LarTPC Electronics Meeting
Current Work at MSU

http://www.pa.msu.edu/~edmunds/LArTPC/Talks/Talk_Feb_2010/

Fermilab Dan Edmunds 23-February-2010

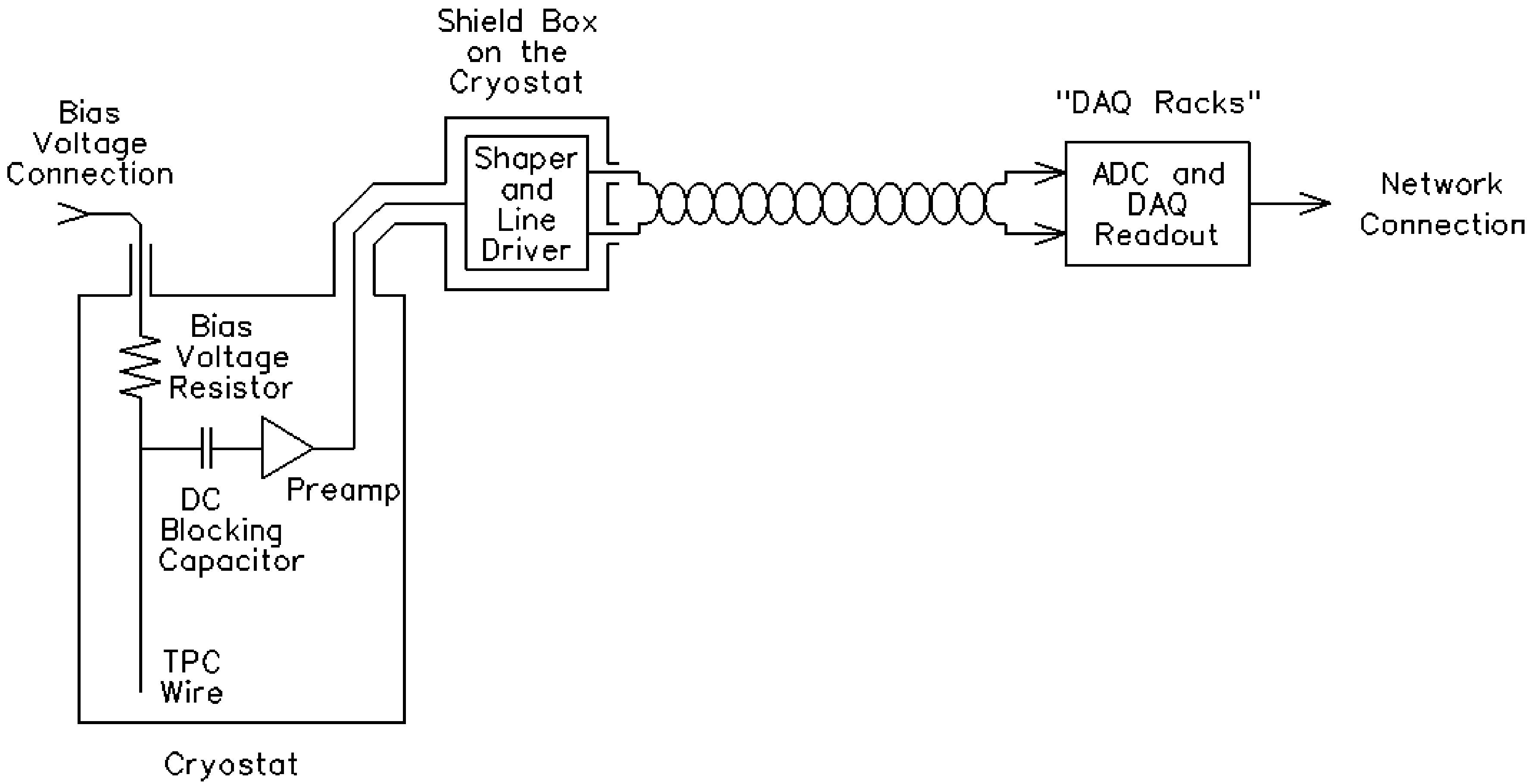
History of the MSU LArTPC Electronics Work

- Built a small warm DAQ system for the Bo LArTPC
- Built a warm DAQ system with cold Bias Voltage distribution for the ArgoNeuT LArTPC
- About one year ago Stephen Pordes ask us to work on a small multiplexed readout DAQ system that would operate cold in LArTPC test cryostats

Motivation and Goals of Our Current Work

- Test this DAQ system in the Bo LArTPC
- Provide a DAQ system for the “no pump out” long drift LAPD LArTPC at Fermi
- Gain experience with multiplexed readout and cold electronics in a LArTPC DAQ system
- Gain experience with digital signals inside the LArTPC cryostat
- Work on ideas to reduce the cost of the DAQ system for a big detector (3 box to 2 box system)

3 Box LArTPC DAQ System



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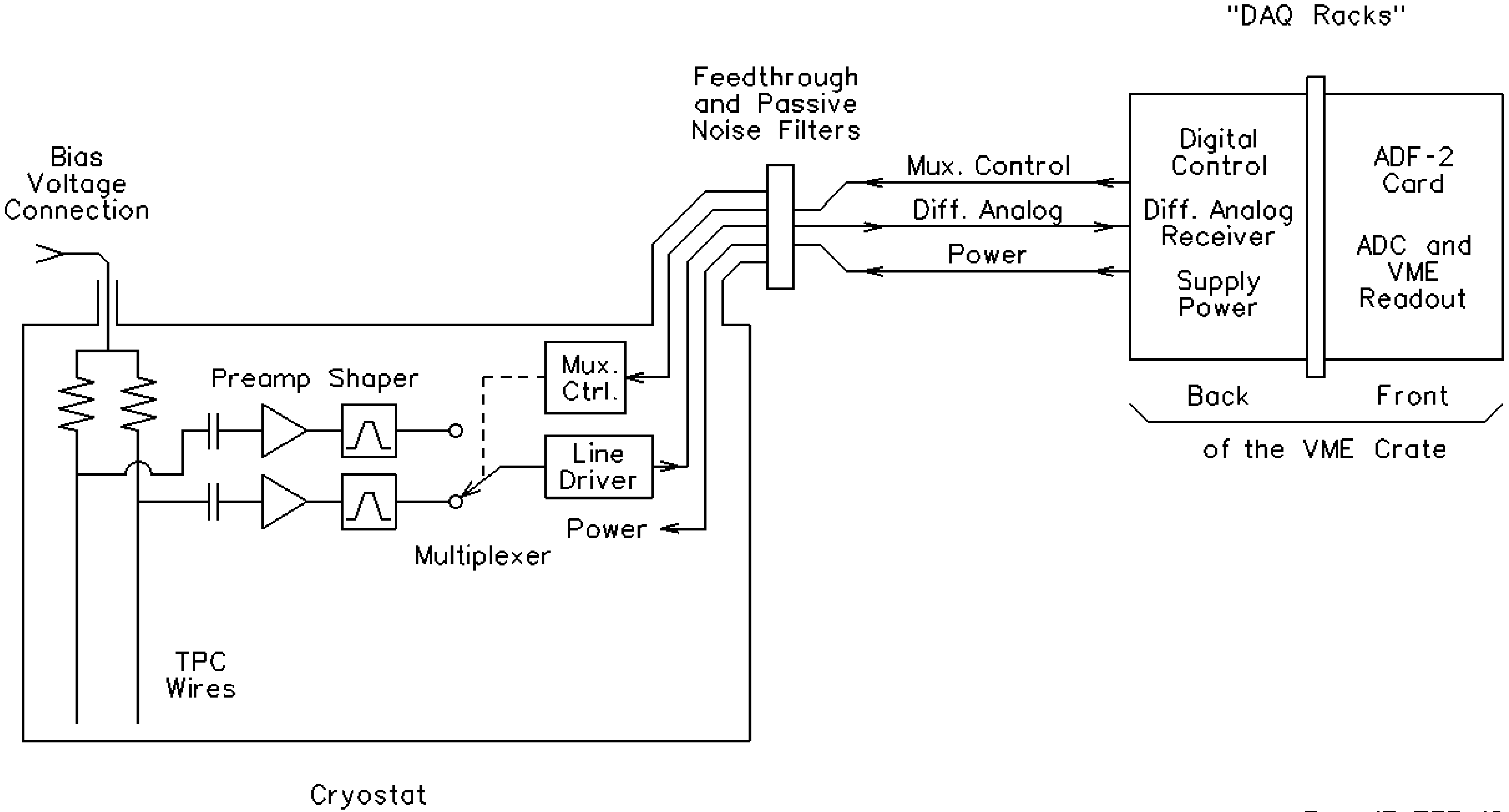
Project Sections of our Current Work:

1. Characterize components at LN2 temperature
2. Inside the cryostat
   - Preamplifier
   - Filter
   - Multiplexer
   - Line Driver
   - Digital Control of the Multiplexer
3. At the Cryostat Feedthrough
   - Passive Noise Filters: power supply, analog common mode, digital control signal coupling transformers
4. In the DAQ Rack
   - Back of the backplane card: power supply regulators, analog signal receivers, digital control signal drivers
   - Firmware for the ADF-2 VME Readout Card
5. DAQ system software

2 Box LArTPC DAQ System



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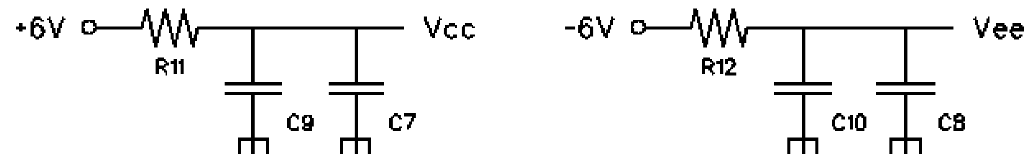
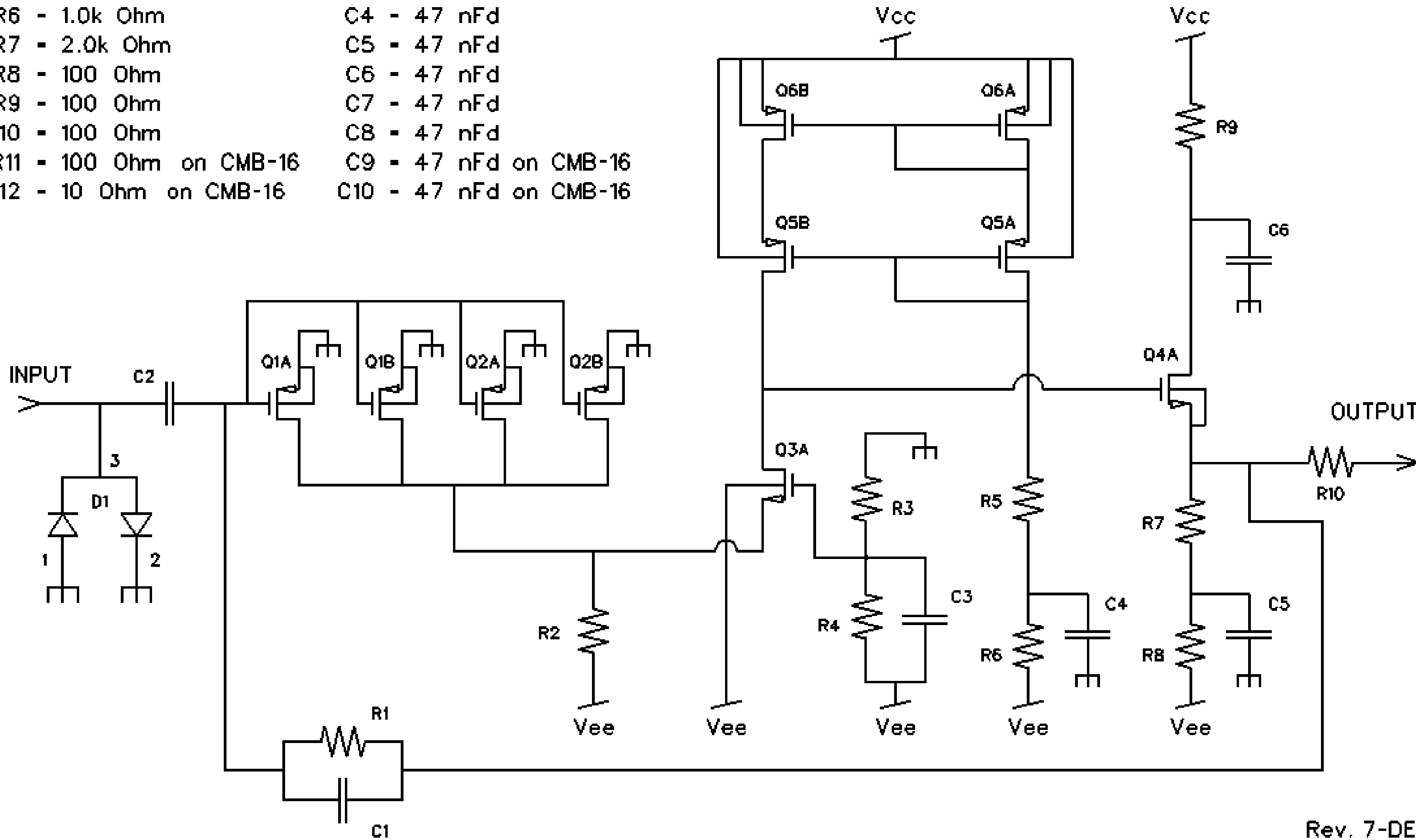
Design Considerations:

- Operate at RT or LN2 temperature without significant adjustment
- Per readout card have a single twist-flat cable running inside:
  - 4 differential analog signals
  - 2 differential digital control signals
  - 3 power supplies (6 conductors)
  - 8 grounds (16 conductors)
  - 50 – 100 mV signal levels
- Control electrical noise inside the cryostat

Cold MOSFET Preamplifier

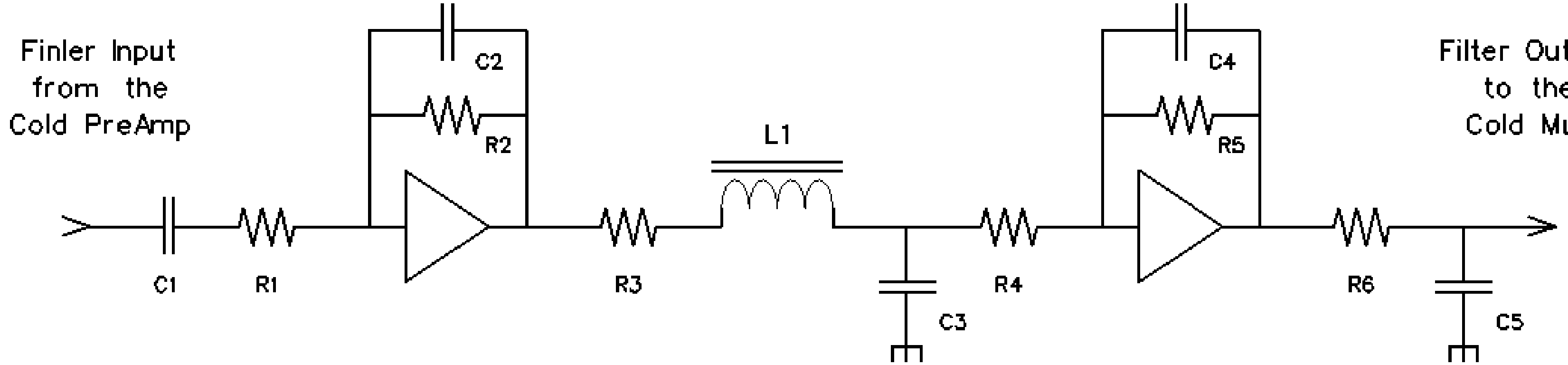
R1 = 100M Ohm	
R2 = 375 Ohm	
R3 = 18.6k Ohm	C1 = 1.8 pFd
R4 = 100k Ohm	C2 = 10 nFd
R5 = 27k Ohm	C3 = 10 nFd
R6 = 1.0k Ohm	C4 = 47 nFd
R7 = 2.0k Ohm	C5 = 47 nFd
R8 = 100 Ohm	C6 = 47 nFd
R9 = 100 Ohm	C7 = 47 nFd
R10 = 100 Ohm	C8 = 47 nFd
R11 = 100 Ohm on CMB-16	C9 = 47 nFd on CMB-16
R12 = 10 Ohm on CMB-16	C10 = 47 nFd on CMB-16





Rev. 7-DEC-09

Cold 3-Pole Filter



The Drift Velocity is 1.5 mm/usec in a 500 V/cm field.
For a 3 to 5 mm plane spacing the risetime will be 2 to 3.3 usec.
For now pick a 2.5 usec peaking time or about 64 kHz.

R1C1 Tau 1.64 usec	R2C2 Tau 560 nsec	R3 = 845 Ohm	R5C4 Tau 500 nsec	R6C5 Tau 110 nsec
R1 = 2k Ohm	R2 = 10k Ohm	L1 = 560 uH	R5 = 49.9k Ohm	R6 = 499 Ohm
C1 = 820 pFd	C2 = 56 pFd	C3 = 2.2 nFd	C4 = 10 pFd	C5 = 220 pFd
		R4 = 10k Ohm		See the Cold Mux Circuit

R2/R1 = 5.0

1/SQRT(L1 C3) = 901k

R5/R4 = 5.0

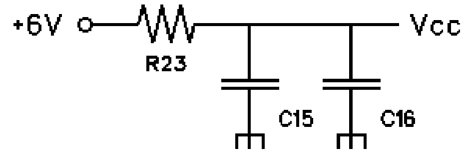
R3/(2xL1) = 754k

Wo > v --> underdamped

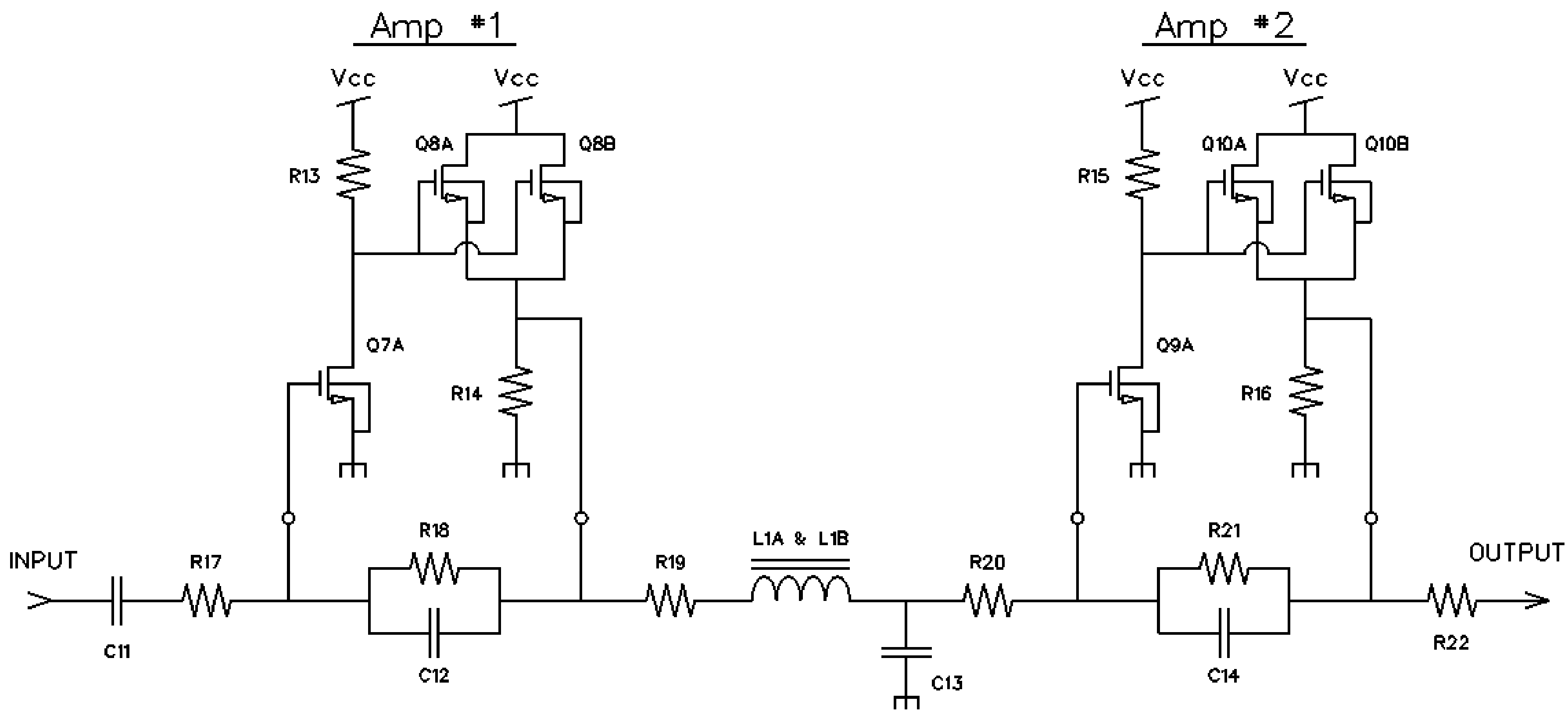
Rev. 18-SEPT-09

Cold 3-Pole Filter

R13 = 6.8k Ohm
R14 - 800 Ohm
R15 - 6.8k Ohm
R16 - 800 Ohm



C15 - 47 nFd
C16 - 47 nFd



R17C11 1.64 usec
R17 - 2k Ohm
C11 - 820 pFd

R18C12 560 nsec
R18 - 10k Ohm
C12 - 56 pFd

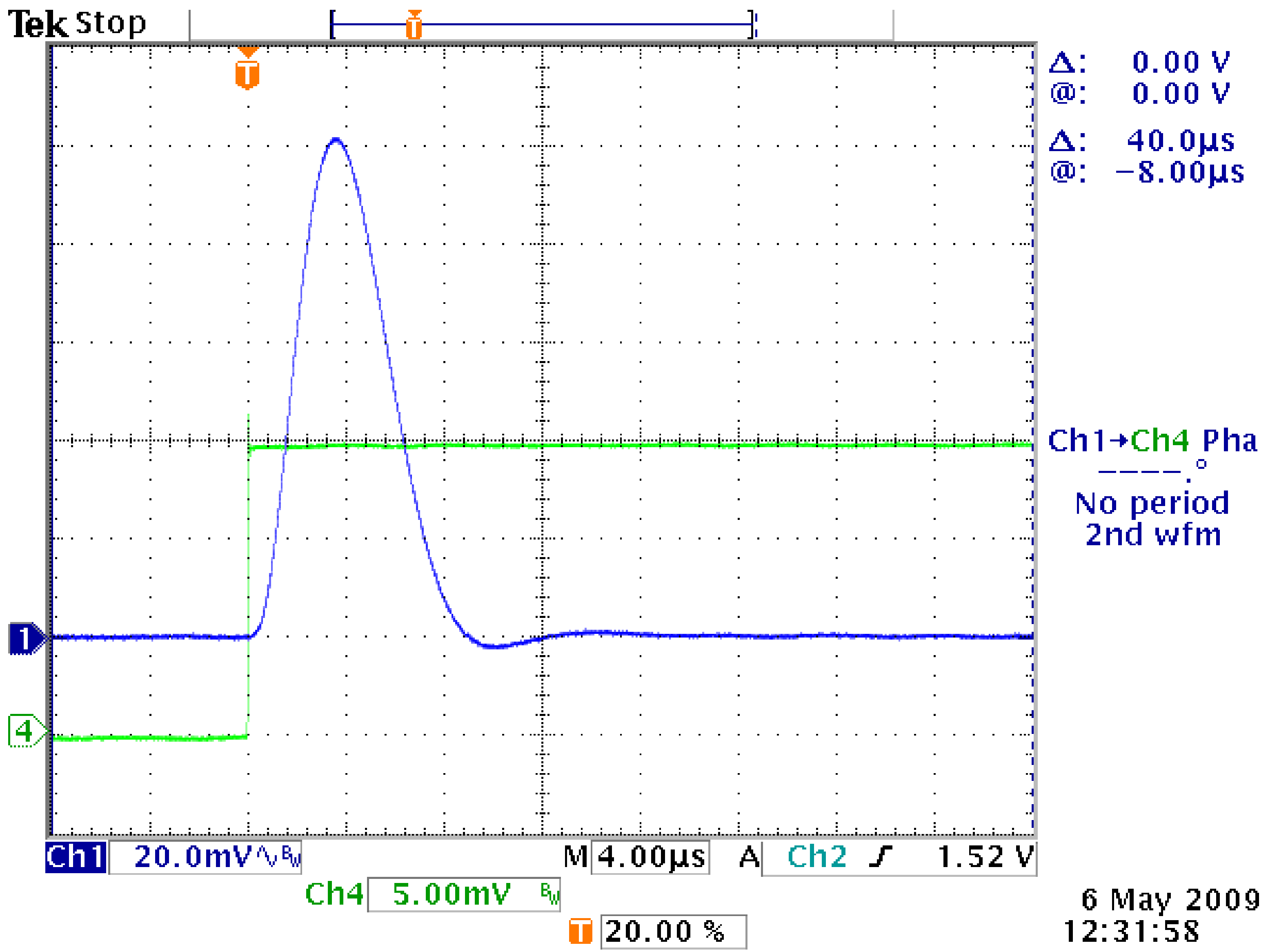
R19 - 845 Ohm
L1 - 560 uH
C13 - 2.2 nFd
R20 - 10k Ohm

R21C14 500 nsec
R21 - 49.9k Ohm
C14 - 10 pFd

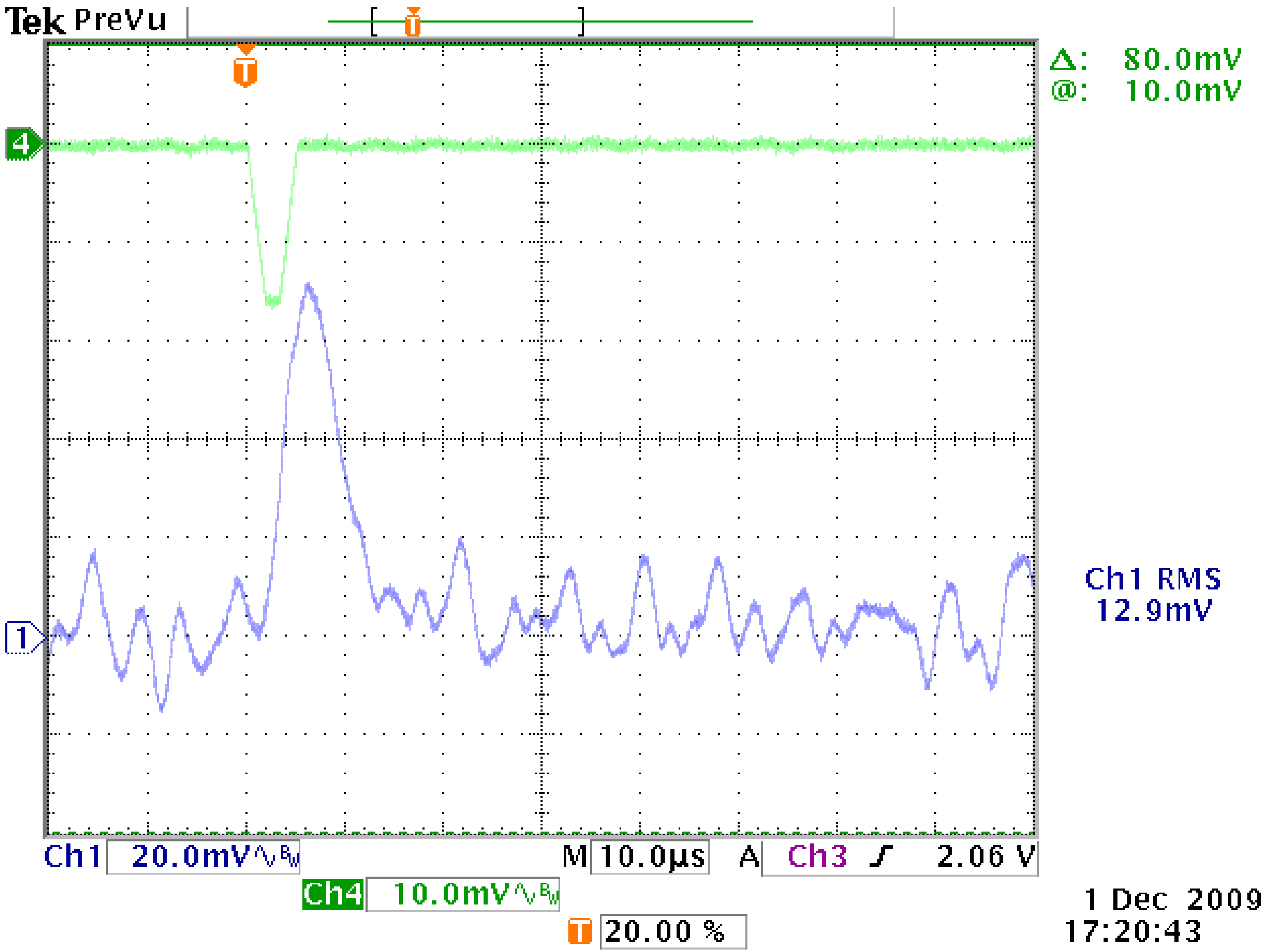
R22 -
100 Ohm

Rev. 15-DEC-09

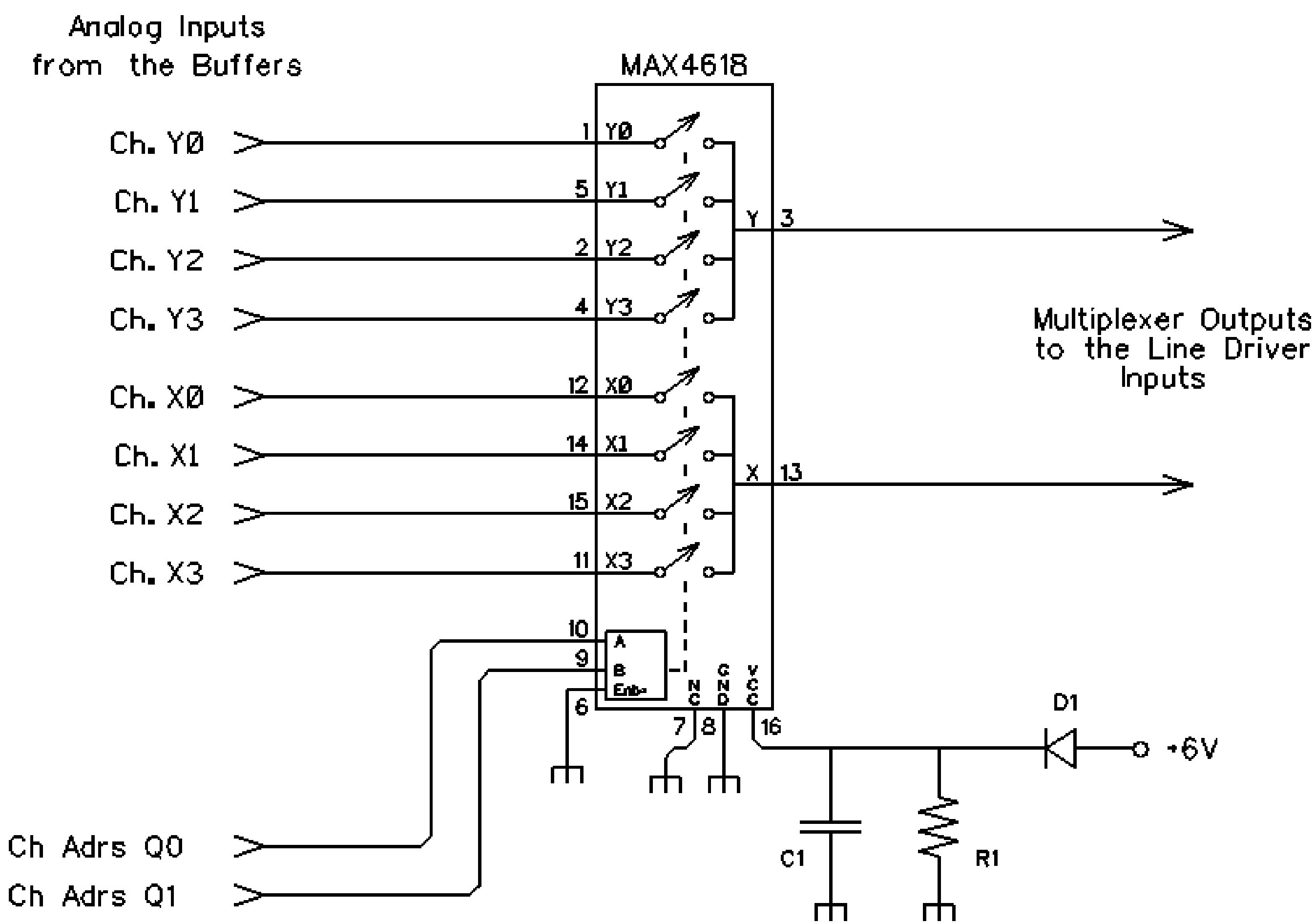
Filter Step Response



Collection Plane Signal
Preamp and Filter

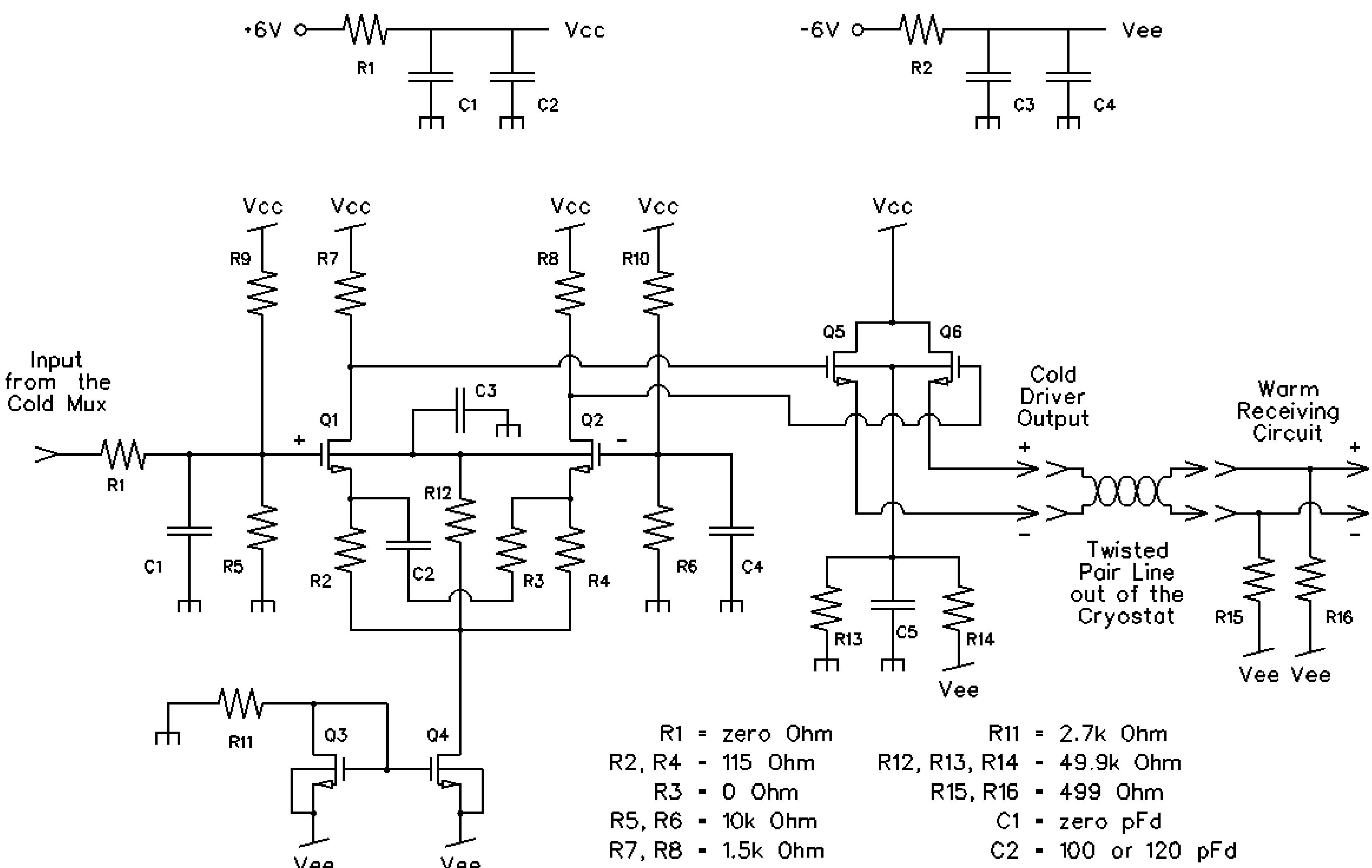


Cold Analog Multiplexer



Rev. 29-OCT-09

Cold MOSFET Line Driver

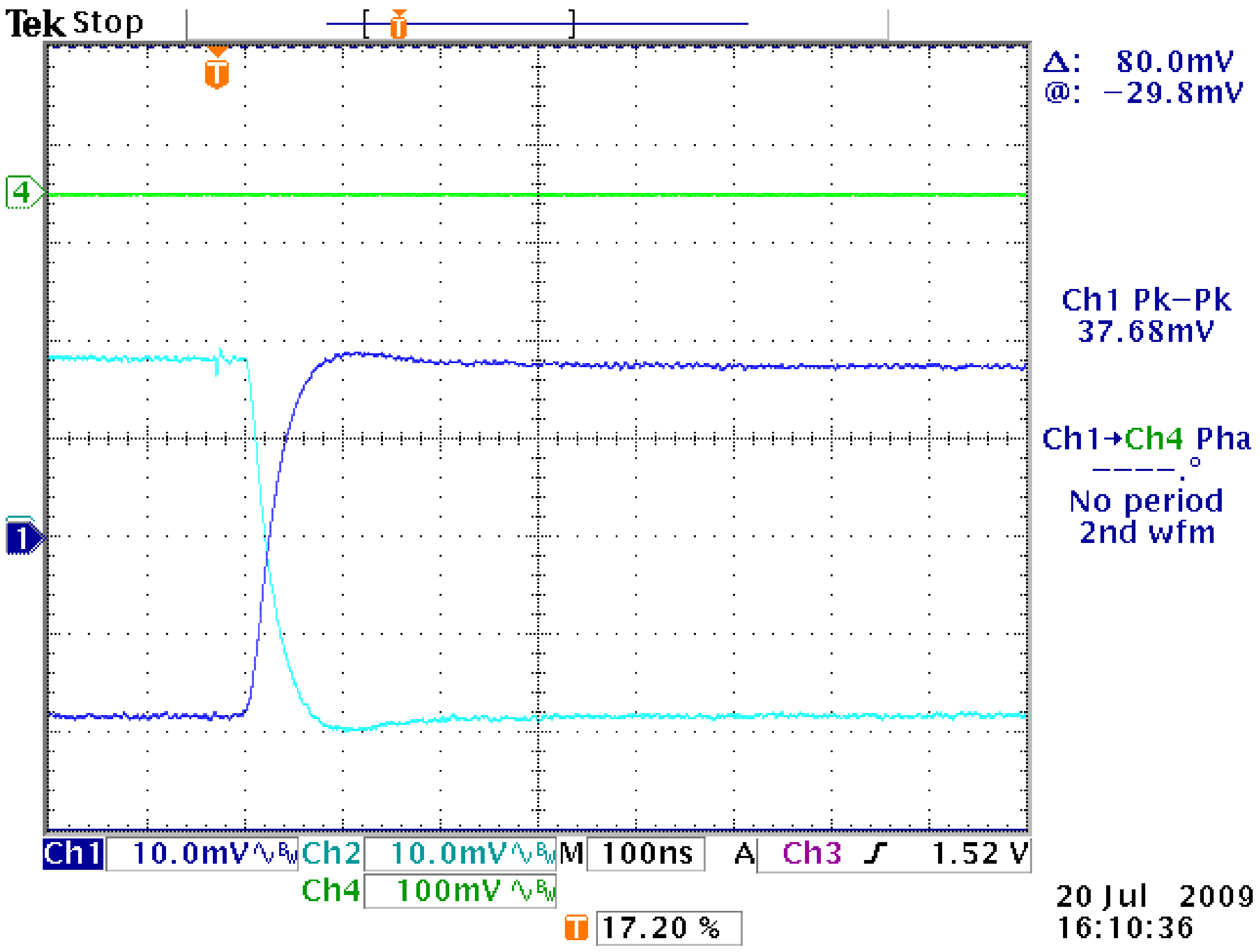


R1 = zero Ohm
R2, R4 - 115 Ohm
R3 - 0 Ohm
R5, R6 - 10k Ohm
R7, R8 - 1.5k Ohm
R9, R10 - 36.1k Ohm

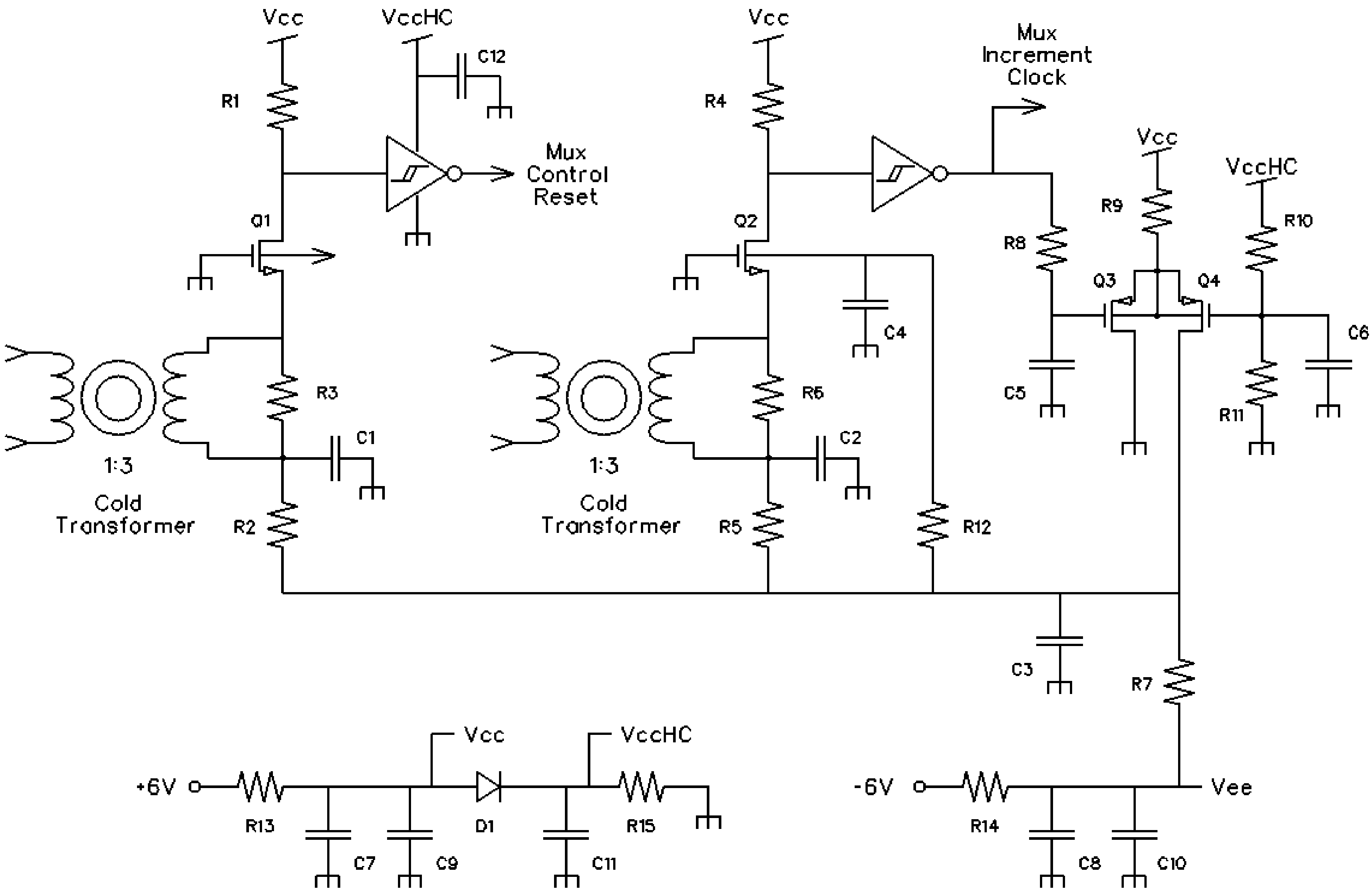
R11 = 2.7k Ohm
R12, R13, R14 - 49.9k Ohm
R15, R16 - 499 Ohm
C1 - zero pFd
C2 - 100 or 120 pFd
C3, C4, C5 - 10 nFd

Rev. 22-SEPT-09

Line Driver and Cable Response



Cold Digital Control Signal Receiver



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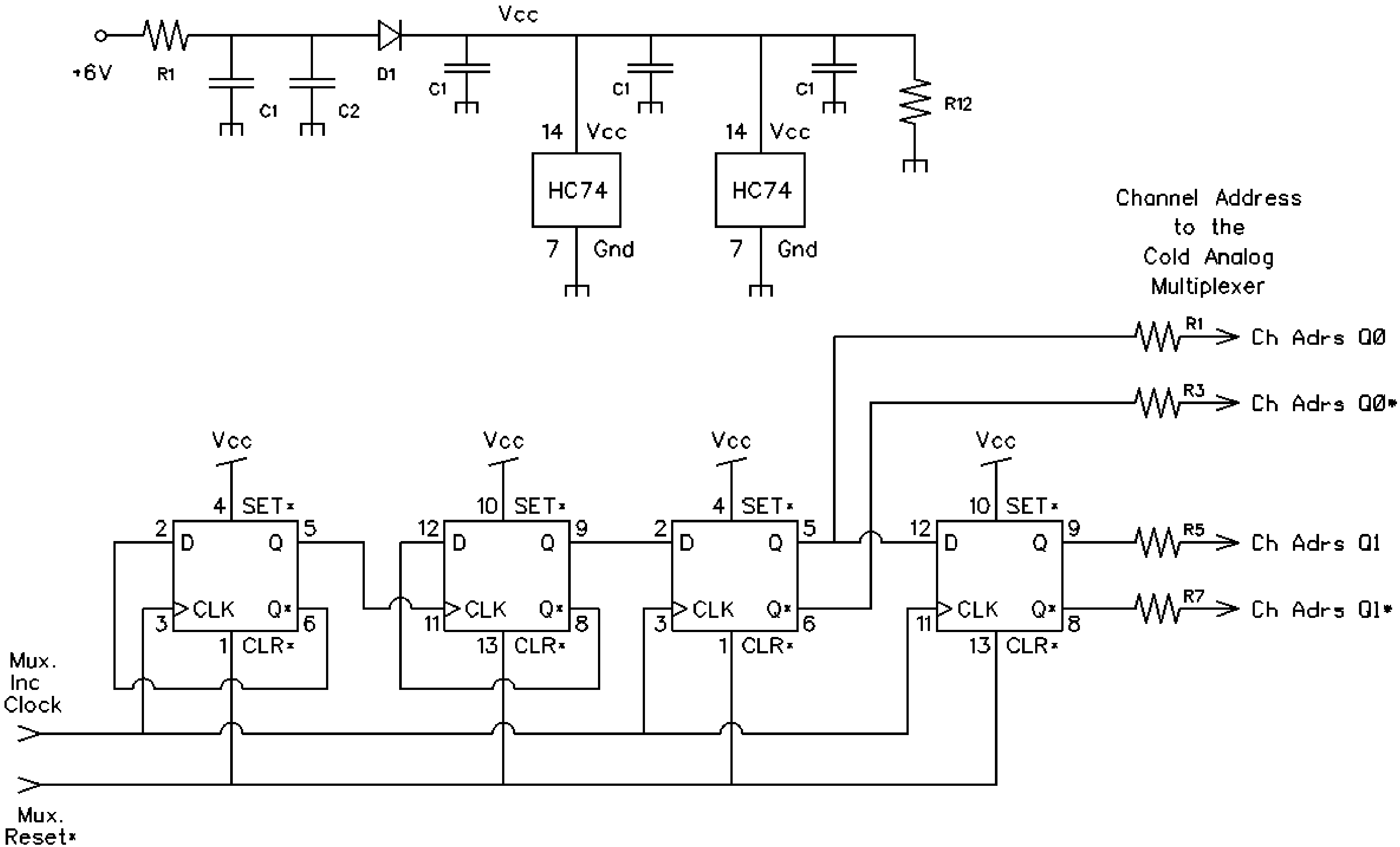
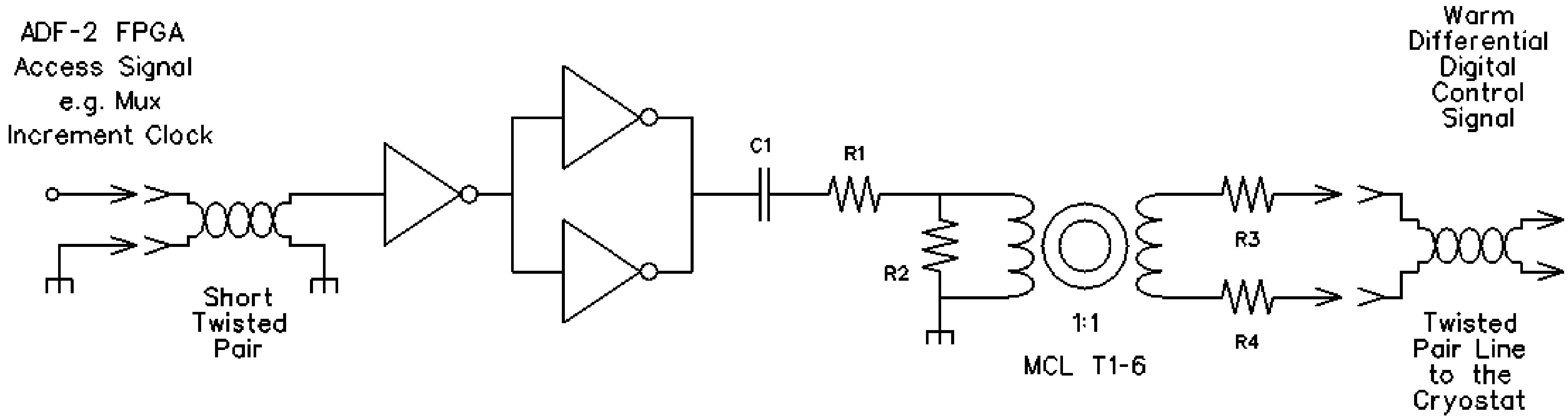
Cold Multiplexer Digital Control



Rev. 26-OCT-09

Warm Digital Control Signal Driver



R1 = 412 Ohm
R2 = 51 Ohm
R3, R4 = 25 Ohm
C1 = 10 nFd

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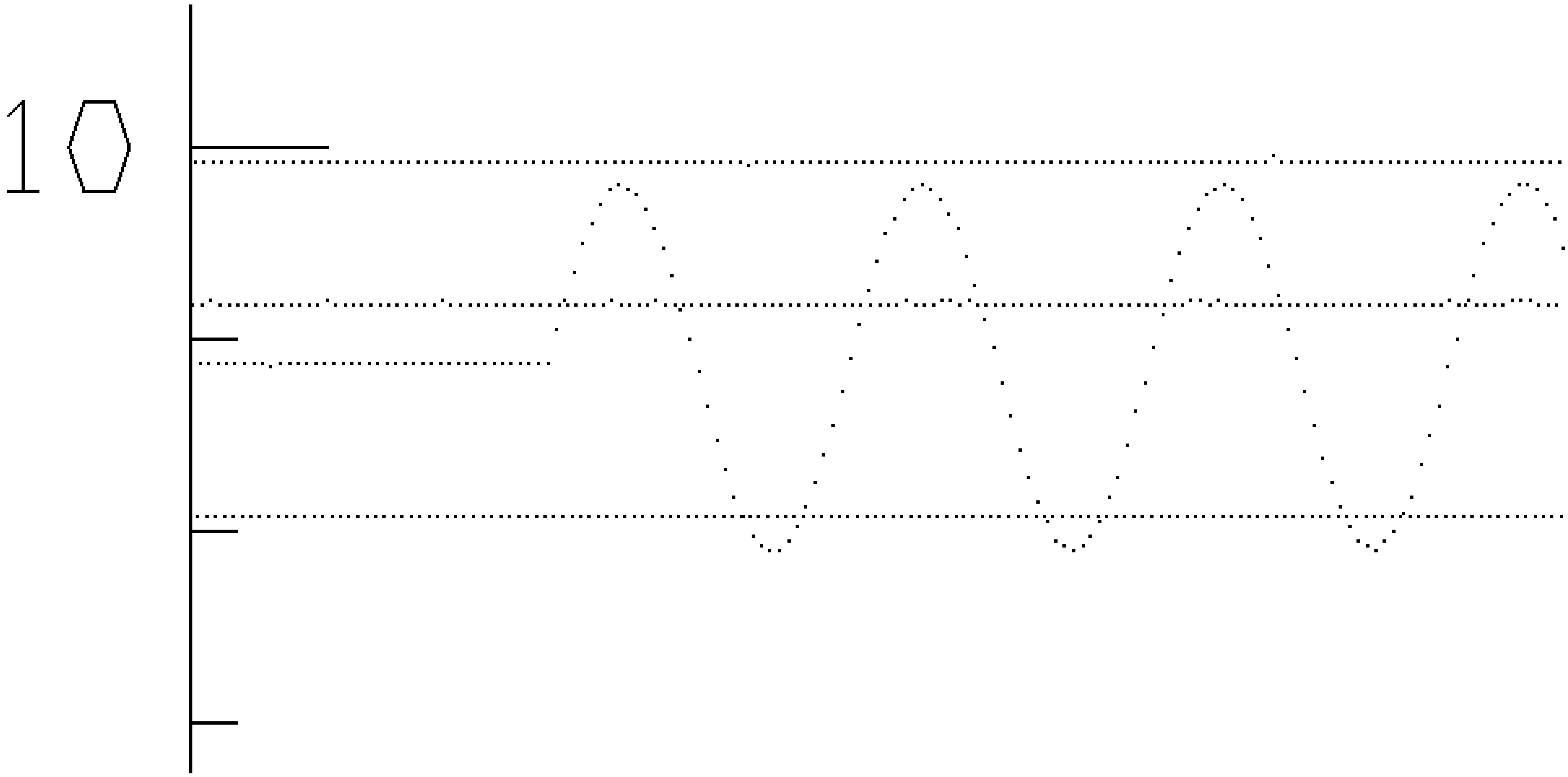
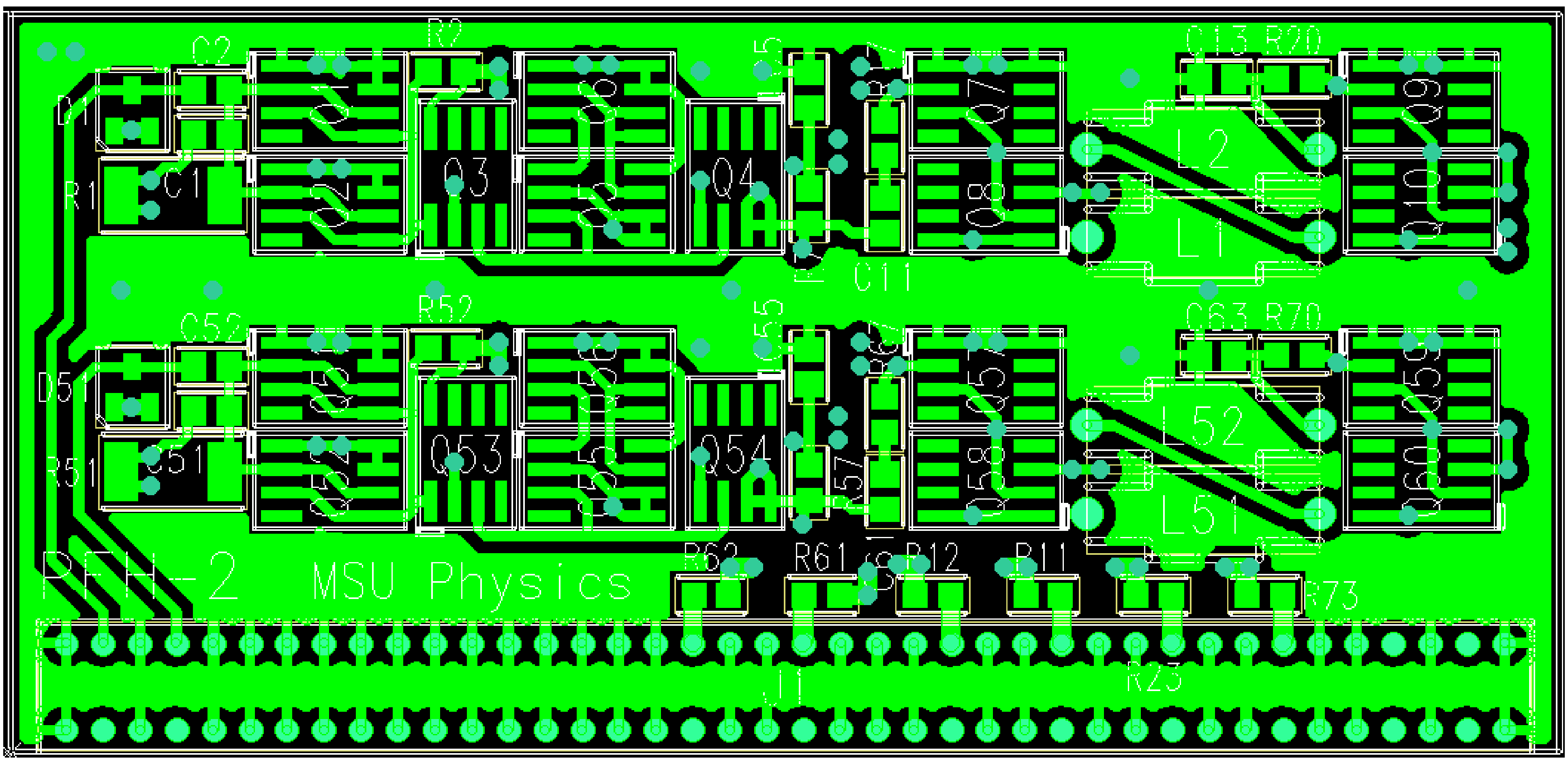
Output from the Chain: Buffer, Multiplexer, Line Driver, Cable, and VME ADF-2 (ADC) Card Checking for Crosstalk

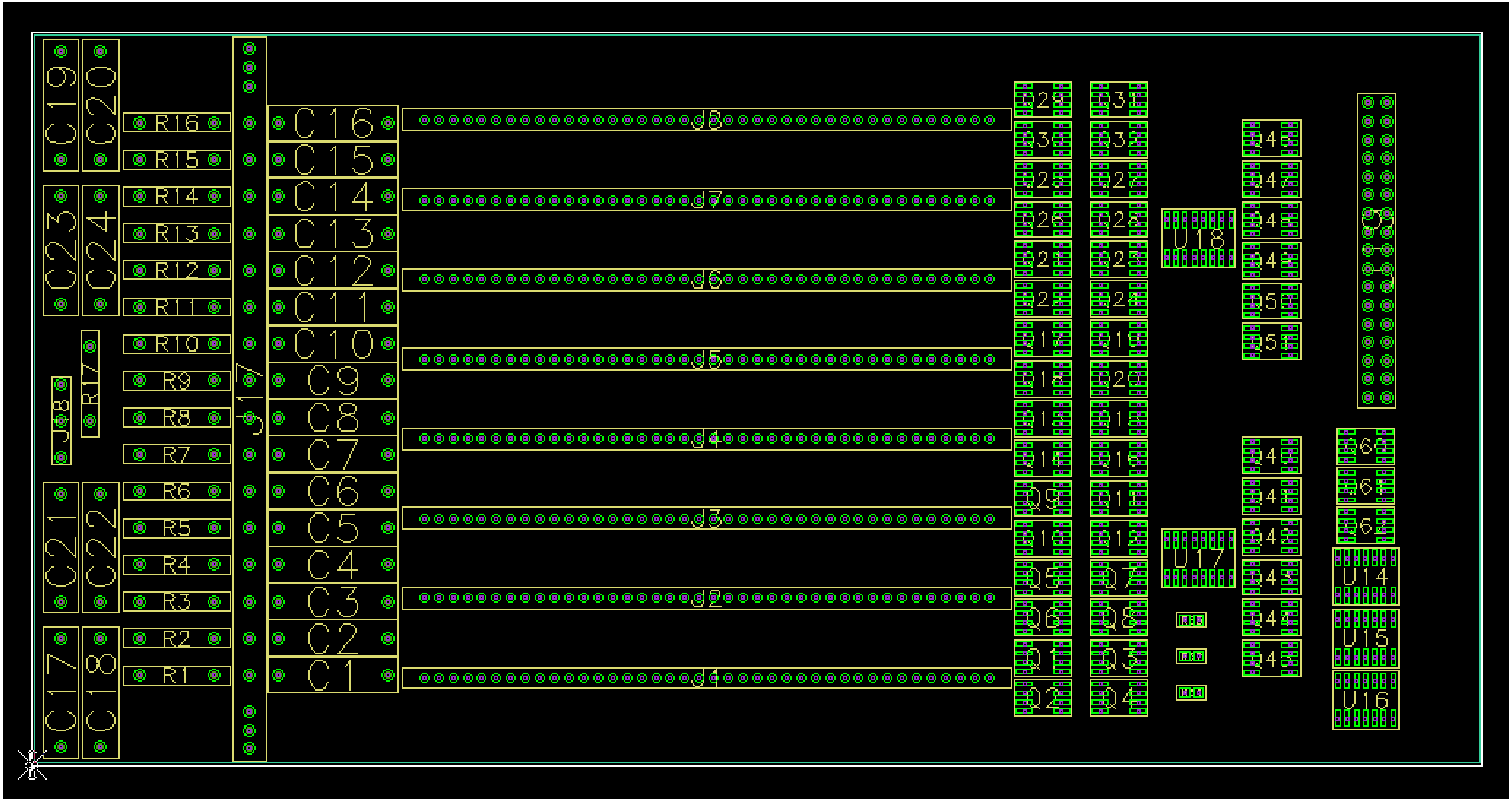


2 Channel Preamp-Filter Card

- 4 layer with ground fill on all layers
- double via connections
- relieved ground plane under Hi Z traces
- compromise between size and ease of modification



16 Channel Mother Board



Engineering Comments:

If Fermi is going to be involved with the DAQ system for a large LArTPC detector (e.g. LBNE) then the electrical engineering work for that system should start soon.

- Technical Challenges
- Cost Control
- Remote Assembly and Operation

DAQ system engineering needs to be integrated with the mechanical and cryogenic engineering.

We should “prove” that a fully thought out warm electronics system will not work before committing to put “all” of the electronics inside.

As far as I know the HEP community has no examples of a large system operating for 10 or 20 years without needing to work on its electronics.

This is a one detector experiment, i.e. it must work.

A thin wall stainless steel vessel will not shield electrical noise. There is no “ground” inside and there is no shield inside.

Need a respected “Noise Czar” early (e.g. now).

Lots of room for DAQ design work:

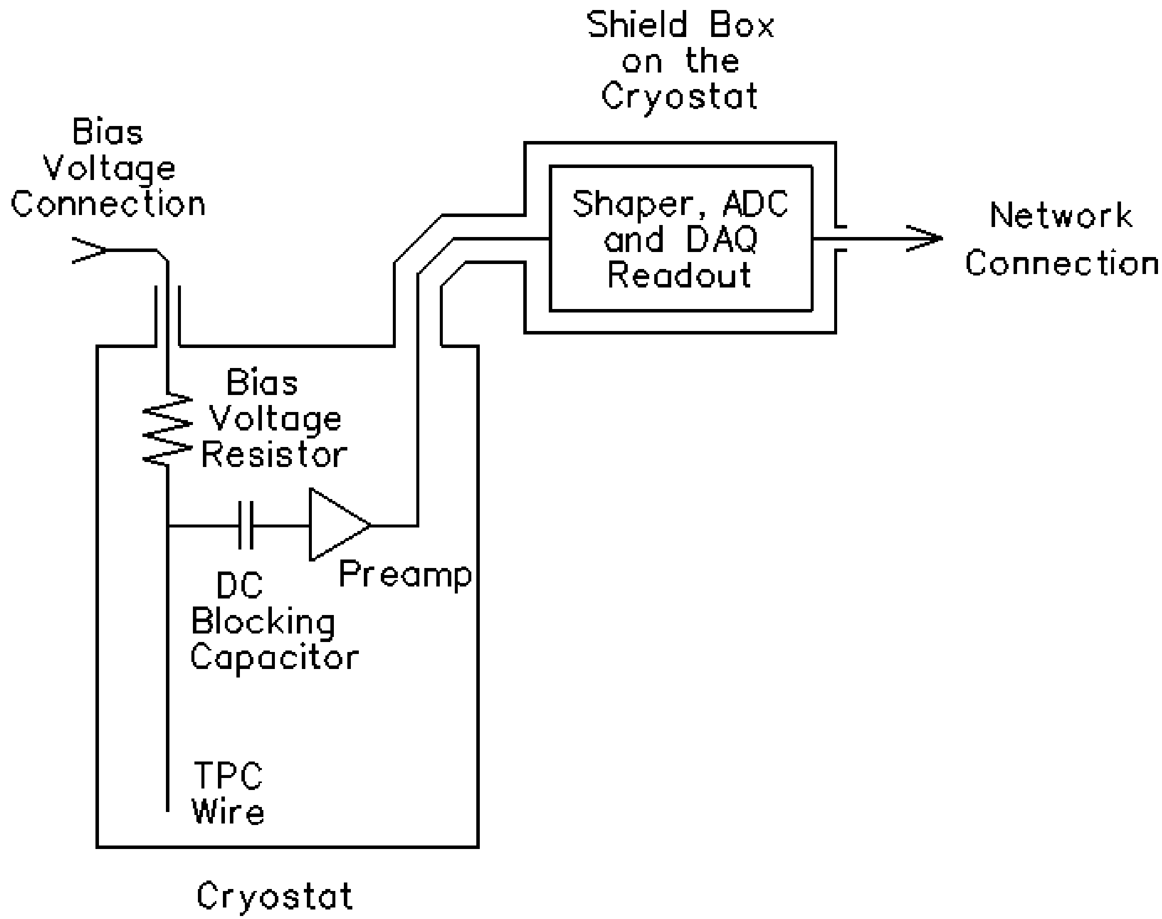
- Filtering of the hit data
  - Inline Digital and Offline
  - Slope dependent hit filtering
  - Raw data beauty vs information content
- Data Compression: Coding, ROI Readout
- Triggering: Beam Spill vs Continuously Alive

Low Temperature Components:

- Some just don't work.
- Subtle problems.
- Circuit implications.

Backup

2 Box LArTPC DAQ System



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