# Photomultiplier Tube (PMT) Amplification

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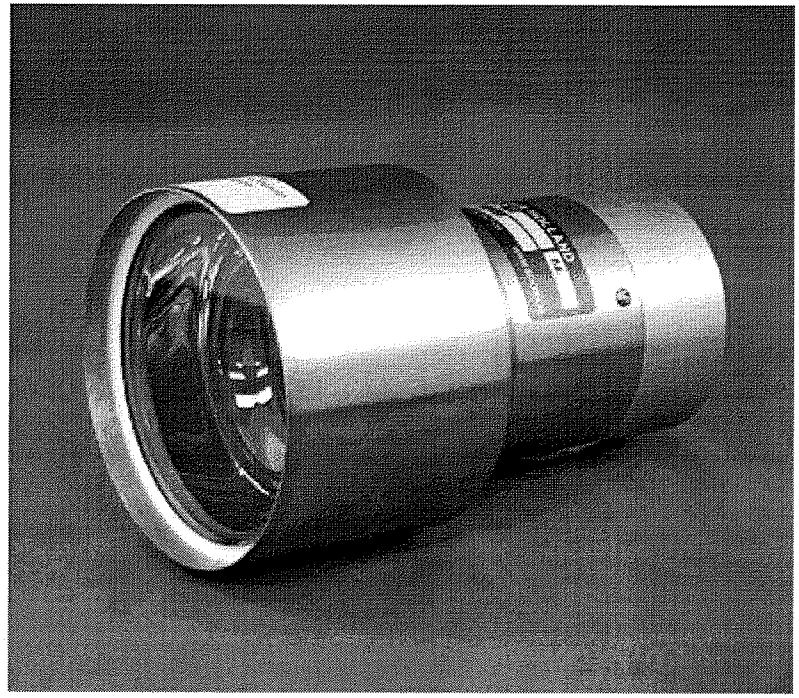
# What is a Photomultiplier?

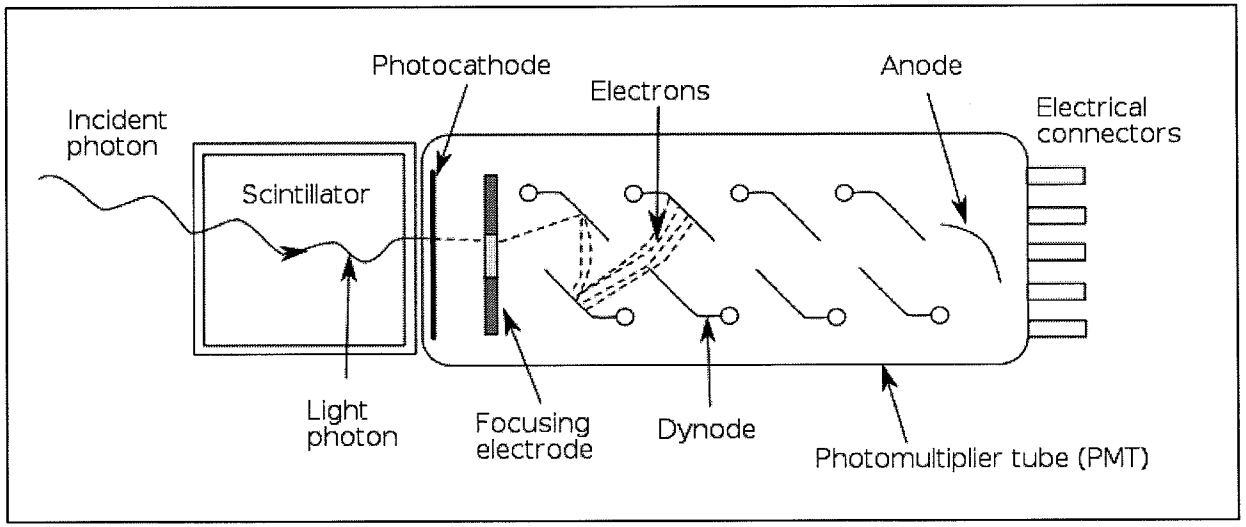
- A photomultiplier is an electronic device used to detect low levels of light



This is a very large PMT. These types are often used in scintillators and various particle detectors.

# What is a Photomultiplier?

- A PMT consists of two basic parts
  - *A photocathode*
  - *An electron multiplier*



# What is a Photomultiplier?

- These devices are capable of detecting individual photons
- The electron ejected from the photocathode is “multiplied”
- The cascade of electrons produces a measurable pulse

# Why Should We Amplify?

- PMT's produce measurable pulses, however these pulses may be masked by electronic noise from the recording device itself
- If we amplify the signal, we can move the pulses above the noise
  - *Single events and multiple events can be more easily distinguished*
- In addition, amplification prevents electronic noise from being considered as an event

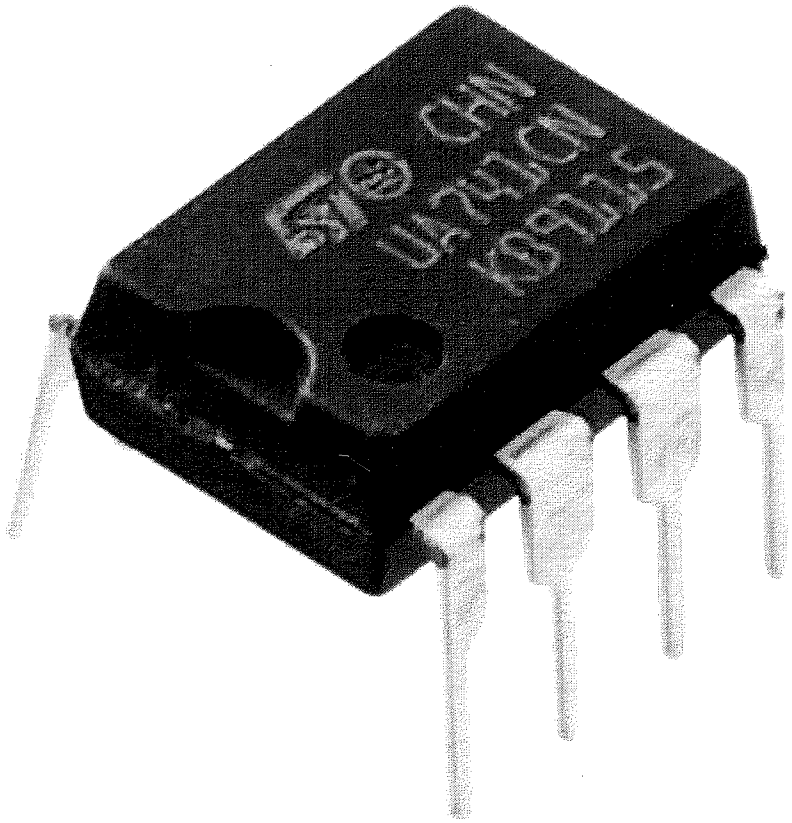
# Amplifiers

- There are many different varieties of amplifiers we can consider
- General properties of a suitable amplifier
  - *Low amplifier noise*
  - *High durability*
  - *Fast Response*
  - *Large Bandwidth (slew rate)*
  - *Large Gain*

# Operational Amplifiers

- When considering our problem, we decided to use an "operational amplifier" or "op amp" for short.
- Op amps are typically integrated chips and are fairly cheap

# Operational Amplifiers



This is the LM741 solid state op amp. This op amp is a very common and very cheap electronic component. This chip is like the Toyota Camry of electronics. Any electronics seller that does not sell this chip is not a real electronics seller.

# LM741 Op Amp

- Benefits
  - *The LM741 is a rugged component*
  - *It is very cheap (approximately $0.50 per chip)*
- Drawbacks
  - *Low slew rate*
  - *Insufficient Bandwidth*

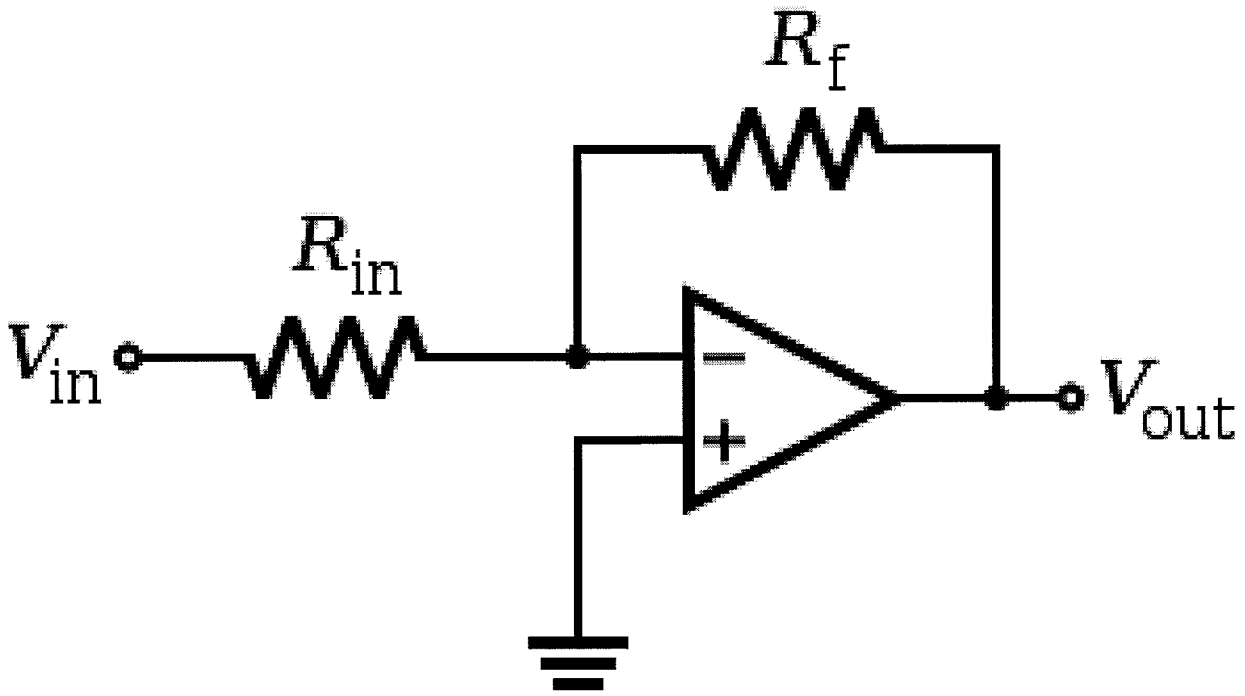
# 595-THS3202D Fast Op Amp

- Benefits
  - *High slew rate and bandwidth*
  - *Capable of large gain*
- Drawbacks
  - *Small size*
  - *Fragile*
  - *Fairly expensive ($10.00 per chip)*

# Considerations

- When using an amplifier the following components are crucial in determining the success or failure of the module
  - *Power Supply*
  - *Inverting/Non-Inverting*
  - *Current Feedback or Voltage Feedback*
  - *Shielded Cables and Short Cables*
  - *Output/Input Impedances*

# Inverting Amplifier




This is an inverting amplifier. An inverting amplifier tends to be more stable in its output than a non-inverting amplifier.

# Voltage Feedback Op Amp

- Output voltage is based upon difference of potentials between two terminals
- No minimum resistance is required to stabilize the output
- The LM741 op amp is a voltage feedback amplifier (VFA)

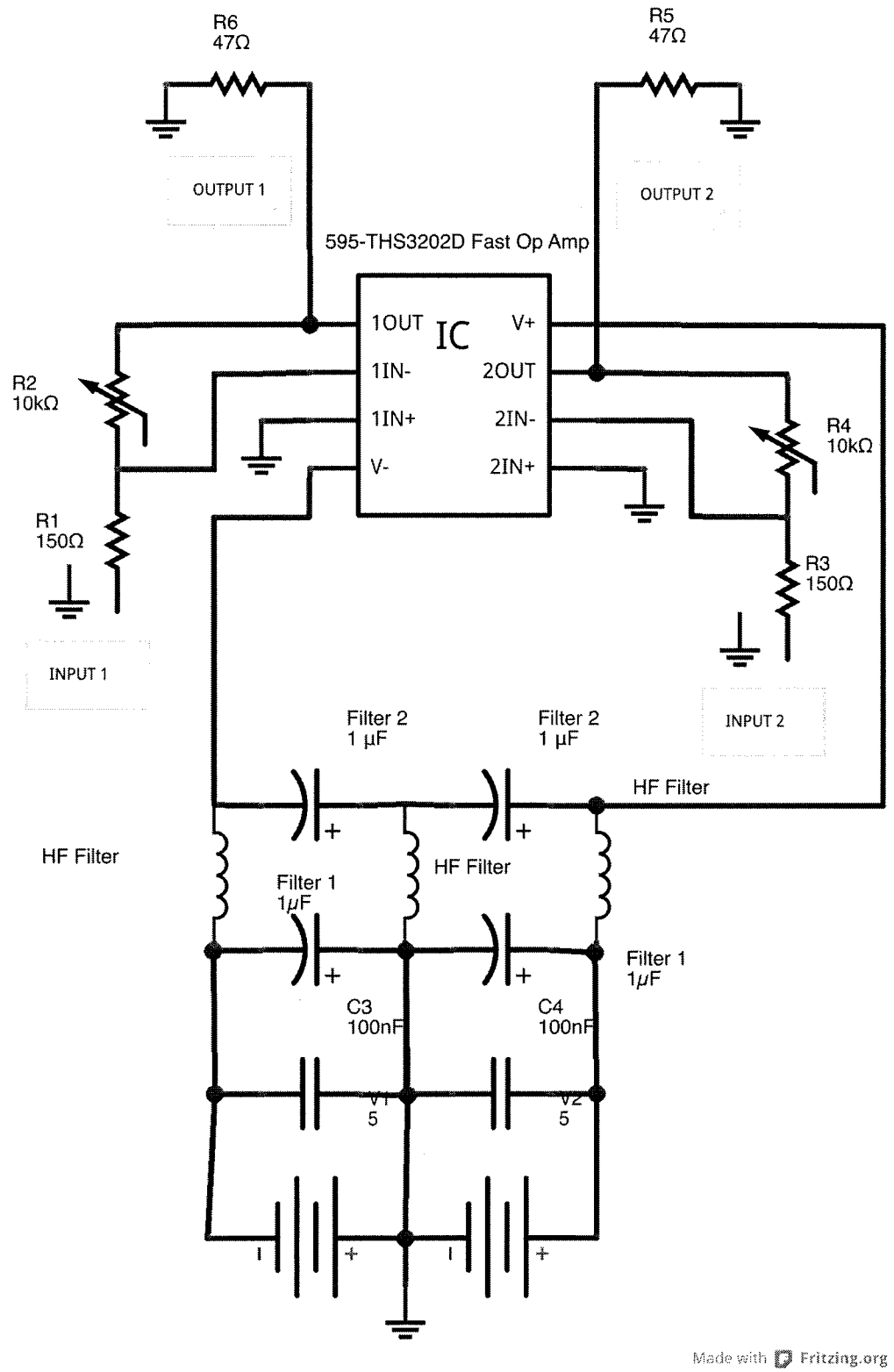
# Current Feedback Op Amp

- Output voltage is based upon a difference in currents between the input terminals
- A minimum resistance on the input terminals is required to stabilize the output
- The 595-THS3202D is a Current Feedback Amplifier (CFA)

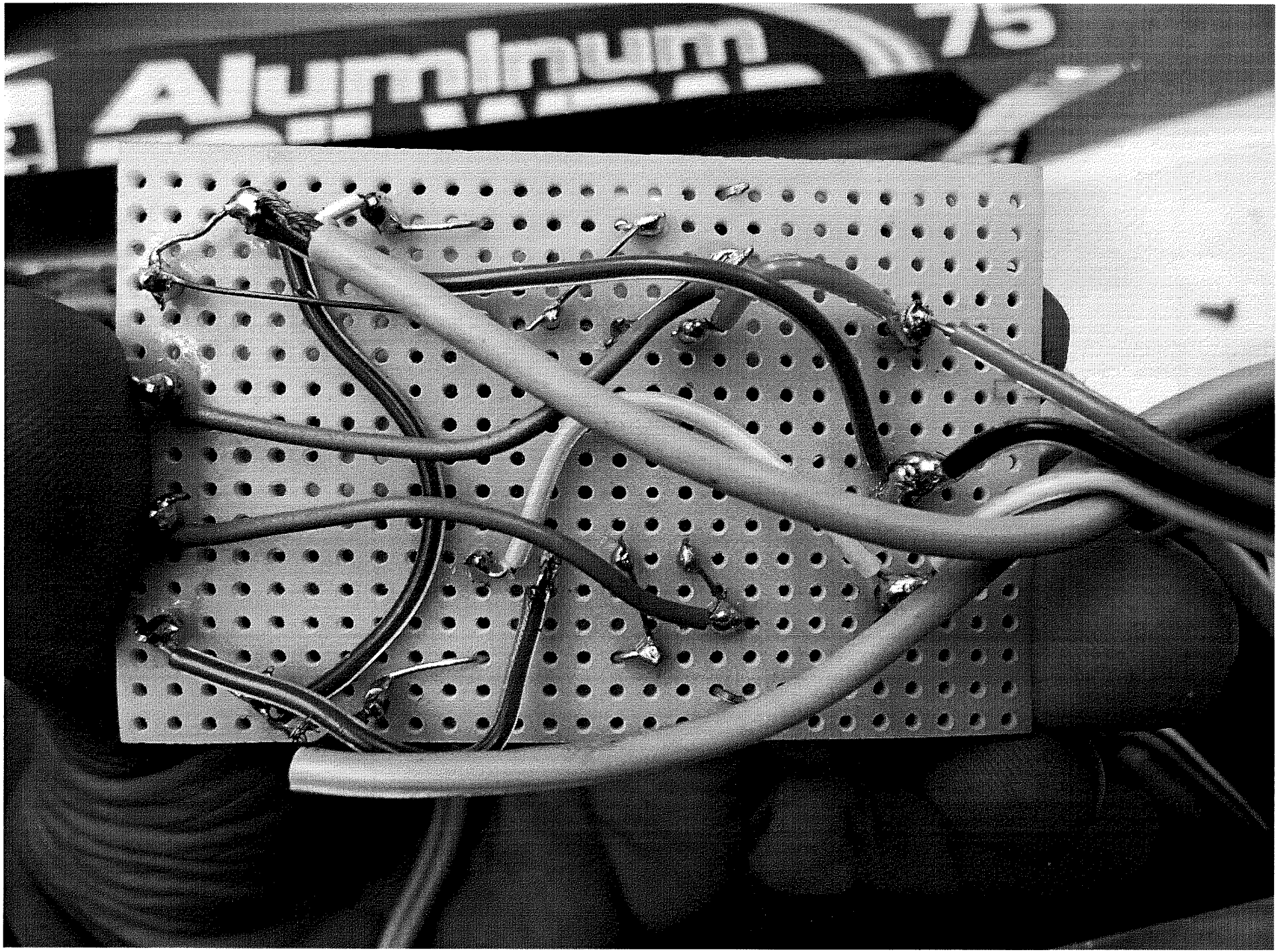
# Drawbacks of a CFA

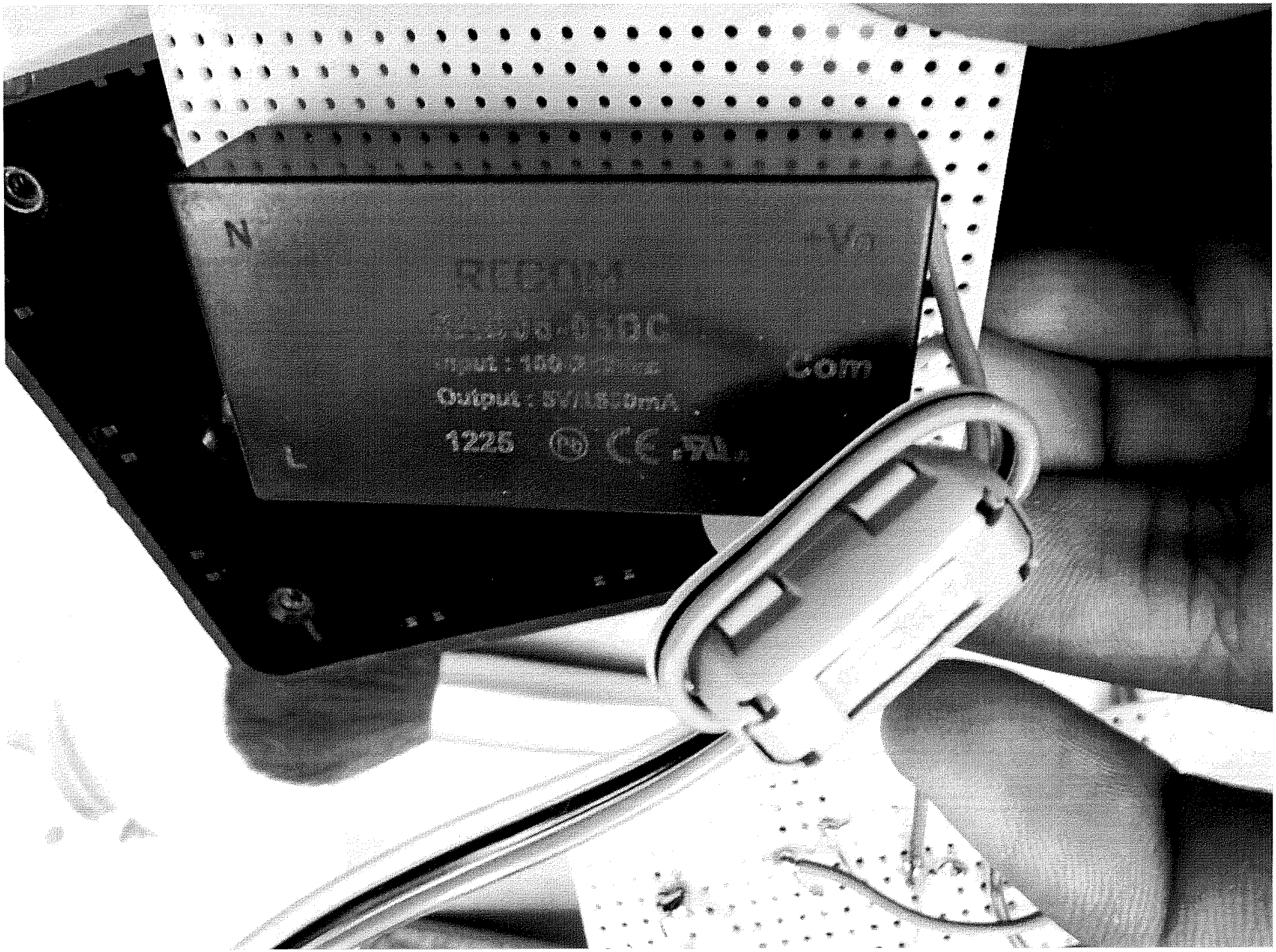
- If no resistor is placed in series with input terminal, the amplifier may began to oscillate
- This will cause the amplifier to oscillate at its own frequency which will swamp out the original signal

# Circuit Design



0.65mm PITCH
SOIC 20PINS
0805
0805
GND
GND
VCC
10
11
20
1


Aluminum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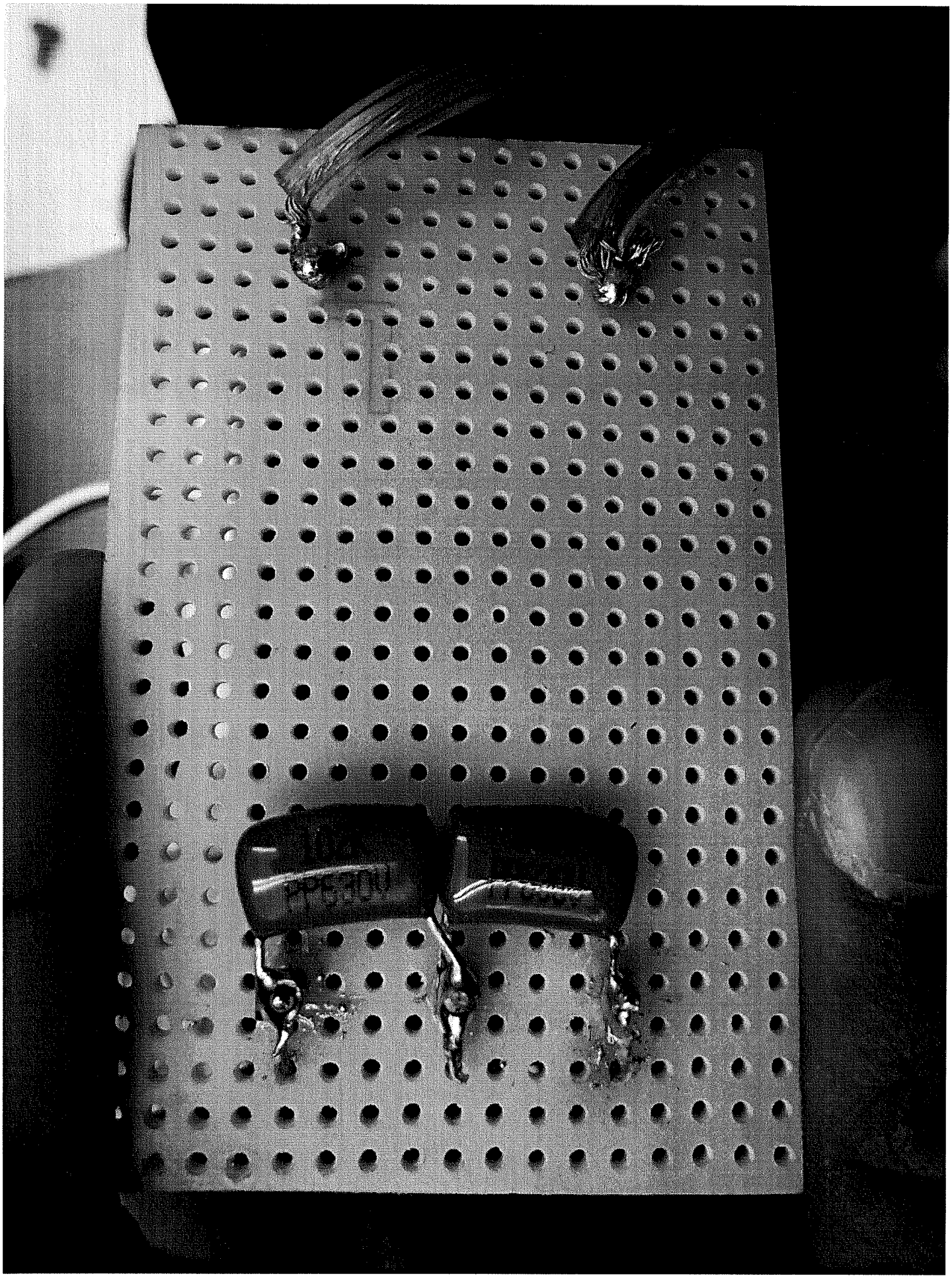
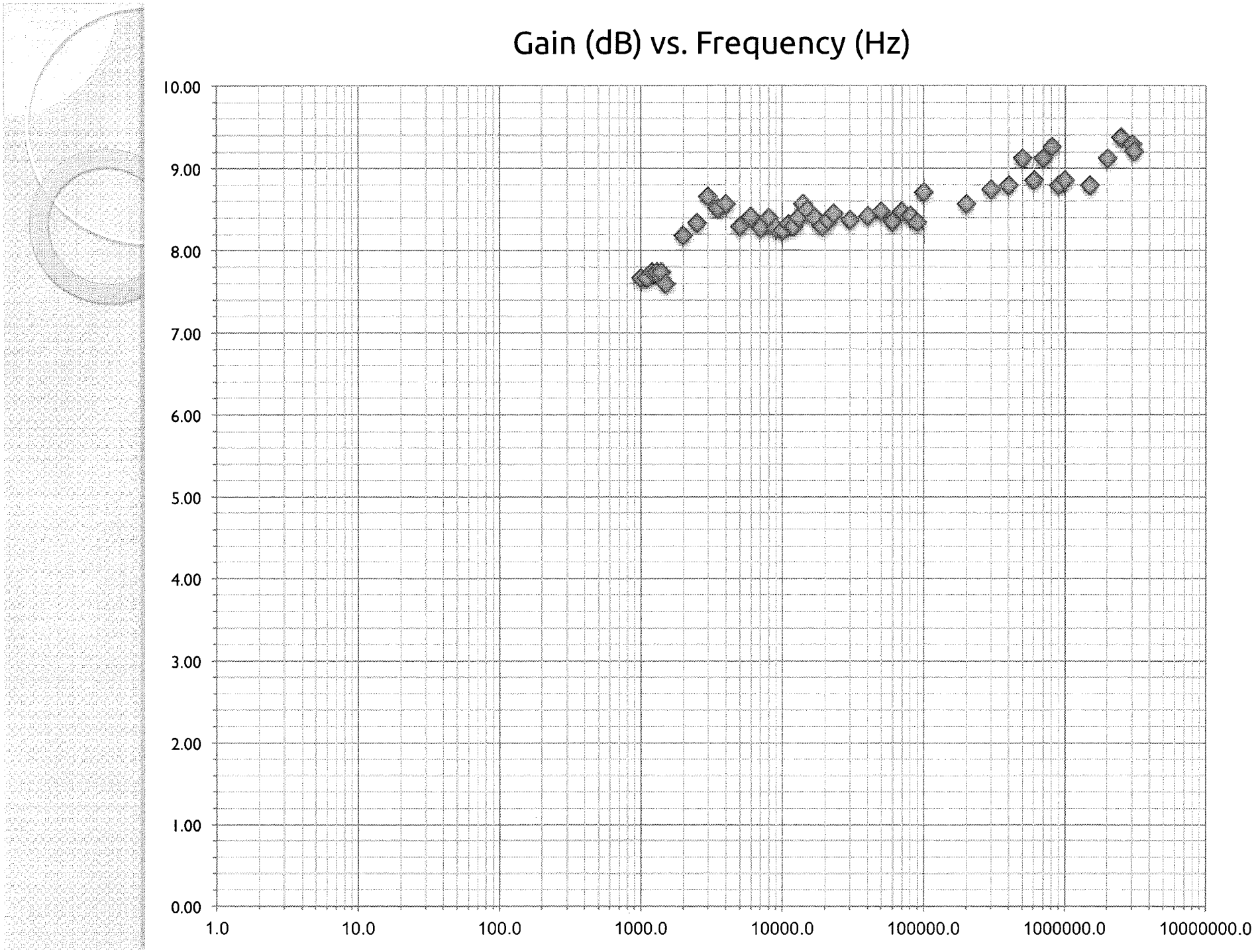
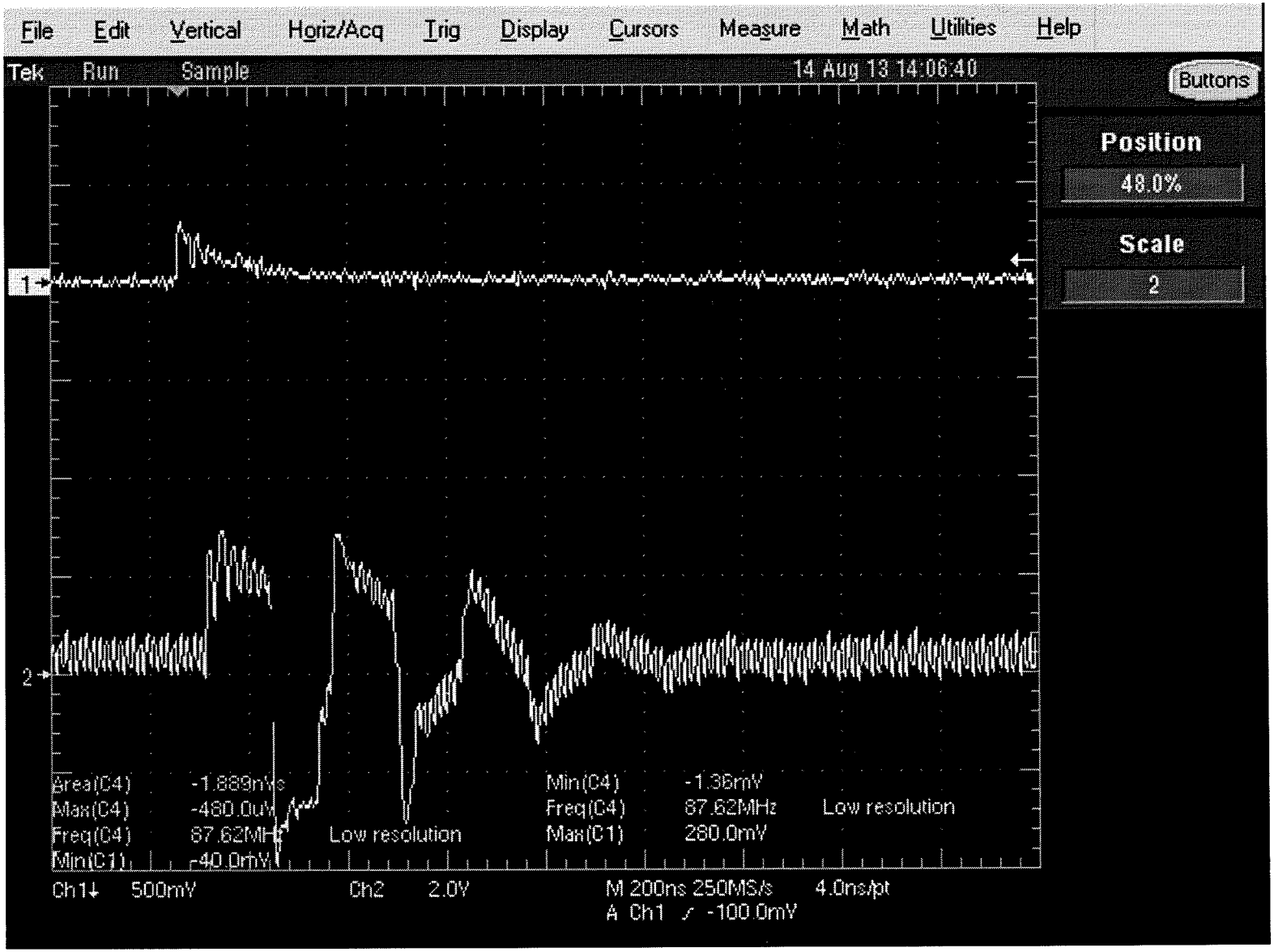


# Amplifier Tests

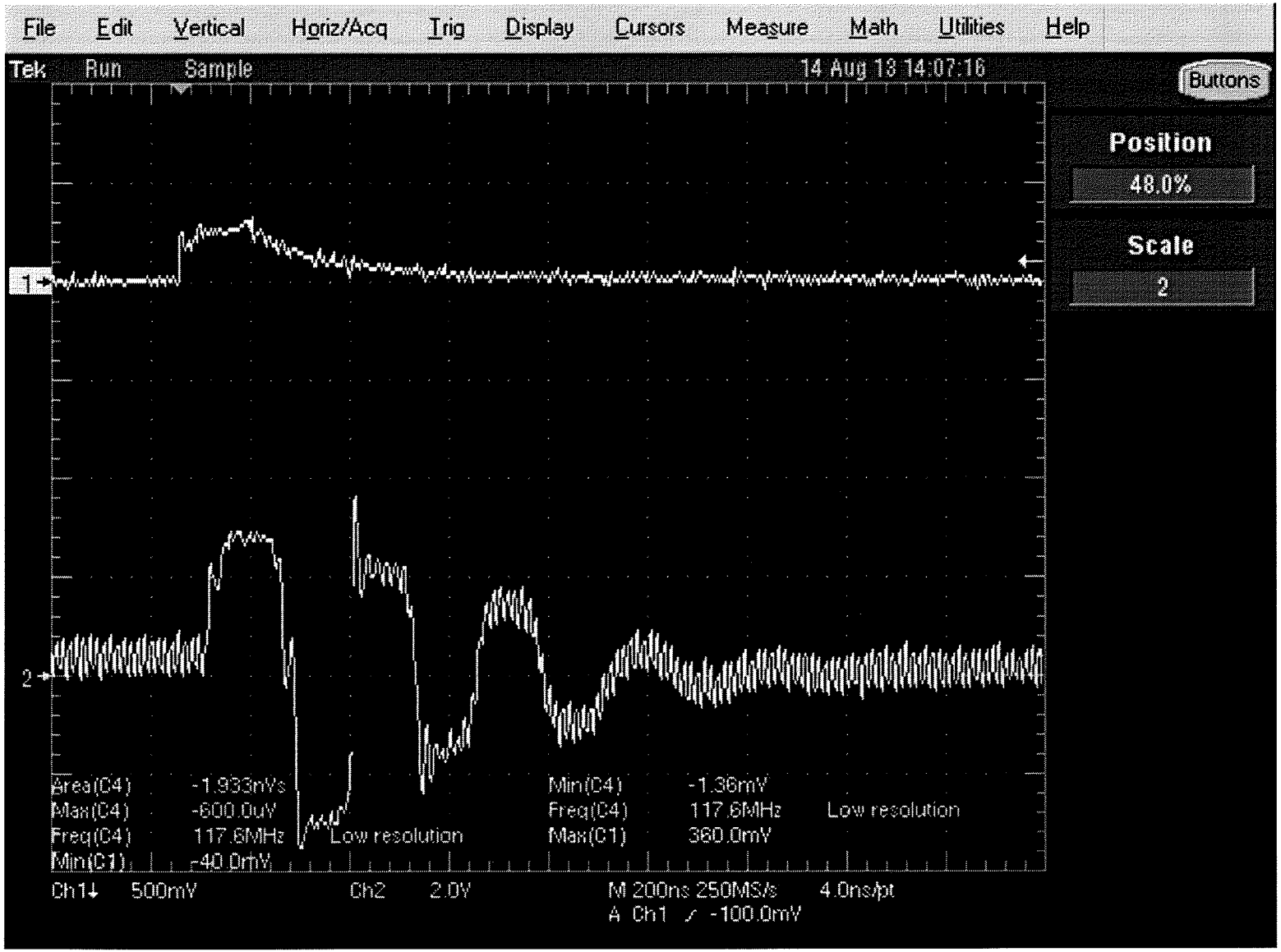
- The amplifier was tested with a frequency sweep from 0 to 3 MHz with a sinusoidal waveform
- In addition the amplifier was tested with an Avtech AV-1030-C pulse generator


Gain (dB) vs. Frequency (Hz)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1.0
10.0
100.0
1000.0
10000.0
100000.0
1000000.0
10000000.0

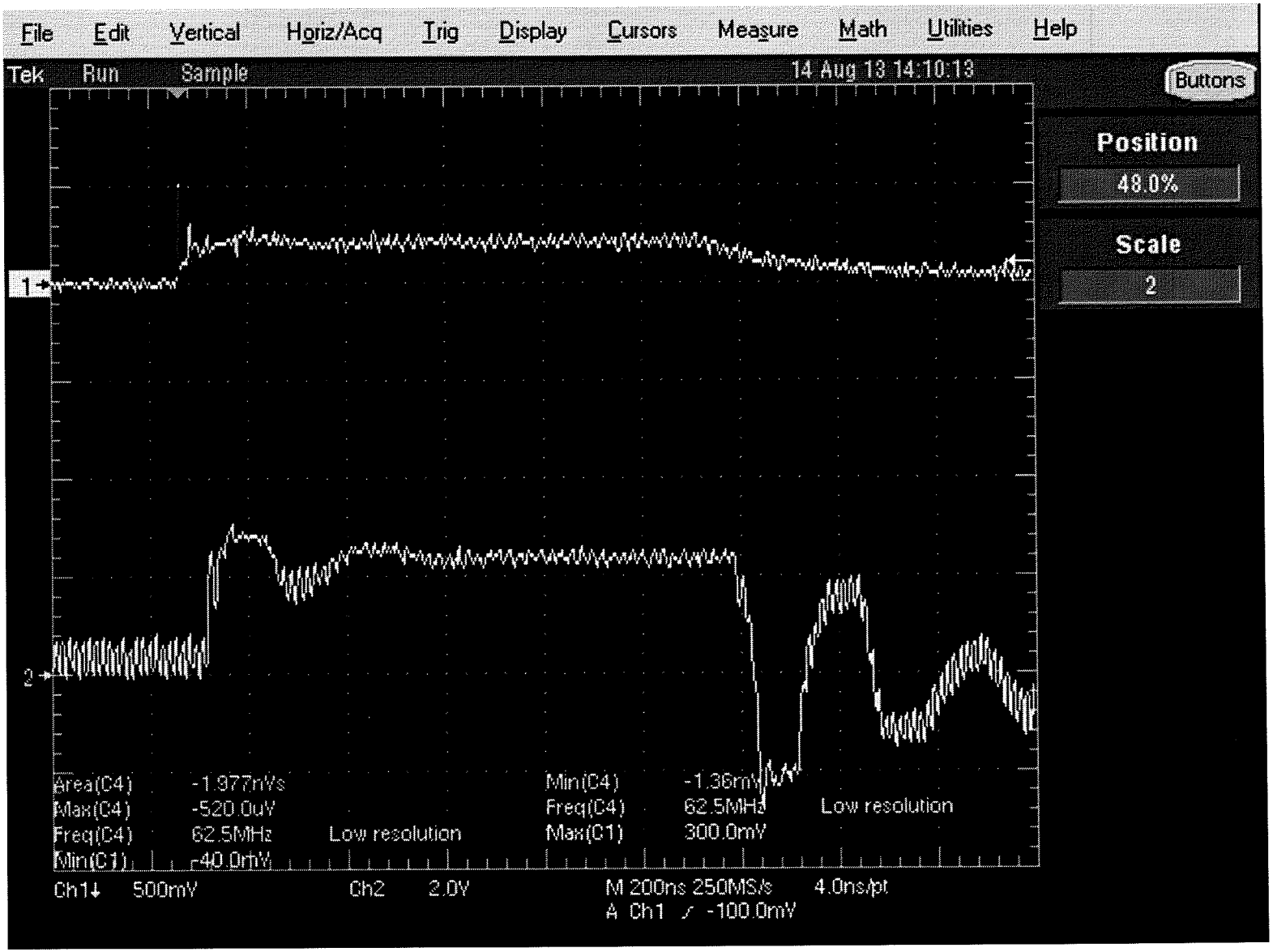
# 15 nanosecond pulse



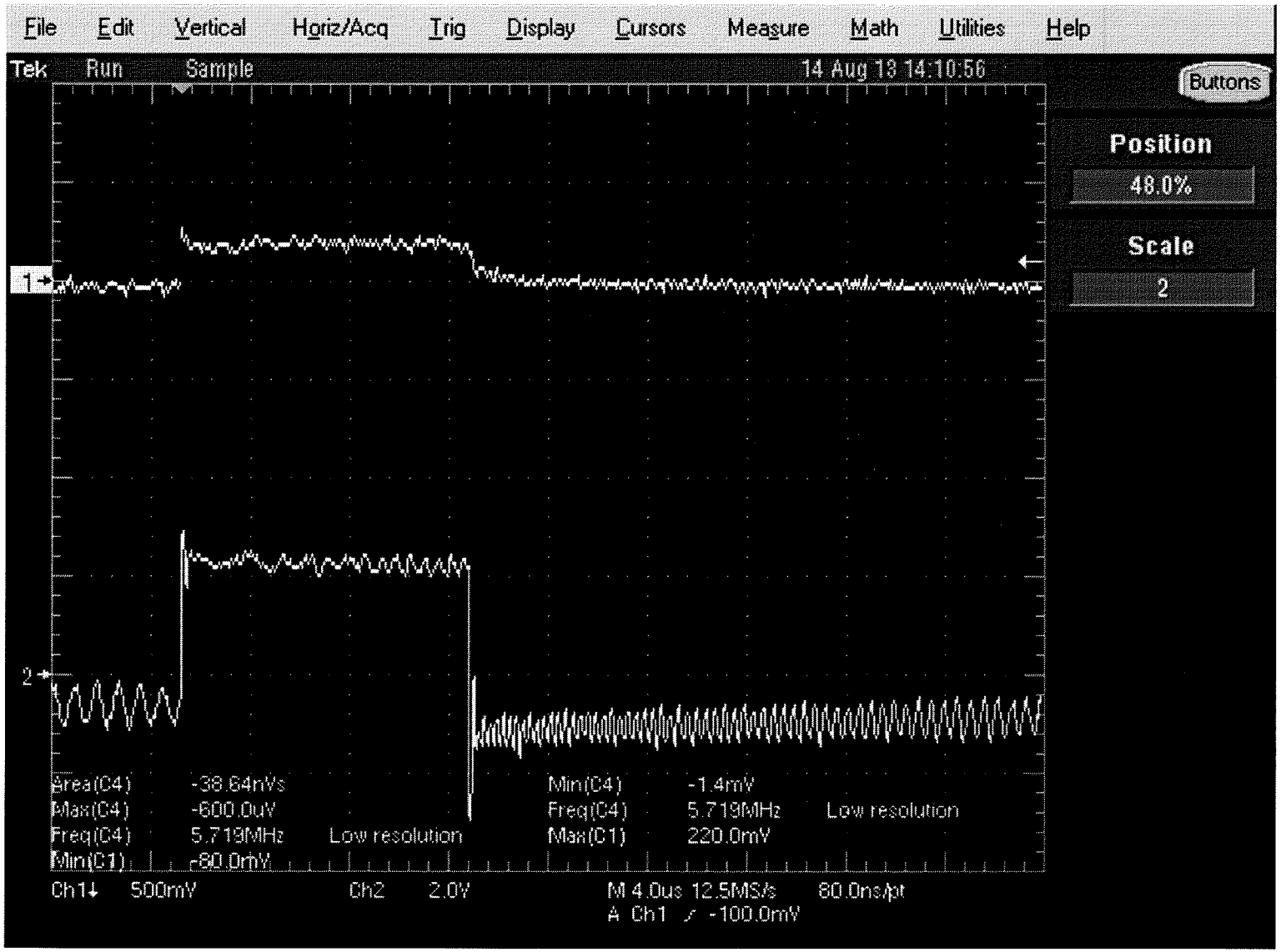
# 100 nanosecond pulse



# 1 microsecond pulse



# 10 microsecond pulse



# Conclusion

- From our frequency sweep tests and our pulse generator tests, we have shown that the 595-THS3202D fast op amp is adequate for the amplification of a PMT signal
- This amplifier is adequate for many nuclear physics experiments

# Questions?