R.N.

LB-911

A UHF BALUN

RADIO CORPORATION OF AMERICA

RCA LABORATORIES DIVISION

INDUSTRY SERVICE LABORATORY

RADIO CORPORATION OF AMERICA

RCA LABORATORIES DIVISION

INDUSTRY SERVICE LABORATORY

LB-911

A UHF Balun

Approved

A UHF Balun

Introduction

With the widespread adoption of a balanced 300-ohm input for uhf television receivers, it is desirable to have a balance-to-unbalance transformer to match the unbalanced impedance of laboratory signal-generators. A balun is also useful in receiver installations where the receiver input and transmission line impedances differ. The balun should provide a low voltage standing-wave ratio (VSWR) and good balance efficiency over the entire uhf television band, preferably without tuning adjustment. Shielding of the device is desirable. Such a balun[1], patterned after the "elevator transformer" used at the antenna input of RCA vhf television receivers, has been found to give good performance. When used in conjunction with a 50 to 75-ohm coaxial transformer[2] to provide the required impedance match between generator and balun input, the VSWR measured better than 1.3 over the uhf band, with balance efficiencies between 85 and 95 per cent. This bulletin gives construction details, measurement procedures, and performance data.

Description

An exploded view of the balun and a suitable shielded mounting are shown in Fig. 1a, and a cutaway assembly drawing is given in Fig. 1b. As indicated therein, the unit consists basically of two open-wire transmission lines (Z_o = 150 ohms) wound on low-loss dielectric forms. Schematically, the device appears as in Fig. 2a and the equivalent circuit Fig. 2b. The lines are connected in parallel at the 75-ohm end and in series at the 300-ohm terminals.

Test Measurement Procedure

Balance Efficiency

The balance efficiency, a figure of merit for baluns, is conveniently measured with a balun comparator[3]. This device consists essentially of two equal load resistors (150 ohms each, in this case) located at right angles, as shown in Fig. 3. A rotatable loop, when in position B, induces equal in-phase voltages in the resistors resulting in a small detector indication for a good balun. In position A (dotted) the currents are out of phase, causing a greater detector output for the same signal generator setting. For a constant detector reference, the ratio R of the two generator output levels can be converted to balance efficiency according to the definition:

$$\text{Balance efficiency } (\%) = \frac{100}{1+R}$$

$$\text{where } R = \frac{\text{generator output in position A}}{\text{generator output in position B}}$$

[1] E. O. Johnson and R. F. Kolar, "Practical TV Antennas for UHF", paper presented at IRE convention, March, 1952.

[2] LB-866, *Noise Factor Considerations and Measurement Techniques at UHF.*

[3] LB-872, *Balance Measurements on Balun Transformers.*

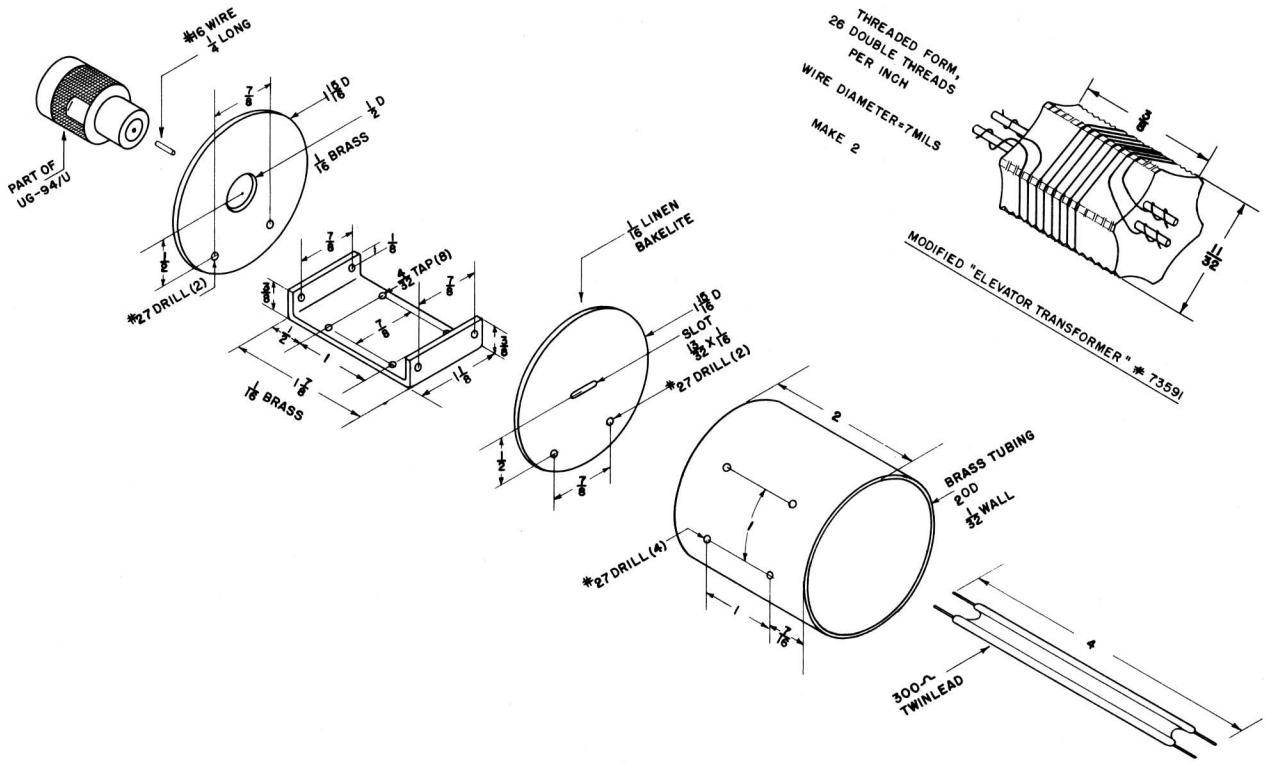

Fig. 1a – Exploded view of uhf balun.

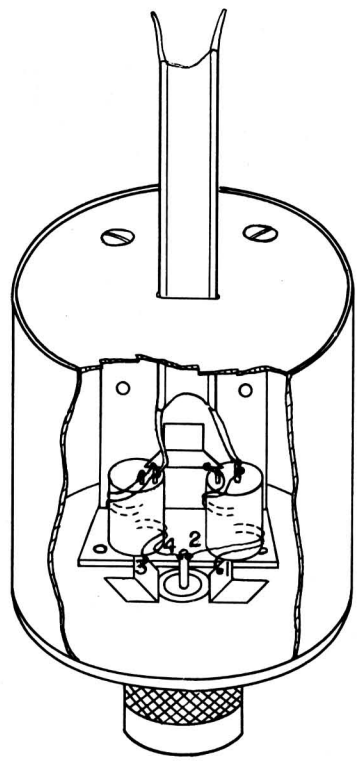

Fig. 1b – Cutaway assembly view of uhf balun.

For convenience, this relation is plotted Fig. 4.

A sensitive measurement system is indicated in Fig. 5. The vhf television receiver is tuned to a channel of low noise figure (2-6) (a.g.c. disabled) and a vacuum-tube voltmeter across the video load resistor used as an indicator. No impedance matching is required at the balun 75-ohm terminals for this test, since with the connection shown, the 75-ohm side of the "transformer" can be regarded as a pickup device. The balance efficiency as a function of frequency is plotted in Fig. 6.

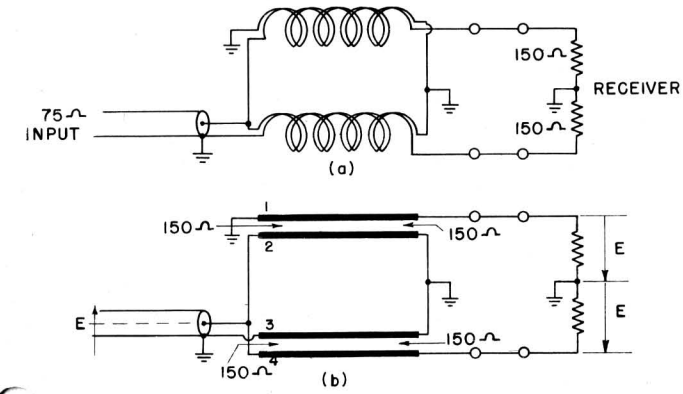

Fig. 2 - Balun wiring and equivalent circuit.

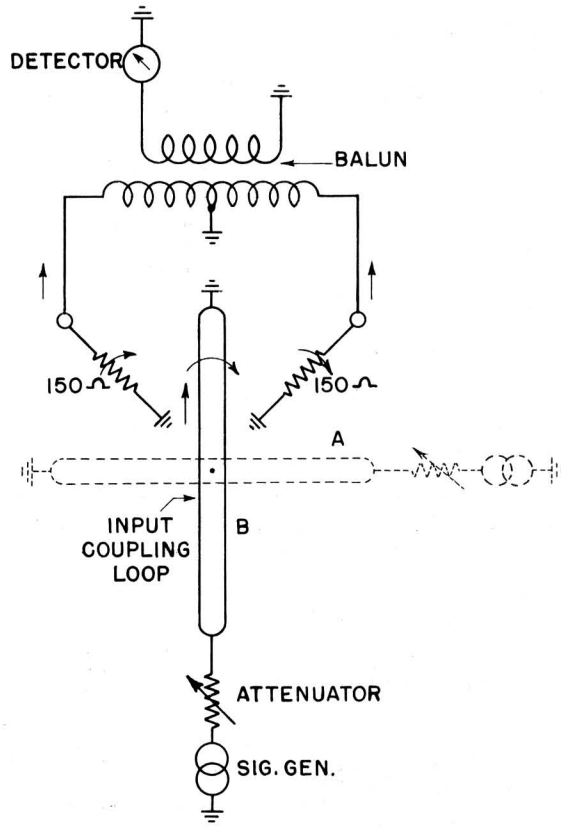

Fig. 3 - Schematic diagram of balun comparator.

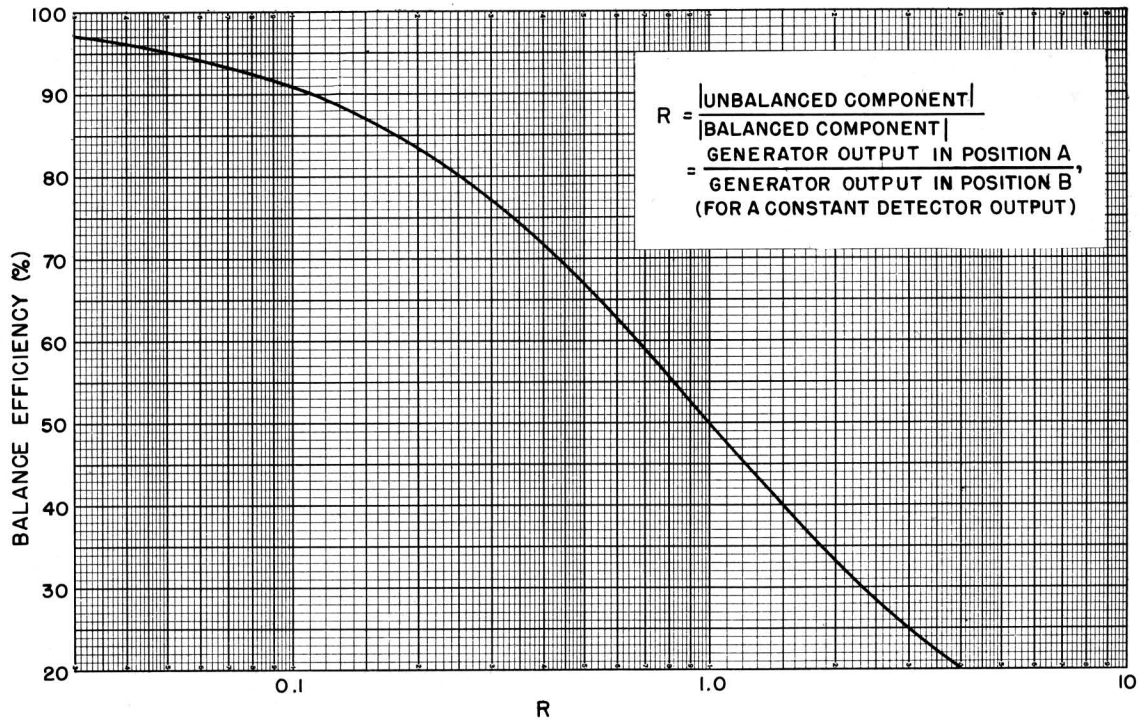

Fig. 4 - Conversion from ratio R to balance efficiency.

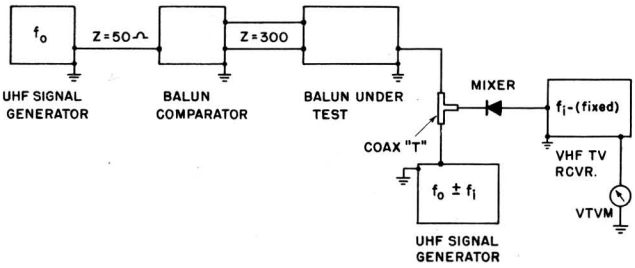

Fig. 5 - Block diagram of balun test setup.

Voltage Standing-Wave Ratio

The balun VSWR looking into the 75-ohm terminals was measured with the 300-ohm side terminated in two coaxially-mounted deposited carbon resistors. With a 50 to 75-ohm coaxial transformer[2] inserted between a uhf admittance meter and the balun input, the overall VSWR was as plotted in Fig. 6. While constructional variations will alter the results somewhat, these curves for VSWR and balance efficiency indicate the performance of a typical unit.

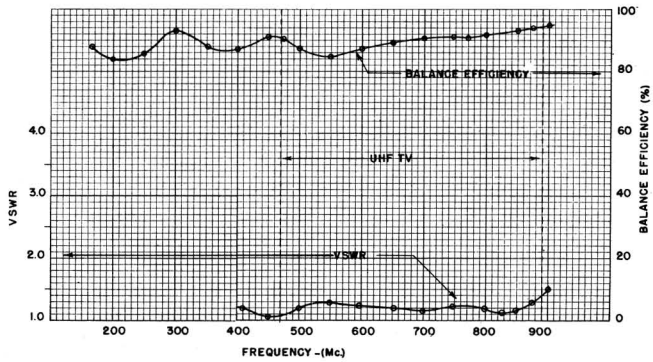

Fig. 6 - Balance efficiency of uhf balun and VSWR as a function of frequency.

Balun Output Voltage

When used in conjunction with a 50-ohm signal generator and coaxial transformer, the equivalent circuit is that shown in Fig. 7. The voltage appearing across the 300-ohm load

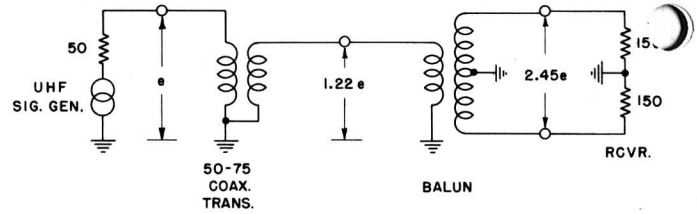

Fig. 7 - Voltage transformations involved when using balun.

will be 2.45 times the voltage across the generator terminals. For a generator having an attenuator which reads open-circuit voltage (e.g., GR-Model 1021), the open-circuit antenn voltage at the receiver is therefore 2.45 times the attenuator setting. With an attenuator which indicates the voltage across a 50-ohm load, (Measurements Model 84) the open-circuit voltage will be 4.9 times the indicated value. Open-circuit voltages are mentioned because of their use in noise-factor, sensitivity, and spurious-response measurements. The voltage across a matched load will of course be one-half the indicated value. This is tabulated below in terms of attenuator reading, e_{att}.

Generator Attenuator reads	Open-circuit volts at 300-ohms	Matched volts across 300-ohms
Open-circuit volts (e_{att}) (GR Model 1021)	2.45 e_{att}	1.22 e_{att}
Volts across 50-ohm load (e_{att}) (Measurements Model 84)	4.9 e_{att}	2.45 e_{att}

When reading noise factors from Fig. 2 of LB-866[2], this balun should be treated as the indicated "loss free transformer" in the matching section tabulation.

Assuming a loss-free transformation, a noise diode will read correctly, after the usual transit-time correction.

Alan T. Brennan

Alan T. Brennan