The LINAC Test Facility at Daresbury Laboratory

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Introduction

The **LINAC Test Facility (LTF)** is dedicated to facilitating research and development of applications in medical, security, and environmental technologies through the operation of a Compact LINAC.

To advance the world's next generation of particle accelerator technologies and attract exciting new opportunities for UK industry, *STFC* and *Teledyne e2v* established a collaboration and strategic relationship in 2018. Teledyne e2v is a leading supplier of RF technologies in radiotherapy, security, and high-energy physics. Gaining access to STFC's unique facilities allowed them to assist with the development of their integrated RF sub-systems.

Figure 1: The Compact LINAC in the LTF. The main components are (1) 3.1 MW S-Band Magnetron, (2) 3-Port Circulator and (3) the 6 MeV Linear Accelerator.

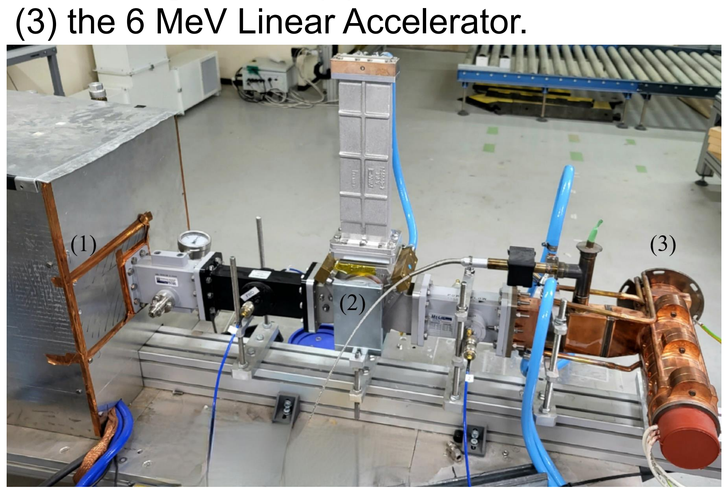
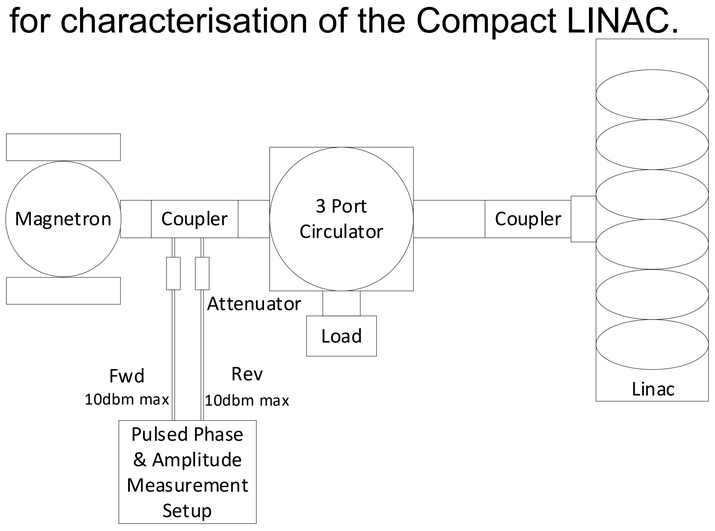


Figure 2: Set-up of measurement apparatus for characterisation of the Compact LINAC.



Operation Conditions

The Compact LINAC system comprises the following main components (see Fig. 1):

- Teledyne e2v AMM1 modulator
- Teledyne e2v MG7095 magnetron paired with an electromagnet
- AFT three-port circulator
- AcceleRAD Technologies 6 MeV Linear Accelerator

The S-Band LINAC produces a **6 MeV** electron or X-ray beam powered by a tuneable S-Band Magnetron. The pulsed RF frequency is **2.998 GHz**, and the peak output power is **3.1 MW**. Further operation parameters are shown in Table 1.

Table 1: Typical Operating conditions

Operation parameters	Value
RF Repetition Rate	50 Hz - 400 Hz
LINAC Forward Power	1.3 MW - 2.2 MW
Pulse width	0.5 µs - 4 µs
Peak Pulse Beam current	35 mA - 240 mA

Work Conducted

Rapiscan Systems was interested in generating 3D X-ray images for more comprehensive cargo screening to improve detection of contra-band and illicit material hidden within dense metal objects. The experiments were designed to use their novel detectors and examine the time of flight of the photons between the X-ray source and an object, allowing algorithms to approximate the position of an object.

Securing enough supplies of clean, safe freshwater is a critical priority. Researchers from the *University of Surrey* supported by the *STFC 'Food Network+'* approached treating wastewater with electron beams degrading organic compounds instantly. The Compact LINAC system could purify wastewater to a very high standard within minutes proven safe for agriculture use.

Teledyne e2v characterised the system performance, looking at changes in magnetron output (see Fig. 2&3). The phase and amplitude of the reflected power to the magnetron was measured during pulsed operation to characterise frequency pulling (see Fig. 4). This knowledge is particularly useful in a LINAC system during development and commissioning phases to optimise RF performance. This will allow Teledyne e2v to improve integration of components in the RF subsystem offering.

Figure 3: Cathode voltage and Anode current measured on the magnetron.

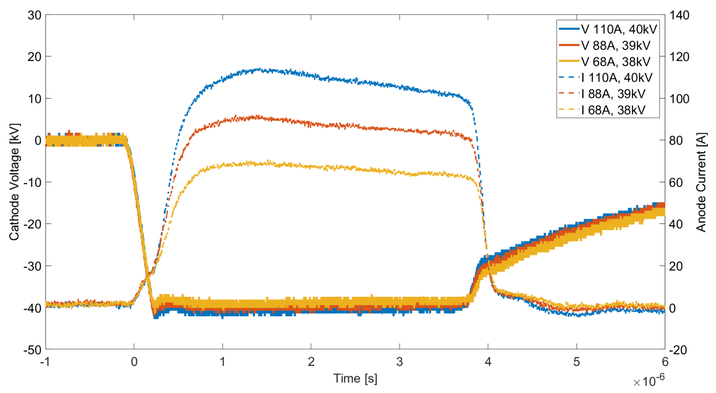
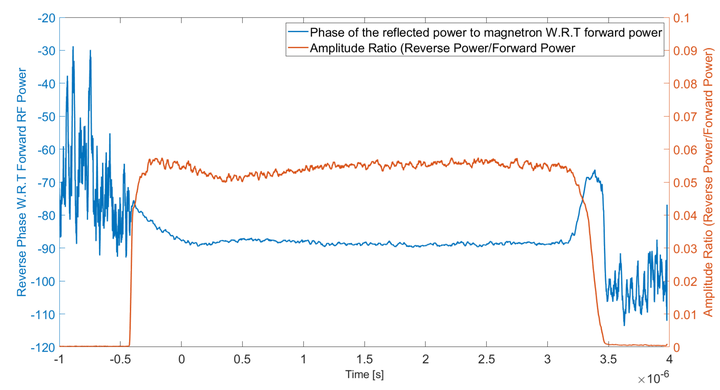


Figure 4: S11 phase and amplitude response of the Compact LINAC RF chain (at LINAC resonant frequency) averaged over 50 magnetron pulses.



Summary and Outlook

The collaboration between STFC Daresbury Laboratory and Teledyne e2v has been very positive. Teledyne e2v explored the use and limits of components in beam-producing systems, enabling this knowledge to be used for future developments.

Possible future upgrades will include the next generation of magnetrons and modulators; providing better life, monitoring and stability.

About the authors:
This poster is a joint collaboration between STFC ASTeC and Teledyne UK.