APPLICATION		REVISION			
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YIG HARMONIC MULTIPLIERS
&
COMB GENERATORS

APPLICATION NOTES

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YIG HARMONIC MULTIPLIERS AND COMB GENERATORS

APPLICATION NOTES

YIG tuned multipliers and comb generators, manufactured at OMNIYIG, contain a Step Recovery Diode, which behaves as a non-linear capacitor. This property is utilized to generate a time domain impulse (fig. 1). The frequency response to this impulse is a series of harmonically related frequencies that follow a $(\sin^2 x)/x^2$ type envelope (solid line fig. 2). There is some design latitude in the placement or location of the zeroes of the function. For low harmonic numbers (less than 20-30) the output can be first lobe, the output conversion loss can be approximated by a $1/n^2$ distribution. For narrow band outputs within the first lobe, the output can be greater than that indicated by $1/n^2$, through careful location of the first zero. Also the first lobe can drop below $1/n^2$ as it approaches the first zero. For moderate and large harmonic numbers, the output will contain the second third lobes. The average power in the second lobe will be about 6 db below a $1/n^2$ distribution and the third lobe will be about 12 db below $1/n^2$.

For the case of YIG tuned multipliers, the output filter structure has losses that can become significant and will add to the above mentioned conversion losses. These filter losses will vary from as little as 2 db to as great as 12 db, depending on the lowest required output frequency. All YIG spheres have a low frequency cut-off point. This cut-off can be extended to lower frequencies by increasing the amount of Gallium doping in the YIG sphere, but only at the expense of lowering the unloaded Q of the sphere. The resultant increase in filter losses can become great enough that system design choices of operating with either the n+1 or n-1 harmonic numbers will show a distinct advantage for the n+1 case. Even though the n-1 case will result in a lower diode conversion loss, the n+1 case will allow usage of a higher Q sphere and resultant lower filter losses. This situation will occur when output are below 2 GHz and especially when below 1 GHz.

Due to the fact that the Step Recovery Diode has a very low input impedance and that the time domain geometry of the impulse is very critical, the input matching is very delicate and highly susceptable to interactions between the amplifier and multiplier sections. An exclusive matching technique, developed at OMNIYIG, allows operation of the multiplier at the $(\sin^2 x)/x^2$ zero locations with only a moderate power loss in what would normally be a zero power output condition (see fig. 2 dashed line). However, the most critical matching and amplifier-multiplier interactions occur in the vacinity of the $(\sin^2 x)/x^2$ zeroes. The simplest solution to this situation is to purchase the amplifier and multiplier from the same source so that the two units can be tuned as a matched set. Lengths of cable between the multiplier and amplifier should be kept under 6 inches. If the amplifier should be purchased from a separate source, there are a few important items to consider. In the case of broad band inputs such as 1-2 GHz or 2-4 GHz, the amplifier should have an output hybrid (fig. 3) that is well matched to 50 ohms. For the case of a single frequency input such as 100 or 200 MHz, the amplifier should be reactively

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matched to 50 ohms and, in addition, should contain a 2 or 3 db pad to provide a resistive load (fig. 4). This 2 or 3 db pad can be either an external coaxial type or can be a Pi type resistor pad that can be built as an integral part of the amplifier output circuitry. In any case where the amplifier is purchased from a separate source it will be highly advantageous to provide a typical amplifier to the multiplier vendor for tuning purposes. Solid state amplifiers are the best for multiplier use as tube types have extremely bad output VSWR's and require prohibitively large amounts of padding between amplifier and multiplier.

When testing a multiplier, do not exceed 1 watt input power and preferably not greater than +29 dbm. In the case where large amounts of interaction between multiplier and amplifier are occuring, the result may be observed as low output power, especially in the vicinity of the $(\sin^2 x)/x^2$ zeroes. In this case, an increase of input power will not necessarily result in an increase of output power and may easily destroy the diode.

The output matching requirements are not so critical for the YIG tuned multiplier, as the filter section isolates the Step Recovery Diode from the output load. However, for the case of the comb generator the output load match can be significant. In this case, if the output VSWR's exceed 2:1, the reflected power returned to the diode can result in sub-harmonic and/or sideband frequency generations.

Ideal operation requirements are shown in fig. 3, fig. 4 and fig. 5. YIG tuned multipliers require the same considerations as all other YIG devices. Tuning coil connections must follow the manufacturer's polarity markings, and heaters must be turned on with approximately 30 seconds warm-up time.

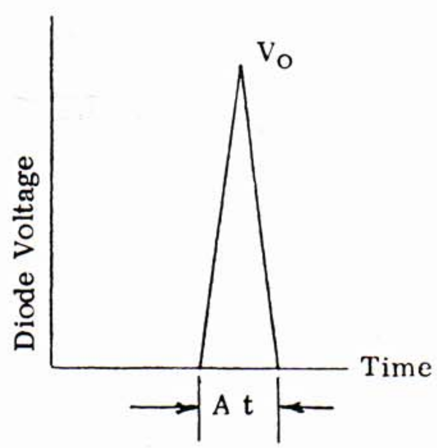

Fig. 1

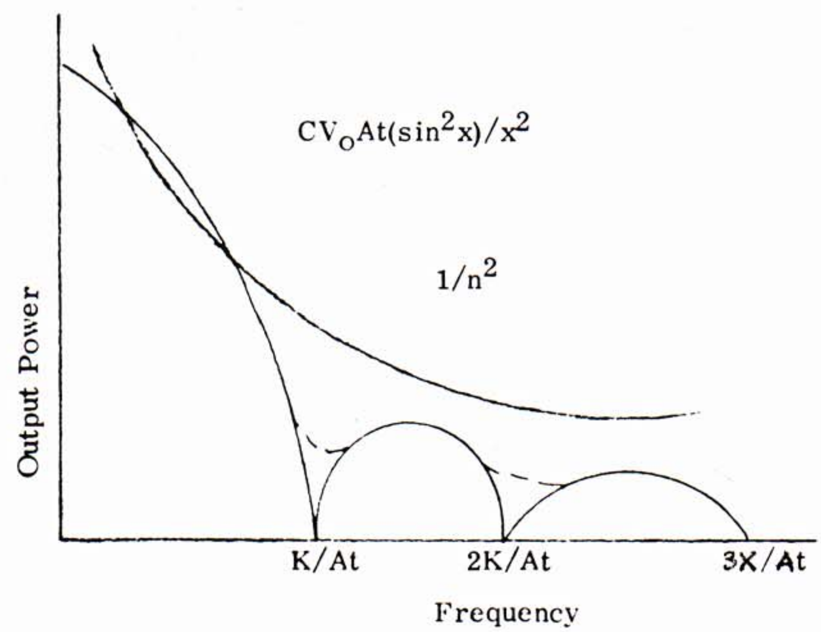

Fig. 2 Frequency response to impulse

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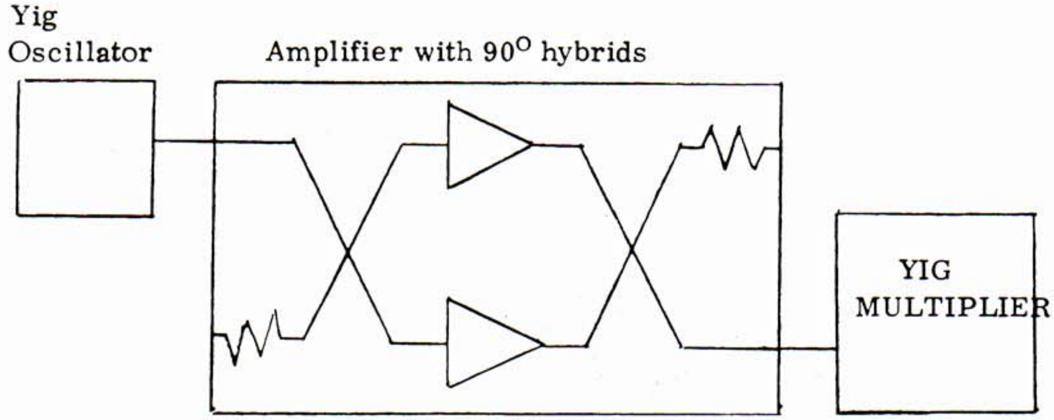

Fig. 3 Multiplier Operation with Broad Band input

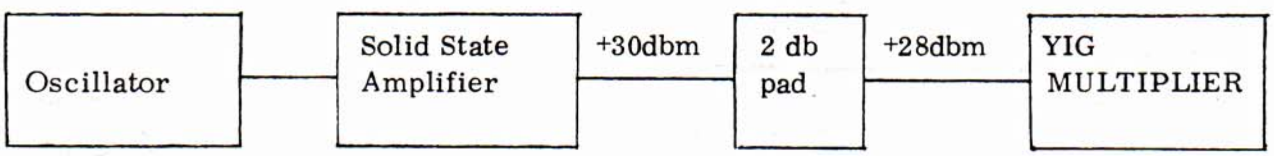

Fig. 4 Multiplier Operation with narrow band input

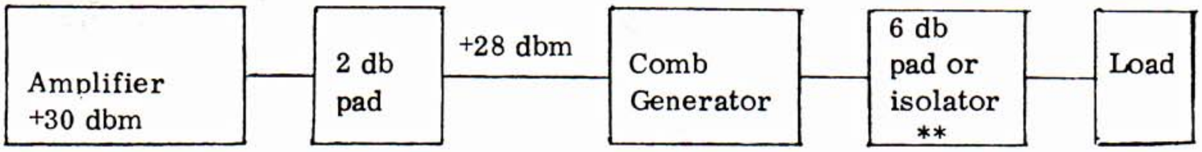

Fig. 5 Comb Generator Operation
Note: **Unnecessary if load has broad band VSWR less than 2:1

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