results from the imperfect cancellation occurring at the junctions which is due to construction tolerances and discontinuity capacity.

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Broadbanding Microwave Diode Switches

In the design of microwave switching networks, it is often necessary to design for minimum VSWR and low loss over a broadband. One class of PIN diode TEM microwave switch may be successfully broadbanded by utilizing the band-pass filter designs published by Mumford [1] and Matthaei [2].

Consider the S.P.D.T. diode switch in Fig. 1 which uses two pairs of PIN diodes shunting a TEM stripline circuit. (Diodes must be paired in stripline circuits to obtain maximum forward bias attenuation.) If the diodes in "diode gate" D' are forward biased and the diodes in D are reverse biased, then most of the incident generator power will flow to G_L and vice versa. The canonical form of the Fig. 1 switch in either condition is a four "stub" band-pass filter consisting of $\lambda_0/4$ shunt stubs of characteristic admittance Y_m separated by quarter wave lengths of connecting line with characteristic admittance $Y_{m,m+1}$. For the condition where generator power flows to G_L, the first stub is Y_1, the second is $Y_2 = Y_{23}'$, the third "stub" (normally denoted by Y_3) is the parallel resonant circuit at D obtained by tuning out the diodes' reverse biasc apacitance with the short inductive stub Y_α, and the fourth is Y_4. The filter will exhibit maximally flat or Tschebyscheff band-pass response if certain prescribed values of characteristic admittance are assigned to Y_m and $Y_{m,m+1}$.

The problem arises as to what value of equivalent quarter wave stub characteristic admittance (Y_3) one must assign to the D and Y_α resonant circuit. This is properly called a "quasi-lumped" stub, since the inductive stub Y_α is loaded by the lumped capacitance of D. One method, found to give good practical results, is to equate the mid-band susceptance slope of the quasi-lumped stub to that of an actual $\lambda_0/4$ stub of characteristic admittance Y_3. This may be done by considering Fig. 2, where

$$B = j\omega C - jY_\alpha \cot \frac{\omega d_\alpha}{V}$$

where

$$V = \frac{3 \times 10^8}{\sqrt{\epsilon_r}} \text{ meters/s}$$

$$\frac{dB}{d\omega} = j\left(C + Y_\alpha \frac{d_\alpha}{V} \csc^2 \frac{\omega d_\alpha}{V}\right).$$

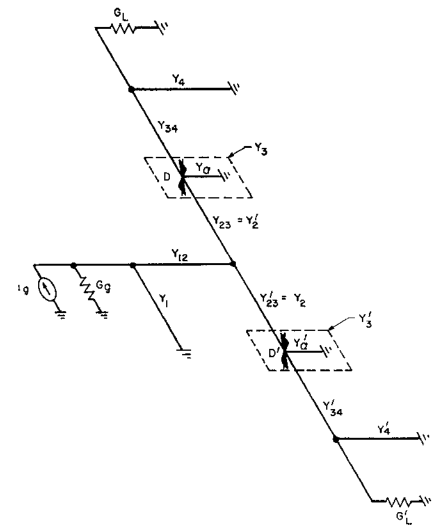

Fig. 1. Schematic diagram of stripline S.P.D.T. diode switch.

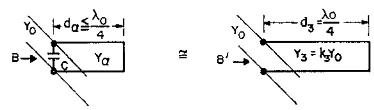

Fig. 2. Quasi-lumped stub and equivalent quarter-wave stub.

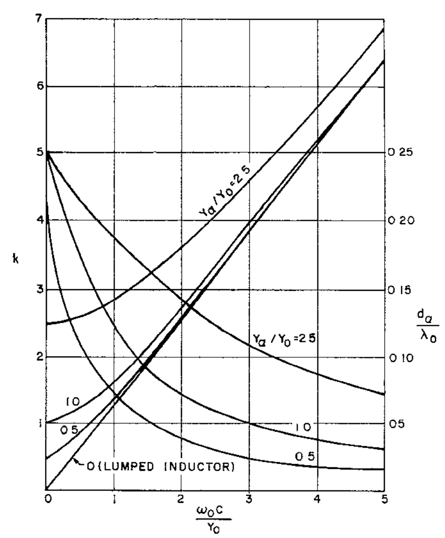

Fig. 3. Equivalent k of quasi-lumped stub (positive slope curves) and length d_α of quasi-lumped stub (negative slope curves), all vs. $\omega_0 C/Y_0$.

Also, for the quarter wave stub

$$B' = -jY_3 \cot \frac{\omega d_3}{V}$$

$$\frac{dB'}{d\omega} = jY_3 \frac{d_3}{V} \csc^2 \frac{\omega d_3}{V}.$$

Equating the two derivatives since we wish the selectivities to be equal near ω_0.

$$C + Y_\alpha \frac{d_\alpha}{V} \csc^2 \frac{\omega d_\alpha}{V} = Y_3 \frac{d_3}{V} \csc^2 \frac{\omega d_3}{V};$$

let

$$\omega = \omega_0, \qquad d_3 = \frac{\lambda_0}{4} \qquad k_3 = \frac{Y_3}{Y_0}:$$

then

$$\csc^2 \frac{\omega_0 d_3}{V} = 1$$

and

$$k_3 = \frac{4}{\pi} \cdot \frac{\omega_0 C}{2Y_0} + \frac{4}{\pi} \cdot \frac{\omega_0 d_\alpha}{2V} \cdot \frac{Y_\alpha}{Y_0} \csc^2 \frac{\omega_0 d_\alpha}{V};$$

also for $B=0$ at $\omega = \omega_0$

$$\omega_0 C = Y_\alpha \cot \frac{\omega_0 d_\alpha}{V}$$

whence

$$k_3 = \frac{2}{\pi Y_0}\left\{\omega_0 C + Y_\alpha \left[\text{arc cot} \frac{\omega_0 C}{Y_\alpha}\right] \cdot \left[1 + \left(\frac{\omega_0 C}{Y_\alpha}\right)^2\right]\right\}. \quad (1)$$

k_3 may be considered as the normalized characteristic admittance of the equivalent quarter wave stub Y_3. Figure 3 plots k vs $\omega_0 C/Y_0$ for various values of Y_α, and may be used for designing a switch or any other bandpass structure with one or more quasi-lumped stubs.

One further constraint faces the designer of the Fig. 1 switch: for a symmetrical configuration (through this is not necessary) $Y_{23} = Y_{23}'$, and when Y_{23} is being used as a coupling line, Y_{23}' must serve as a shorted stub, and vice versa. Hence, the filter design equations must be examined to find if any cases exist where $Y_{23} = Y_{23}'$. In this respect Mumford's [1] equations for maximally flat filters are particularly useful since they have the constraint that $Y_{m',m+1} = Y_0$ for all cases. Therefore, the designer need only choose the case where $Y_{23} = Y_{23}' = Y_0$. Then, for the 4-stub filter $Y_3 = Y_0$ and $Y_1 = Y_4$. However, if the designer must use a diode capacitance C such that $Y_3 > Y_0$, then he should build a filter with an odd number of sections, and place D in the center since for maximally flat filters the center stub always has the highest characteristic admittance.

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Organic Superconductor and Dielectric Infrared Waveguide, Resonator, and Antenna Models of Insects' Sensory Organs

With reference to Little's recent paper [1], the following comments may be of value:

Nature may have long ago discovered the facts concerning the feasibility of organic

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macromolecules with superconducting properties at a transition temperature corresponding to living tissue. Such macromolecules may be playing this unique role in insects'[1] sensory hairs, spines, and pit pegs. The reason for this suggestion follows.

The hypotheses of Grant [2], Callahan [3], and Marais [4] concern selective sensing of infrared radiation by insects' hairs, spines, and pit pegs for food searching, navigation, etc., and invoke infrared-frequency "dielectric" waveguide, resonator, and antenna models for these sensory organs. Although the entomologists should have used the results of dielectric waveguide, resonator, and antenna theory [5] instead of the hollow metallic-tube counterparts, their results, fortunately, do not seriously jeopardize their hypotheses. Their results, however, will have to be corrected not only in this respect but also where classical electromagnetic waveguide and resonator theory are concerned with coherent and polarized electromagnetic waves. This is generally not the case in the instance just cited except to the extent that black-body radiation possesses coherence in sufficiently minute space-time [6]. Furthermore, the mode of propagation in the dielectric tubular waveguide and antenna is likely the asymmetric hybrid fundamental, HE_{11}, mode. This mode is proposed in contrast to other modes because the dielectric tubular waveguide and antenna is capable of operating in a single mode provided the ratio of wall thickness to real dielectric constant thereof is reduced to a sufficiently small value. Furthermore, with such a waveguide and antenna, an essentially single-lobed radiation pattern may be realized. In other words, when the wall thickness is small enough to make the tubular dielectric waveguide beyond cutoff for all other modes, the HE_{11} mode is unique. It is appropriate to mention that the wall of the waveguide, resonator, and antenna may be a thin sheath on the supporting tissue or not differentiable from it.

Although there is much promise for the waveguide and antenna model of the sensory spine and hair of the insect and for the resonator model of the pit-peg, there is prospect for considering another model for these sensory organs; the organic superconducting model. This comprises essentially an organic superconducting tubular waveguide and/or "leaky" antenna, "leaky" being defined here as an antenna possessing a longitudinal array of periodic apertures, for which recent evidence seems to be at hand.[2] At the base of the hair, spine, and pit-peg is the peg. The peg seems to function as the detector (or generator) of the selectively received (or transmitted) and enhanced infrared radiation. It is proposed that these pegs not only comprise thermal detectors of essentially the electric component of the incident electromagnetic infrared waves, but also alternately function as a hypersonic [9] detector (or generator) of these waves. It is further proposed that the hair and spine function as a terminating dielectric tubular waveguide and antenna with the HE_{11} mode, or organic superconducting tubular waveguide with the fundamental H_{11} mode or the circular electric H_{01} mode with mode filter, and associated "leaky" (or periodically apertured) waveguide antenna with the latter modes.

The pit of the pit-peg functions as a hollow (or liquid) dielectric or organic superconducting resonator with iris aperture. The wall of the spherical or cylindrical resonator, i.e., pit, may be continuous or of a picket-fence structure with the appropriate modes to match such boundary conditions and terminating aperture or waveguide and antenna, i.e., hair and spine, and probe, i.e., peg.

In addition to these proposed sophisticated models, consideration may seemingly be given to the simple short ($\sim\lambda/10$) dipole superconducting antenna [10] model of the hair and spine of the insect. However, this proposal is not likely even for organic superconducting antenna with transition temperature at or above the insect's body temperature, because of the location of the peg at the base of the hollow (or liquid filled) hair and spine and pit-peg of the insect.

In contrast to the foregoing proposed dielectric and organic superconducting models of the sensory hair, spine, and pit-pegs of insects for ultrasensitive infrared reception and transmission for food searching, navigation, etc., at the associated dominant atmospheric infrared window, it seems extraordinary that nature has not resorted to the presumably simple task of utilizing thin normal metal waveguide and resonator and antennae since she has presumably long ago superbly mastered the technique of depositing thin metallic films [11] on insect[3] tissue. This situation may mean that utilization of a dielectric waveguide[4] is simpler than a metallic one and may be much simpler than a superconducting one.

The proposed electrical models already present formidable experimental and theoretical tasks for physicists and entomologists, because they require determination of pertinent physical, electrical, and optical, i.e., infrared, parameters of the salient micron size, living and dead, components and systems of the extraordinarily developed sensing organs of insects, which evidently function at the dominant infrared atmospheric windows. Nevertheless, this task will have to be done if significant progress is to be made in matching electrical models to the insects' remarkable sensing organs and their extraordinary performances

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[3] For example, wing-case of the beetle, Plusiotis Resplendens.

[4] It may be necessary to include consideration of Fiber optics [12] too.

Orthogonal Coupling to YIG Delay Lines

Recently, many experiments have been conducted for the purpose of investigating the microwave delay properties of single-crystal YIG [1], [2]. Three forms of delay have been observed: fixed acoustic, variable spin-acoustic, and variable pure spin propagation [3]. At short delays the initiating pulse makes observance of the delay pulse extremely difficult. We have conducted experiments using rod-like YIG samples and a two-port coupling arrangement similar to that employed by Olson [3]. Both the pure-spin and the spin-acoustic delay modes were observed. With this arrangement, the initiating pulse appeared at the output line reduced in amplitude by 25 dB. This signal was due to stray coupling between input and output lines, as it was present with the static magnetic field removed. The pure-spin delayed echoes incurred a transmission loss of 20 dB, and hence, interference between delayed and undelayed pulses was observed at short delays. The output coupling line was then oriented orthogonal to the input line. Both types of delay modes were unaffected by this

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