Optical Attenuation Sensor for Process Control

Eric A. Borisch

Jeremy D. Protas

Scott D. Ruppert

Christopher J. Spiek

Francis L. Merat, Advisor

**April 21, 1999**

Project Background

- Originated by a company in the Cleveland area

- Robotic binary epoxy sprayer
  - Currently using an optical spectrum analyzer for process control
  - Looking for an inexpensive alternative

Project Goals

- Decreased cost

- Wide dynamic range

- Strong correlation

- Stability

Our Solution

- Frequency source
- Light emitting diode – phototransistor pair
- Amplify & rectify the detected signal
- Take the DC value of the AC component

OSCILATOR   LED   PHOTO-NPN   DC BLOCK   LOCK-IN   LPF

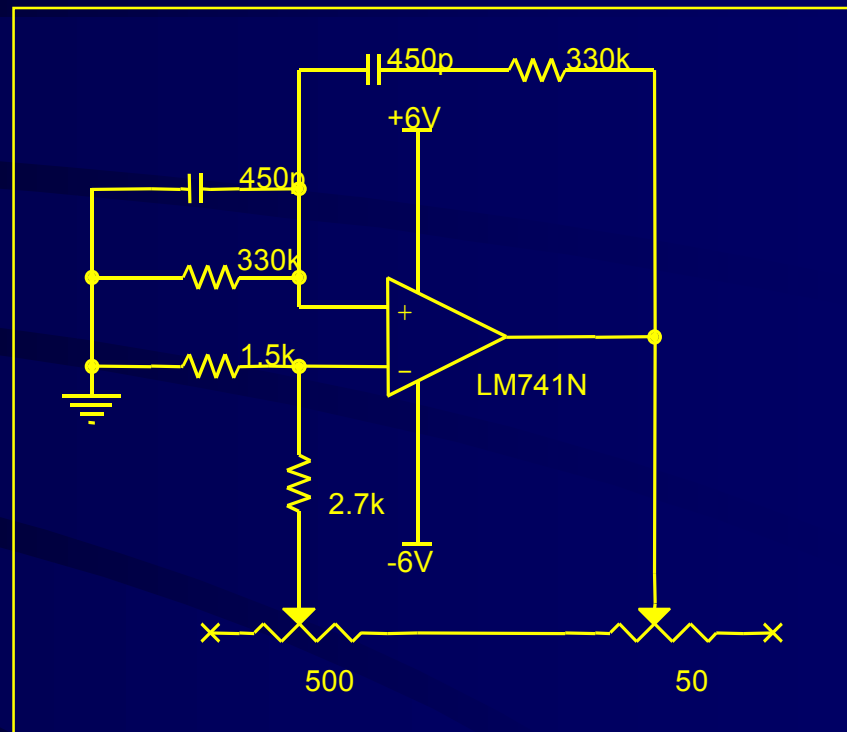LNA   AD630   DC OUTPUT

REFERENCE SIGNAL
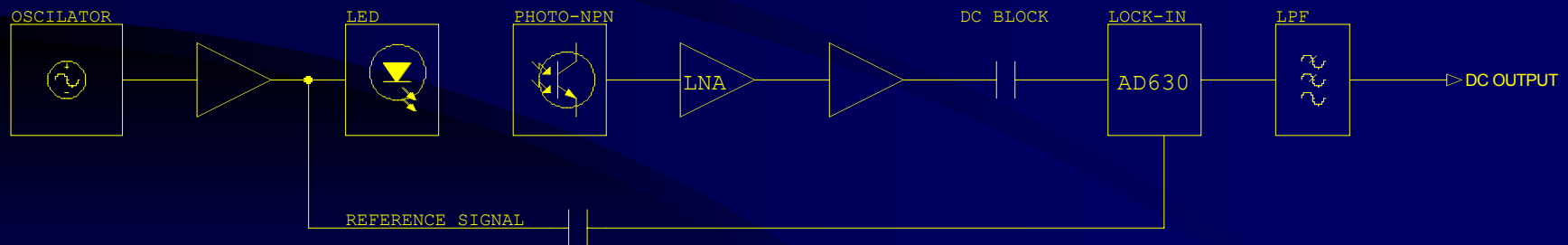
Design Considerations

- Oscillator design
- Optical transmission and detection
- Attenuation measurement
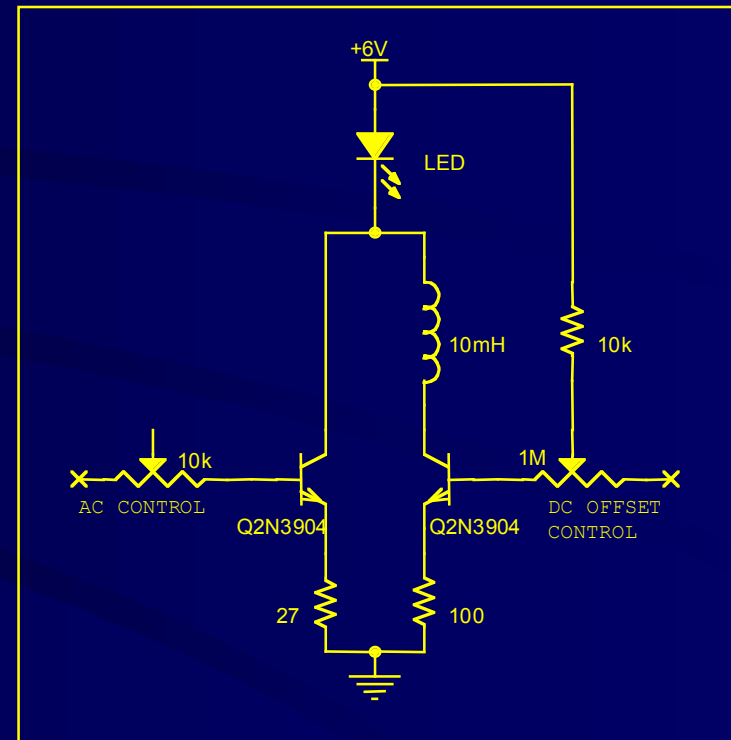- Output

Oscillator Design

- Onboard
- Sine wave or square wave
- Wien Bridge oscillator

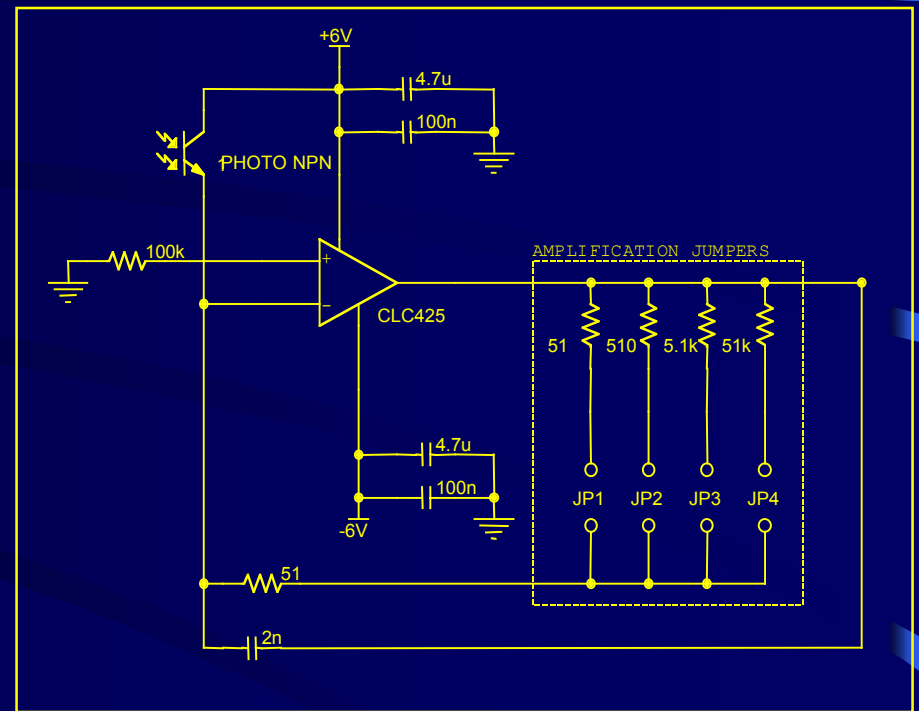

Wien Bridge oscillator

Optical Transmission

- High output infrared LED

- Separate AC & DC drive controls

LED Drive

Optical Detection

- Phototransistor instead of photodiode

- Low noise amplifier
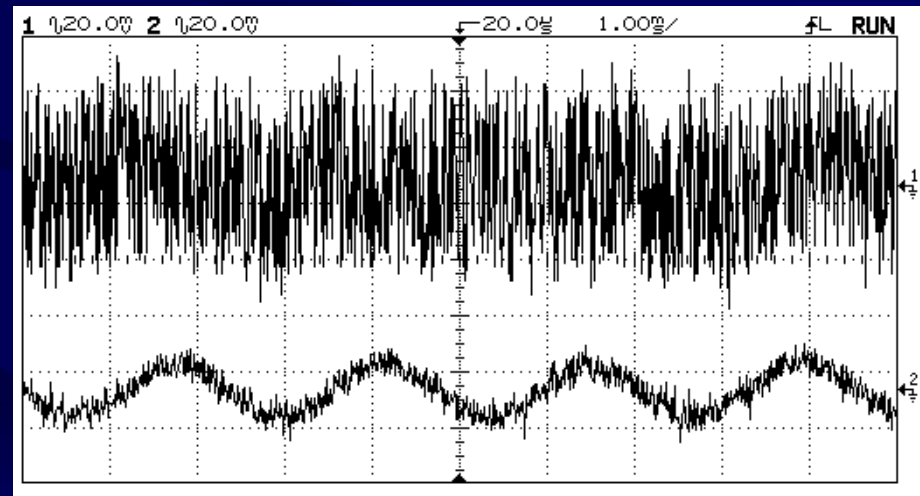
- Variable gain

- Over-amplification detection

Photoreceiver/Amplifier

Optical Attenuation
Sensor for Process Control

Attenuation Measurement

- AD630 - Lock-in amplifier
- Reference & received signals compared
- Low pass filter

Optical Attenuation
Sensor for Process Control

Output

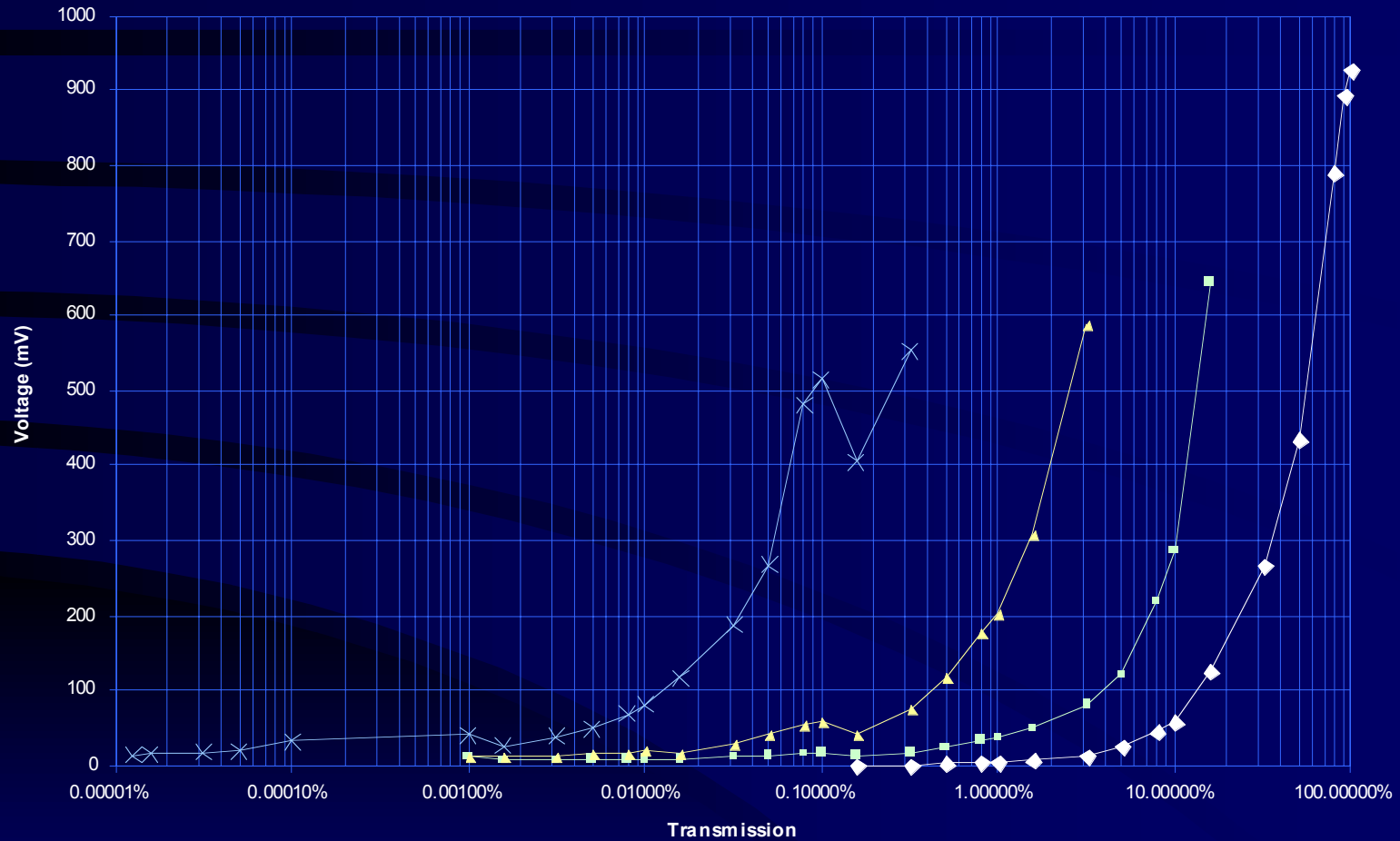- DC value
- Output circuit
  - Adjustable set points
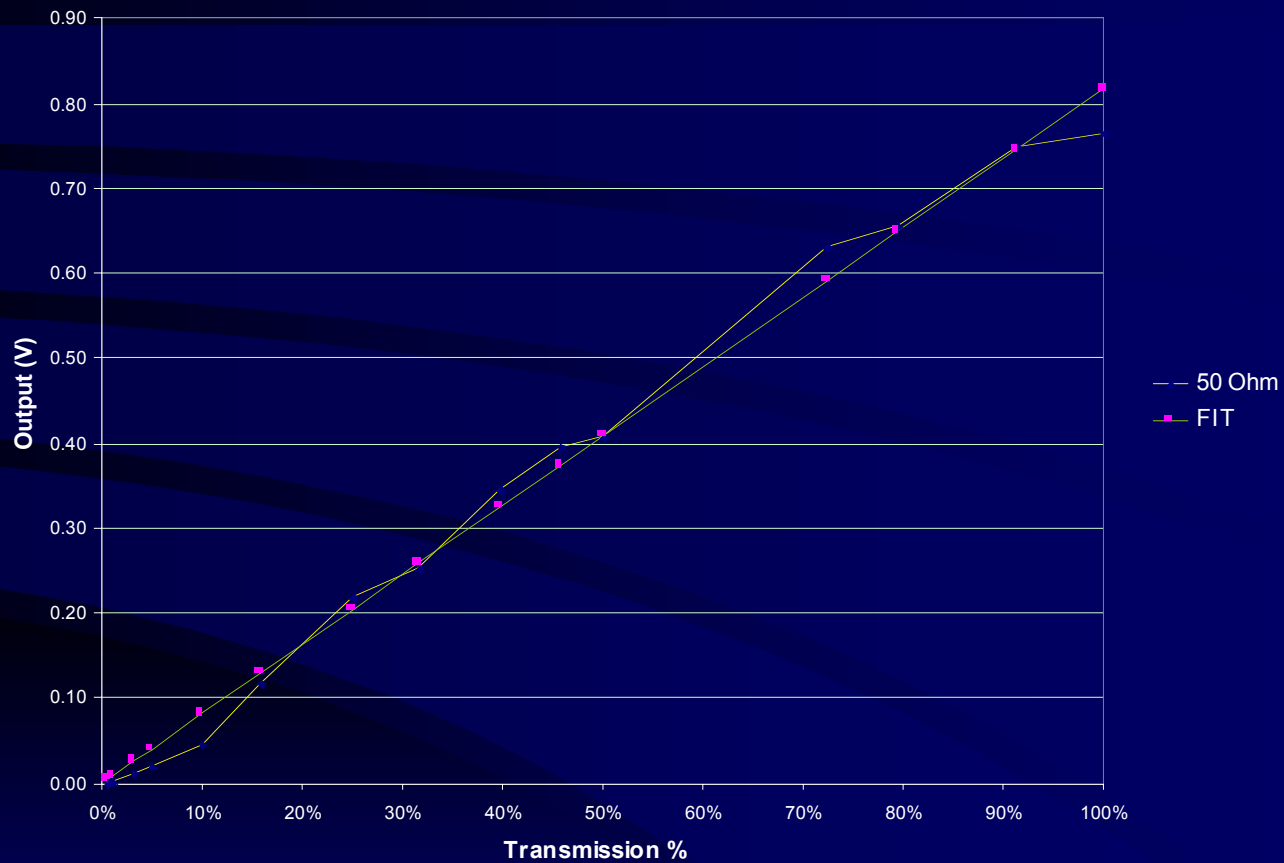 - Easy to read

Results

- Over 50 dB dynamic range

Results

Output Voltage

Results

- Over 50 dB Dynamic Range
- DC output linearly correlated with optical attenuation
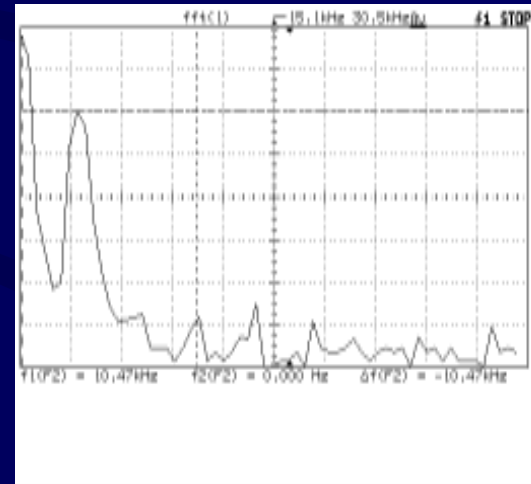
Results

Low Amplification
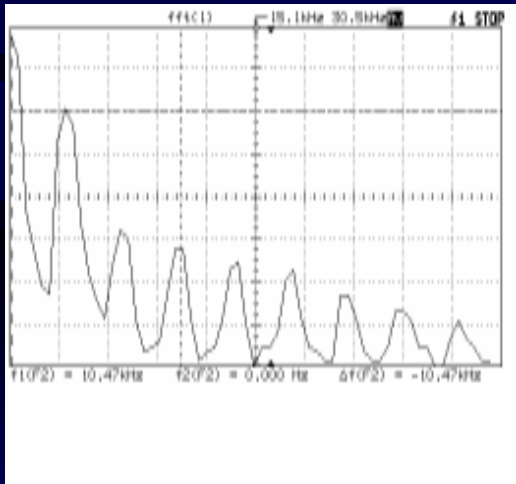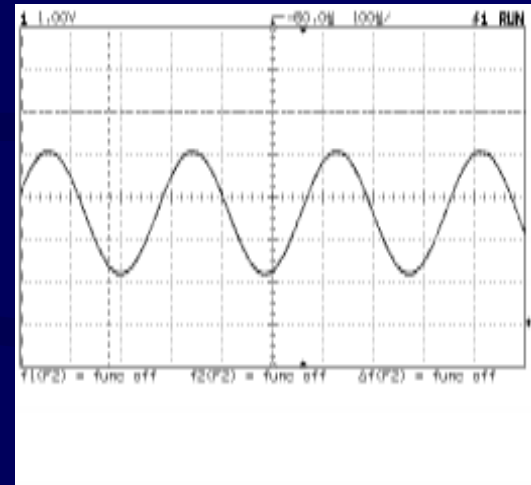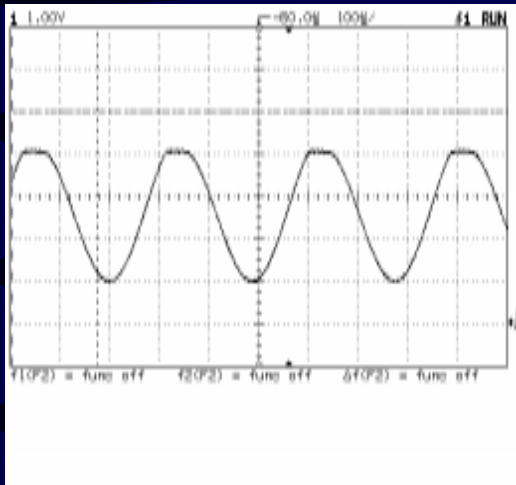
Optical Attenuation
Sensor for Process Control

Results

- Over 50 dB Dynamic Range
- DC output linearly correlated with optical attenuation
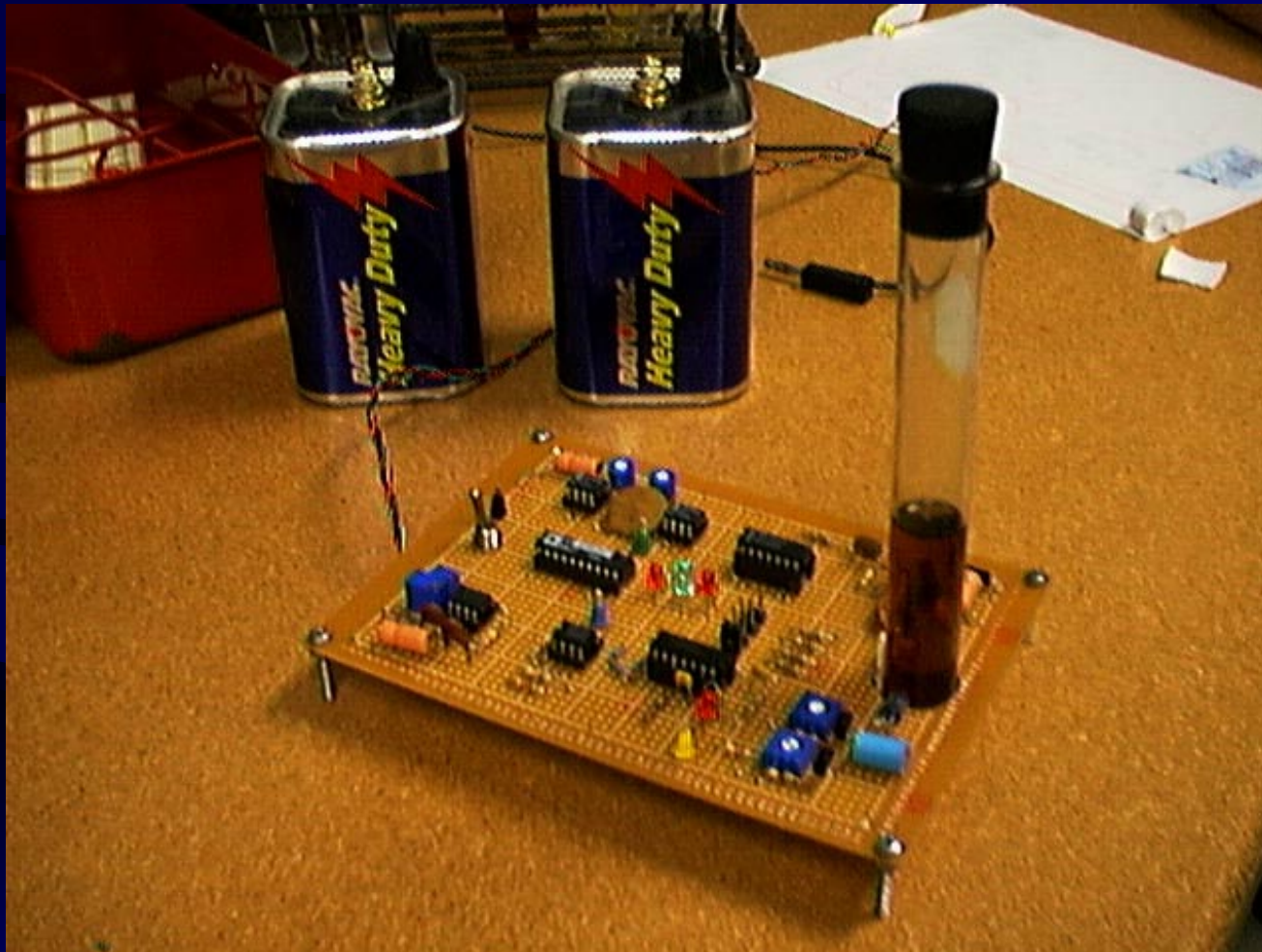- Crosstalk

Results

Optical Attenuation
Sensor for Process Control

Recommendations

- Better sine wave oscillator
- Auto-ranging or application specific
- Packaged for industrial environment
- Multiple circuits with neural network

Demonstration

Optical Attenuation
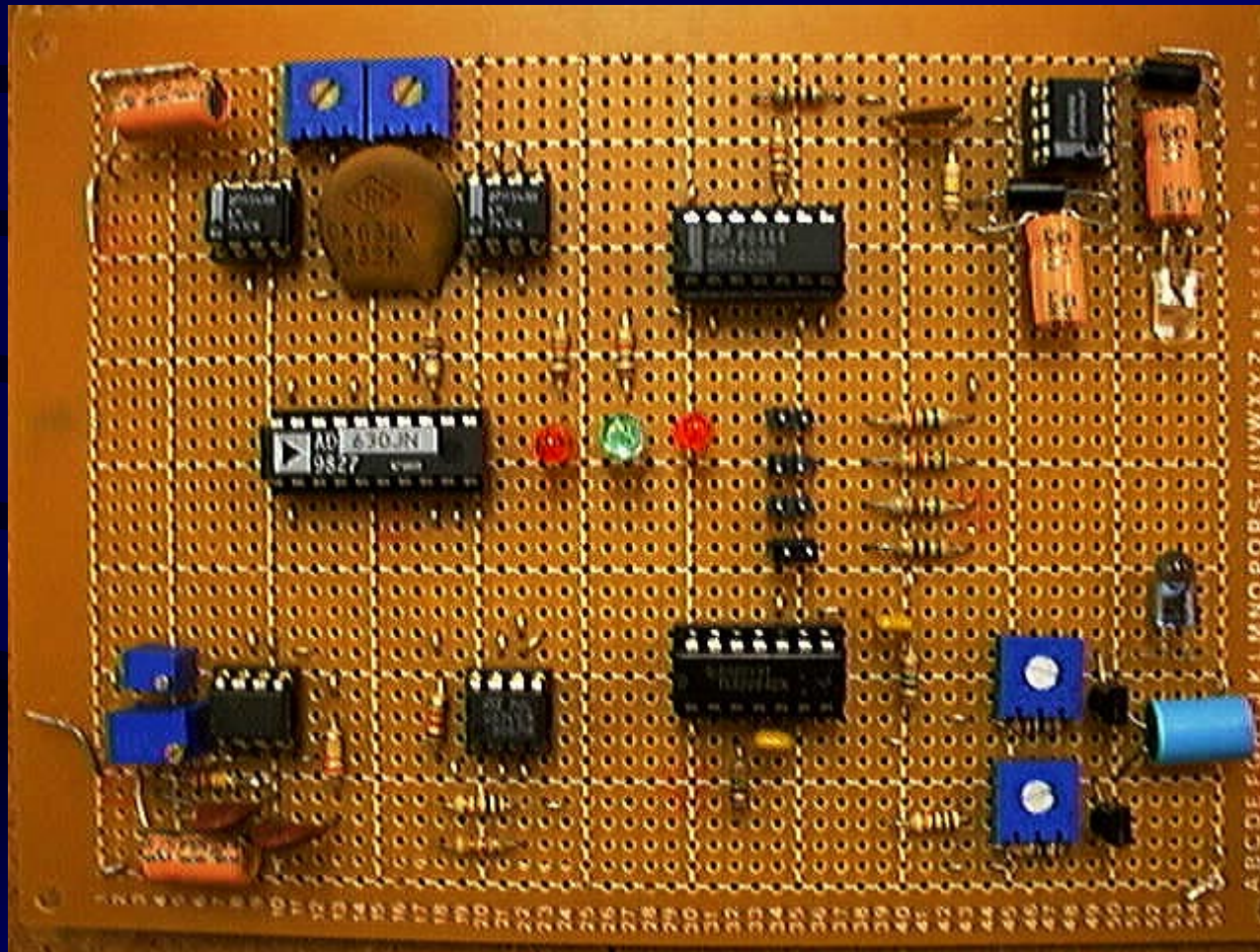Sensor for Process Control

Conclusions

- Goals
  - ☑ Decreased cost
  - ☑ Wide dynamic range
  - ☑ Strong correlation
  - ☑ Stability

- Results
  - Under $50
  - Over 50 dB
  - Repeatability & Linearity
  - Unaffected by Transients

Any Questions?

Optical Attenuation
Sensor for Process Control