STATUS ON LOW ENERGY (10 MEV RANGE) X-BAND LINACS DEVELOPED WORLDWIDE

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Abstract

Portable X-band linear accelerators characteristics are analyzed. An attempt is made to summarize the commercial application areas in accordance with achievable beam basic characteristics using available microwave power sources, especially magnetrons. Guidelines for the further research and linac characteristics improvement in order to meet the customers' requirements are presented.

1. Introduction

The history of portable linear accelerators powered by X-band magnetrons started in the early 60s. The reason for entering into a shorter wavelength region to accelerate charged particles was quite obvious - to reduce the size and weight of accelerator head. Technological problems in building such a device were considerable enough to create some difficulties for a new generation of portable linac systems. Part of the problem was that a small, comparatively cheap, and reliable microwave power source was not reliable enough at power levels over 1 MW. However, magnetrons with power of 0.25 to 0.5 MW were successfully applied for accelerator technique. The necessity to operate at low power levels boosted up the technology of X-band accelerators and encouraged designers in the United States and Russia, where most of the work has been done, to generate new ideas for accelerator development. Therefore, during more than a thirty year period, interest in these unique machines has grown and been supported by few groups in the accelerator designers society. Currently, portable X-band accelerators are commercially available with a 1.5 MW magnetron. Recently, the 10 MeV level was approached and a beam over 12 MeV was delivered in a 1 m long section with the same magnetron. This opens new horizons for application in various fields- non-destructive testing, radiology, free electron laser technique, various radiation source simulations, well logging, etc.

2. X-band Linear Accelerator Models and Parameters

Small Accelerator Laboratory of Moscow Engineering Physics Institute under supervision of Dr. I.S. Shchedrin developed a number of X-band linacs U-30, 31, 32, 33, 34, 35, 36 [1, 2, 3]. All structures are travelling wave, except U-34 (Fig.1) [3] and powered by 0.25 or 0.5 MW magnetron.

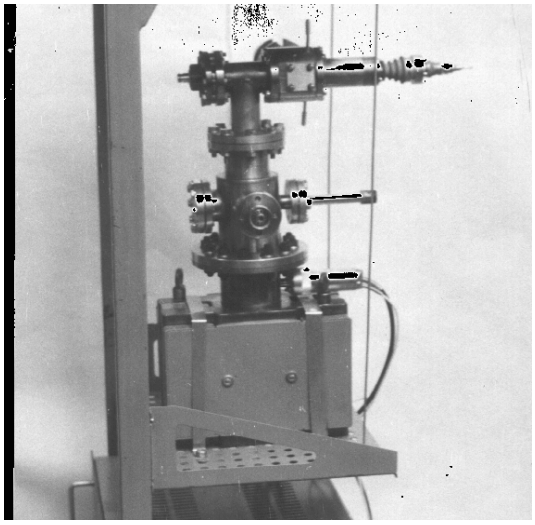

Figure 1: U-34 1 MeV, 30 mA, 11.6 cm SWF section designed for 0.5 MW magnetron.

Basically, these machines are not portable and once installed are not transported any more. New systems are being developed to improve portability of the units.

The linacs that were used as portable electron and/or X-ray sources in field are summarized in the following table.

Accelerator &	Energy MeV	Current mA	Dose Rate R/min@1m	Magnetron MW	Acc. length m(TW/SW)	Mass kg	Application
[4] ISTOK,Russia	1	50	-	0.3	0.27 (SW)	-	test piece
UT-8A[5] VNIIAGG, Russia	6	0.5	-	0.5	2.0 (TW)	100	well logging
MINAC 1.5 SRC, USA [6]	1.5	30	2.5	0.2	0.4 (SW)	16	NDT, curing
MINAC 4 SRC,USA[6]	3.9	100	100	1.5	0.3 (SW)	25	NDT, curing
MINAC 6 SRC, USA [6]	6.0	50	300	1.5	0.5 (SW)	41	NDT, therapy

We have developed MINAC-9 [7] which was supposed to be a prototype of the system for electron beam therapy system in operating room [8]. Recently, a high gradient standing wave structure has replaced a second regular section of this two-section linac and allowed us to increase the achievable energy limit to 12.5 MeV using the same 1.5 MW magnetron.

One of the unique features of 9 and 13 MeV units is a possibility of smooth broad band energy regulation. We feel that this upgraded version of 9 MeV section is still not at the energy limit. A predicted limit with the same magnetron is around 15 MeV. Microwave design is shown on Fig.2.

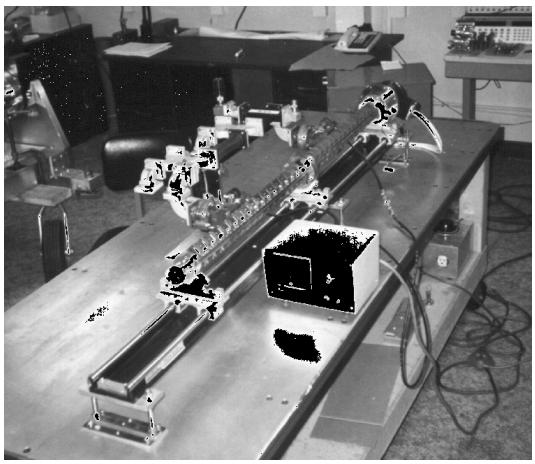

Figure 2: Design of 9 and 13 MeV MINAC system.

This is a working prototype with removed magnetic shield.

9 and 13 MeV accelerator testing is currently in progress. The characteristics are stable and reliable. 9 MeV accelerator section is recommended for NDT application and will be a good addition to a family of MINAC units.

This recent advances has developed some interest in this accelerators as potential injectors for portable free electron lasers.

3. Main applications of X-band portable linacs today include the following:

1. Non destructive examination of thick wall and dense components with equivalent thickness up to 30 cm of steel (example: MINAC 4/6). Real time data processing is possible in some cases.
2. Radiation therapy (MINAC 6/9/13)
3. Well logging (UT-8A, not used any more)
4. Electron beam curing (MINAC 1.5/4)
5. Injectors for portable FEL (MINAC 9/13) - new potential application.
6. Electron beam treatment of various objects (U30...U36, MINACS).

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