

**Director's Review of the Project X  
Cost Range Estimate:  
Modulator/Charging Power Supply**

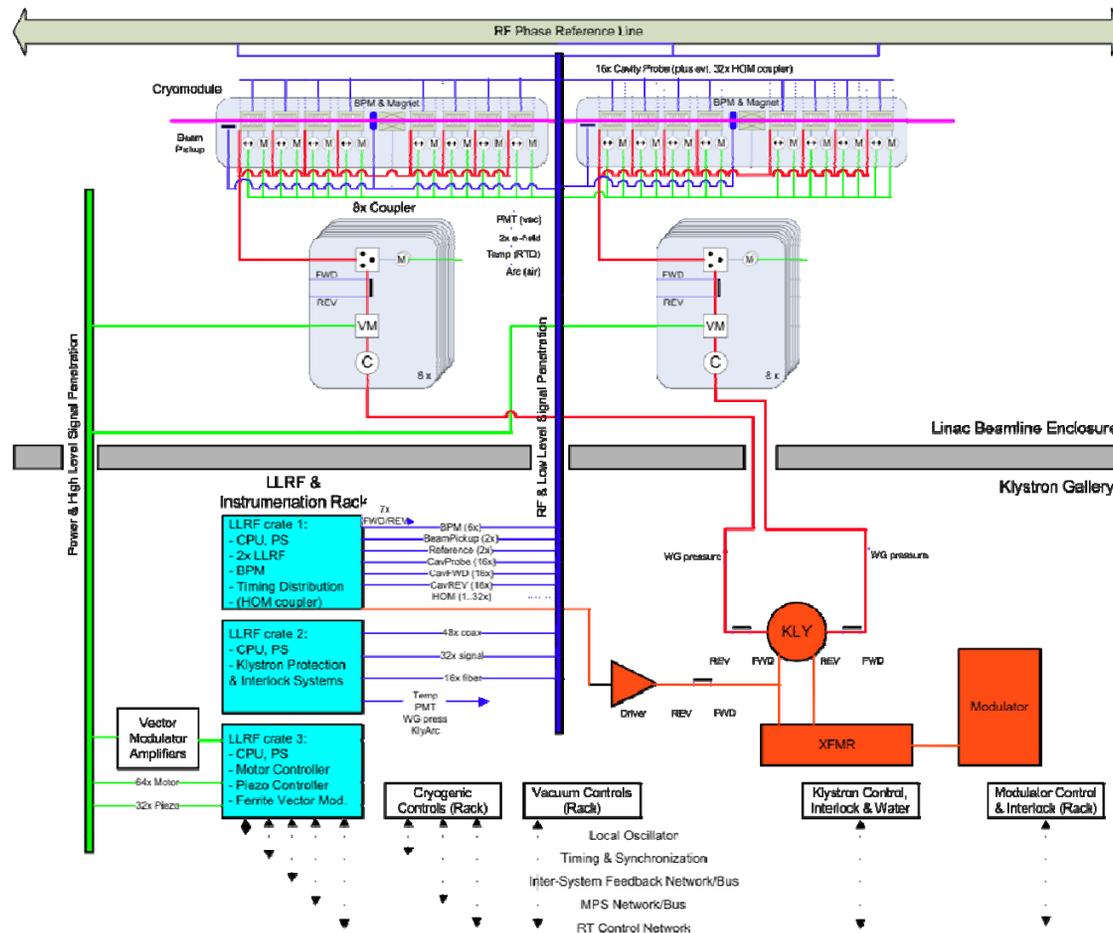
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Project X Director's Review  
March 16, 2009

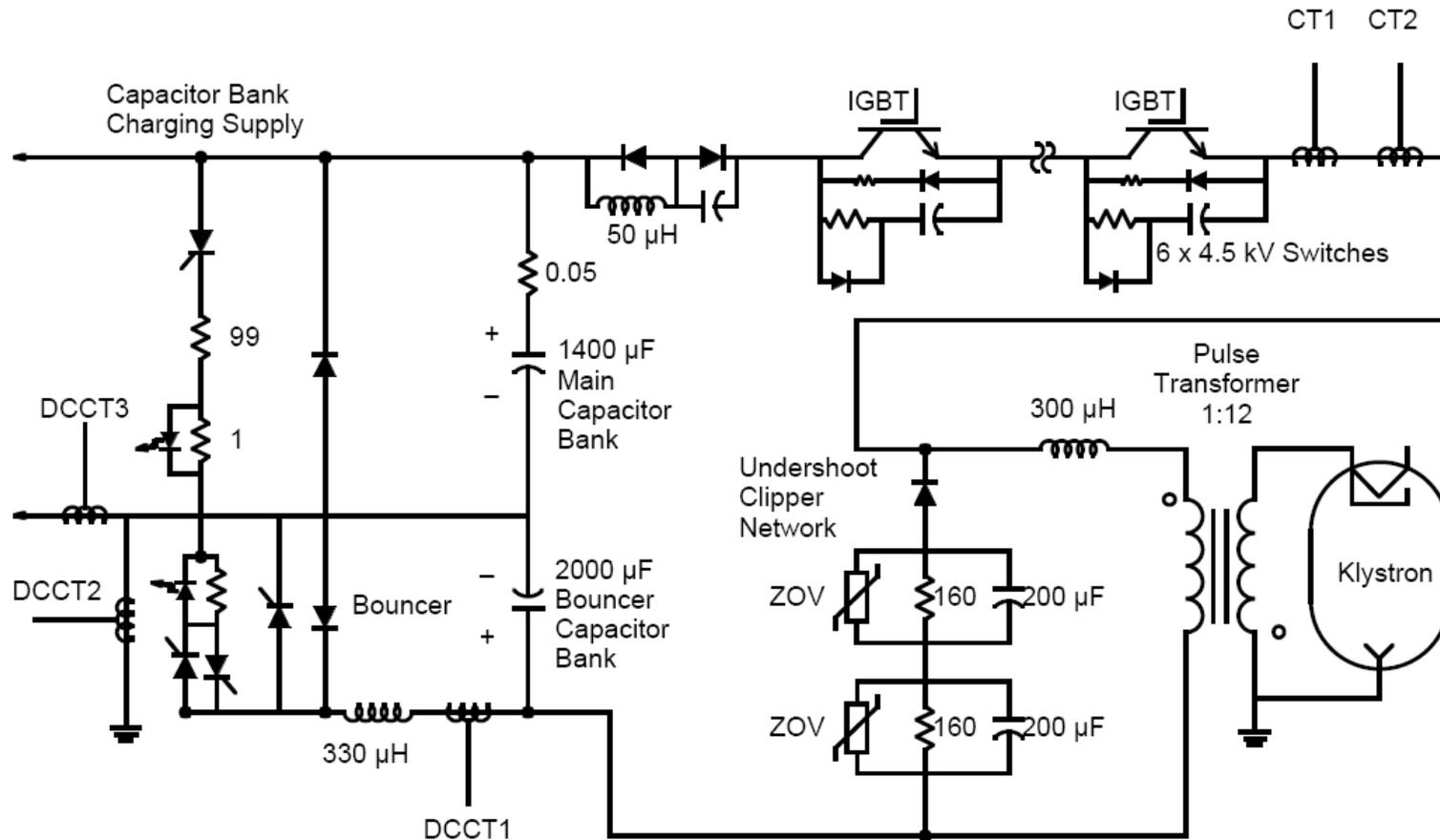


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- Scope of Estimated Work
  - Boundary Conditions /Assumptions
  - Basis of Estimate
  - Technical Risks/Associated Cost Exposure
  - Potential Technical Revisions
  - Role of Outside Collaborators
  - Summary



- 31 systems plus 3 spares (8, 325 MHz and 23, 1.3 GHz)
- Modulator (and Pulse Transformer)
- Charging Supply
- Modulator Controls
- Klystron/Solenoid Slow Interlocks (water, temp, vacuum)
- Klystron Support (solenoid supply, filament supply, Ion pump)
- Primary Interfaces:
  - Input power 480 VAC
  - Output to Klystron gun (not klystron waveguide nor RF drive)
  - Accelerator control system (ACNET, or RT e.g.)





# Boundary Conditions & Assumptions



This package has the following additional interfaces:

- Power/Utilities
  - 230 VAC Power, 3 separate circuits
  - 120 VAC Power, 2 separate circuits
  - LCW (about 20 gpm for modulator, charging PS, and pulse xfmr only)
- Control Inputs
  - Trigger from clock system (pulse modulator)
  - Output voltage setpoint
  - On / Off command for charging supply / modulator
  - Safety system interlocks
- One low-level output to inhibit RF protection system (within pulse)



- Experience: 5 bouncer type modulators built in the past 10 years
- Recent Procurement for Major Cost Parts
- Engineering Estimate for control and misc parts

- System M&S Costs
  - Pulser Total \$210k
    - Undershoot \$ 5.0k
    - Controls/Instr. \$ 45.0k
    - Cabinet \$ 16.2k
    - Caps and Bouncer \$ 61.0k
    - Crowbars \$ 9.7k
    - Main Switch \$ 24.0k
    - Bouncer Switch \$ 2.7k
    - Misc. \$ 45.0k
  - Charging Power Supply \$110k

# Project X Basis of Estimate (cont)



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- Klystron Support \$ 16k
  - Pulse Transformer \$157k
  - Total M&S for one system: \$493k
  - Mass production multiplier assuming 5% per doubling = 0.77
  - Total M&S for 34 systems =  $493 \times 0.77$  (=380 ea)  $\times 34 = \$12.9\text{M}$
  - Labor Estimate per system (FTE years)

Pulser Assembly	1.9	Tech
Final Assembly	0.6	Tech
Installation	0.2	Tech
	0.06	Electrician
Testing	0.2	Tech
Engineering oversight	0.25	Engineer



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- Change in technical requirements (pulse length, operating voltage, repetition rate) – higher contingency
  - Modulator cost sensitive to steel and copper rates (pulse xfmr costs went from 110k to 156k in 2 years) - higher contingency
  - We always seem to underestimate labor (labor approx. equal to M&S costs minus pulse transformer)
  - Suggested contingency = 35%



- Existing charging power supply
  - has poor power factor when operating at reduced voltage
  - inconvenient during startup for test stand operation
  - new design to mitigate these problems
  - possible collaboration with PISA in process
- Technical advances in HV solid state switching devices
- Marx-type modulator: if proven to be reliable and cheaper we will want to adopt the technology.



- SLAC
  - Meeting on RF Generation/Distribution Strategy for Project X
    - Steve Holmes (FNAL): “Establish a team with shared leadership and both SLAC and Fermilab personnel in major roles. Task them to define the system and split up the work in an effective manner.”
    - Tor Raubenheimer (SLAC): “collaboration, but with SLAC given significant responsibilities and authorities”
- PISA
  - Develops unity power factor charging power supply.

# Project X Collaborators (cont.)



- Industry responsible for the complete modulator construction, assembly and testing. Problems can occur when utilizing outside vendors for a complicated performance specification.
  - pre-qualify vendors
  - use two vendors (risk and cost evaluation)
  - requires elaborate detailed specification
  - if vendor(s) use Fermilab subsystem specs, who is responsible for performance?



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- Need a stable modulator specification
  - M&S costs well-known based on recent modulator projects
  - Risks are low
  - Some development work needed on charging power supply but not a cost or technical risk.