the resulting straight line is determined from this graph and the linear output signal from the log converter as displayed on the oscilloscope is adjusted so as to have a matching slope. The gain and sweep controls of the monitor oscilloscope permit this adjustment to be readily accomplished.

The outstanding advantage of the present system is the fact that data acquisition can be as fast as the repetition rate of the pulse generator permits. Thus rapid attenuation changes can be recorded with ease using a high speed streak camera and the attenuation values can be measured rapidly and conveniently from the developed film by using a microfilm reader. It was for this purpose of high speed test capability that the present system was devised and used.

In normal routine operation, the authors use a Sperry ultrasonic attenuation comparator model 56 A001 coupled with a Matec automatic attenuation recorder model 2470 which provides automatic gain control. These units alone permit accurate automatic recording (±0.1 to ±0.2 dB) of attenuation values from exponential patterns on a built-in strip chart recorder at chart speeds of 0.25 to 20 cm/min and a full scale deflection of 0.5 sec. The total linear readout range is 30±0.5 dB and the accuracy of readout is ±0.2 dB on the 20 dB range and ± 0.1 dB on the 10, 5, and 2 dB ranges.

For high speed testing the authors use an auxiliary monitoring Tektronix 535 oscilloscope in addition to the 'scope built into the Sperry unit. The logarithmic converter is inserted between the Sperry unit and the Tektronix 'scope. Hence the monitor on the Sperry unit displays the exponential pulse pattern [Fig. 2(b)] and the exponential matching curve while the auxiliary Tektronix scope displays the linearly decreasing pulse pattern [Fig. 2(a)]. The Tektronix 'scope display is photographed using a Polaroid 'scope camera, a Cine-Kodak Special II, a Dumont type 321-A oscillograph record-camera or a Fastax WF-17 streak camera depending on the speed of the test being run. The limiting factor in the present system, with respect to test speed, is the repetition rate of the pulse generator which has a maximum of 1000 pulses/sec. The logarithmic converter, however, is not concerned with this since the time between echoes is the factor determining whether or not it can be used successfully. For the logarithmic converter shown in Fig. 1 the frequency response is flat out to 1 MHz.

This present system has all the advantages of the system described by Yabe and Roberts plus the additional advantages that have been described above. The simplicity of the logarithmic converter permits its use in most existing systems.

The authors wish to thank Charles Mayes and Wolfgang Sachse for technical assistance, and Mrs. Corinne Harness for typing the manuscript. The work was supported by the U. S. Army Ballistic Research Laboratories, Aberdeen Proving Ground.

---

[1] M. Yabe and J. M. Roberts, Rev. Sci. Instr. 39, 131 (1968).

Simple Low-Impedance High-Voltage Coaxial Transmission Line Pulser

R. R. Alfano and N. Yurlina

The Bayside Laboratory, Research Center of General Telephone & Electronics Laboratories Incorporated, Bayside, New York 11360

(Received 19 August 1968; and in final form, 9 September 1968)

THIS note describes the construction of a simple 6 Ω coaxial transmission line pulser capable of delivering voltage pulses as high as 2.5 kV with a risetime of 1 nsec and falltime of ~7 nsec with a pulse width of ~30 nsec.

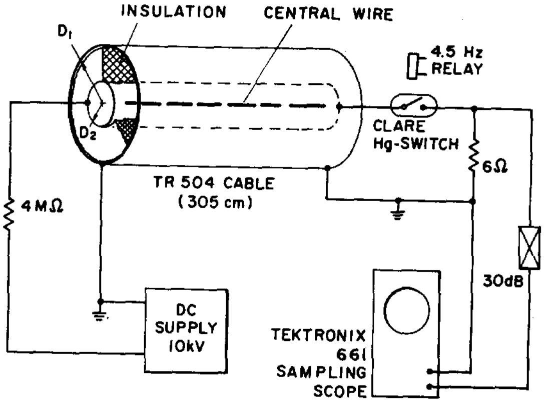

FIG. 1. Low impedance coaxial transmission line pulser.

We have converted a 50 Ω double-shielded coaxial transmission line to 6 Ω by utilizing the outer shields as the high- and low-voltage ends. The central wire which is commonly used as the high end was not utilized. This technique eliminates the need for construction of a stripline to obtain a low-impedance line. Lower-impedance pulsers, typically of the order of 1 Ω, can also be readily constructed by this method.

It is well known that the most convenient and practical way to create high-current, short-duration pulses is to discharge a dc voltage through a transmission line. The transmission line pulse generator consists of a transmission line, usually a 50 Ω coaxial cable, which is charged through a leakage resistor by a dc voltage supply. A magnetic reed Hg switch is used to hold off the high dc voltage (as high as 10 kV). When the relay closes the Hg switch, the transmission line discharges into a matching load resistor, and half of the applied voltage is delivered to the load with a risetime and a falltime of the order of 1 nsec. (A 100 nsec pulse of 5 kV can be obtained with a 50 Ω pulser at a repetition rate of 4.5 Hz.) The pulse width, which is determined by the length of cable used, is of the order of 10 nsec/m.

The pulse generator described in this note is shown in Fig. 1. It consists of a Times Wire and Cable TR504 double-coaxial-shielded 50 Ω cable, a Clare Hg-wetted relay switch A135893 Hg 2c encased in a General Radio insertion unit No. 874X, sorrounded by Dow Corning silicone grease. Three of the four Hg-switch pins have been *carefully* filed off.

By using the two shields of TR504 cable as the high and low ends, where the i.d. of the outer shield is 6.48 mm and the o.d. of the inner shield is 5.59 mm and $\sqrt{\epsilon}\approx 1.5$, the standard expression for a coaxial line gives an approximate impedance of 6 Ω. The breakdown voltage of the dielectric between the shields is 6 kV. With TR506 cable an impedance of 2 Ω can be obtained.

The Clare Hg-wetted relays are designed to match a 50 Ω coaxial line. The principal effect of the impedance mismatch at the switch is to produce ringing at the start of the pulse and to increase its falltime.

Figure 2 shows a typical voltage pulse, ~2 kV, across a 6 Ω carbon resistor. The slashes are caused by the response of the sampling oscilloscope to the low repetition rate of 4.5 Hz.

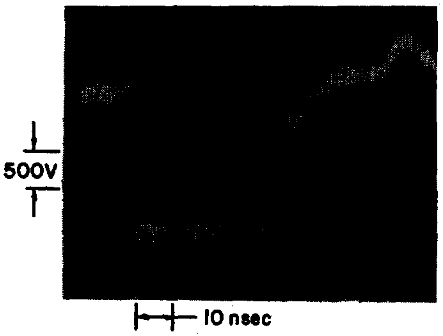

FIG. 2. Typical voltage waveform across 6 Ω carbon resistor.

This low-impedance pulser has been used to pulse low-resistivity bulk n-GaAs devices through the Ohmic, past the Gunn, and into the avalanche regime.

Magnetic Suspension Densimeter*

J. W. BEAMS

Department of Physics, University of Virginia, Charlottesville, Virginia 22903

(Received 21 August 1968; and in final form, 6 September 1968)

ESSENTIALLY the magnetic densimeter determinations consist in freely suspending magnetically a small ferromagnetic body (or buoy) inside of a small transparent container which is filled with a solution whose density ρ and partial specific volume $\bar{v}$ is to be determined. When the buoy B is freely suspended at rest at a constant vertical position inside of the solution, the upward force F exerted by the axial magnetic field H of the air core support solenoid is given by the relation $F=M(dH/dz)$, where M is the magnetic moment of the suspended body and z is the distance along the vertical. In the original design[1–4] both M and dH/dz are varied simultaneously and the assumption is made that $M\cong K'H$, where K' is a constant. This gives the relation $K'H(dH/dz)=(\rho-\rho_B)Vg=K_1K_2I^2$, where ρ_B is the density of the suspended buoy, V is the volume of the buoy, g the acceleration of gravity, and I the current in the solenoid. For an air core solenoid, $H=If_1(z)$ and $dH/dz=\mathrm{I}f_2(z)$ so that at a constant vertical position $H=K_1I$ and $dH/dz=K_2I$, where K_1 and K_2 are constants which may be determined by calculation, but which usually are determined by calibration with solutions of known density. In practice K' is not strictly constant but varies slowly with H even when the supported buoy contains magnetically soft material. Consequently in order to obtain the desired precision it is necessary to calibrate with a number of solutions of known density over the working range of the densimeter. Furthermore the sensitivity is inversely proportional to $(\rho-\rho_B)$ so that it is necessary to construct and calibrate several buoys with different ρ_B, S. With the arrangement described in this paper most of the above time-consuming procedures are not required and the ultimate reliability of the method is improved. This is accomplished by maintaining H constant at a given vertical position of the buoy and varying dH/dz alone. Figure 1 shows a schematic diagram of the apparatus. The buoy B, usually made by enclosing a ferromagnetic body in glass, is freely suspended by the air core solenoids S_1, S_2, and S_3 inside the solution contained in C. It is convenient, though not necessary, if S_2 and S_3 have the same number of turns and are as nearly identical as possible. All three coils have a common vertical axis. When S_2 and S_3 are identical they are usually, although not necessarily, spaced at a vertical distance