Modulator of the German FuG224 Berlin Microwave Radarset

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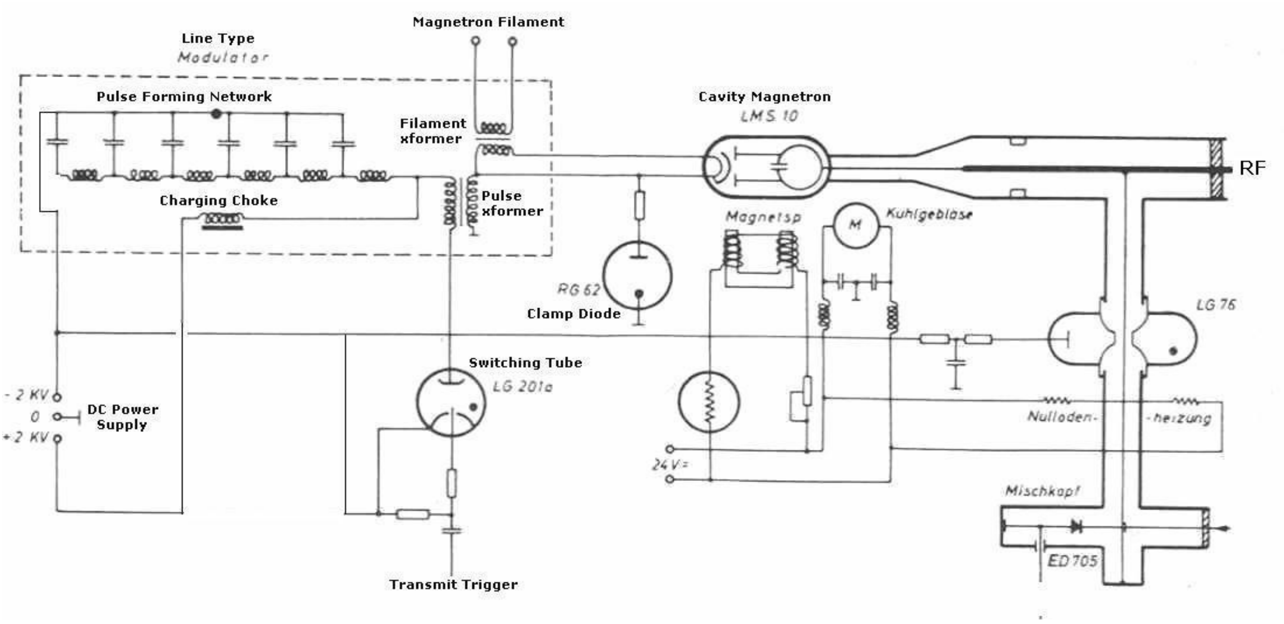
When the German radar developer reengineered the British H2S airborne radar, found near Rotterdam, they utilized for the first time a Pulse Forming Network (PFN) as energy storing device to realize a so called line type modulator for their FuG224 radar transmitter. The PFN serves the dual purpose of storing exactly the amount of energy for a single pulse and of discharging this energy into the load in the form of a pulse of specified shape. The use of an inductance as charging element increases the efficiency obtained, because it is then possible to charge the PFN to approximately twice the DC supply voltage by so-called inductive charging. If one picks the pulse-repetition frequency equal to twice the resonant frequency given by the charging choke inductance and the PFN storage capacitances the peak voltage on the network is approximately twice the DC supply voltage.

In order to reduce the voltage on the PFN, a step-up transformer is inserted between the PFN and the load. If the PFN has the basic characteristics of a transmission line, if the pulse transformer is ideal, and if the load is purely resistive and matched to the transmission line, then a rectangular output pulse will be obtained. It is customary to mismatch the load slightly in order to promote formation of a slight negative voltage on the switching device in order to enhance recovery of the switch. Bifilar secondary windings on the step-up transformer provide a convenient means to couple in heater current for the transmitting device.

Simplified Schematic of the FuG224 Transmitter

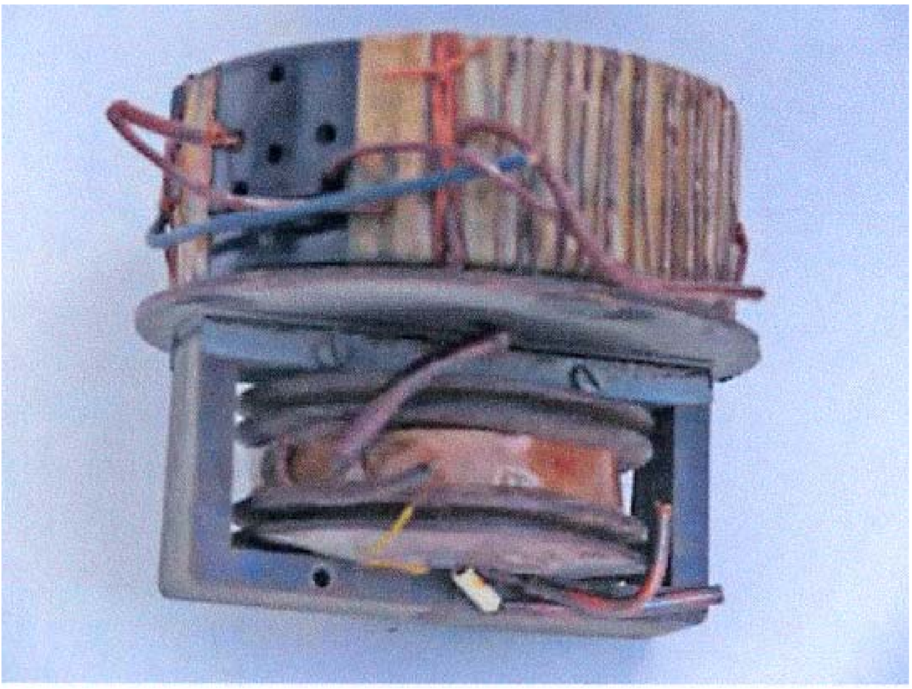


The photo shows the Pulse Forming Network of the German FuG224 Radar Transmitter reproduction.
The PFN consists of six sections. The total network capacitance is divided between the sections and each condenser is connected to a tap on the solenoid. The taps are located to obtain equal inductance for all sections except the first that has twice the inductance, the ratio of length to diameter of the coil is chosen by a method to give a mutual inductance which is 15% of the selfinductance of each centre section. Six or more sections built in this manner give already a good result concerning the pulse shape ripple.

Retracing the Pulse Forming Network parameter

Number of section 6
Capacitance per section approx. 800 pf
Inductance per section approx. 3.5 µH (except of the first section with 7 µH)
Total Network Capacitance approx. 4800 pf
Pulse Width 0.8 µs
Peak Voltage approx. 8000 Volts
Stored Energy 0.1536 Joule on peak voltage
Available Peak Power for 0.8 µs pulse 192 kW
Impedance Z_0 66 Ohms

The photo shows the pulse transformer combination of the German FuG224 radar transmitter. The upper part of the picture shows the toroidally wound step-up transformer as it was typical used in German radar equipments. The core consists of a thin metal strip wound to give a hollow cylinder. According to references the step-up ratio of the Berlin pulse transformer is 1:4.5
The lower part of the combination is wound on an E-type core and seems to be the filament transformer for LMS 10 Magnetron.



The British WWII microwave radars used typically three electrode fixed spark gap tubes (CV 85 and CV 125) as switching devices in the radar modulator. The German Berlin microwave radar was equipped with a similar three electrode fixed spark gap tube with the designation LG 200 or LG201.
The American WWII AN/APS-15 X-Band airborne radar used a Hard Tube Pulser equipped with a 715B Oxyd Cathode high vacuum triode as switching device.
The first Hydrogen Thyratons as for instance the types 3C45, 4C35, 5C22 came in use after WWII.
One exception was the AEG S1/3iII Helium Thyratron used in the German FuG200 Hohentwiel radar transmitter however, it was operated with a low prf of 50 Hz.