Upgrade of the Linac RF Peak Detector unit at the Australian Synchrotron

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INTRODUCTION

The AS 100 MeV 3 GHz Linac structure is made of a 90 keV GUN, a 500 MHz subharmonic prebuncher unit (SPU) -, preliminimary buncher (PBU), final buncher (FBU) and two accelerator structures. The structure is powered by two 35 MW pulsed klystrons, and transmitted across the SF6 pressurised WR284 waveguide RF distribution system. The low level electronics include two pulsed 400W S band amplifiers to drive the klystrons, and two UHF amplifiers for the GUN and SPU. All of which are manually adjustable in phase and amplitude. Details of the Linac layout are shown in Figure 1.

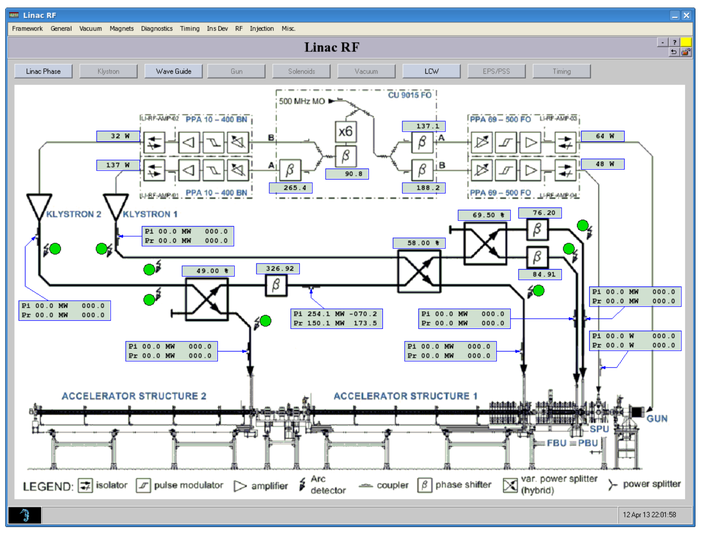


Figure 1 Linac RF GUI showing layout

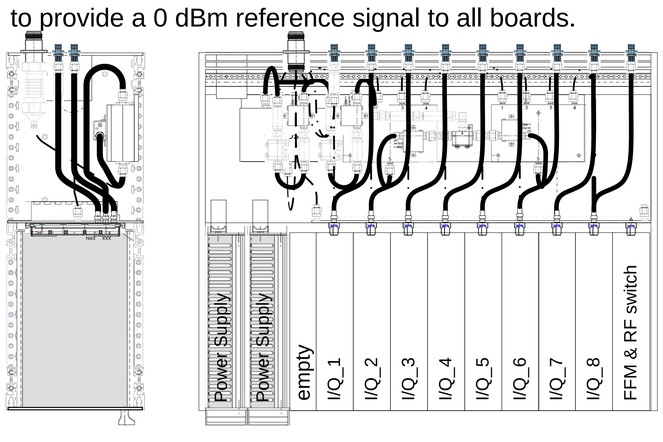
The AS has been operating in Top Up mode since May 2012, where the injection system injects a single bunch every few minutes to maintain 200 mA in the 3 GeV Storage Ring. Several upgrades of the Linac have been necessary since the operation started in 2007, to improve reliability. The major upgrades for the Linac include: the timing system, waveguide extension and the phase monitoring system described in this paper.

ORIGINAL DESIGN LIMITATIONS

- Peak detector was integrated into the Linac control system with limited data acquisition
- A Siemens PLC processes only a forward power analogue signal with a soft interlock power exceeded and a reverse power exceeded from a digital signal.
- Response time cannot provide an immediate interruption during a pulse, but disables the next shots in case of an alarm until manually reset.
- All RF input signals were additionally filtered with a BP and the displayed power resolution was 1 MW indicating possible noise issues with this design.
- It requires two crates to process six bi-directional couplers

KEY DESIGN FEATURES FOR NEW SYSTEM

- Simplified design to fit two channels on a single Euro board, each channel measuring I and Q with a 5380 but also amplitude with an 8362 for protection power exceeded.
- Up to eight modules can be plugged into the 19 inch RF shielded rack (320 mm deep) and an extra slot is allocated for a future module to provide a fast fault memory with a nanosecond switch to interrupt the RF (Figure 2 & 4).
- The back half of the crate hosts a 500 MHz to 3 GHz frequency multiplier and signal distribution to provide a 0 dBm reference signal to all boards.



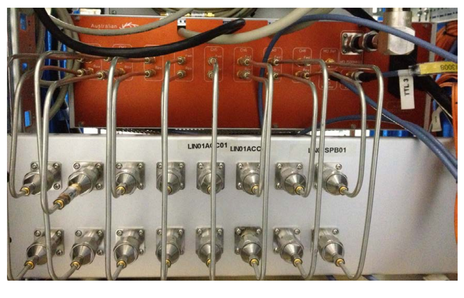


Figure 3 N type patch panel

Figure 2 Linac phase monitoring system layout

- The heavy low loss microwave cables from the Linac are connected to an adjacent N type patch panel, followed by attenuators for level adjustment before being connected to the SMA RF inputs seen in Figure 3.

KEY DESIGN FEATURES FOR NEW SYSTEM (cont.)

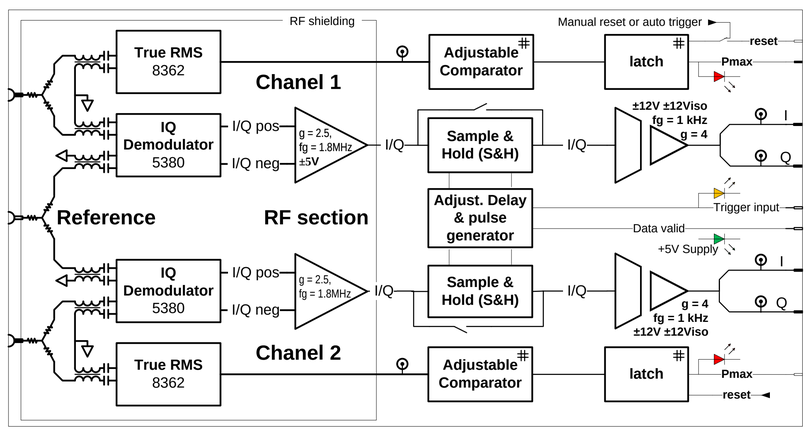


Figure 4 Linac phase monitoring module flow diagram

- Useful debugging supports are front panel monitoring outputs for I, Q and power, status LED's for board supply, trigger and power exceeded plus on board test pins.
- Special effort was put into a low noise design and good EMC practices. Key design features for this approach include: low emission P/S's from Kniel, isolation to mains and all outputs, short RF microstrip lines close to the connectors, and building all modules into cassettes - or optionally to cover the RF section only.

MEASUREMENTS WITH NEW SYSTEM

- We measured a useful dynamic range of >40 dB and a demodulation accuracy of better than 0.1 dB and 1 degree respectively. (Figure 4)
- The measured noise figures were excellent and achieved a resolution of 0.1 degrees and 0.02 dB respectively; and still remarkably 1 deg and 0.2 dB at -32 dB in pulsed mode.

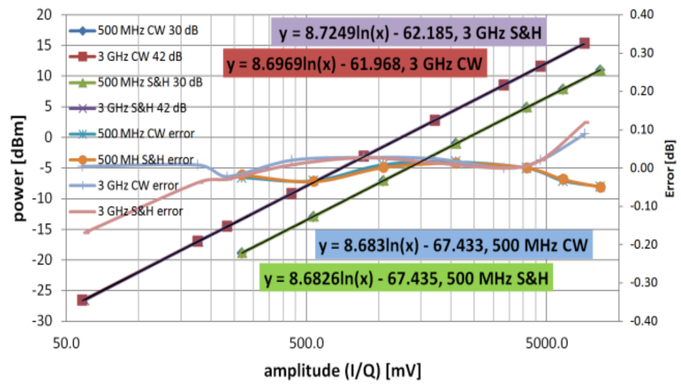


Figure 5 Dynamic Range test results

FUTURE DEVELOPMENTS

The next upgrades will be the FFM and nanosecond switch module and possibly the same upgrade for the Booster RF system. Future development of a soft Low Level Electronics system is also likely, to automatically readjust slow drifts in phase and amplitude.

CONCLUSION

The new in-house designed Linac RF peak detector unit has been operating successfully since May 2012. The compact system provides excellent performance, EMC, thermal stability using conventional cooling only and will minimise maintenance without the need to retune elements on the boards. The system has already proven to be a great diagnostics tool for trouble shooting.

Material costs for one complete system are less than AU$20,000, including assembly but they can easily be reduced to suit a tighter budget.

ACKNOWLEDGEMENTS

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