ATTENUATOR FOR OBSERVATION OF FAST RISE-TIME HIGH VOLTAGE PULSES

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When observing fast signals of high voltage, we have to use an attenuator between the signal source and an oscilloscope. If we want to observe signals of 1 nsec rise-time, the attenuator has to be what works well in a frequency range reaching 300 MHz. Besides, it has to endure the peak currents of pulses and the heat produced in it. If the input power of the attenuator is less than 100 mW, we can use resisters whose size is much smaller than the wavelength of VHF electromagnetic wave. Attenuators with good characteristics in VHF range can be obtained by a π-shape or a T-shape network of resisters put in a coaxial line. Attenuators of high wattage cannot be made by this method because of the larger size of resisters. A special consideration is necessary in this case. We have made an attenuator for fast pulses using a 200 watt resister for RF load which is in the market, and its structure and performance are given in the following.

The RF load resister is such that carbon is coated on a ceramic cylinder and there is no spiral cut on the surface. The structure of the attenuator is shown in fig.1. The input coaxial cable is connected to the flared section which is made of sheet copper. The characteristic impedance is held 50 ohms throughout the flared section. The 50 ohm RF resister, its permissible power being 200 watts, is connected to the larger end of the inner conductor of the flared section. The outer conductor over the resister is tapered toward the output end of the resister. Kobayashi[*)] reported the method to calculate the optimum rate of tapering for minimizing the reflection of signals in the case of VHF dummy loads. The tapering rate calculated by the method is exponential. We adopted a linear tapering rate by approximation instead of the exponential one. The output end of the 200 watt resister is connected to the outer cylinder by a parallel combination of eight 4-ohm resisters of 1/8 watt. These resisters are arranged radially as shown in fig.1 in order to reduce the inductance of this part. The signals across the parallel combination of resisters are fed through a 50 ohm resister to the inner conductor of the output coaxial cable. The outer conductor of the cable is connected to the output end of the tapered cylinder over the 200 watt resister by a cone

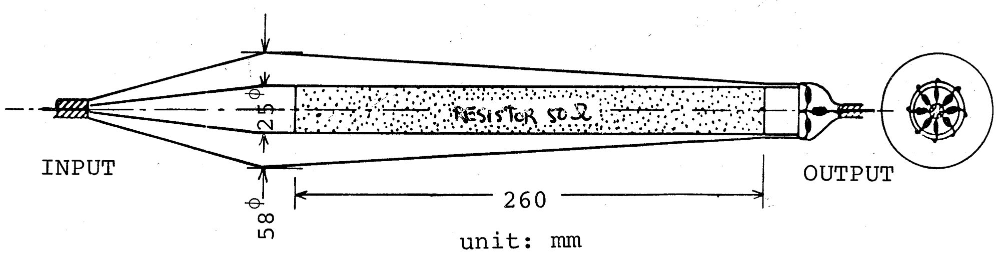


fig.1 Structure of the attenuator.

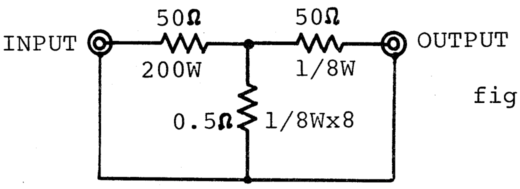
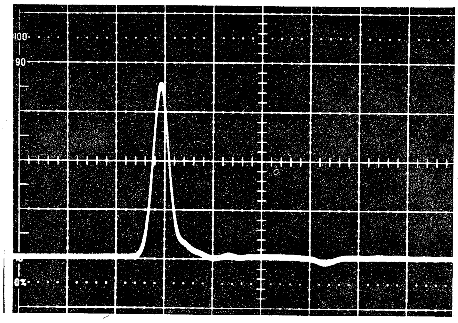
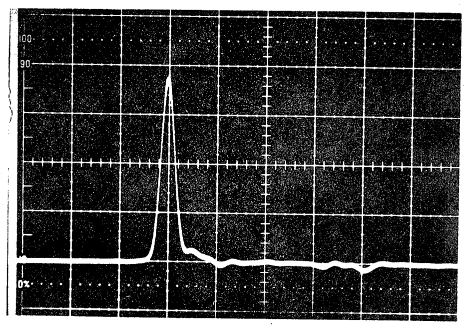


fig.2 Circuit diagram of the attenuator



Vert: 20V/div.
Horiz: 10nsec/div.

(a) Wave form of source signal.



Vert: 0.1V/div.
Horiz: 10 nsec/div.

(b) Wave form of attenuated signal.

fig.3

made of sheet copper. The circuit diagram of the attenuator is shown in fig.2. When the output is connected to an oscilloscope with a 50 ohm termination, signals are attenuated by 46 db.

As a measure of reflection of signals caused by the attenuator, we measured the VSWR sending continuous waves ranging from 80 MHz to 2 GHz toward the input of the attenuator. The measured VSWR distributes between 1.02 and 1.5 against frequencies. To see the fidelity of the attenuated wave forms to the original ones, we took the both pictures by oscilloscope. The wave forms are shown in fig.3. As the signal source, we used a pulse generator which generates pulses by avalanche operation of transistors. We can conclude that the fidelity of wave form is fairly good. The permissible wattage for continuous operation is less than 200 watts, because the resister is enclosed in the tapered cylinder. However, if some ventilation holes are punched or if a forced air cooling is adopted, the wattage can be raised easily.

*) Kobayashi, S. : Denkitsushingakkai-Zasshi 34 (1951) 391.