Ion source RF system

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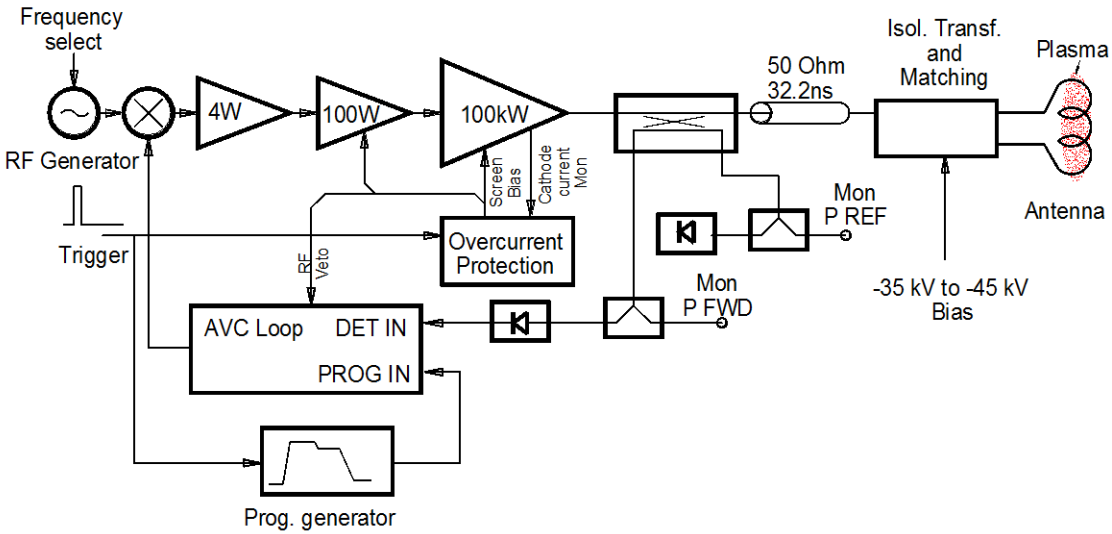
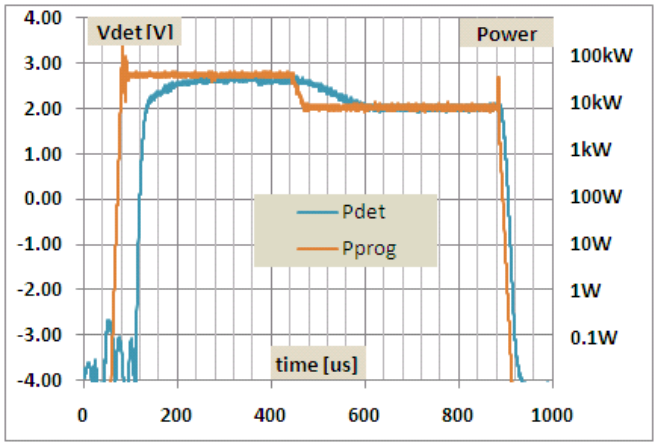
System description





- Wideband solid-state drivers
- 2 MHz ±200 kHz, 100 kW final stage
  - 2 ms burst at 2 Hz or 50 Hz
  - 50Hz requires power supply upgrade
- Wideband 1÷1 isolation transformer
- Capacitive matching network
- PLC control and interlock system

- Forward power controlled by AVC servo system
- Frequency agile operation compensates plasma detuning effects
- High directivity (30dB) directional coupler for plasma electrical characteristics on line measurement

Present status

- Two RF systems installed:
  - Production source in operation in Linac4
  - Development source in operation in the 3MeV test stand.
- Spares of all critical items are available (custom built or long lead time)
  - screen pulsers, HV capacitors etc.
- Integrated in the control system
  - interlock, ON/OFF controls, etc.
- Integrated in Beam Interlock System
  - veto from BIS can cut source RF
- New low-level control system:
  - RF reference signal generation
  - function generation for forward power programming
- Remote data acquisition and treatment in control system:
  - acquisition of RF forward, reflected and plasma light signals
  - amplitude and phase detection
  - on-line signal processing and calculation of plasma electrical characteristics (R_{Plasma} L_{Plasma} and P_{Plasma})

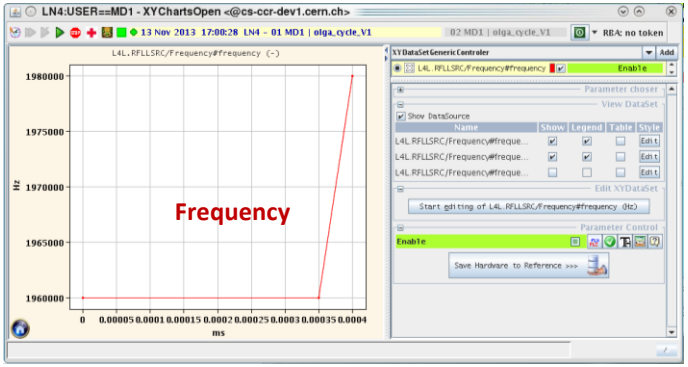
RF low-level control

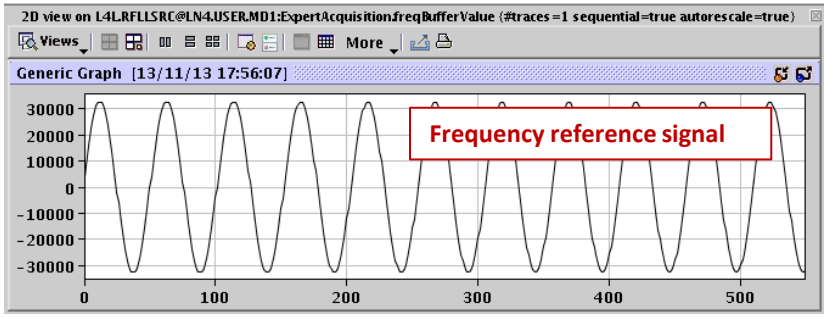
- A system for RF signal generation and acquisition has been implemented
- Uses standard CERN VME controls hardware:
  - **2-channel arbitrary waveform generator** for RF frequency reference and amplitude control function
  - **high speed digitizer** for signal acquisition at 50 Msample/s
  - **timing receiver** for synchronization with the control system
  - **CPU board** running Linux
  - custom FESA **software** for signal generation and processing

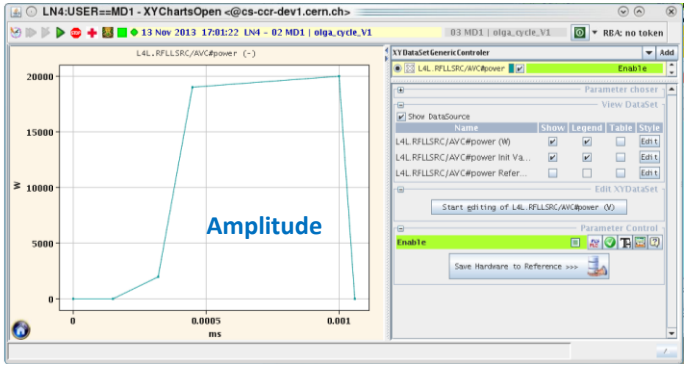
RF signal generation

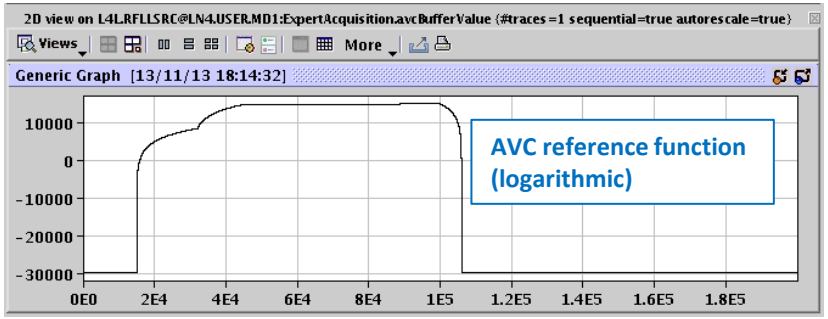
- Freely programmable frequency and amplitude functions edited using control system (InCA)
- Fine-tuning of frequency and amplitude along the pulse allows compensation of plasma detuning effects
- Settings management (history etc.) via control system

- Waveforms calculated in the front-end computer FESA software
- Programmed into 100 Msample/s arbitrary waveform generator



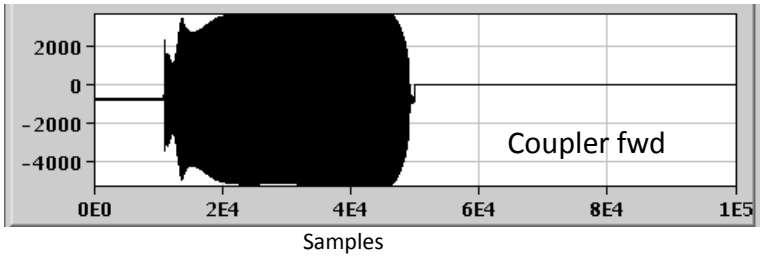




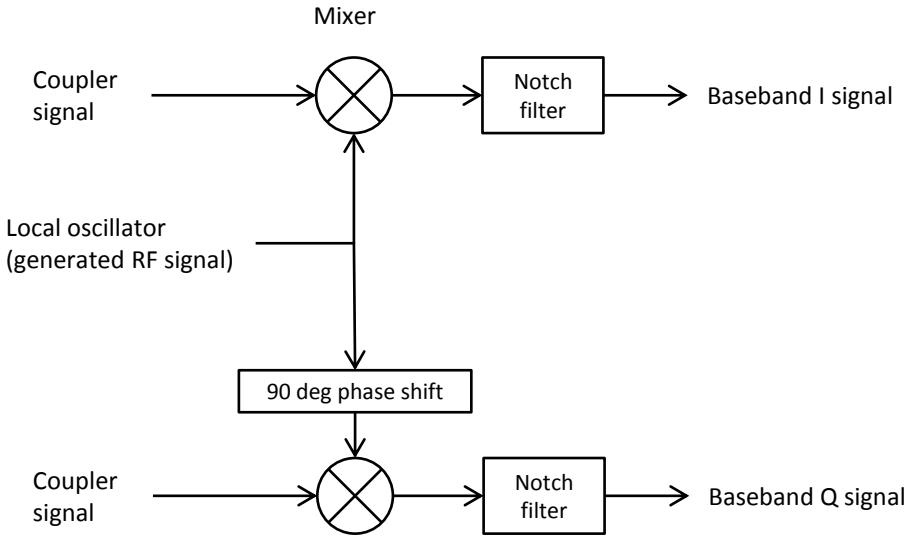


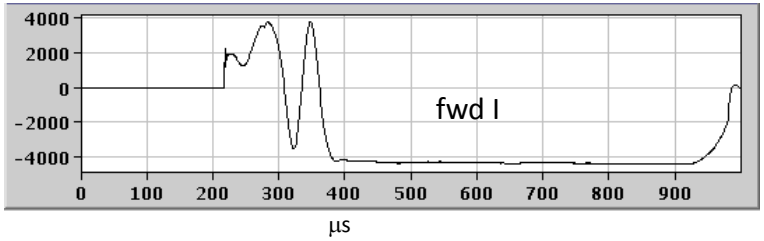
Signal acquisition and processing

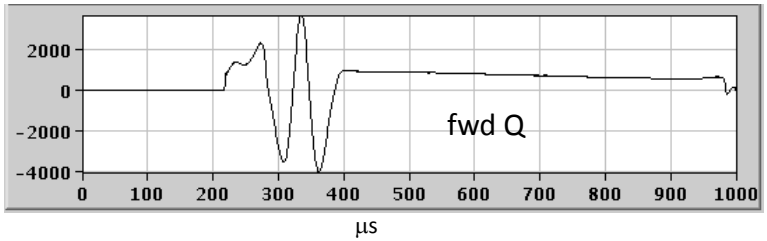
- Direct sampling of signals at 50 Msamples/s (pulse by pulse):
  - directional coupler forward
  - directional coupler reflected
  - plasma light signal



- Forward & reflected signals are demodulated in software into I (in-phase) and Q (quadrature):

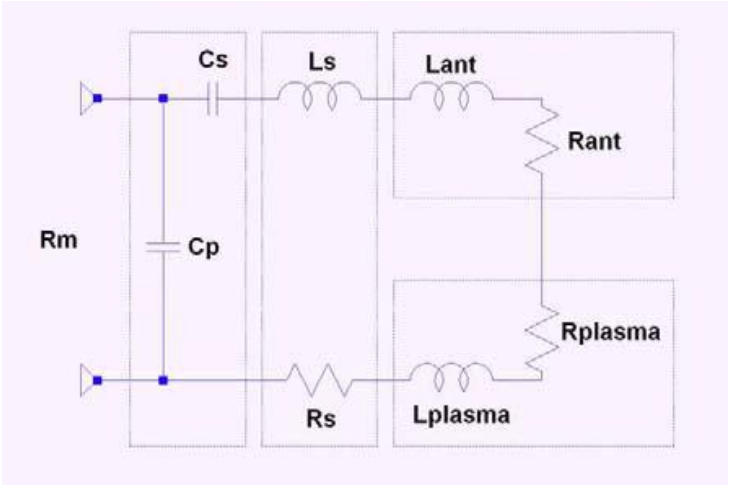




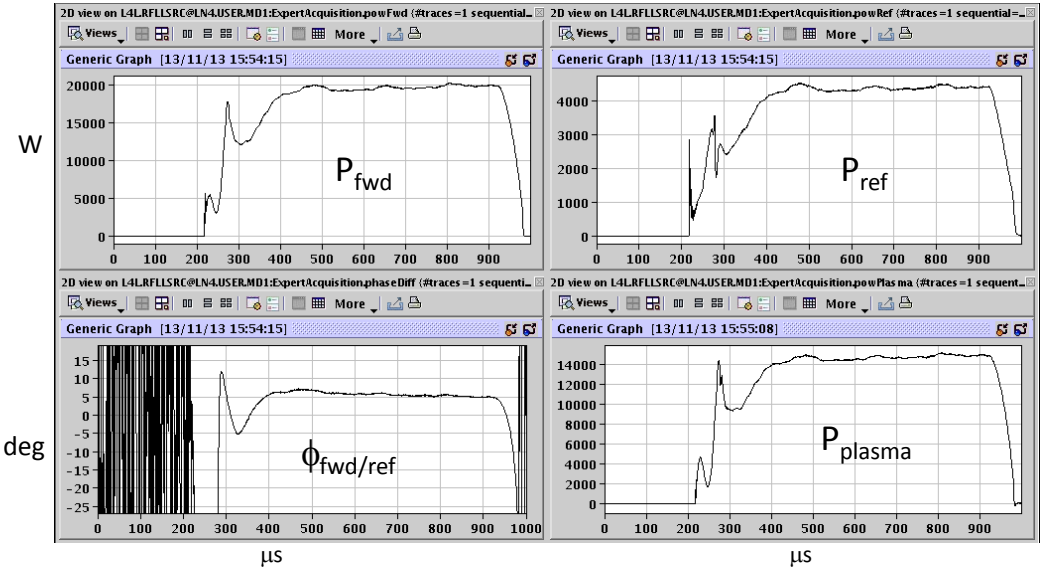


Signal acquisition and processing

- From I and Q signals of coupler forward/reflected, derive:
  - forward/reflected power
  - phase difference forward/reflected



- Using equivalent circuit model (M. Paoluzzi) estimate:
  - plasma impedance
  - plasma power
  - power loss
  - …



Remaining work for low level RF controls

- Make selected signal acquisitions available in standard CERN framework (OASIS) – few days, in progress
- Validate online calculation of plasma parameters and calibrate – few days, in progress
- Clean up some control system details (function timebase units, device names etc.) – at suitable opportunity
- Provide comprehensive user documentation – in progress

Resources needed for source operation

- Operation of the two sources for:
  - Stable production for the Linac4
  - Components development for the 3MeV test stand.
- Each component is to be validated in the development source before installation in the production one. This requires a number of iterations for matching network design, construction and overall characterization.
- Parts installed in Linac4 have limited lifetime and spares must be prepared. They probably also include dedicated matching network parts fitting the specific antenna coil.
- For each iteration two days from RF engineer/technician are required.

Summary

- High level RF system:
  - development is complete
  - installed in Linac4 as well as in 3MeV test stand
  - spares of all critical items available
  - resources still needed to support the ongoing development of the source
- “Final” Linac 4 RF generation and measurement system has been implemented
  - uses standard BE/CO hardware components and software framework
  - flexible control of RF frequency and amplitude
  - remote RF signal measurements and parameter calculation
  - small amount of additional functionality still being implemented
- All RF equipment integrated into the control and Beam Interlock systems