DESIGN AND PERFORMANCE OF AN INTEGRATED THREE CHANNEL TRACKING YIG PRESELECTOR

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ABSTRACT

A description is presented of a six section electronically tunable YIG filter that is partitioned into three isolated channels of two sections each, all contained within the same r-f structure and a common magnetic yoke. The design specifications are summarized for this three channel preselector and the performance results given for a 10% tuning range at X-band. The key features of ±0.5 dB amplitude tracking and ±10 degrees phase tracking between channels are maintained over the frequency band and a temperature range of -37°C to +71°C.

INTRODUCTION

Single and dual channel YIG preselectors have been widely deployed in the receiver front ends of electronic surveillance systems for many years. The use of YIG filters in radar system front ends has been much more restrictive in the past because of noise figure considerations, switching speed limitations and other system dependent factors. In recent years improvements in mixer diode noise figure performance, the need for diode burnout protection and a generally more hostile electromagnetic environment have combined to make low loss YIG filters more attractive to radar designers. Specifically, the in-band CW and peak power limiting characteristic[1] of the YIG filter together with its skirt rejection of out-of-band signals provides a unique combination of receiver protection features that cannot be matched by any other single microwave device.

In this paper a three channel two section tunable YIG preselector is described that meets the precision monopulse phase and amplitude tracking requirements of an advanced seeker antenna system. The device performance data are believed to be the first published results achieved with an integrated r-f structure and magnetic housing design containing all three channels. A brief description of the r-f measurement techniques used to evaluate tracking performance of the three channel device over time and temperature is also presented.

Design Specifications and Construction

The electrical design specifications for the integrated three channel YIG preselector are listed in Table I. Although mechanical characteristics are not indicated, there were size and weight constraints imposed on the design because of the mounting location on the back face of a small monopulse seeker antenna and comparator network that ruled out consideration of three separate filter housings.

A disassembled view of the integrated three channel preselector is shown in Figure 1. The r-f structure contains six 0.015 inch diameter YIG spheres in a gap spacing of approximately 0.060 inch length that must be maintained plane, parallel and magnetically uniform over all operating conditions. Input and output coupling to each channel is provided by semi-rigid coaxial cables with captivated SMA female connectors. Tuning coils connected in series fill the inner shell of the upper and lower housings that comprise the re-entrant magnetic yoke. The entire assembly is held together by the three screws shown in the illustration, and the unit weighs approximately nine ounces.

TABLE I
ELECTRICAL SPECIFICATIONS FOR THREE CHANNEL YIG PRESELECTOR

Tuning Range	10% @ X-Band
3 dB Bandwidth	20 MHz max.
Insertion Loss	2.5 dB max.
Limiting Level	+10 dBm min.
Off Resonance Isolation	50 dB min.
Passband Ripple	0.5 dB max.
Channel to Channel Isolation	40 dB min.
Amplitude Tracking between Channels	±0.5 dB max.
Phase Tracking between Channels	±10 deg. max.
Operating Temperature Range	-37°C to +71°C

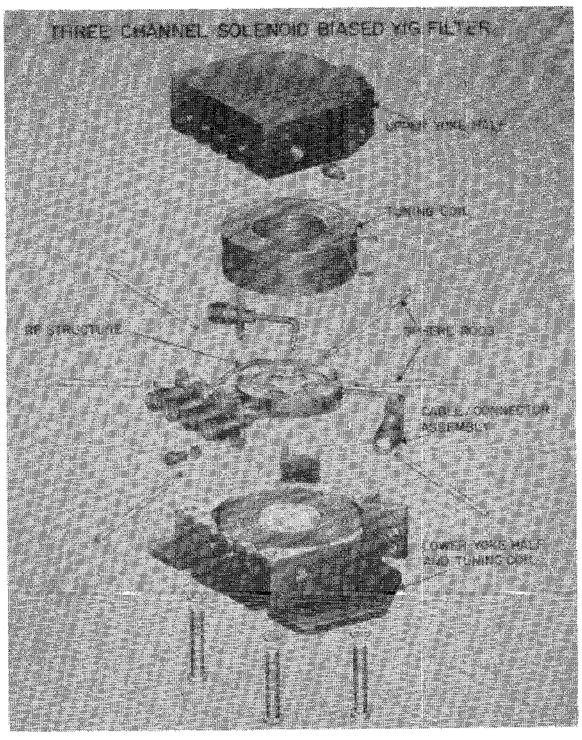


Figure 1. - Dissassembled View of Three Channel YIG Preselector

Measurement Methods and Test Results

Measurements of the preselector r-f characteristics were obtained using several techniques. Baseline acceptance test data at room temperature were measured with an HP Automatic Network Analyzer. This technique required transmission testing of the individual channels in 1 MHz steps over a passband for several different current settings, and hence center frequencies, throughout the tuning range. Amplitude and phase tracking information were obtained from these data by carefully ensuring that the current settings were identical for each channel that was measured.

However, for evaluating the tracking performance over temperature and under dynamic tuning conditions an instantaneous measurement technique was constructed that allows simultaneous display and evaluation of each channel. Block diagrams of the test equipment set-ups for measuring amplitude and phase tracking performance are shown in Figures 2(A) and 2(B), respectively. A four way power divider splits the test signal evenly, three of which go to the filter input ports and the fourth is terminated or used as a reference signal for the phase detector measurements.

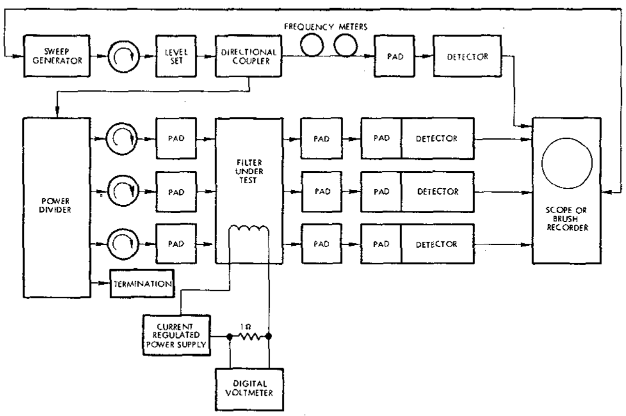


Figure 2(a). - Block Diagram of Amplitude Tracking Measurement Technique

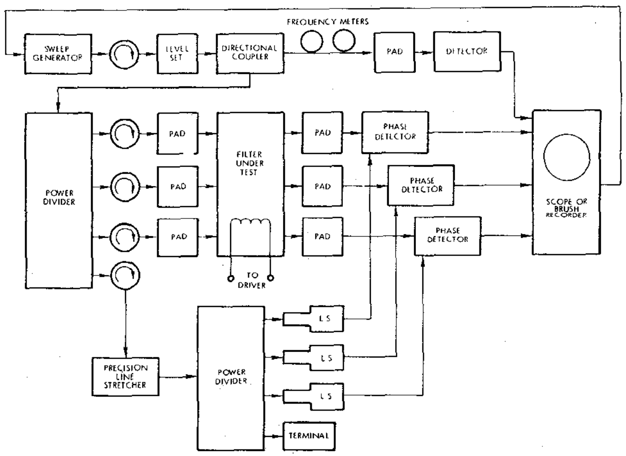


Figure 2(b). - Three Channel YIG Filter Phase Tracking Measurement Set-up

The amplitude data are displayed on a multi-channel oscilloscope or brush recorder. Representative photographs of the three channel amplitude response are shown in Figure 3 over the tuning range at room temperature and the temperature extremes. Since the horizontal and vertical scales of the graticule are calibrated in megahertz and dB respectively, the insertion loss, passband ripple and bandwidth can be directly obtained for comparison with the ANA data. The amplitude tracking performance is the key data of interest, however, and is seen to be within the 1 dB range as specified. The horizontal graticule lines correspond to approximately 1 dB separation in the upper half of each photo.

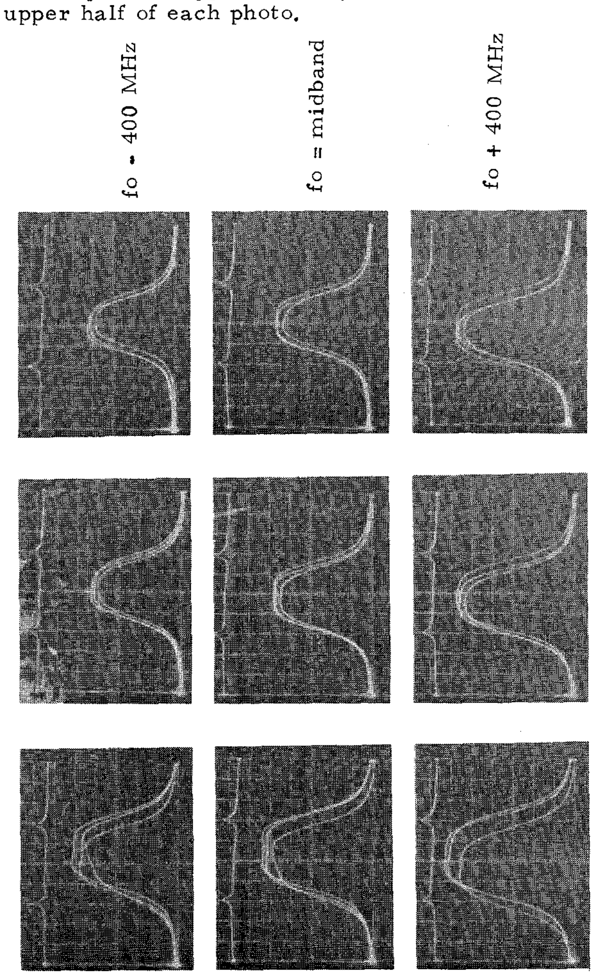
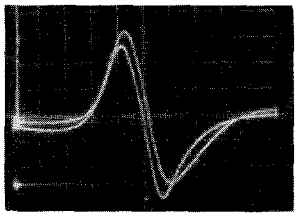


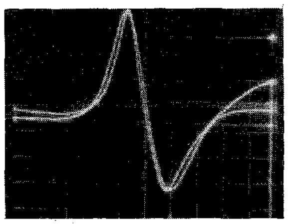
Figure 3. - Scope Photographs of Three Channel Filter Amplitude Tracking Versus Frequency & Temperature.

Phase tracking between channels is of primary interest over the center portion of the passband, and scope photographs of the different channel phase detector responses are shown in Figure 4. The horizontal separation of the peak to peak swept frequency phase responses correspond to the 3 dB bandwidth of each filter channel and the vertical graticule corresponds to approximately 25 degrees per division.

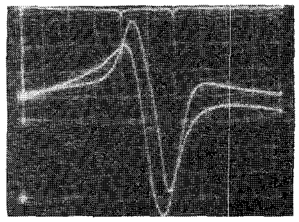
In order to obtain precision phase tracking data as a function of time and temperature a brush recording of each phase detector output was obtained using a stable CW source centered in the passband. During the three minute interval following application of the bias current, differential phase between channels was measured to be less than 5 degrees over the -37°C to +71°C temperature range. Typical plotted results measured at midband are shown in Figure 5.



fo - 400 MHz



fo = Midband



fo + 400 MHz

Figure 4. - Scope Photographs of Three Channel YIG Filter Azimuth and Elevation Channel Phase Tracking Responses

HORIZONTAL SCALE = 20 SECONDS/DIV.

VERTICAL SCALE = 4.5°/DIV

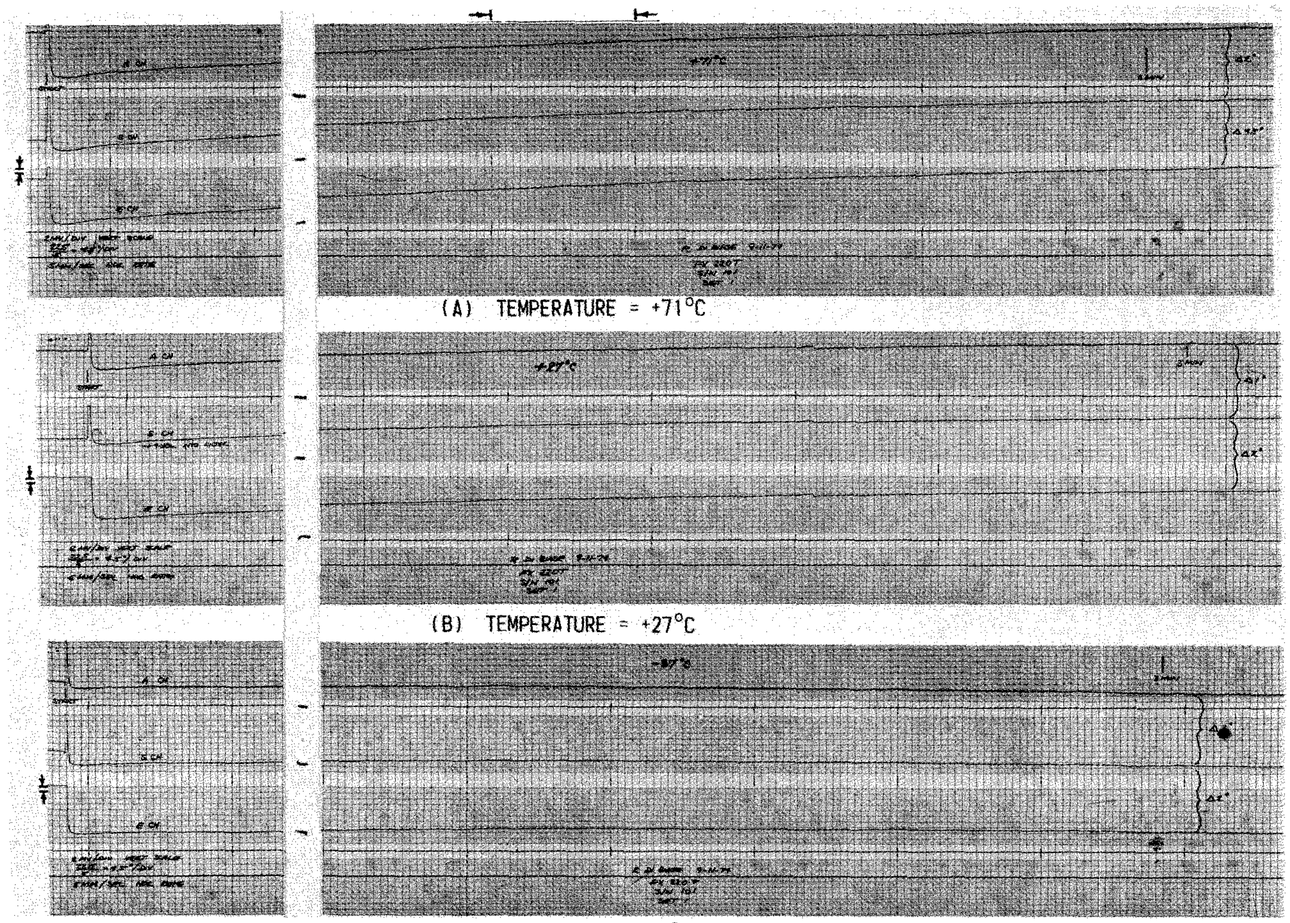


Figure 5. - Brush Recordings of Three Channel YIG Filter Phase Tracking Performance as a Function of Time and Temperature at Midband Frequency

CONCLUSIONS

Several three channel solenoid biased tracking preselectors have been built and tested to specifications required for precision monopulse receiver system performance. The units have been thoroughly evaluated at the component level and integrated with a seeker antenna, monopulse comparator network, and three channel receiver front end. The entire assembly was interfaced with its guidance electronics hardware and the system subjected to a complete MIL-SPEC airborne environmental program followed by a successful captive flight test evaluation without any measurable degradation in performance.

[1]R. A. Sparks and R. DiBiase, "Premature Decline Limiting in X-Band YIG Filters," 1975 International Microwave Symposium Digest, pp. 243-245, May, 1975.

NOTES