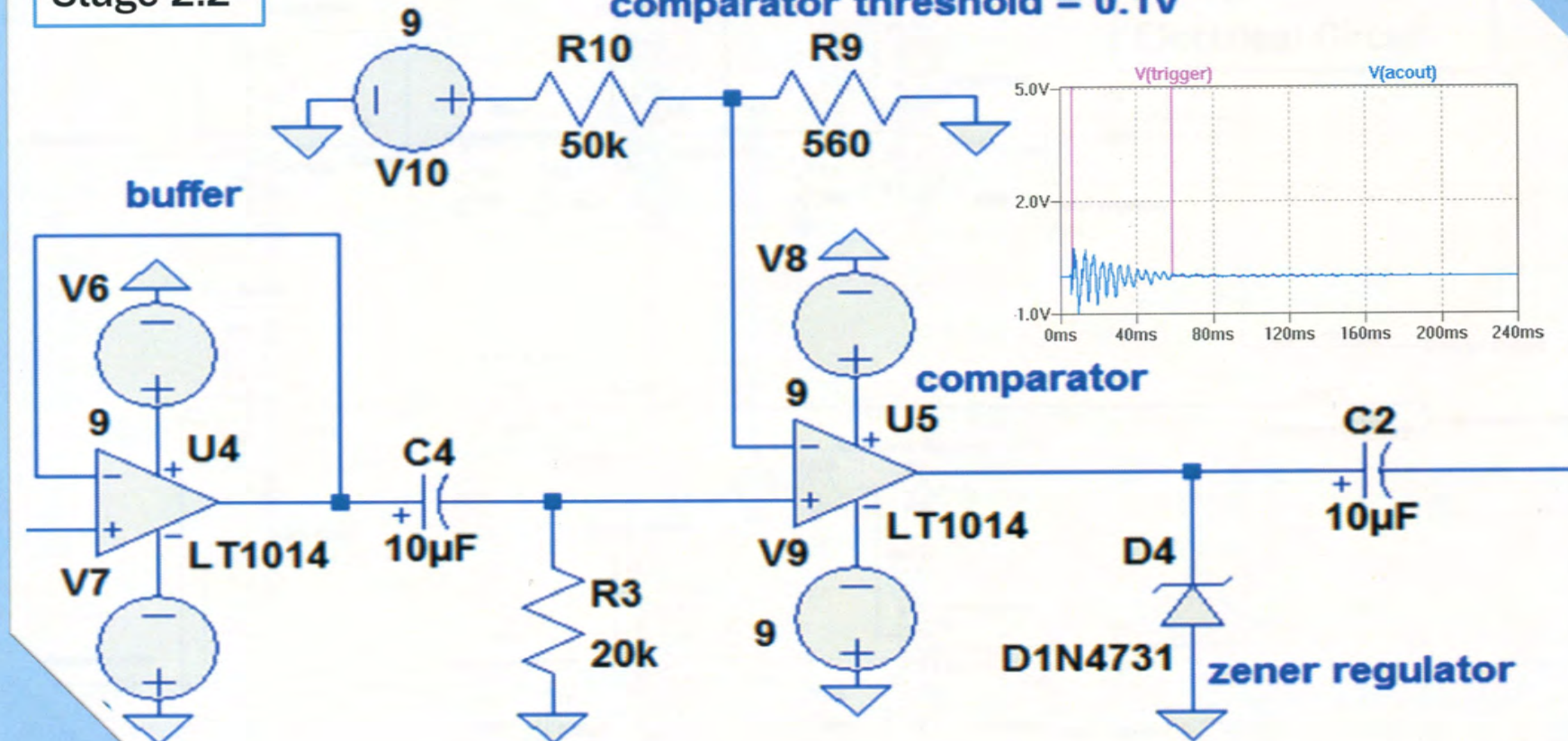


ELECTRICAL

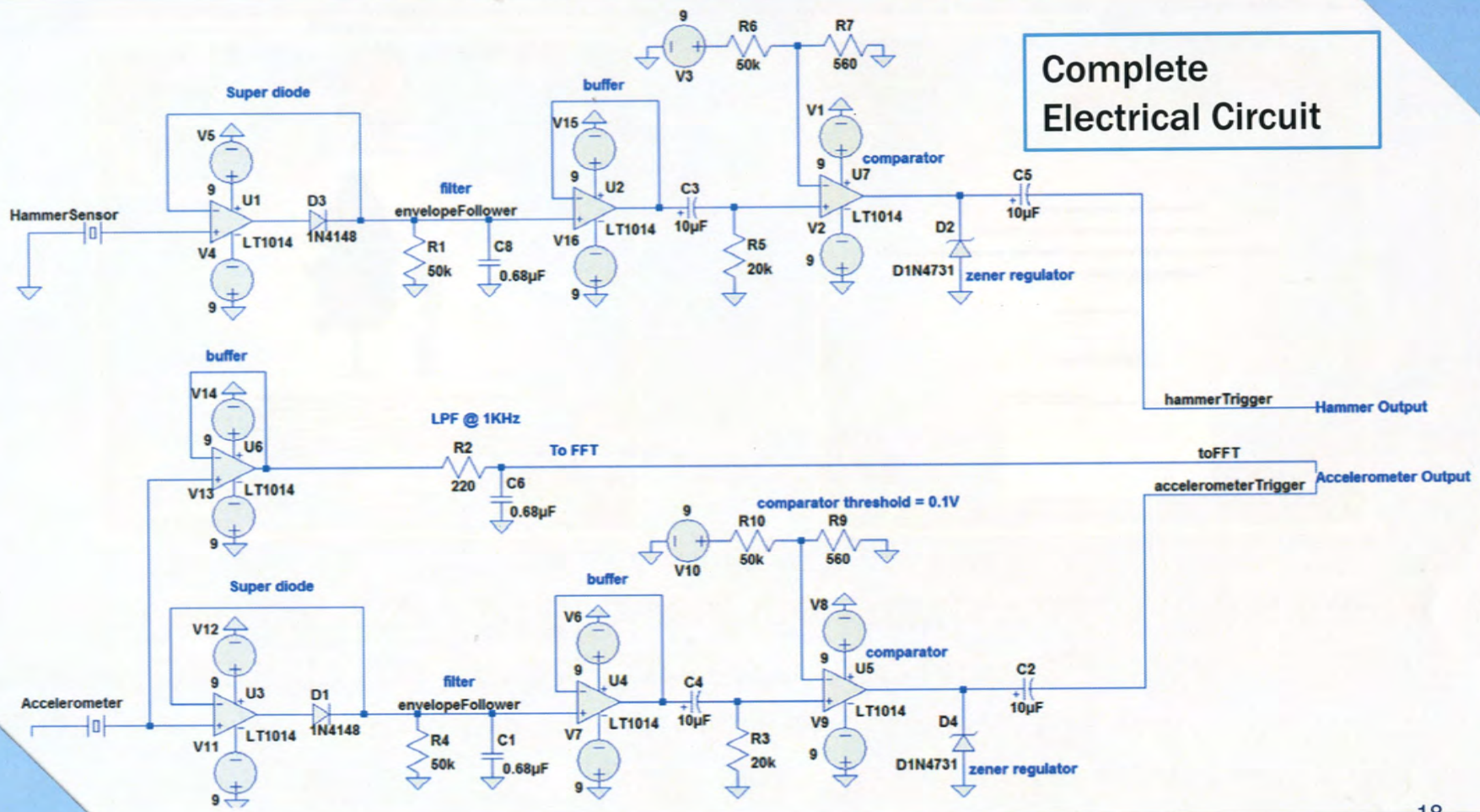


Stage 2.2

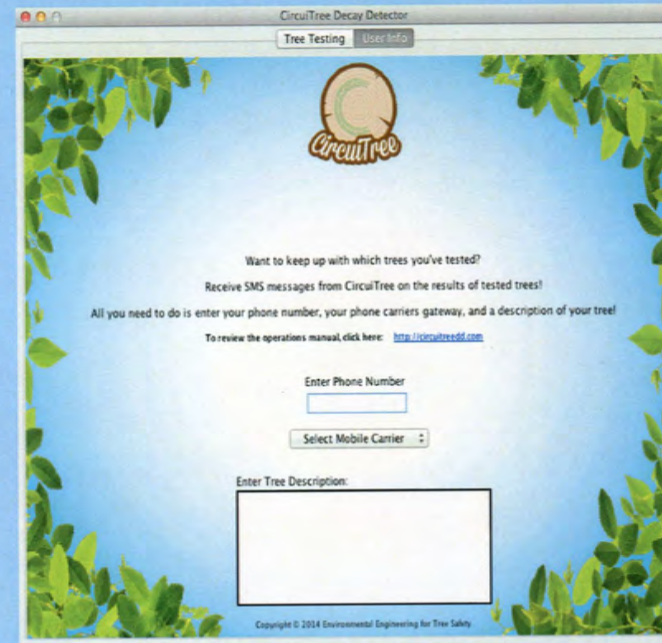
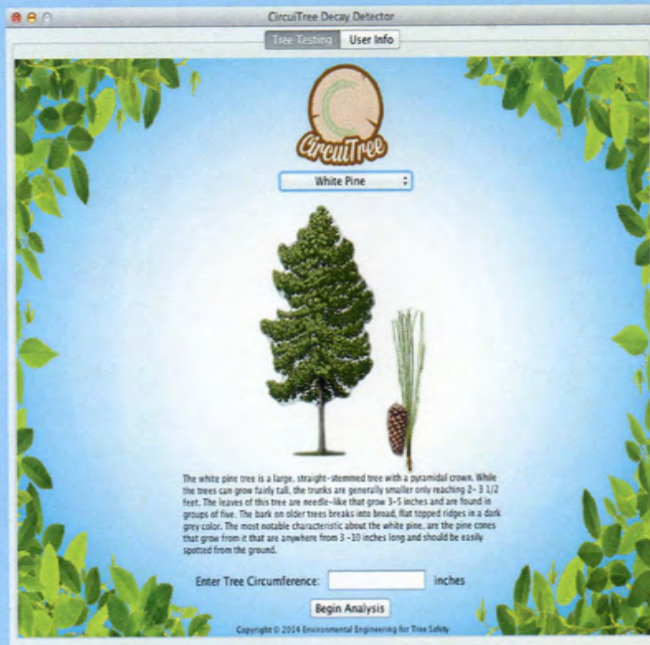
comparator threshold = 0.1V



ELECTRICAL



SOFTWARE



The user selects a tree type, enters the circumference of the tree, and clicks a button to run the test. When a tree type is selected a graphic of the tree, its respective leaf, and a description appears on the GUI so that the user is assured that the correct type of tree is tested.

SOFTWARE



CircuitTree Decay Detector

Tree Testing User Info



Want to keep up with which trees you've tested?
Receive SMS messages from CircuitTree on the results of tested trees!
All you need to do is enter your phone number, your phone carriers gateway, and a description of your tree!
To review the operations manual, click here: <http://circuitreedd.com>

Enter Phone Number

Select Mobile Carrier ▾

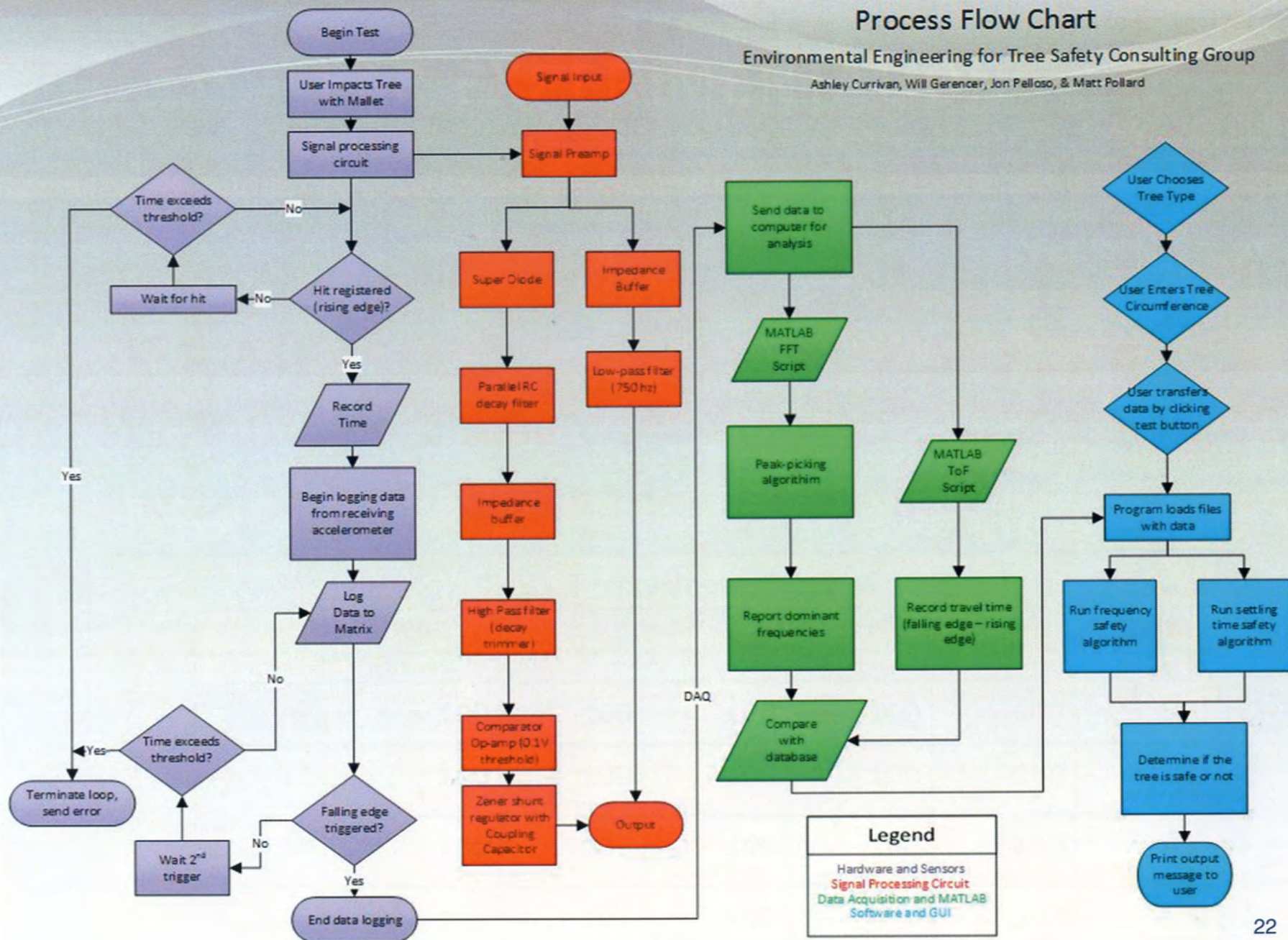
Enter Tree Description:

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CircuiTree Decay Detector Process Flow Chart

Environmental Engineering for Tree Safety Consulting Group

Ashley Currihan, Will Gerencer, Jon Peloso, & Matt Pollard



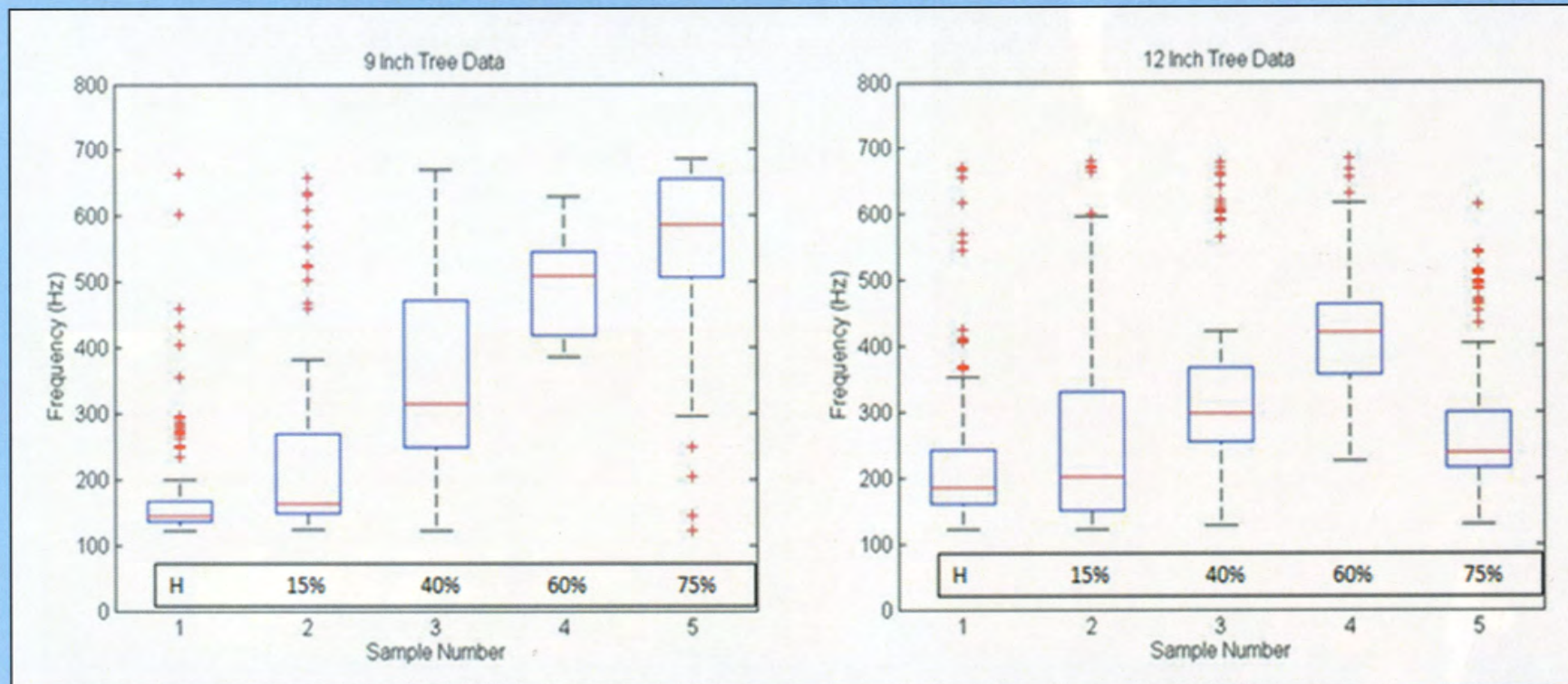
LAB EXPERIMENTATION



- 24 different trunk sections secured to a workbench via a set of clamps
- Varying trunk diameter and decay
- A total of 2,200 experiments undertaken

Diameter (in)	Decay % (of diameter hollowed out)						
		No Decay	15%	30%	45%	60%	75%
	9	100	100	100	100	100	100
	12	100	100	100	100	100	100
	15	100	100	100	100	100	100
	18	100	100	100	0	100	0

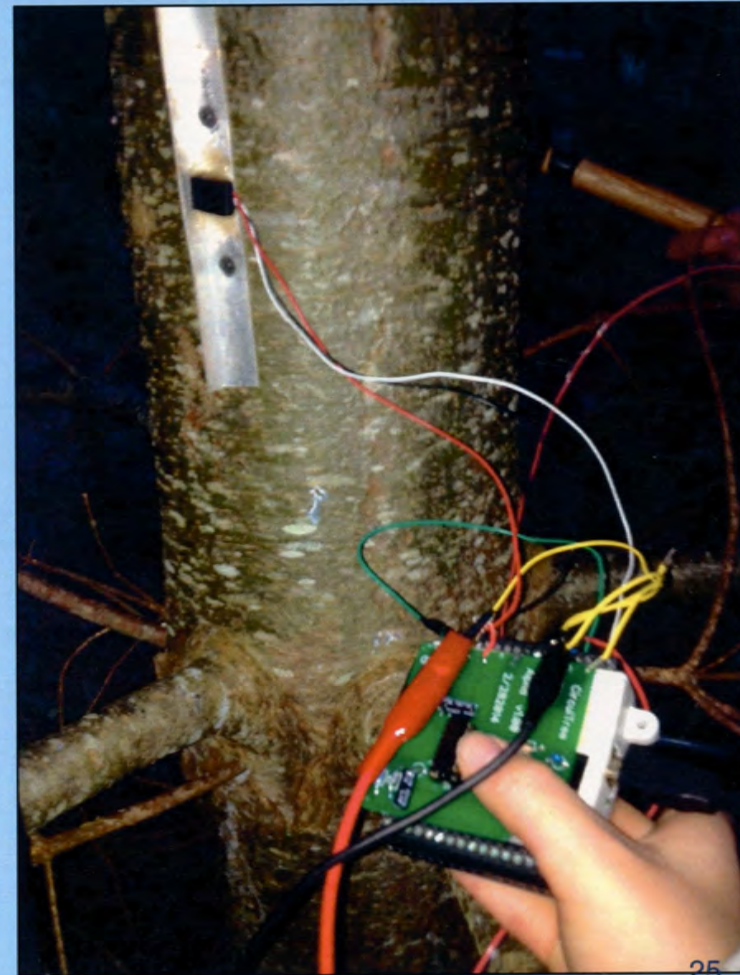
SUMMARY OF LAB RESULTS



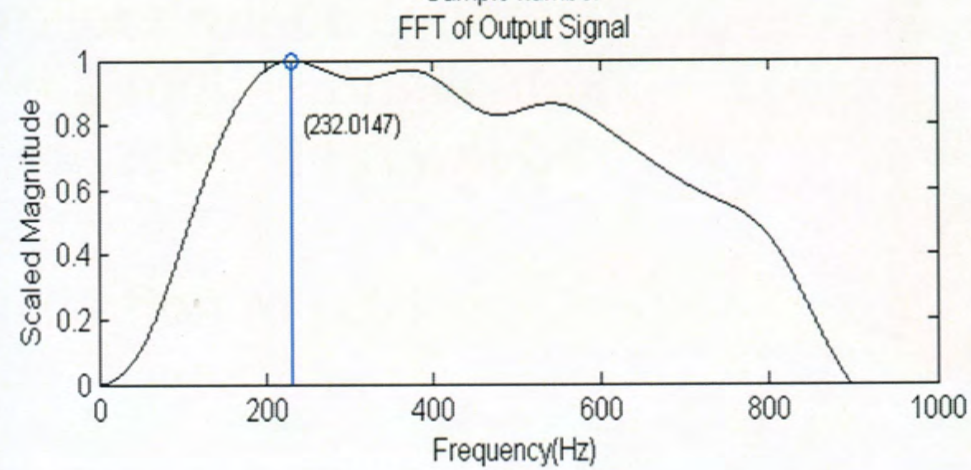
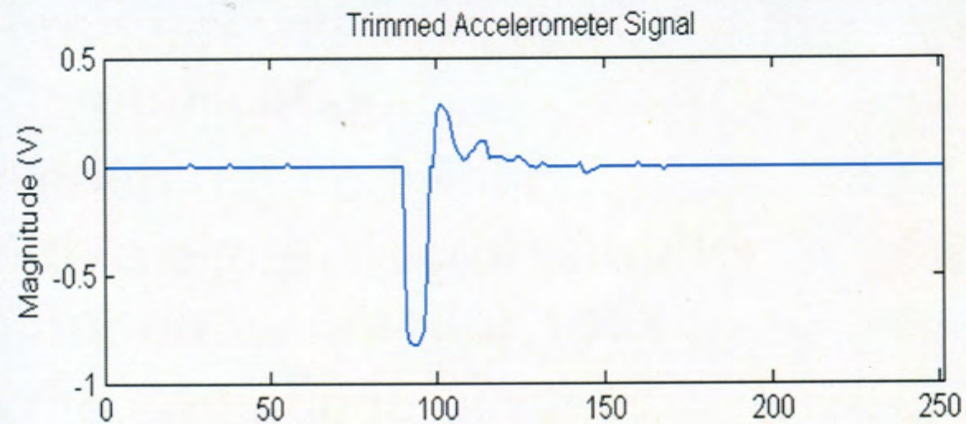
TESTING IN THE FIELD



- CircuiTree tested on white pine trees found in Colt State Park, Bristol, Rhode Island
- Variety of diameters and heights
- All assumed to be healthy specimens.



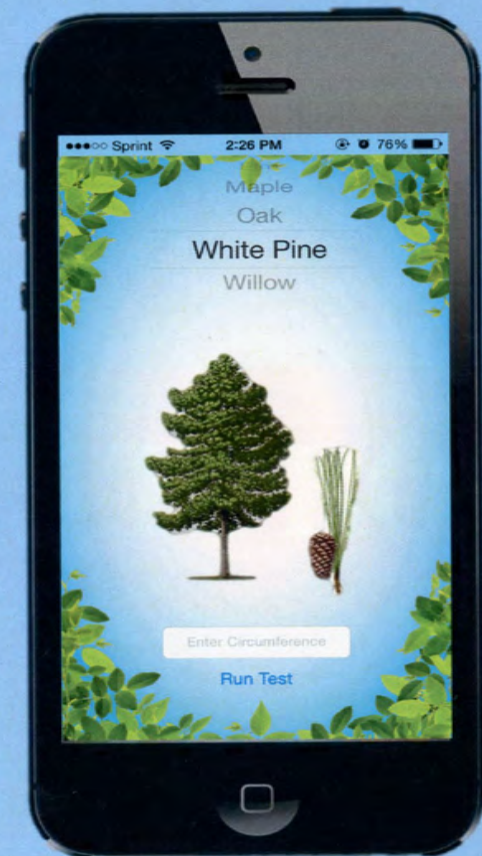
FIELD RESULTS



FULL SCALE IMPLEMENTATION



- The DAQ computer will be replaced with an Apple iOS application.
- Data acquisition method will be replaced with a digital microcontroller with an appropriate sampling rate.
- Data from the embedded microcontrollers will be sent over Bluetooth to a mobile application, where the collected data will be processed.
- Mobile application to retrieve files wirelessly.



BUSINESS PLAN



- Pursue a licensing strategy - Define royalty, performance guarantees and length of partnership.
- Approach companies with complementary product lines such as Husqvarna, John Deere and Toro.
- Manufacturing cost of commercialized product \$20.01.
- Expected sales price of \$49.99.
- Anticipated sales in year 1 of \$305,000 to the consulting group based on licensing agreement.



Husqvarna

TORO



JOHN DEERE

OUTREACH PLAN



- USDA Forestry Services – Hazard Tree Management Program
- USDA Tree Failure Database Program
- International Society of Arboriculture (ISA)
- Tree Care Industry Association (TCIA)
- Nursery Associations



QUESTIONS AND COMMENTS

