Thus because $N_1=N_2$,

$$N_o=\frac{N_nA_1}{A_2}+A_1L_c(N_{c2}-N_{c1}). \quad (3)$$

It is known that the noise powers contributed by the mixer crystals in both cases are not always identical [3], [4]. In case (a), one can derive an expression for this noise component, following the considerations in [4]–[6] as

$$N_{c1}=\left[t+\left(\frac{\beta P_{LO}}{f_m{}^{\gamma}}+1\right)\frac{\alpha^2R_{IF}P_o}{L_cA_1S_f}\right]kT_0 \quad (4)^3$$

where

$$t=\frac{\beta P_{LO}}{f_{IF}{}^{\gamma}}+1$$

t = temperature noise ratio of the crystals on the frequency f_{IF}
$\beta_1\gamma$ = constants characterizing the mixer crystals
α = nonlinearity coefficient of the crystals
R_{IF} = IF impedance of the mixer crystals
P_{LO} = local oscillator power level at the mixer crystals
P_o = output carrier power level of the oscillator under test
S_f = suppression factor of the carrier suppression filter
f_{IF} = frequency of the IF amplifier
f_m = mean frequency of the narrow-band amplifier connected next to the second detector
k = Boltzmann's constant
T_0 = temperature in degrees Kelvin.

In case (b) the mixer crystals noise contribution is

$$N_{c2}=tkT_0. \quad (5)$$

Substituting (4) and (5) into (3), one can obtain the noise power of the oscillator under test

$$N_o=\frac{N_nA_1}{A_2}-\left(\frac{\beta P_{LO}}{f_m{}^{\gamma}}+1\right)\frac{\alpha^2R_{IF}P_o}{S_f}kT_0. \quad (6)$$

After analyzing this final result it becomes clear that it is impossible, in the general case, to eliminate the influence of the mixer crystals noise in the superheterodyne method. The mixer crystal noise is allowed for only in the case when

$$N_{c1}=N_{c2}. \quad (7)$$

Equation (6) shows that if the carrier power level of the oscillator under test at the input of the mixer is kept small,[4] or if the temperature noise ratio of the crystals used in the superheterodyne mixer is small enough (Doppler crystals), the condition (7) will be fulfilled. Only then will (6) have the following form:

$$N_o=\frac{N_nA_1}{A_2}. \quad (8)$$

This equation was assumed heretofore as always valid by all investigators, as far as it is known to the author.

One can give an expression for the measurement error which is made when (8) is always assumed valid:

$$\delta=\frac{\left(\frac{\beta P_{LO}}{f_m{}^{\gamma}}+1\right)\frac{\alpha^2R_{IF}P_o}{S_f}kT_0}{\frac{N_nA_1}{A_2}-\left(\frac{\beta P_{LO}}{f_m{}^{\gamma}}+1\right)\frac{\alpha^2R_{IF}P_o}{S_f}kT_0}. \quad (9)$$

One can estimate the value of this error in a simple example. Suppose a reflex klystron with carrier power level $P_o=30$ mW has been measured. The noise power in unity bandwidth of the fluorescent noise source is $N_n=1.42\cdot10^{-19}$ W/Hz (15.5 dB). The equal crystals used in the superheterodyne receiver have parameters

$$\alpha=20\ V^{-1}$$

$$t_m=\left(\frac{\beta P_{LO}}{f_m{}^{\sigma}}+1\right)$$

$$=10^4\ (40\text{ dB}) - \text{temperature noise ratio}$$

$$R_{IF}=200\Omega.$$

The used carrier suppression filter has a suppression factor $S_f=2.10^3$ (~33 dB). The two typical measurements have given the following results:

case (a): $A_1=500$ (~27 dB)
case (b): $A_2=\ \ 1$ (0 dB).

Computing the carrier/noise factor of the measured klystron on the bases of (8), one obtains the following result: $P_o/N_o=146.3$ dB/Hz. On the other hand, based on the exact equation (6), one obtains $P_o/N_o=151.15$ dB/Hz. The measurement error determined on the bases of (9) is $\delta=209$ per cent.

The foregoing example shows that the only condition given so far, that the tested oscillator carrier power level should be at least 10 dB below that of the local oscillator [1], is unsufficient, in practical cases, to accomplish (7).

The determination of sufficient conditions for correctness of the superheterodyne method is, in general, a complicated problem. In practice, however, one can confine oneself to determining the admissible carrier power level $P_o'=P_o/A_1S_f$ for the used superheterodyne receiver. Below that level (8) is valid. This can be done experimentally, by determining the noise power N_o on the bases of (8), for several values of P_o' changing the suppression factor S_f. [Changes of A_1 have no influence on measurement results; see (6).] For power levels smaller than the admissible level, N_o given by (8) will be constant. Only then will the measurement error be permissibly small and the results of oscillator noise correct; and then the superheterodyne method may be thought of as a substitution method.

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[3] Expression (4) is also true for the case of a ESR spectrometer with superheterodyne detection. Then f_m is the modulation frequency of the magnetic field.
[4] By using an effective carrier suppression filter.

ADI Auxiliary Publications Program

On many occasions a manuscript submitted for publication must be condensed or otherwise abridged to reduce the number of pages it will require in the final published form. This is a natural result of the competition among authors for the limited space available within the journals of their choice. While the author may be aggrieved at the cutting of his masterpiece, the readers may often be annoyed at the resulting limited discussion of difficult points. Another situation where this policy is awkward is in the presentation of tables for design (filter design for example). To be useful to a designer the tables must be complete and to the proper number of places. If the theory is presented with only sample calculations or a portion of the table printed, a great deal of utility is lost. Yet this detailed information may be useful to such a small proportion of the profession that the editor cannot justify committing all the pages needed to make it useful to anyone at the expense of other equally meritorious manuscripts.

I believe that there is an escape from this dilemma which has been long available but has gone unnoticed. The American Documentation Institute (ADI) maintains an Auxiliary Publications Program at the Library of Congress where the editor of any recognized journal can deposit documents with the Photoduplication Service. This document may be the complete computed tables for the manuscript on filter design as in the example given previously. The conventionally published portion would be the theory and application with a note stating that the complete tables are available from the Photoduplication Service, Library of Congress, Auxiliary Publications Program upon payment of $X. Some readers may have seen such notes in the course of reading other journals.

With the rapid development of photocopying techniques, some publications have reacted defensively out of a fear that widespread copying of selected articles would reduce the number of their paid subscribers. On the other hand, fast new economical photocopying techniques make services like the Auxiliary Publications Program of the ADI much more attractive supplements to conventional publication of manuscripts in professional journals. Photocopying can become a great new dimension in the publication of professional society journals,

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not a threat to them. The permanency of a depository at the Library of Congress in effect guarantees an eternal availability of reprints at no added cost to the society or its publications.

There are many other aspects of this ADI Auxiliary Publications Program which come to mind and could be explored once the use of the service, as here outlined, to meet the present acute need is widely accepted. I believe they would naturally follow with experience in using the service as presently constituted, but it would be premature to speculate in this correspondence.

I urge the Editor of the IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES to consider using this ADI program immediately and bring it to the attention of the IEEE Editorial Board for discussion.

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Editor's Note: It is recommended that authors who wish to take advantage of this form of dissemination of their results proceed as follows.

The author submits his paper or correspondence item and auxiliary documents (such as tables) to the Editor of these TRANSACTIONS with the understanding that, if accepted,

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Calibration of Coaxial Bolometer Units

The Radio Standards Laboratory of the Institute for Basic Standards (National Bureau of Standards, U. S. Department of Commerce) announces that services are now available for the measurement of calibration factor of nominal 50-Ω coaxial bolometer units and coaxial bolometer-coupler units. These devices have proved useful in the accurate measurement of CW RF power in coaxial systems over a range of 1 mW to 10 watts. At present the service is offered for bolometer units at two frequencies only, 100 MHz and 1 GHz; for bolometer-coupler units the service is offered at 30, 100, 200, 300, 400, 500 MHz, and 1 GHz. Plans call for extension of the frequency range to at least 10 GHz and for essentially continuous frequency coverage.

A bolometer unit includes both the bolometer element and the bolometer mount in which the element is supported. The element may be of the barretter type, consisting of a short length of silver wire of approximately 0.0001-inch diameter (Wollaston wire); or it may be the thermistor type, in the form of a bead of semiconductor material. As a metallic conductor the element has a positive temperature coefficient of resistance, as a semiconductor the coefficient is negative. The element is designed to have a resistance in the range of 50 to 200 Ω and is made a part of a bridge circuit. The bridge provides a means of measuring the RF power absorbed by the element in terms of accurately known dc power which is substituted for the RF power in order to restore bridge balance when the RF power is withdrawn. This dc power is known as the substituted dc power.

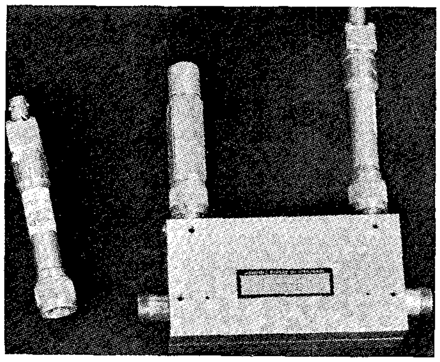

Fig. 1. The Radio Standards Laboratory calibrates coaxial bolometer units used for the accurate measurement of HF power. Left: a bolometer unit for measuring HF power up to 10 mW. Right: Bolometer-coupler unit for measuring HF power up to 10 watts. The present frequency range extends to 1 GHz (1000 million c/s).

The element is supported in the bolometer mount at a position where it absorbs a maximum amount of the RF power fed into the bolometer unit. In one form a single element is used; in another, two elements are used in a symmetrical arrangement between the inner and outer coaxial conductors. It is common practice to use a type *N* connector to join the bolometer unit into the measurement system. However, several types of precision connectors are being developed by industry which will provide for greater precision in performing the calibration.

The calibration factor for bolometer units is defined as the ratio of the substituted dc power in the bolometer unit to the RF power incident upon the bolometer unit. The calibration factor of a bolometer unit combined with a coaxial directional coupler is defined as the ratio of the substituted dc power in the bolometer unit on the side arm of the coupler to the RF incident upon a nonreflecting load attached to the output port of the main arm.

Bolometer units are calibrated at power levels of 1 and 10 mW only. Bolometer-coupler combinations are calibrated for coupling ratios in the range of 3 to 30 dB. Bolometer units should be of the fixed tuned or untuned broadband type and permanently attached to the coupler. The directional coupler should have good design features, with a directivity of at least 30 dB, and a VSWR no greater than 1.10 for the input and output ports of the main arm of the coupler.

Limits of uncertainty in determining the calibration factor of a well-designed bolometer unit or bolometer-coupler unit are within one per cent; although somewhat wider limits in the uncertainty of measurement may result for bolometer units and for bolometer-coupler units having a VSWR above 1.05.

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Discrepancies in Dielectric Waveguide Mode Cutoff Conditions

The rederivation of the characteristics of modes of propagation along a dielectric rod by Biernson and Kinsley [1] kindled renewed interest in work we published in 1960 on the same topic [2]. Whereas our interest in the dielectric rod waveguide was as a surface wave transmitting structure at microwave frequencies, Biernson and Kinsley analyze this configuration mainly as a model of retinal cones, sensitive to optical frequencies. Since the electromagnetic field equations are, of course, identical in both regimes, a direct comparison is possible.

The comparison is somewhat hampered by the fact that Biernson and Kinsley, being interested in dielectric rods whose permittivity is only slightly higher than that of the surrounding medium, derive and present their results mainly in the limit of the permittivity ratio approaching unity. Our results, which are exact for all values of the permittivity ratio ϵ, agree with theirs in the limit $\epsilon=1$, but not always for higher, realistic values of ϵ. In particular, there is disagreement in the equation for the cutoff frequencies of the higher-order hybrid HE modes of propagation. Biernson and Kinsley give two expressions for this cutoff condition, which contradict each other. Although this at first suggests merely some typographical error, comparison with our results shows that neither one of their expressions is correct.

Biernson and Kinsley give the cutoff condition for HE modes for $n \geq 2$, once in their (91) as

$$J_{n-2}(v) = -[\delta/(2+\delta)]J_n(v) \qquad (1)$$

and again in their summary Table I as

$$J_{n-2}(v) = [\delta/(2+\delta)]J_n(v) \qquad (2)$$

where v is a normalized frequency variable and $\delta = (\epsilon-1)/\epsilon$. The correct result, when translated into their notation, is

$$J_{n-2}(v) = -[\delta/(2-\delta)]J_n(v). \qquad (3)$$

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