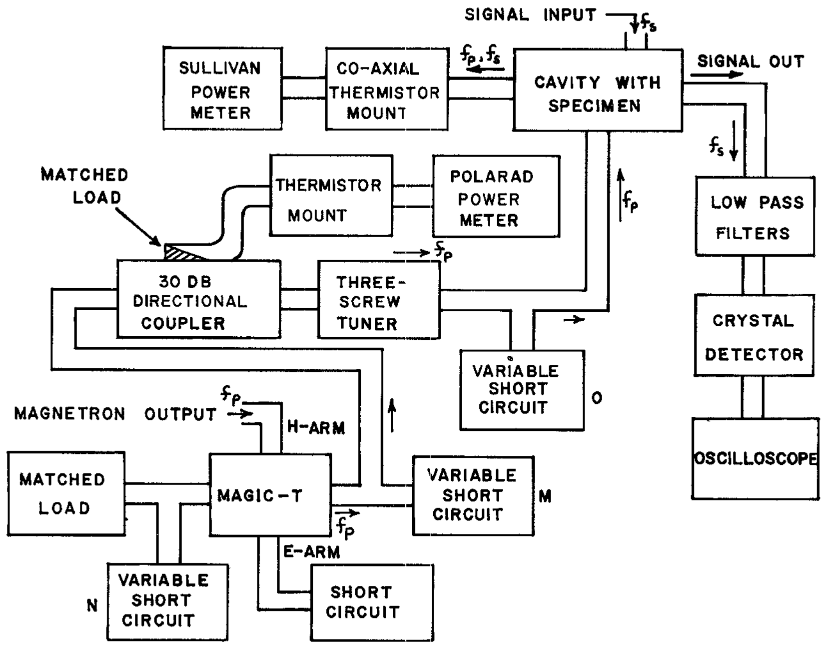


Fig. 6. Circuit arrangement for high power measurements.

where $P$ is the power supplied and $W$ is the energy stored. For a composition of 90.2 per cent $BaTiO_3$ of $\epsilon_r'=35$ and $\tan\delta=1/36$, the peak electric field is 7.8 kV/cm for an input power of 3.5 kW. The value of $\Delta f'/\Delta f$ necessary for large gain can be estimated as follows.

For large gain, the negative conductance presented to the signal circuit is equal to its conductance $G_{T1}$. Then [6]

$$G_{T1} = \frac{\omega_1\omega_2 C_3^2}{4G_2}.$$

Let $C_p$ be the capacitance of the cavity at the pump frequency $f_p$ and let $\Delta C$ be the capacity swing for the half-power points. Then

$$\frac{C_3}{\Delta C} = \frac{Q_p}{C_p}\sqrt{\frac{G_2 G_{T1}}{\omega_1\omega_2}} \tag{5}$$

where $Q_p$ is the $Q$ of the cavity at the pump frequency.

Beringer [7], considering the equivalent circuit of a lossless, unperturbed cavity to be a $LC$ circuit, derives the following expressions for the equivalent capacitance $C_a$ and inductance $L_a$ of the cavity, $C_a=\epsilon/K_a^4 V$ and $L_a=\mu K_a^2 V$ where $V$=volume of the cavity and

$$K_a = \omega_a\sqrt{\mu\epsilon} \tag{6}$$

The cavity has a number of normal modes which are the periodic solutions of Maxwell's equations. Each of the modes is characterized by a resonant angular frequency $\omega_a$.

$$\text{Let } f_3:f_2:f_1 = 3:2:1 \tag{7}$$

Substitution of (7) in (6) results in

$$C_p = \frac{4}{81}\sqrt{C_i C_s} \tag{8}$$

Substitution of this value of (8) in (5) gives us

$$\frac{C_3}{\Delta C} = 20.25\sqrt{\frac{Q_p}{Q_i Q_s}}$$

the subscripts $i$ and $s$ refer to the idler and signal frequencies, respectively. Assume $Q_p=Q_iQ_s$ then $\Delta f'/\Delta f=20.25$. For large gains approaching oscillation, the ratio of $\Delta f'/\Delta f$ should be 20, but some gain is to be expected when this ratio is lower than 20.

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S. N. DAS
Dept. of Elec. Engrg.
Clarkson College of Technology
Potsdam, N. Y.

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## A Plea for Clarity in Waveguide Designation

Apparently the use of letters to designate waveguide sizes [1] or frequency bands [2] is deeply ingrained in the microwave field. In addition, a number of standardization systems exist such that one may find an amazing number of different numbers and letters to describe a single size of waveguide. It may be noted in passing that the situation is worse for waveguide flanges.

In Table I, (pp 248–249) the International Electrotechnical Commission [3], British RCSC [4], American Military [5], American Civil EIA [6], and NATO [7], designation systems are tabulated along with the code letters used by American, British, European, and Japanese waveguide equipment manufacturers to designate the different sizes of rigid rectangular waveguide of approximately 2 to 1 dimension ratio.

The confusion caused by using letter designations is obvious while the different designation systems can hardly be said to contribute to clarity in specification. At this point it is felt that a plea should be entered for the IEC system: it has been worked out by an international organization and it is available in English and French for both English and metric measurement systems [3]. It is suggested that all specifications should carry the IEC designation in addition to any other system used. For example: "The instrument is available in RG-67/U (153 IEC-R 100 aluminum) waveguide." Such usage would certainly further international understanding in what is now a muddle of confusing waveguide designations.

M. M. BRADY
Norwegian Defence Research Establishment
Kjeller, Norway

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TABLE I

Five Rigid Rectangular Waveguide Designation Systems and Band and Waveguide Size Letters in Use by Different Authorities and Manufacturers. Only inside Dimensions are Given, Because Outside Dimensions Vary Between the

| Inside Dimensions | | Cutoff freq MHz | IEC 153 IEC-R ( ) | RCSC WG ( ) | JAN RG-( )/U | | | | |
|---|---|---|---|---|---|---|---|---|---|
| width in | height in | | | | copper or brass | aluminium | magnesium | silver | silver plated |
| 23.000 | 11.500 | 256.5838 | 3 | 0.0 | | 290 | | | |
| 21.000 | 10.500 | 281.0203 | 4 | 0 | | 291 | | | |
| 18.000 | 9.000 | 327.8571 | 5 | 1 | | 201 | | | |
| 15.000 | 7.500 | 393.4285 | 6 | 2 | | 202 | | | |
| 11.500 | 5.750 | 513.1676 | 8 | 3 | | 203 | | | |
| 9.750 | 4.875 | 605.2746 | 9 | 4 | | 204 | | | |
| 7.700 | 3.850 | 766.4191 | 12 | 5 | | 205 | | | |
| 6.500 | 3 250 | 907.9119 | 14 | 6 | 69 | 103 | 206 | | |
| 5.100 | 2.5500 | 1157.143 | 18 | 7 | | | | | |
| 4.300 | 2.1500 | 1372.425 | 22 | 8 | 104 | 105 | 207 | | |
| 3.500 | 1.750 | 1686.122 | | 9 | | | | | |
| 3.400 | 1.7000 | 1735.714 | 26 | 9A | 112 | 113 | 208 | | |
| 2.8400 | 1.3400 | 2077.852 | 32 | 10 | 48 | 75 | 167 | | |
| 2.613 | 1 1614 | 2258.494 | 35 | | | | | | |
| 2.372 | 1 122 | 2487.905 | | 11 | | | | | |
| 2.2900 | 1.1450 | 2576.865 | 40 | 11A | | | | | |
| 2.2441 | 0.9972 | 2629.759 | 41 | | | | | | |
| 1.8720 | 0.8720 | 3152.392 | 48 | 12 | 49 | 95 | 168 | | |
| 1.5900 | 0.7950 | 3711.222 | 58 | 13 | | | | | |
| 1.3720 | 0.6220 | 4301.184 | 70 | 14 | 50 | 106 | 169 | | |
| 1.1220 | 0.4970 | 5259.702 | 84 | 15 | 51 | 68 | 170 | | |
| 0.9000 | 0.4000 | 6557.141 | 100 | 16 | 52 | 67 | 171 | | |
| 0.7500 | 0.3750 | 7868.570 | 120 | 17 | | | | | |
| 0.6220 | 0.3110 | 9487.705 | 140 | 18 | 91 | | 172 | 107 | |
| 0.5100 | 0.2550 | 11571.43 | 180 | 19 | | | | | |
| 0.4200 | 0.1700 | 14051.02 | 220 | 20 | 53 | 121 | 173 | 66 | |
| 0.3400 | 0.1700 | 17357.14 | 260 | 21 | | | | | |
| 0.2800 | 0.1400 | 21076.53 | 320 | 22 | | | | 96 | 271 |
| 0.2240 | 0.1120 | 26343.80 | 400 | 23 | | | | 97 | 272 |
| 0.1880 | 0 0940 | 31391.88 | 500 | 24 | | | | | |
| 0.1480 | 0.0740 | 39876 63 | 620 | 25 | | | | 98 | 273 |
| 0.1220 | 0.0610 | 48369.23 | 740 | 26 | | | | 99 | 274 |
| 0.1000 | 0.0500 | 59014.27 | 900 | 27 | | | | | |
| 0.0800 | 0.0400 | 73767.84 | 1200 | 28 | | | | 138 | 278 |
| 0.0650 | 0.0325 | 90791.19 | 1400 | 29 | | | | 136 | 276 |
| 0.0510 | 0.0255 | 115750.0 | 1800 | 30 | | | | 135 | 275 |
| 0.0430 | 0.0215 | 137267.6 | 2200 | 31 | | | | 137 | 277 |
| 0.0340 | 0.0170 | 173491.0 | 2600 | 32 | | | | 139 | |

TABLE I (Cont'd)

SYSTEMS. EXCEPT FOR WG 9 AND WG 11 RCSC SIZES, ALL DIMENSIONS ARE THOSE GIVEN BY THE IEC. THE CUTOFF FREQUENCY IS COMPUTED USING A SPEED OF LIGHT OF $c=299792.5$ KM/SEC.

| EIA WR-( ) | NATO NWG [ ] | | | | | | Band and Size Letters Used |
|---|---|---|---|---|---|---|---|
| | Copper 2A( ) | Brass 3A( ) 4A( ) | Aluminum 1A( ) | Magnesium 5A( ) | Silver 6A( ) | Silver Pres 6A( ) | |
| 2300 | | | | | | | P |
| 2100 | | | | | | | J, N |
| 1800 | | | 01 | | | | J |
| 1500 | | | 02 | | | | H |
| 1150 | | | 03 | | | | F |
| 975 | | | 04 | | | | E |
| 770 | | | 05 | | | | D |
| 650 | 06 | 06 | 06 | | | | L |
| 510 | 07 | 07 | 07 | | | | |
| 430 | 08 | 08 | 08 | | | | LS, M, R |
| | | | | | | | |
| 340 | 09 | 09 | 09 | | | | MS |
| 284 | 10 | 10 | 10 | 10 | | | S |
| | | | | | | | |
| | | | | | | | |
| 229 | 11 | 11 | 11 | | | | SC |
| | | | | | | | |
| 187 | 12 | 12 | 12 | 12 | | | C, G, H |
| 159 | 13 | 13 | 13 | | | | C, CA |
| 137 | 14 | 14 | 14 | 14 | | | A, C, G, J, XB, XN |
| 112 | 15 | 15 | 15 | 15 | | | B, H, W, XB, XL |
| 90 | 16 | 16 | 16 | 16 | | | X, XS |
| 75 | 17 | 17 | 17 | | | | M, XG |
| 62 | 18 | 18 | 18 | 18 | | | G, KU, P, U, Y |
| 51 | 19 | | | | 19 | | |
| 42 | 20 | 20 | 20 | 20 | 20 | | K |
| 34 | 21 | | | | 21 | | |
| 28 | 22 | | | | 22 | 37 | A, KA, R, T, U, V |
| 22 | 23 | | | | 23 | 38 | B, Q, V |
| 19 | 24 | | | | 24 | 39 | F |
| 15 | 25 | | | | 25 | 40 | M, V, W |
| 12 | 26 | | | | 26 | 41 | E, Z |
| 10 | 27 | | | | 27 | 42 | W |
| 8 | | | | | | 43 | F, N |
| 7 | | | | | | 44 | |
| 5 | | | | | | 45 | A, G |
| 4 | | | | | | 46 | |
| 3 | | | | | | 47 | R |