RF controls for NLCTA - Functional Requirements

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Introduction

The EPICS based VME system will be responsible for controlling the generation and delivery of X-band high power RF at NLCTA. No RF will be allowed without operation of the EPICS controls.

Specifically the control system will:

Implement a fault recovery protocol:
1) determine the viability of the next pulse at 120 Hz (max) based on information from this and earlier pulses. Linear combinations of input signals will be required.
2) Prevent the next pulse(s) if so required. This will be done using either the VMIC DAC or D O. Digital output(s) may be generated to trigger diagnostics hardware.
3) recover operation in any one of several (~10) different ways based on info from previous pulses

Stabilize the RF power/ RF power changes:
4) maintain RF levels using basic 'trim'/'autotrim' functions at a few 1/10's Hz rate
5) ramp up/down RF levels using programmed slew rate; either in response to fault or for multi-day turn on/processing (as in PEP2). RF power will be controlled through DAC/SAM channels. The DAC's control pulse width and amplitude.

Perform comprehensive logging; integrated with SCP:
6) Provide history records of typical parameters (average, rms, max/min) at 1 minute intervals
7) Provide detailed records of abnormal events (classification based on database tolerances; either absolute or fractions of other signals). The records must include pulse number and all associated digitized data.
8) Record structure vacuum gauge signals. Vacuum signals should be included in the abnormal event records.

Backup
9) not be redundant. A backup hardware system (the system presently in place) will provide redundancy.

Calibrate
10) provide tools for calibration. This could be correlation plot with instructions for database update (as a start)

User interface
11) Allow flexibility in protocol parameters

The process will control at most three modulator/klystron installations, called NLCTA station 0, station 1 and station 2. Each station will control more than one RF structure system (at most 2), each with its own protection signals. Thus, a station's operation can be dictated by one of the structures and the sequencer will consider the structures independently, computing their states independently and responding to the worse of the two; as per recipe. We expect that the structures will (mis)behave independently (usually).

Protocol

Following fabrication, RF structures apparently require high voltage discharges in order to reach a given level of operation, both in terms of stability and voltage. They also can be badly damaged by breakdowns. The protocol will change as we learn more about the difference between those breakdown events that promote future stable operation and those that cause damage. It may also change as the structure ages.

For each pulse we will acquire:

1) reflected energy (iRE)
2) input forward energy (iFE)
3) load forward energy (lFE)
4) fault time within pulse (overflow w/o breakdown) (tRE)
5) time of radiation pulse (") (tPMT)

and compute:

6) Missing energy (ME=lFE-iRE)
7) Fault location using tRE and tPMT

Table 2 shows an example of how to proceed based on a simple categorization of 9 different types of events.

Table 1: Breakdown event categories

time / sequence	energy / vacuum / location
1) no problem pulse for many minutes (Steady operation)	1) very small missing energy; close to structure entrance and close to end of pulse (Soft)
2) problem with previous pulse (Multi-pulse)	2) large missing energy; generally closer to front of structure; any time within pulse (Hard)
3) recovery from last fault (Low threshold ~usually)	3) large evolution of gas (Gas)
	4) large missing energy; generally closer to front of structure; any time within pulse; very low iFE (Hard, Low threshold)

Frequency of each fault type depends on structure history (freshly brazed...) and on agressiveness of processing

Table 2: response matrix to faults as a function of missing energy, time since last pulse and vacuum.

Time scale	Breakdown strength	response
SO	S	Do nothing; check next pulse of course
MP	S	Stop; wait short time; resume at full power
LT	S	Stop; wait short time; resume at small pulse width/amplitude
SO	H	Stop; expect problems on return to full power; use table to ramp drive/pulse width; wait a second for vacuum pressure update
MP	H	same as above
LT	H	Stop; more problems on return to full power; use slower table ; wait a second for vacuum pressure update
SO	G	Stop; wait for vacuum to improve before resume; very slow return
MP	G	same as above
LT	G	Stop; wait for vacuum to clear; drop back to level seen just before and stay for a while

Wait times and threshold levels must be programmable.

Hardware inputs

The hardware to be installed consists of 24 fast pulse analog input channels (CAEN GADC), 16 TDC channels (LRS1176), 16 channel VMIC DAC, 32 channel VMIC VSAM and 32 digital output / 32 digital input channels. The inputs are shown in Table 3 (for March - May 2001 there will be two controlled stations each with two structures).

Table 3: Signal inputs

Channel	Station - Structure	Signal
GADC 1	1-1	input RE (iRE)
G2	1-1	input FE
G3	1-1	load FE (lFE)
G4	1-2	input RE
G5	1-2	input FE
G6	1-2	load FE
G7	2-1	input RE
G8	2-1	input FE
G9	2-1	load FE
G10	2-2	input RE
G11	2-2	input FE
G12	2-2	load FE
G13	1-	TWT input
G14	2-	TWT input
G15	1-	Klys input
G16	2-	Klys input
G17	1-	Klys out
G18	2-	Klys out
TDC 1	1-1	input RE (tRE)
T2	1-1	PMT 1 (tPMT)
T3	1-2	input RE
T4	1-2	PMT 1
T5	2-1	input RE
T6	2-1	PMT 2
T7	2-2	input RE
T8	2-2	PMT 2
T9	1-	Klys out
T10	2-	Klys out
DAC 1	1-	ATTN 1
D2	1-	ATTN 2
D3	2-	ATTN 1
D4	2-	ATTN 2
D5	1-	Pulse Width 1
D6	2-	Pulse Width 2
SAM 1-4	Match DAC	
SAM 5-8	1-1	Vac
SAM 9-12	1-2	Vac
SAM 13-16	2-1	Vac
SAM 17-20	2-2	Vac
D O 1	1-	Dead man permit
D O 2	2-	Dead man permit
D O 3	1-	mod reset
D O 4	2-	mod reset
D O 5-12		Pulse ID LS Byte

D I 1	1-	Mod ok
D I 2	2-	Mod ok

RF Trim and stabilization

General status and error handling - Check of state with respect to modulator - should we expect RF
Check of gains of each stage (tolerances on computed signals) - Is this pulse nominal?
RF slow ramping (days, hours) - processing up

User interface

Protocol parameter changing and logging

Integration with SCP

Record keeping (history and error)
record of rms, mean, state flag?
integration with correlation plots
fast history of SAM vac data
'data' history of faults