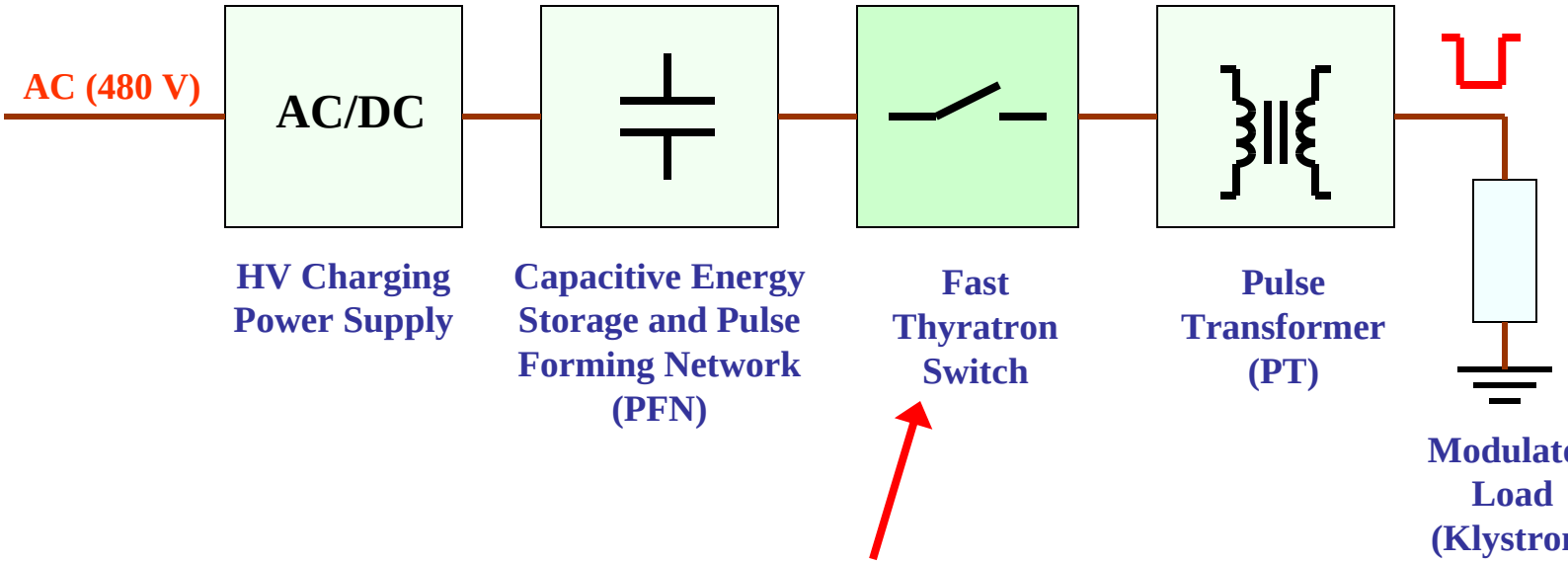
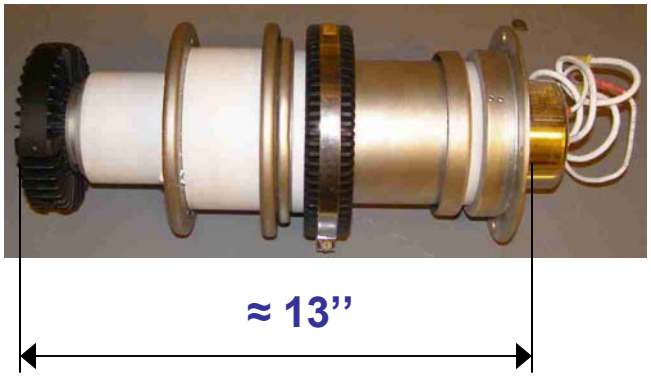
Thyratron Related Problems in the Linac Modulator

- **Possible reasons why the Linac Modulator does not pulse**
- **Possible reasons why some of the pulses are missing**
- **Possible reasons why excessive pulses are produced**

Thyratron Related Problems in the Linac Modulator



CX1836A thyratrons that are employed in the Linac modulators are Deuterium filled fast switching devices.

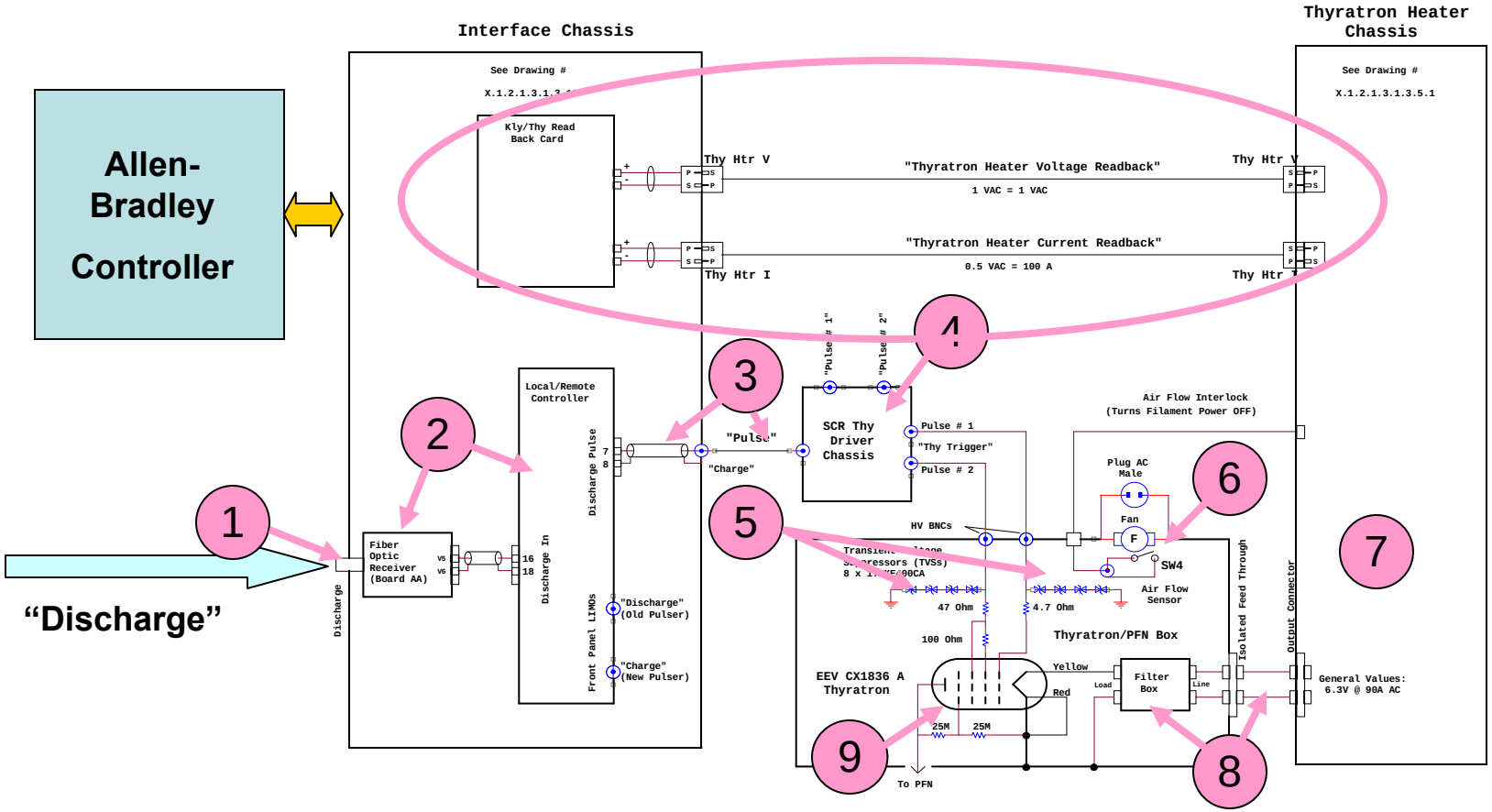


The thyratrons require very accurate filament voltage setting, proper air cooling, special measures to be taken to reduce switching loses, etc.

Nevertheless, average lifetime of the Linac thyratrons never exceeded 18,000 hours, and old tubes generate additional problems to surrounding components.

Let’s discuss some of the problems and methods of finding and fixing them.

Thyratron Filament, Control, and Readback Circuits

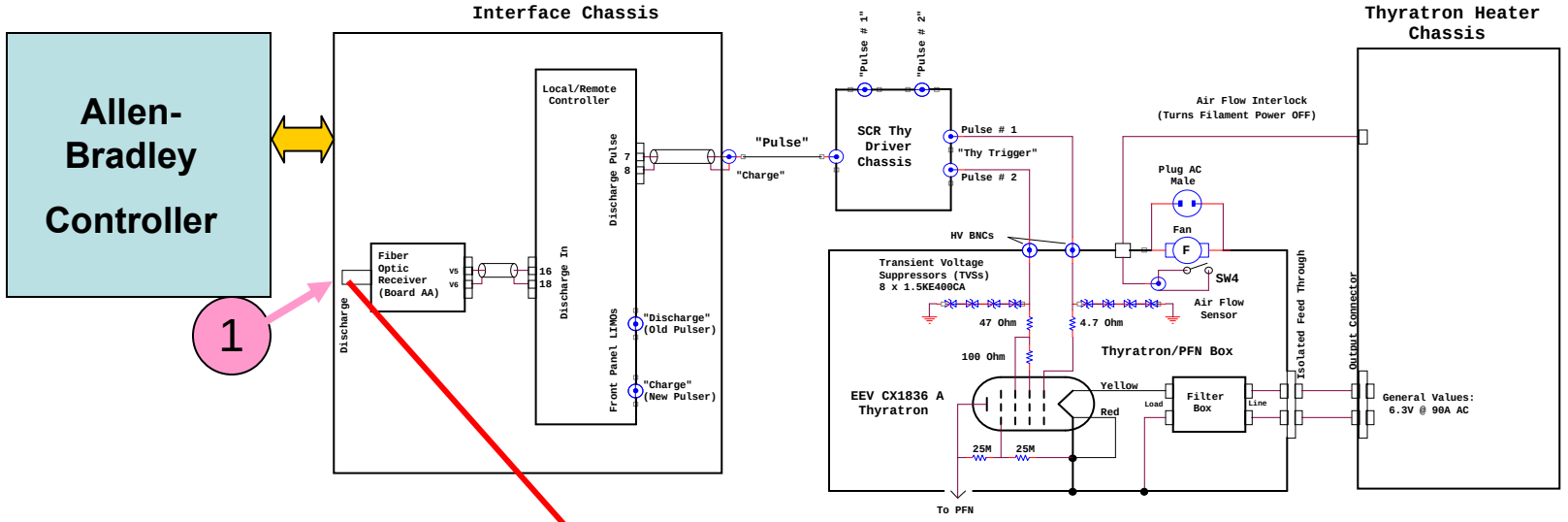


There are many reasons why the thyratron will not pulse at all…

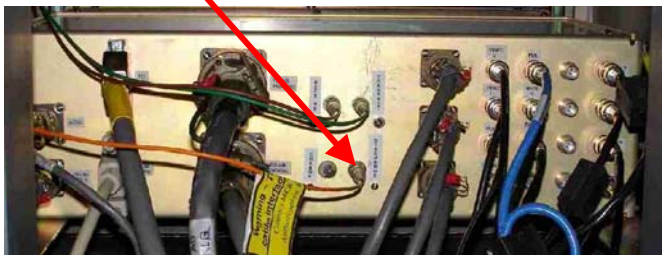
There are much fewer reasons to miss some pulses or to produce excessive pulses

This is Filament voltage and current readback area. Any real problem here will cause modulator trip. If the readings look abnormal and the modulator is running, look into Allen-Bradley controller.

Reasons Not to Pulse



1. Discharge command fiber-optic cable is damaged, NOT connected, or there is no light pulse.



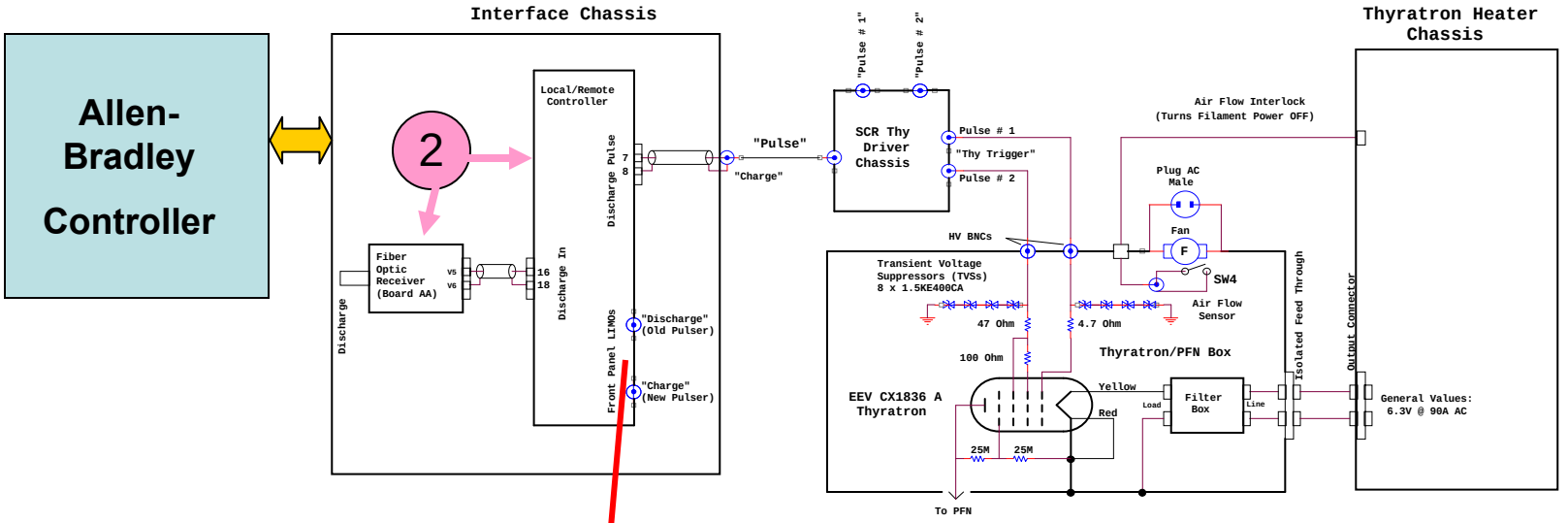
Interface Chassis

Rear View

Human eye is not able to detect light pulse in this cable.

If you have reason to suspect pulse absence, make sure that the modulator is in at least “Ready-to-Pulse” state, then contact Nick DiMonte.

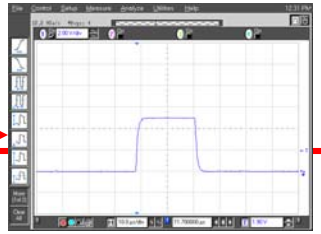
Reasons Not to Pulse



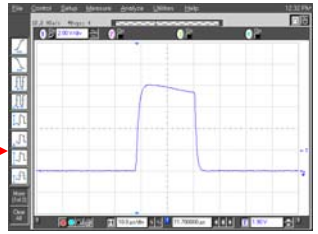
2. Optical receiver or Local/Remote PCB of the Interface chassis failed

Interface Chassis

Front View



or



Connect scope to the “Discharge” LEMO connector if old-style driver is in use

Or

Connect scope to the “Charge” LEMO connector if new-style driver (“Prepulser”) is in use.

Observe 20-us, 5-V pulses for old system (8-V for new one).

Reasons Not to Pulse. Recognize Type of the Driver

Old-style Thyratron Driver.

New-style Thyratron Driver.

Front panel with “Power On” indicator and two BNC connectors to monitor pulses at TTL level in the middle of the Driver’s logic board

New-style Thyratron Driver.

Rear panel.

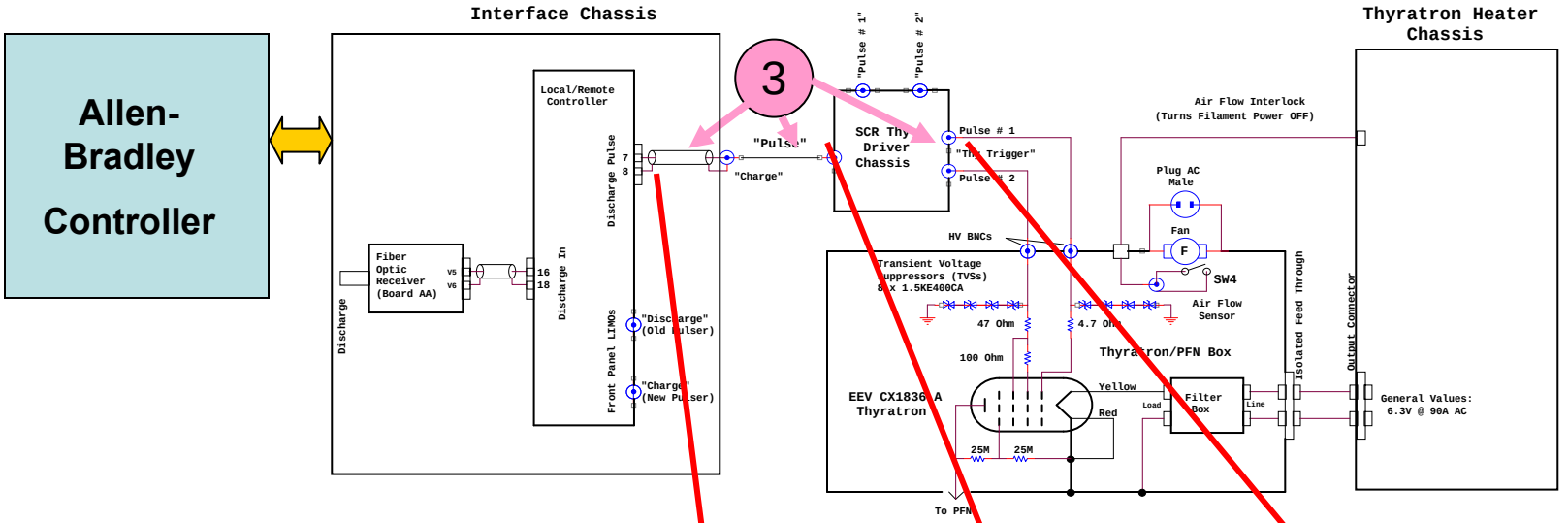
Reasons Not to Pulse

Old-style Thyratron Driver input cable must be connected to “Discharge” or “Pulse” BNC connector of the Interface chassis rear panel

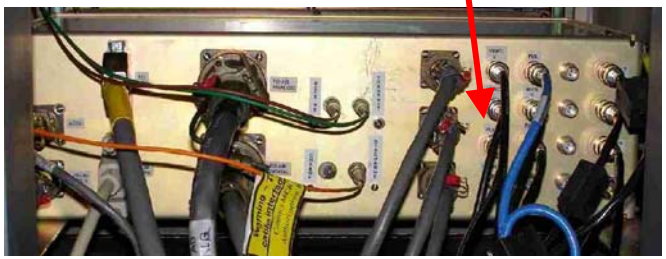
Interface chassis rear panel

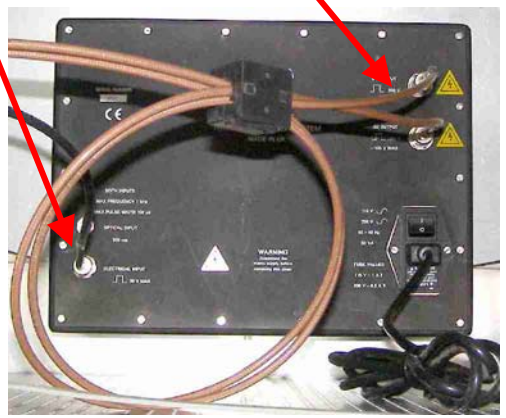
New-style Thyratron Driver input cable must be connected to “Charge” BNC connector of the Interface chassis rear panel

Reasons Not to Pulse



3. Driver's input or output cable is connected to a wrong BNC connector of the Interface chassis,

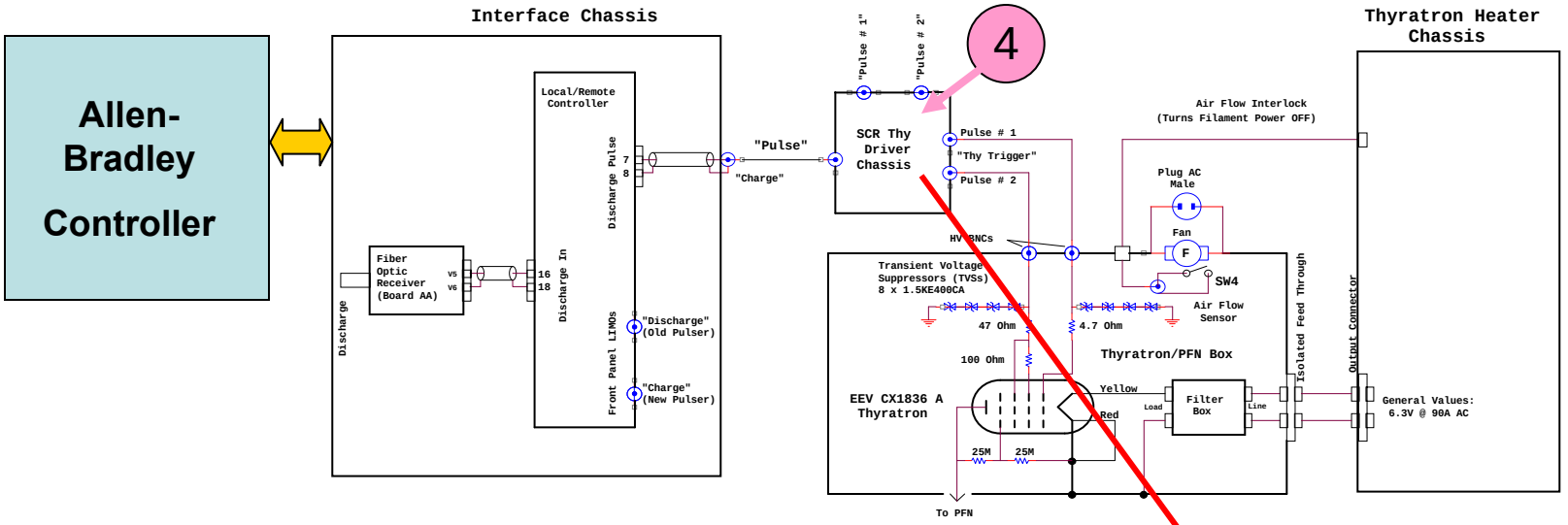




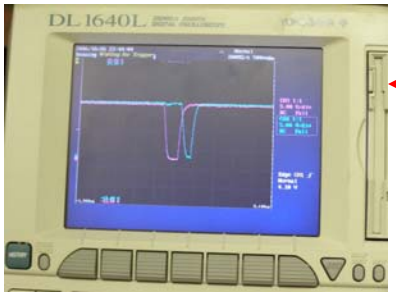
Or

Any of the input/output cables is damaged or disconnected including thyratron ends located in the PFN cabinet

Reasons Not to Pulse

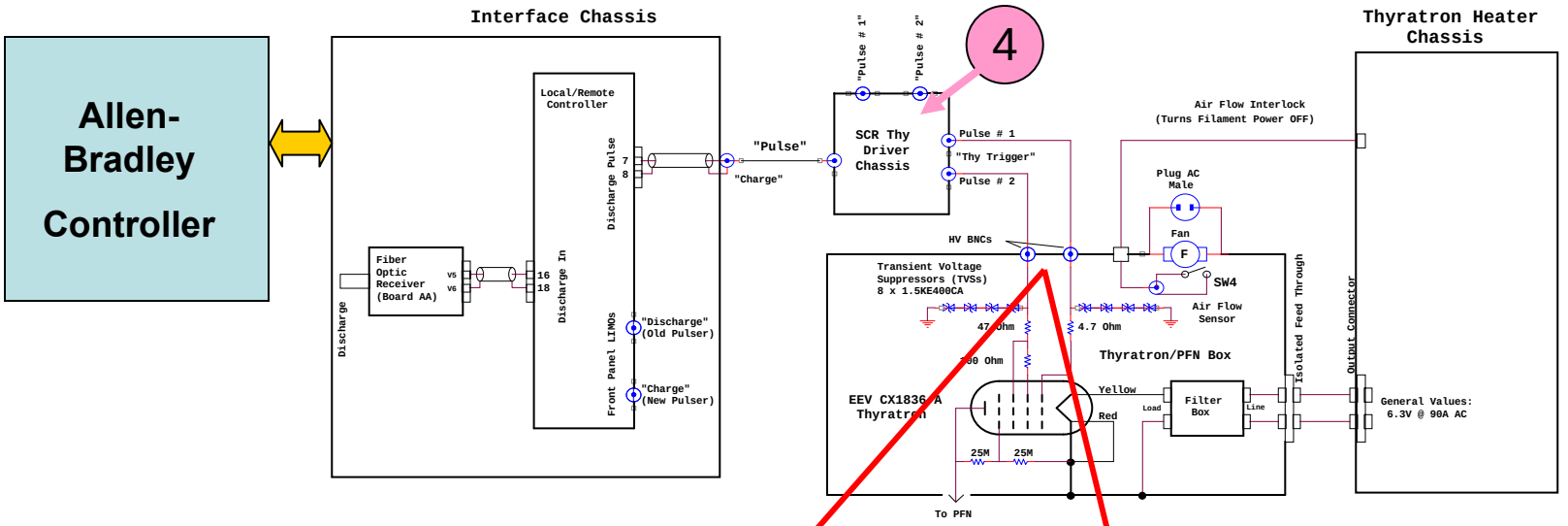


4. The Driver is not functioning properly



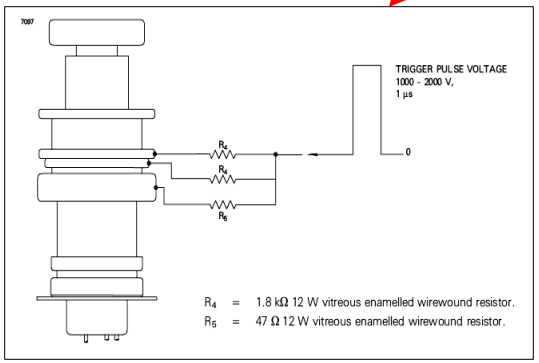
If logical circuits of the new-style driver work properly, two 15-V pulses will be observed. Time delay between the pulses is about 500 ns.

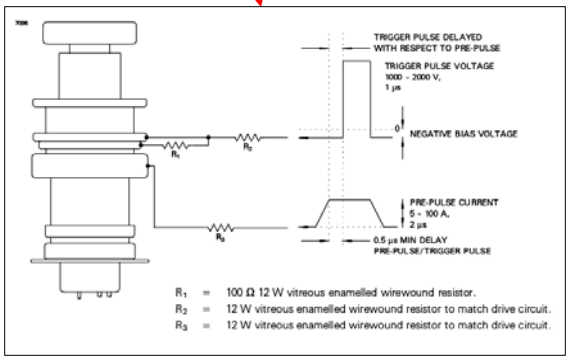
Reasons Not to Pulse



4. The Driver is not functioning properly

Observing HV output pulses at the Driver's output connectors is possible using special HV probes, but it requires special measures to obey all safety rules.

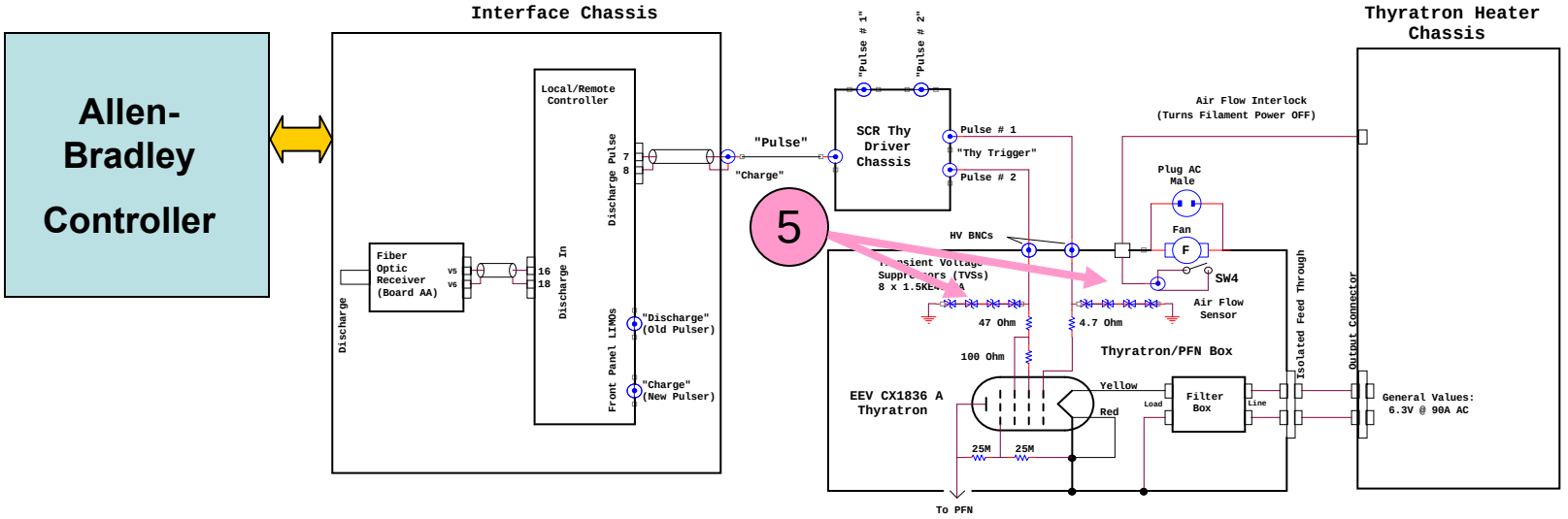




HV Pulse in the old-style Driver

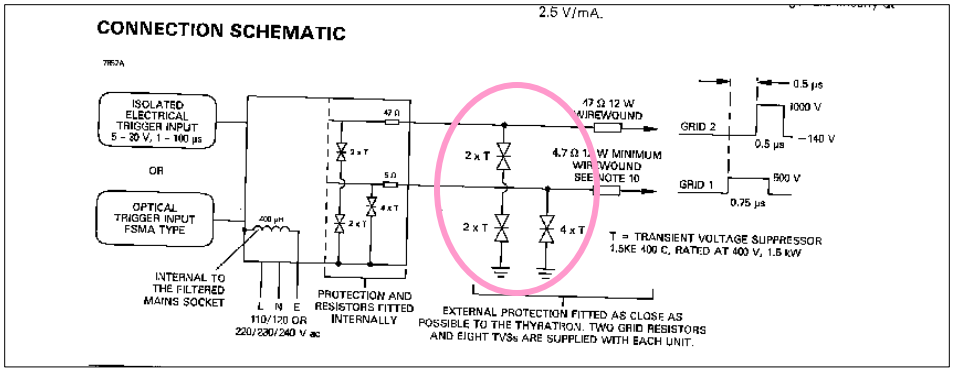
HV Pulses in the new-style Driver

Reasons Not to Pulse



5. The Transient Voltage Suppressors Failed

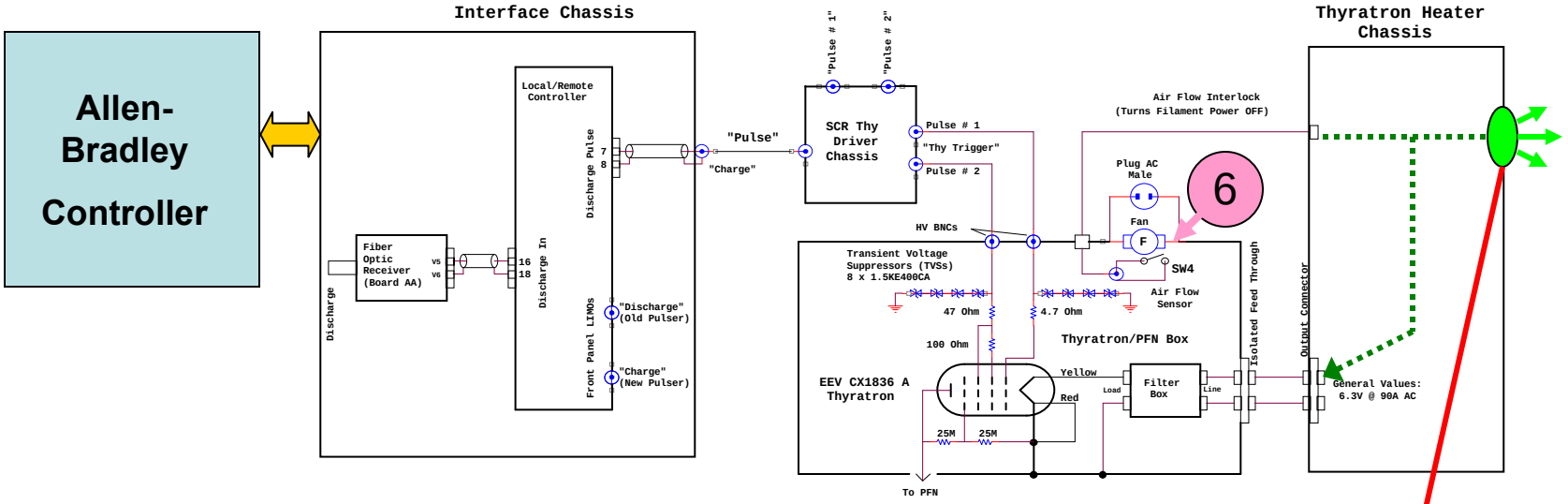
Usually, the Suppressors or Transorbs fail to short state. It happens more often in the modulators where older thyratrons are in use.



The transorbs are located behind the side panel of the Thyratron box

The only way to fix the modulator is to replace failed transorbs

Reasons Not to Pulse

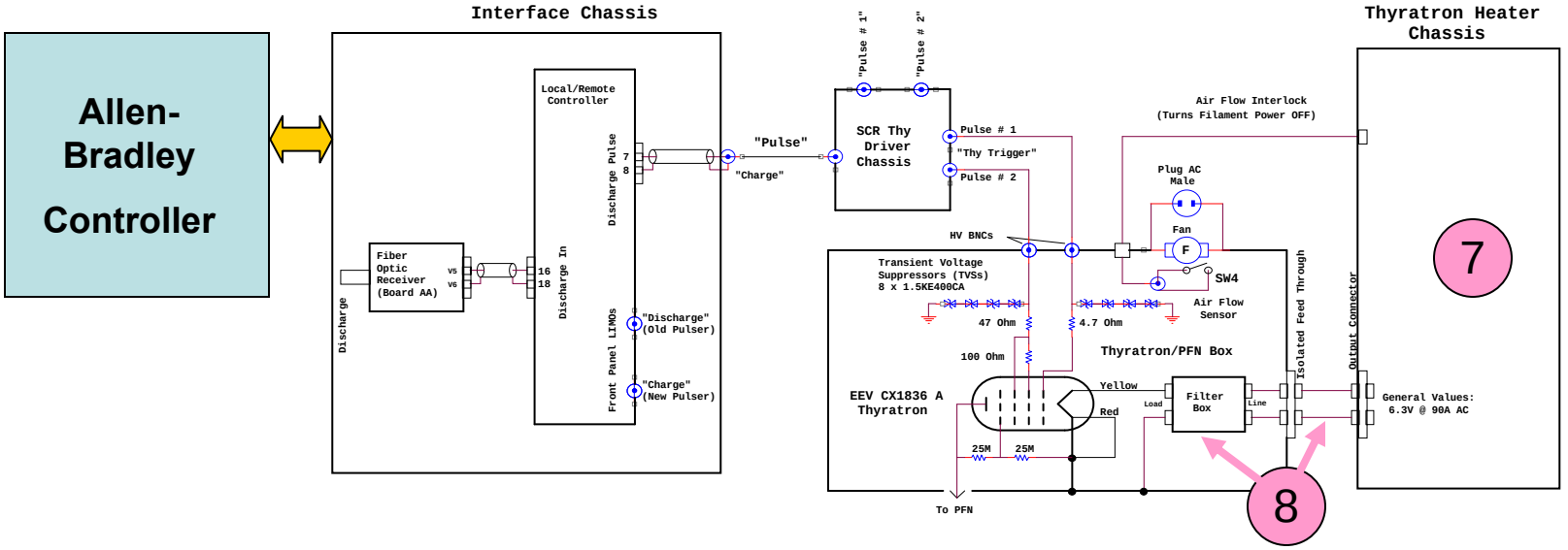


6. Thyratron cooling fan Failed

The fan is equipped with an air flow sensor. If flow is insufficient, thyratron filament power supply will be turned off, and the modulator will trip

The fan and sensor are located on the side panel of the Thyratron box

Reasons Not to Pulse

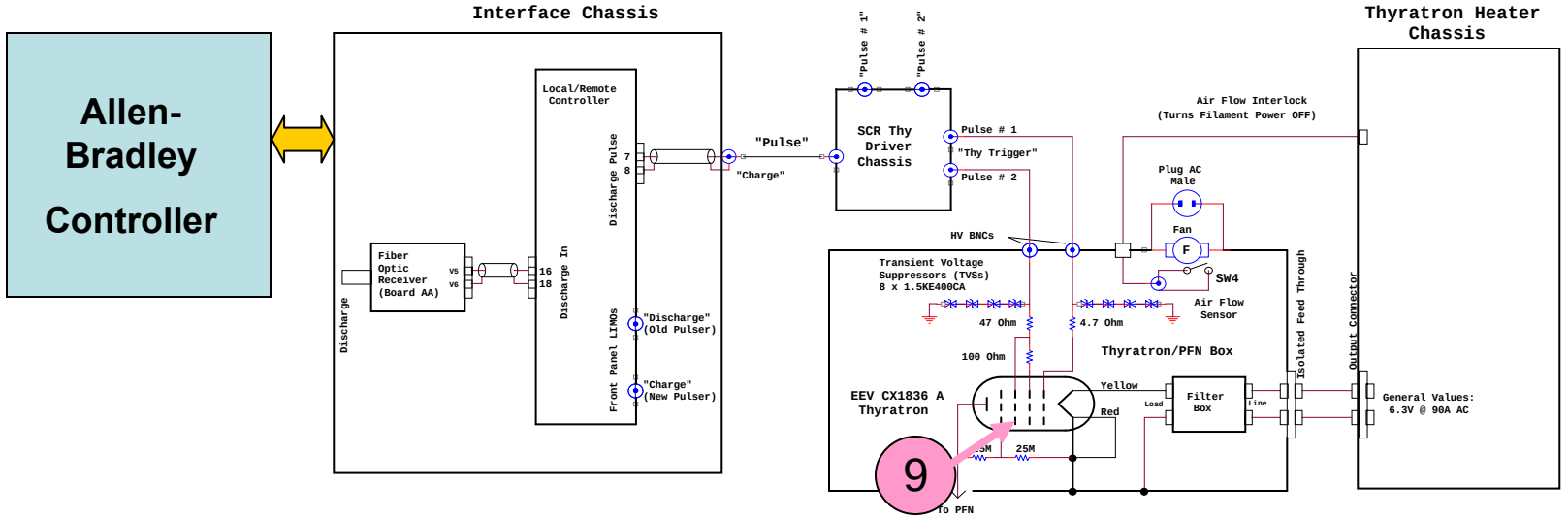


7 & 8 **Serious problems with the thyratron filament power supply and associated circuits will cause “Filament Under- or Overcurrent” trip, and the modulator will be turned off.**

In most cases, the variac voltage regulator of the power supply fails.

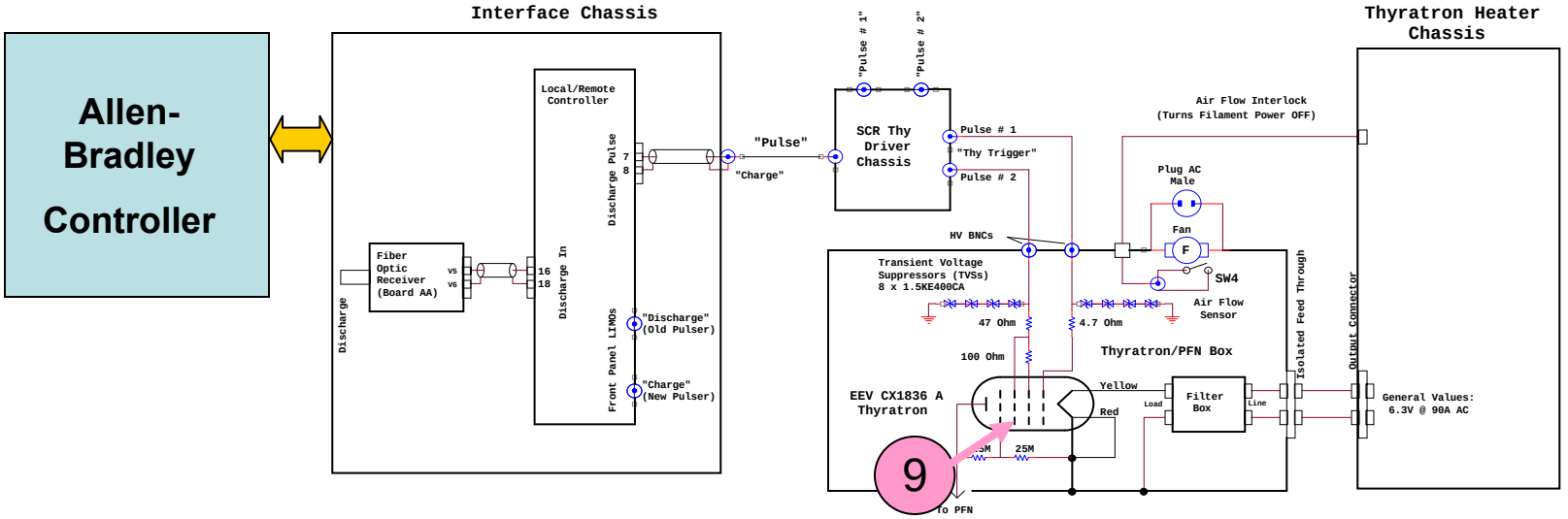
The power supply needs to be replaced and fixed later on the bench.

Reasons Not to Pulse



9. The Thyratron associated problems:
   a. Everything else confirmed O.K. but the thyratron will not pulse;
   b. Some pulses are missing;
   c. The thyratron produces excessive pulses;

Reasons Not to Pulse, Miss Pulses or Produce Excessive Pulses



9.a Everything else was checked and confirmed O.K., but the thyratron would not pulse.

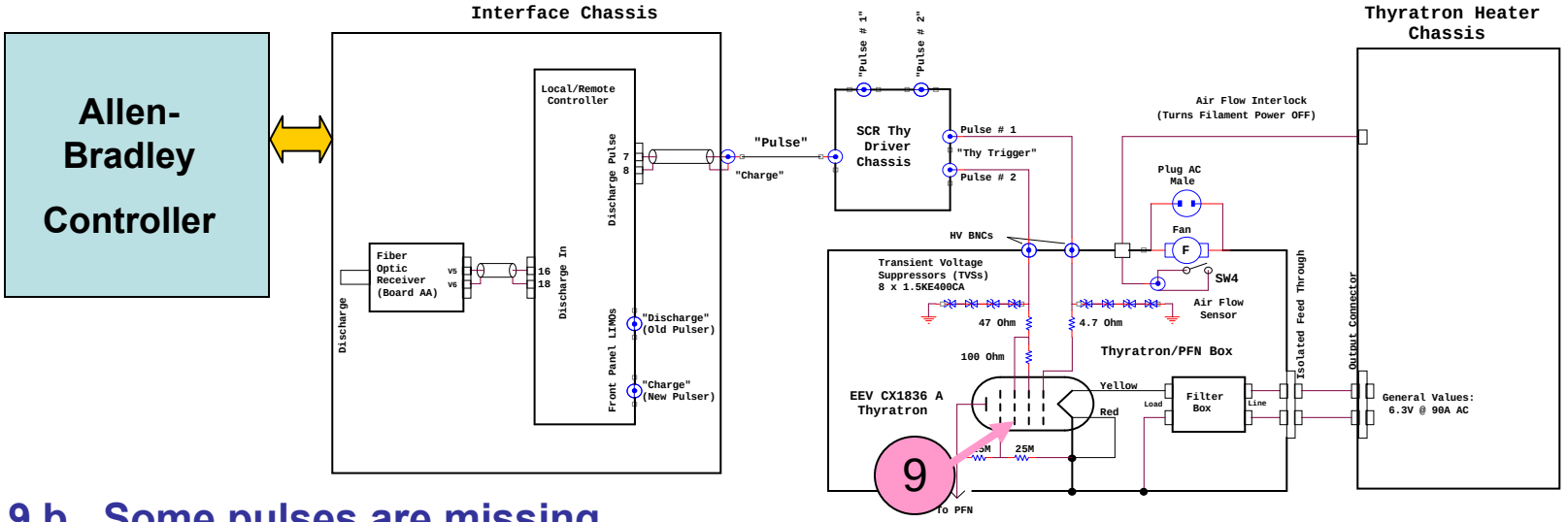
The modulator DOES NOT trip. Filament voltage and current look O.K. The PFN may be charged to the normal operational voltage level. Integrity of the PFN output cables was checked and found O.K.

Most likely, the tube's Deuterium reservoir is empty (or almost empty) or underheated because of some tube's internal problems. This means tube's "End-of-Life".

The tube needs to be replaced.

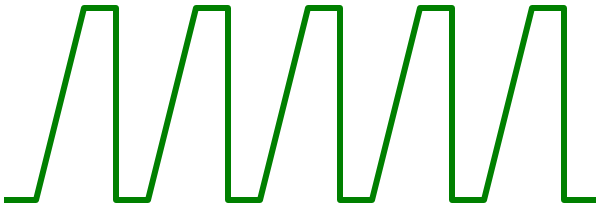
It is also possible that 15-min warm-up time period is not finished.

Reasons Not to Pulse, Miss Pulses or Produce Excessive Pulses



9.b Some pulses are missing.

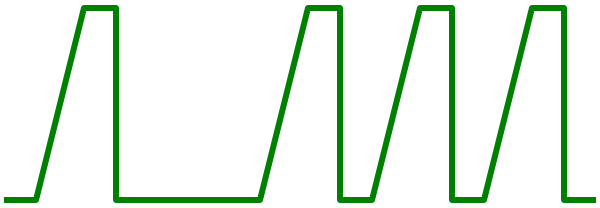
It may be found while observing PFN voltage with a scope or sometimes by listening to the sound from the oil tank.



Normal pulsing.

Possible problems:

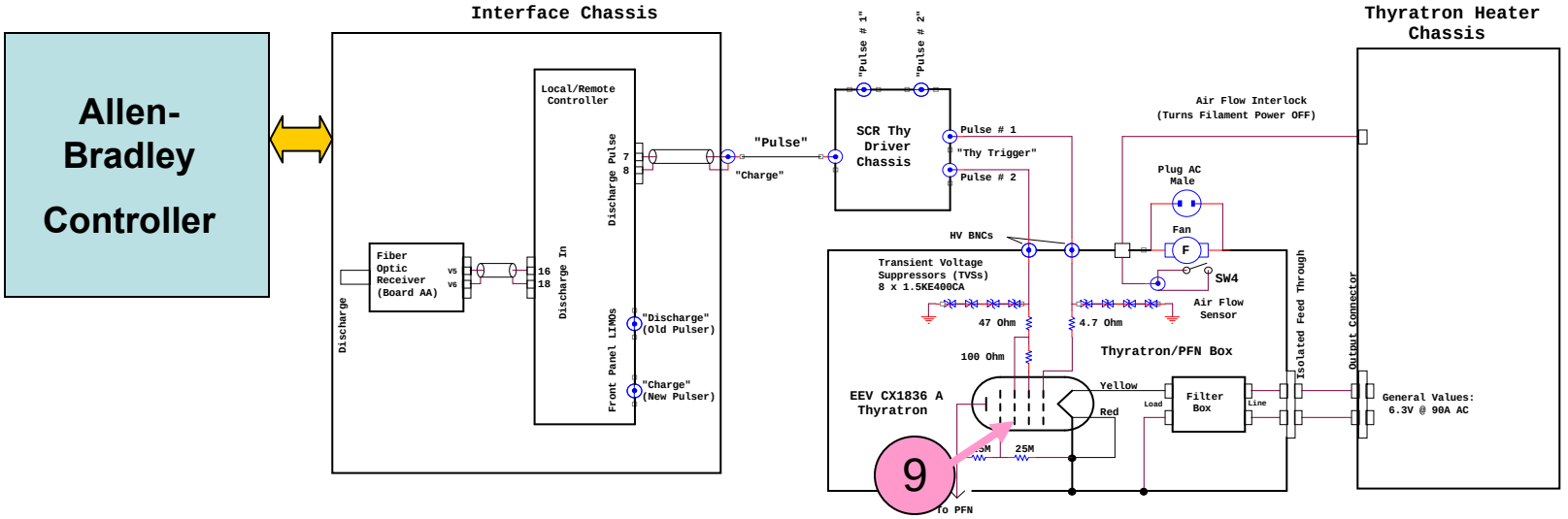
- Low filament voltage (must be 6.3V)
- Tube's "End-of-Life" is approaching; you can try to increase filament voltage a little. It may eliminate the problem for some while.



Some pulses are missing.

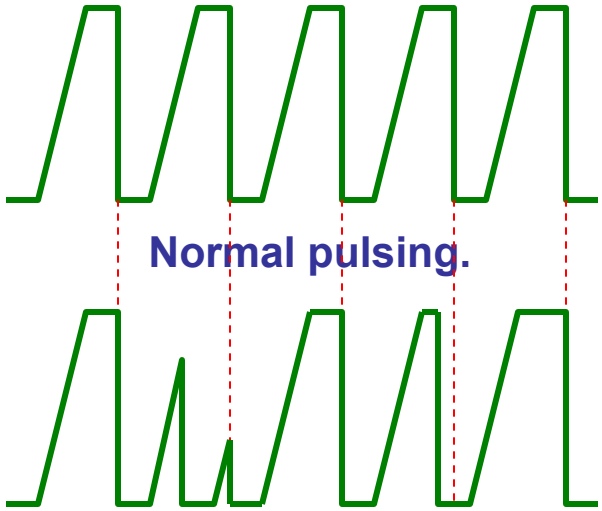
Note: If filament voltage is too low, the tube may stop pulsing completely.

Reasons Not to Pulse, Miss Pulses or Produce Excessive Pulses



9.b The thyratron produces excessive pulses (or the tube pulses by its own).

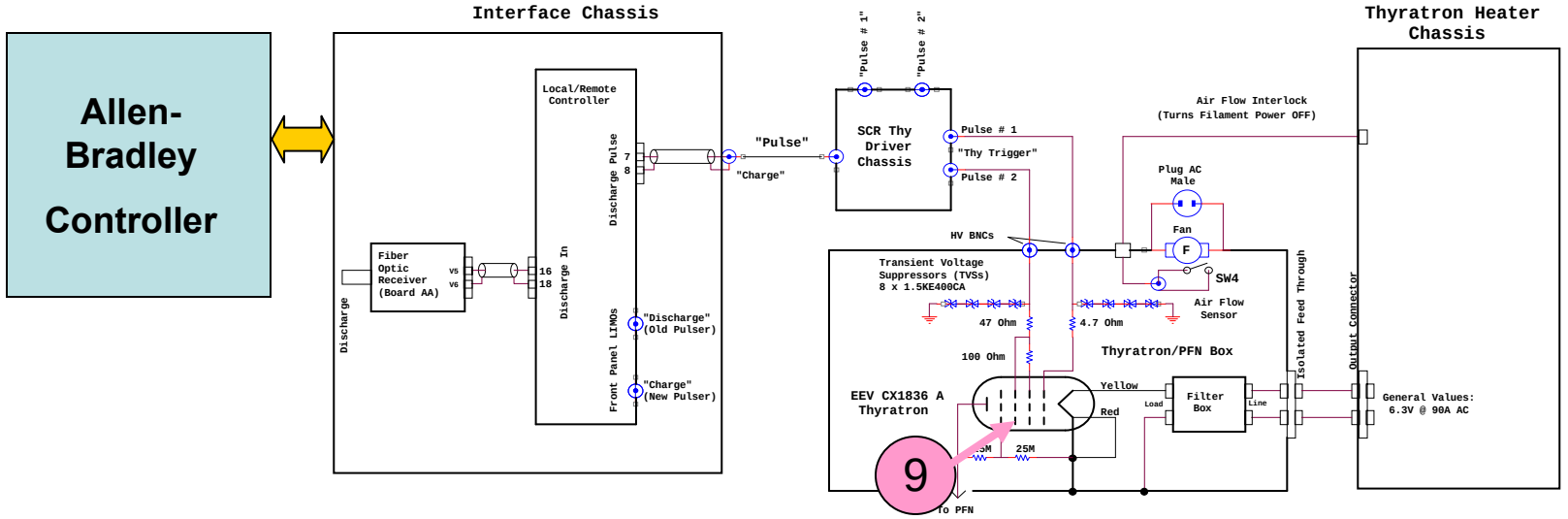
It may be found while observing PFN voltage with a scope or sometimes by listening to the sound from the oil tank.



Normal pulsing.

Excessive pulsing.

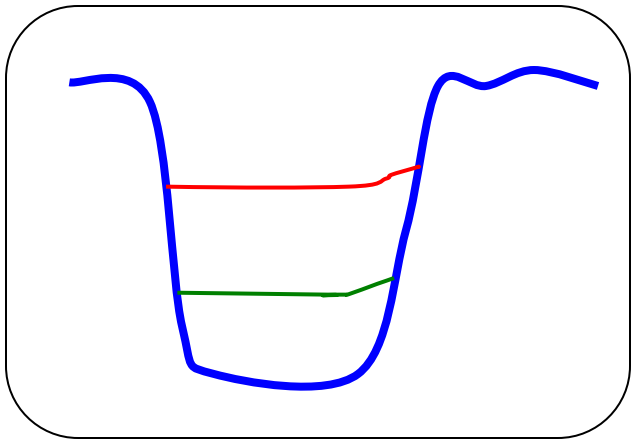
Reasons Not to Pulse, Miss Pulses or Produce Excessive Pulses



9.b It also may be found while observing Cathode voltage/current with a scope.

Possible problems:

- **Too high filament voltage (must be 6.3V);**
- **Tube's internal problems: the Deuterium reservoir is overheated. Nothing can be done because the reservoir filament is combined with the cathode one.**
- **The tube is defective. Such a tube was found recently in one of the modulators: it did not hold high voltage.**



Another symptom of the same problem: several pulses have lower amplitude than the others