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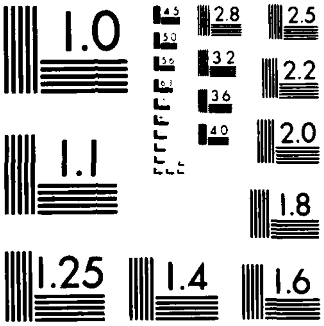

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Structures Technical Memorandum 368

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FUSELAGE TORSION OF A CT4 AIRCRAFT

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SUMMARY

The fuselage torsion mode of a CT4 aircraft has been examined using an impulsive testing technique. The mode shape and natural frequency are presented.

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CONTENTS

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1. INTRODUCTION

In reference 1, the natural modes and frequencies of a CT4 tailplane were presented. Subsequent to this, a lightly damped anti-symmetric tailplane vibration, at 11 hertz, was recorded in flight. A vibration at this frequency is noted in reference 1 but, at that time, was considered to be the elevator rotation mode, and was not investigated further due to time limitations.

Aircraft number A19-071 was made available by the RAAF, and a period of one day was allocated for the investigation of this mode to be carried out at Point Cook.

2. TEST PROCEDURE

Because the vibration to be investigated appeared lightly damped, and because the modes of vibration appeared well separated, an impulse technique was considered suitable. This enabled the test to be carried out with minimum equipment, and in a much shorter time than for the more traditional ground vibration test method, using multiple shakers and a distributed force input.

The equipment required for this test procedure was a two-channel FFT spectrum analyser, two accelerometers, a portable computer, a digital plotter and a hammer. A tape recorder was also used to store the data for future processing if needed.

The aircraft was in a fully serviceable condition, with all controls locked to prevent control surface rotation beyond the limits of backlash. No attempt was made to obtain a low frequency suspension for the aircraft.

Measuring stations were marked on the tailplane, fin and fuselage as shown in Figure 1. The actual locations are listed in Table 1. Measuring stations were also located on the leading and trailing edges of the wing tips.

An accelerometer was attached to the structure at location T2B, to act as a reference while another accelerometer was attached to the structure at each of the measuring stations listed in Table 1 in succession. For each location of the travelling accelerometer, the aircraft was excited by a number of impulses applied manually close to location T2B. The average response was measured for both locations and the root-mean-square spectrum obtained. Figures 2 to 11 show the spectra for the extremities of the structure. Slight variations in input levels were corrected for by using the transfer function of the response with reference to the fixed accelerometer output. The amplitude of the transfer function at 11.4 hertz was taken to be the amplitude of the mode at that location. The phase of the transfer function at this frequency was recorded and used to determine the mode shape. After measuring in some detail around the tail of the aircraft it became clear that the mode under investigation did not include any bending or torsion of the tailplane or fin. Measurements were then taken along the fuselage and on the wing tips to confirm the suspicion that the mode is a fuselage torsion mode.

In order to estimate the damping of the mode the recorded time-history was passed through an 18 hertz low-pass filter and captured on the spectrum-analyser using a sampling rate of 1024 samples per second and a 1 second time history. Figure 12 shows this time-history taken at the tip of the tailplane.

3. RESULTS

The only mode of interest in this test was the mode at 11.4 hertz. Table 2 lists the transfer function measurements taken at the various locations, and Figure 13 illustrates the mode shape. For clarity, only the leading edge points are plotted. A fully detailed plot would reveal that there is no noticeable deformation of the fin and tailplane assembly. The mode is quite clearly a fuselage torsion mode. The location of a nodal line for this mode is made difficult by the small amplitudes of signals along the fuselage, and the fact that measurements were being made on the exterior of a box section undergoing torsion. However, Figure 13 indicates the relative motion of the surface of the fuselage and the tips of the wing and tailplane, with the area around the wing root being generally of such small displacement that analysis becomes extremely inaccurate using the impulsive technique adopted for this particular test.

From Figure 12, which shows the decay of the vibration in the mode, the damping is estimated to be approximately 1 percent of critical.

4. CONCLUSIONS

The vibration at 11.4 hertz, measured at the tailplane during flight tests, has been investigated and found to be a fuselage torsion mode.

It has been demonstrated that for lightly damped and well separated modes, such as the one described here, a simple impulsive testing technique is adequate for modal identification. Accurate location of nodal lines is not so easy because of the limits placed on the input energy levels using this technique. A complete ground vibration test with distributed input forces still remains the ideal method to obtain such information.

REFERENCES

1. Goldman, A. Resonance Tests on the Tail of a CT4 Aircraft.
ARL-STRUC-TECH-MEMO-345 September 1982.

TABLE 1(a) LOCATION OF TAILPLANE MEASURING STATIONS

Distance from Aircraft Centre-Line (cm)	Distance from Tailplane leading edge (cm)			
	12.5	32.5	45.0	80.0
12.5	T4A T5A	T4B T5B	T4C T5C	T4D T5D
77.5	T3A T6A	T3B T6B	T3C T6C	T3D T6D
150.0	T2A T7A	T2B T7B	T2C T7C	T2D T7D
160.0	T1A T8A	T1B T8B		T1D T8D

TABLE 1(b) LOCATION OF FIN MEASURING STATIONS

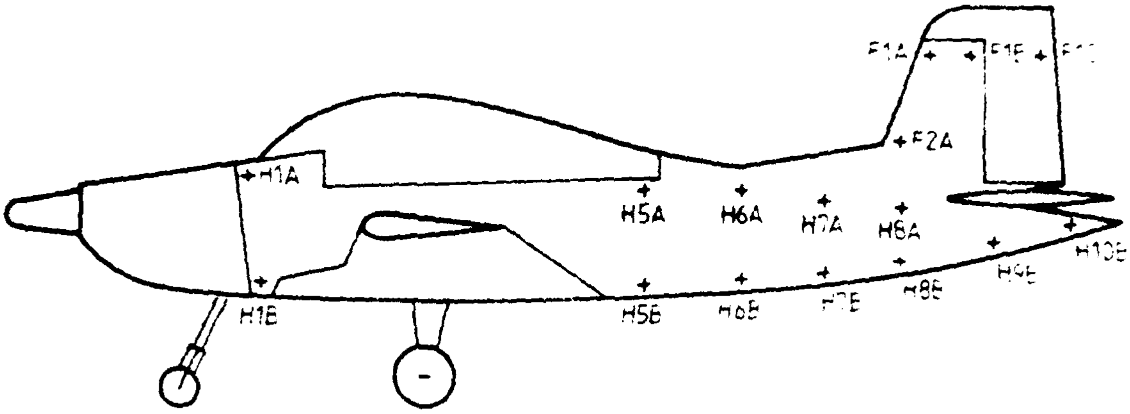
Distance from tailplane (cm)	Distance from fin leading edge (cm)		
	5.0	30.0	70.0
45	F2A		
105	F1A	F1B	F1C

TABLE 1 (c) LOCATION OF FUSELAGE MEASURING STATIONS

Distance aft of engine firewall (cm)	
5.0	H1A, H1B
275.0	H5A, H5B
327.0	H6A, H6B
382.5	H7A, H7B
432.5	H8A, H8B
482.5	H9B
522.5	H10B

TABLE 2. MEASUREMENTS OF TRANSFER FUNCTION IN THE MODE AT 11.4 HERTZ

Location	Amplitude	Phase (Degrees)	
T1A	0.86	-4	
T1B	0.85	-2	
T1D	0.77	1	
T2A	[illegible]	-1	
T2B	0.75	-1	
T2C	0.76	-2	
T2D	0.76	-2	
T3A	0.33	-2	
T3B	0.35	-2	
T3C	0.43	-2	
T3D	0.41	-2	
T4A	0.04	-3	
T4B	0.04	-4	
T4C	0.07	-1	
T4D	0.07	7	
T5A	0.04	-187	
T5B	0.05	-177	
T5C	0.08	-184	
T5D	0.05	-199	
T6A	0.31	178	
T6B	0.35	-182	
T6C	0.43	-185	
T6D	0.39	-190	
T7A	0.68	-183	
T7B	0.76	-183	
T7C	0.76	-183	
T7D	0.73	-189	
T8A	0.87	-183	
T8B	0.44	-184	
T8D	0.77	175	
F1A	0.18	184	
F1B	0.18	-185	
F1C	0.34	26	
F2A	0.07	-185	
H10B	0.007	24	
H9B	0.017	-7	
H8B	0.01	-11	
H8A	0.004	-177	
H7A	0.006	-176	
H7B	0.004	-25	
H5A	0.013	185	
H5B	0.013	-13	
H1A	0.005	-63	
H1B	0.009	-42	
W1A	0.25	-180	Port Wing Tip
W1B	0.3	-180	
W12A	0.22	-11	Starboard Wing Tip
W12B	0.26	-12	



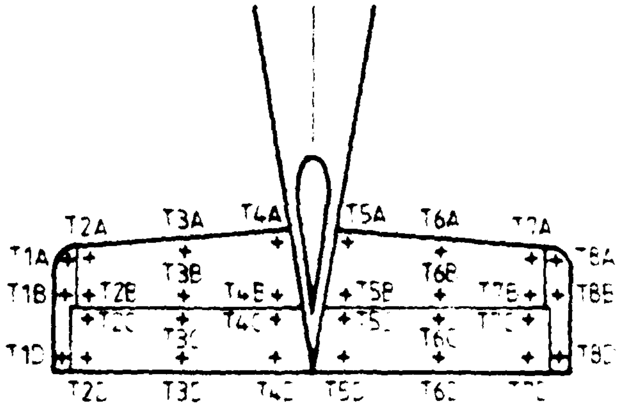


FIG.4 LOCATION OF [illegible] STATIONS

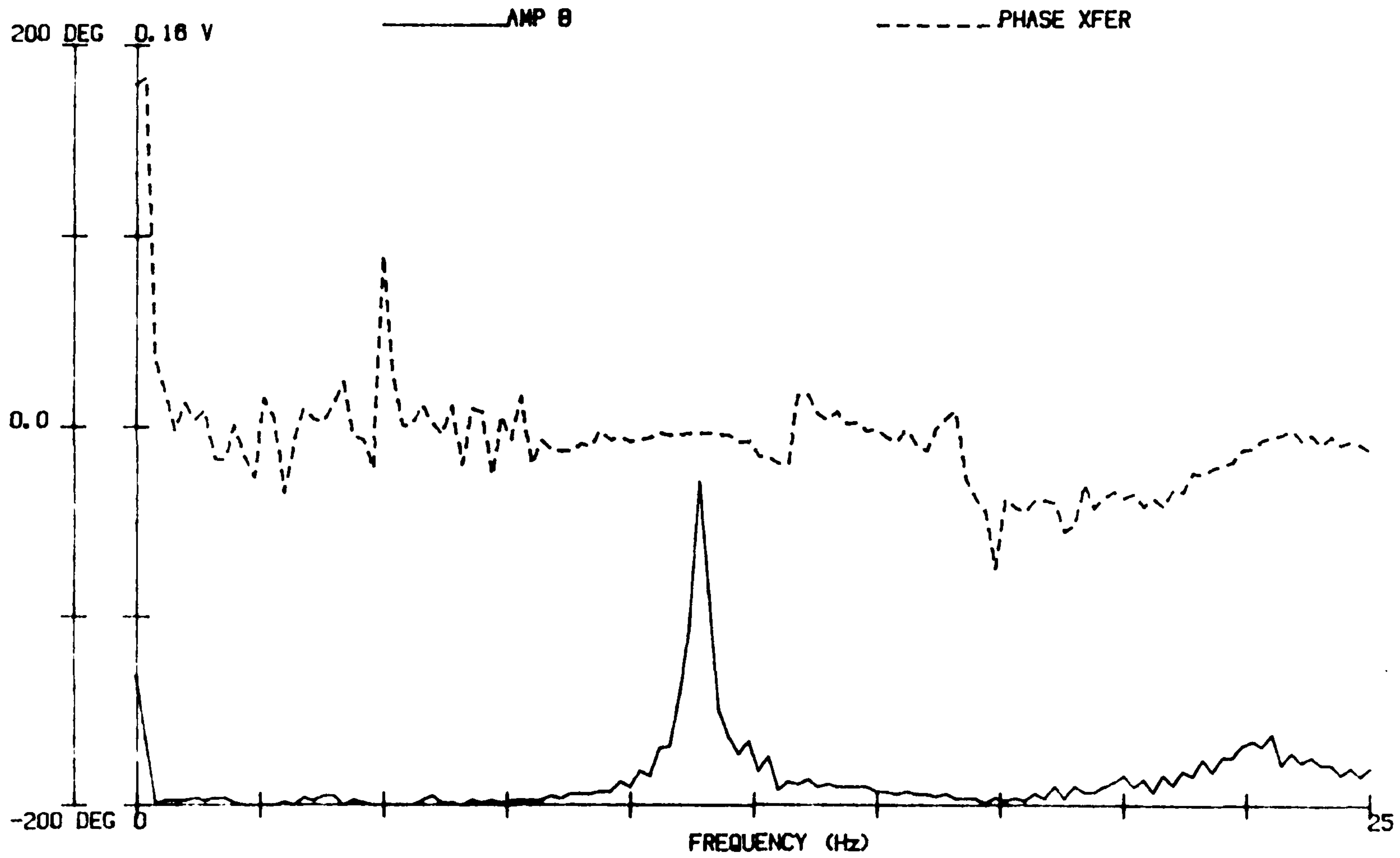


FIG.2 RESPONSE AT LOCATION T1A

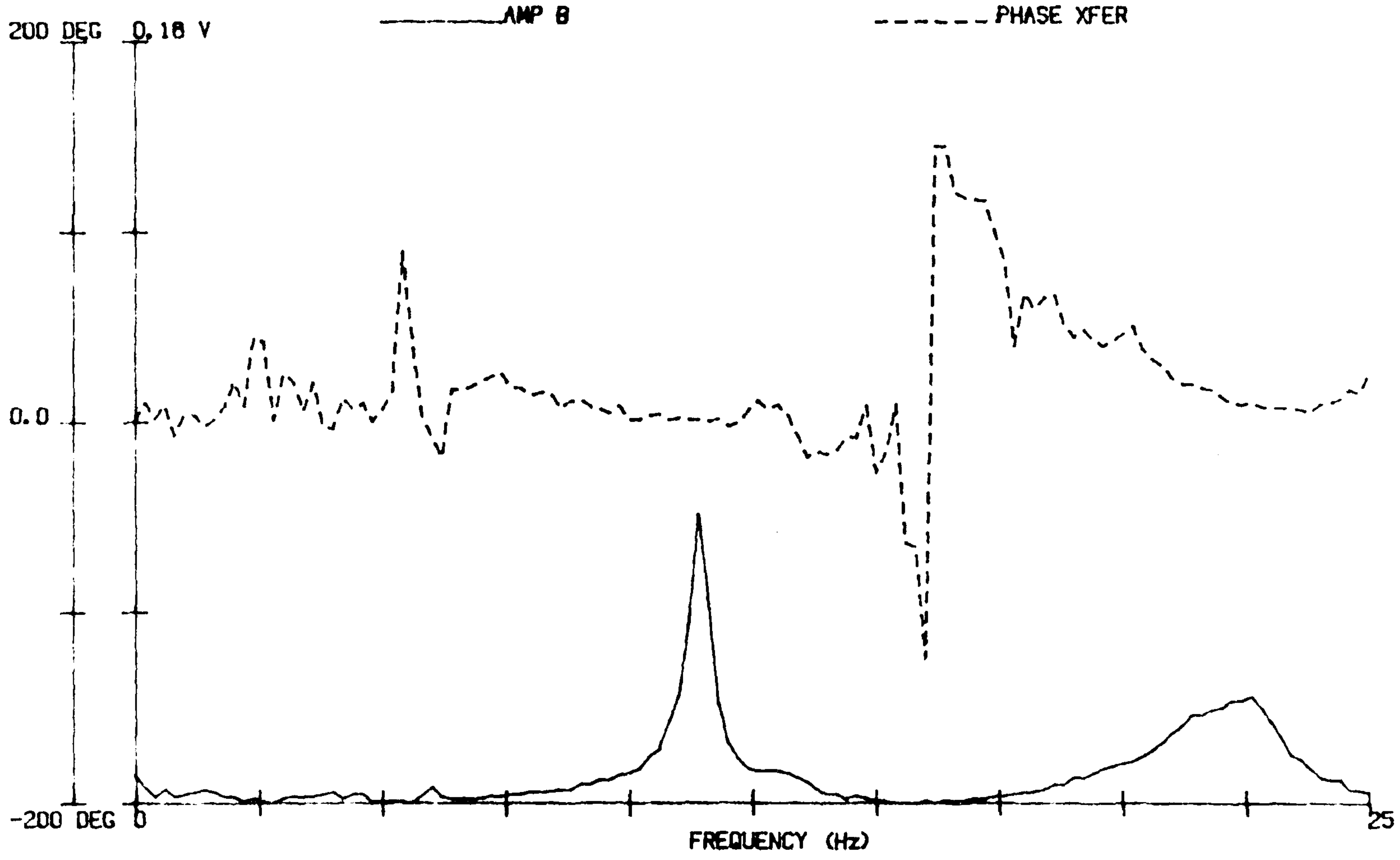


FIG. 3 RESPONSE AT LOCATION T1D

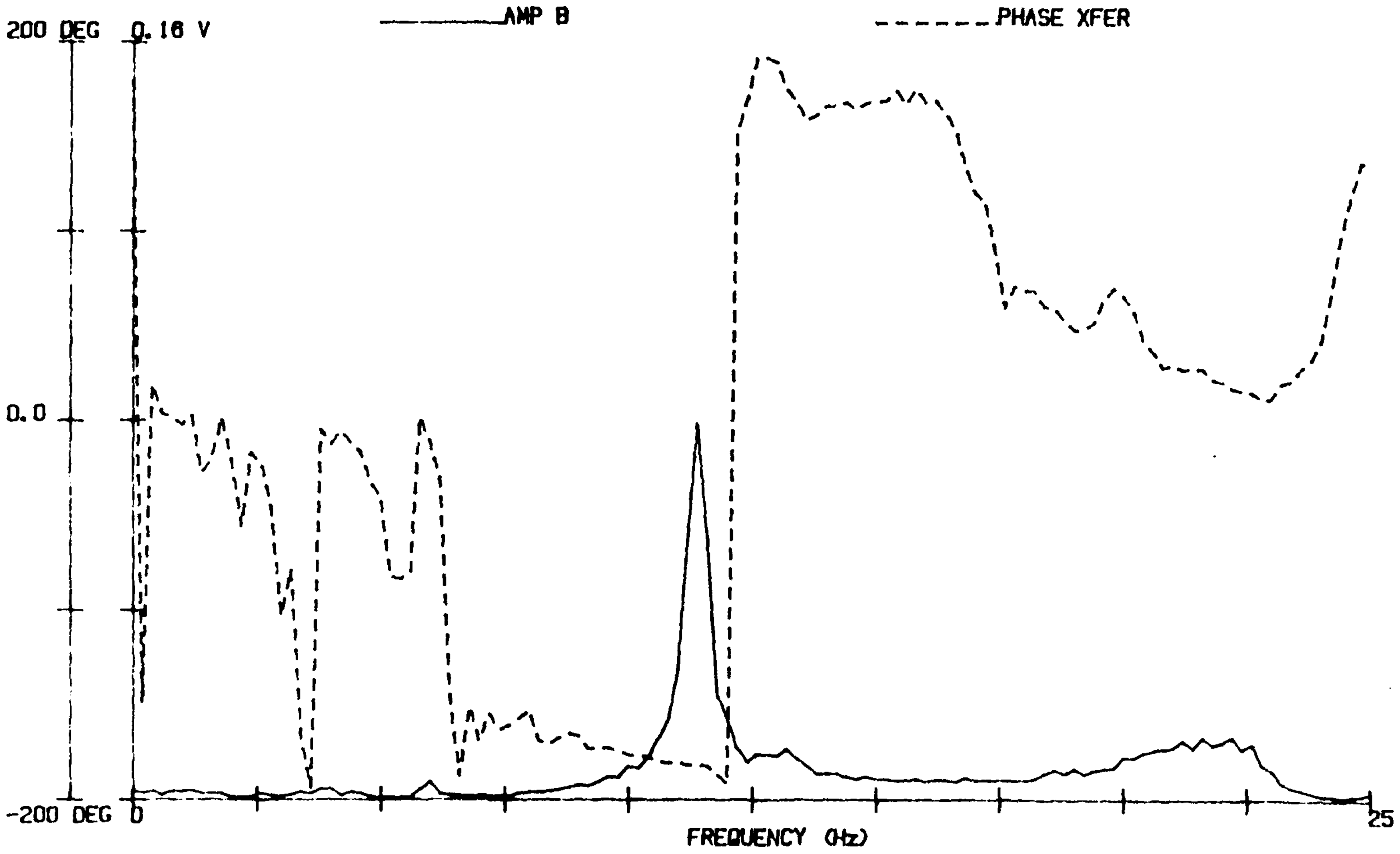


FIG.4 RESPONSE AT LOCATION T A

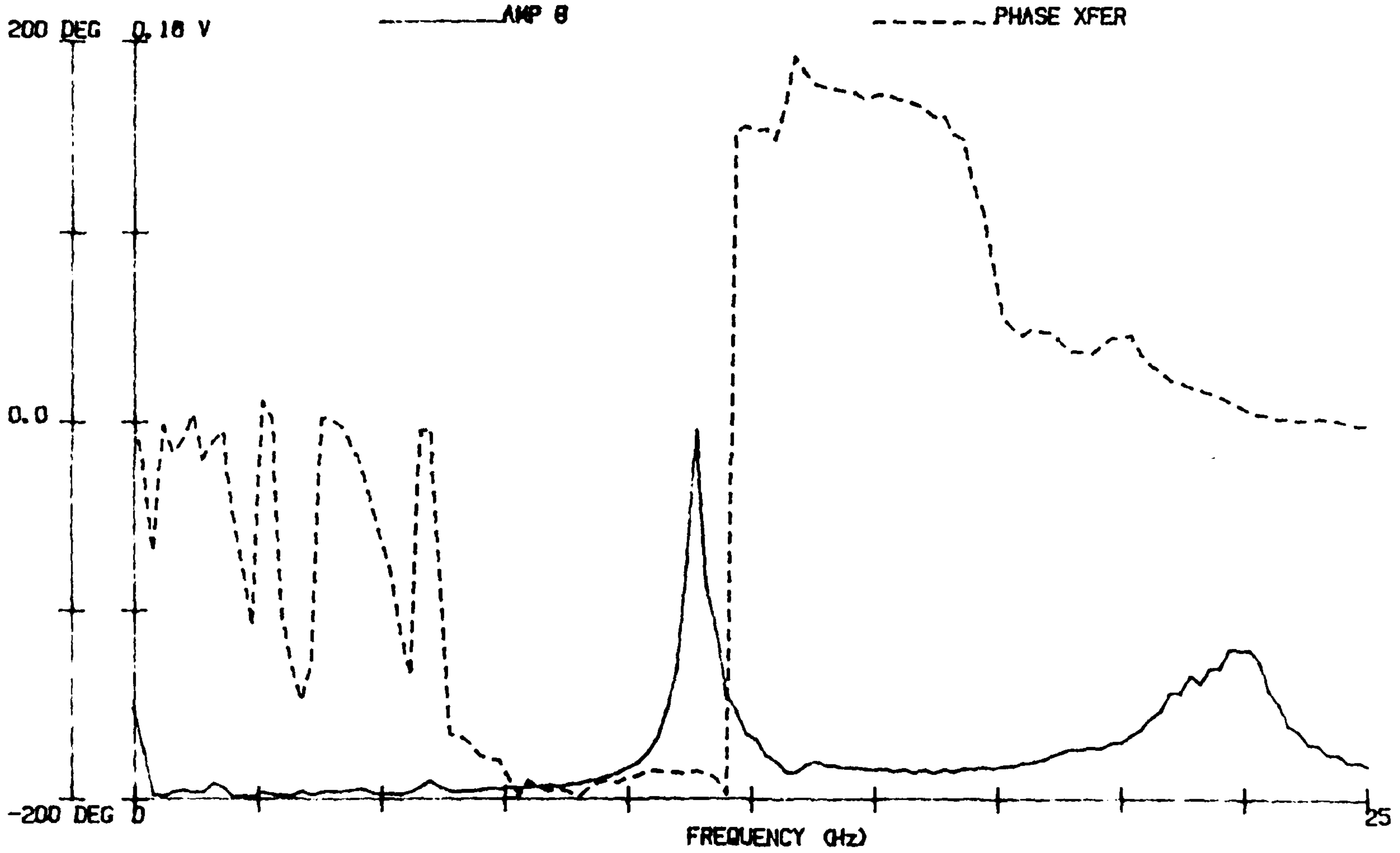


FIG.5 RESPONSE AT LOCATION T'D

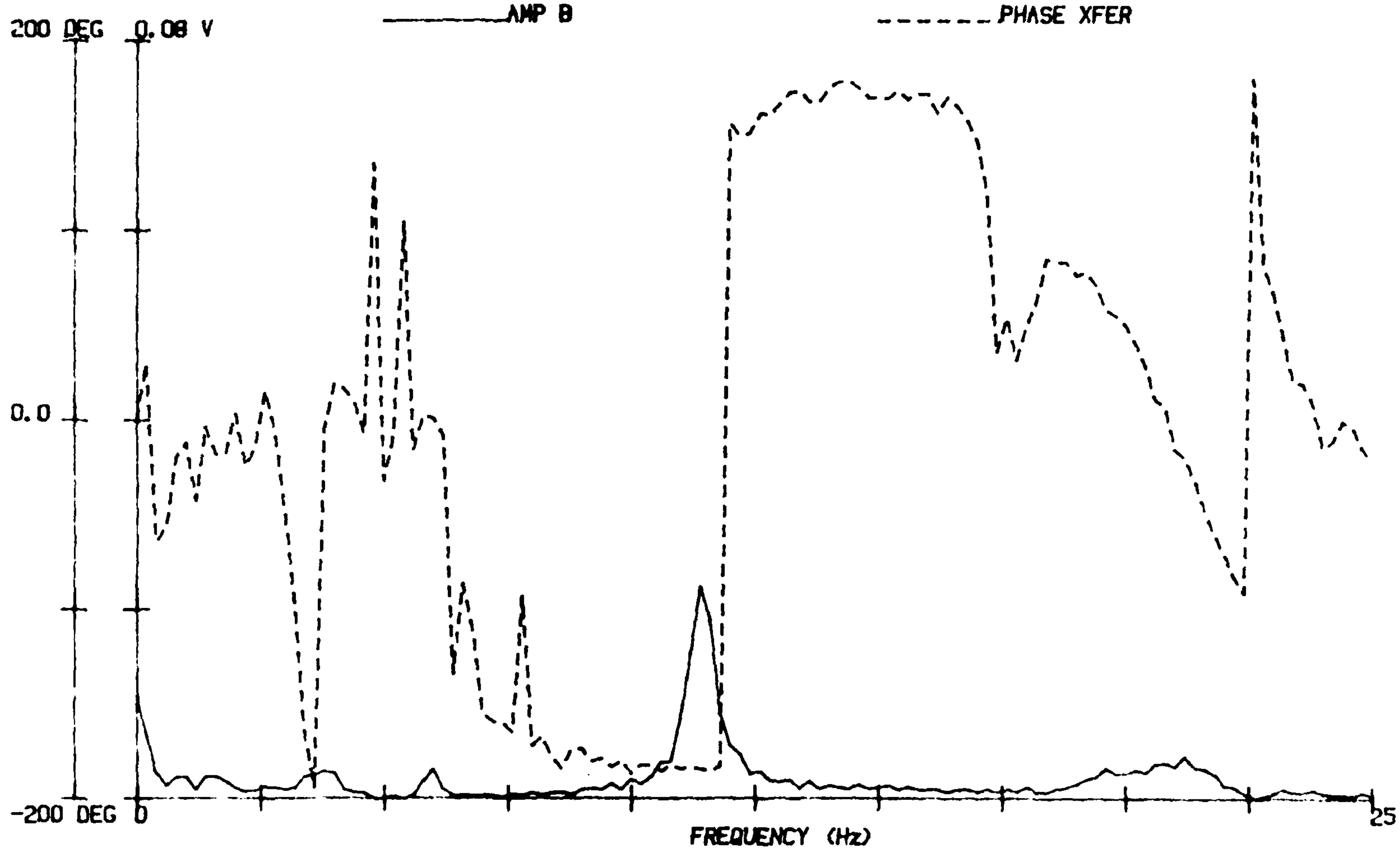


FIG.6 RESPONSE AT LOCATION F1A

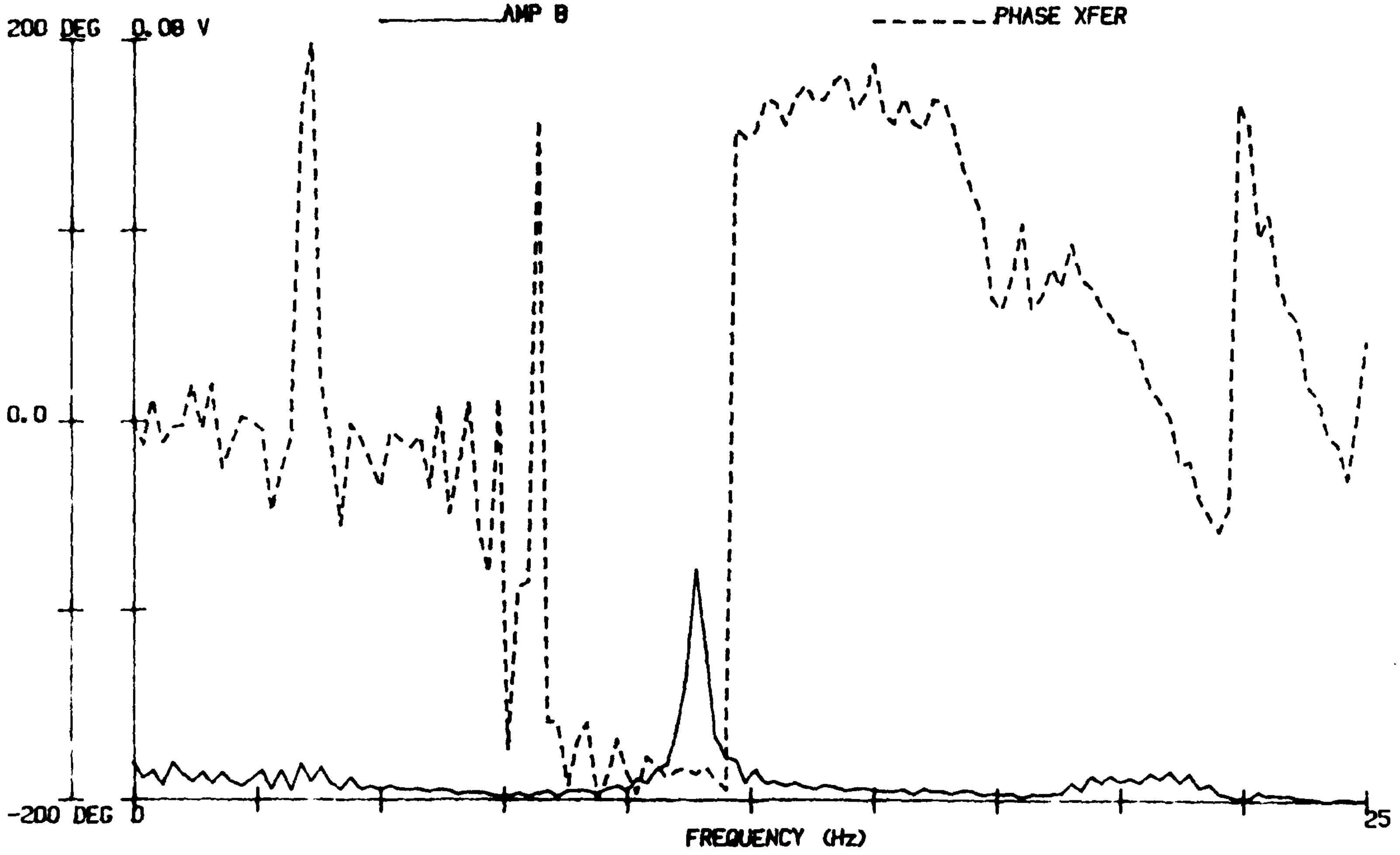


FIG.7 RESPONSE AT LOCATION F12

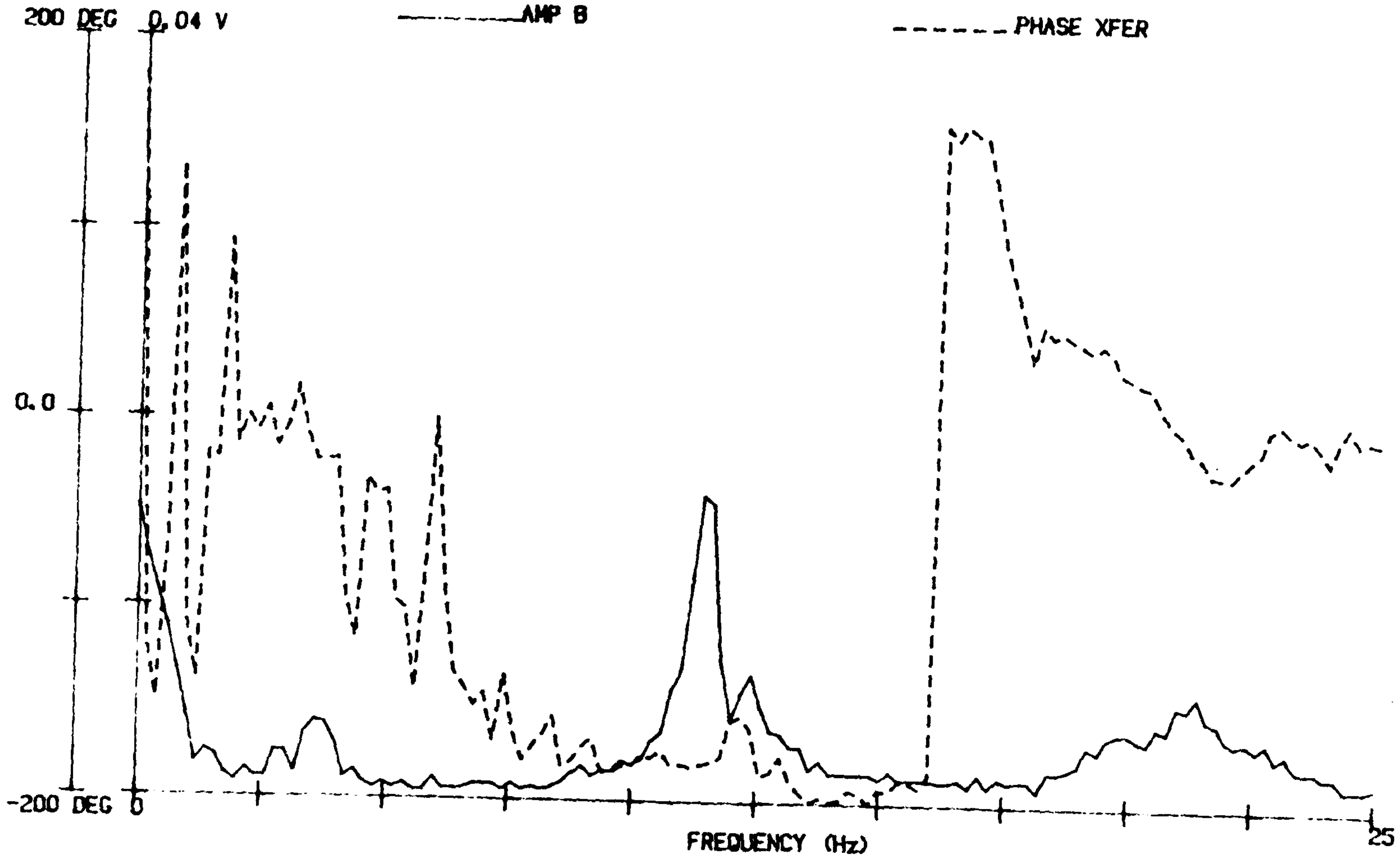


FIG.8 RESPONSE AT L.E. PORT WING

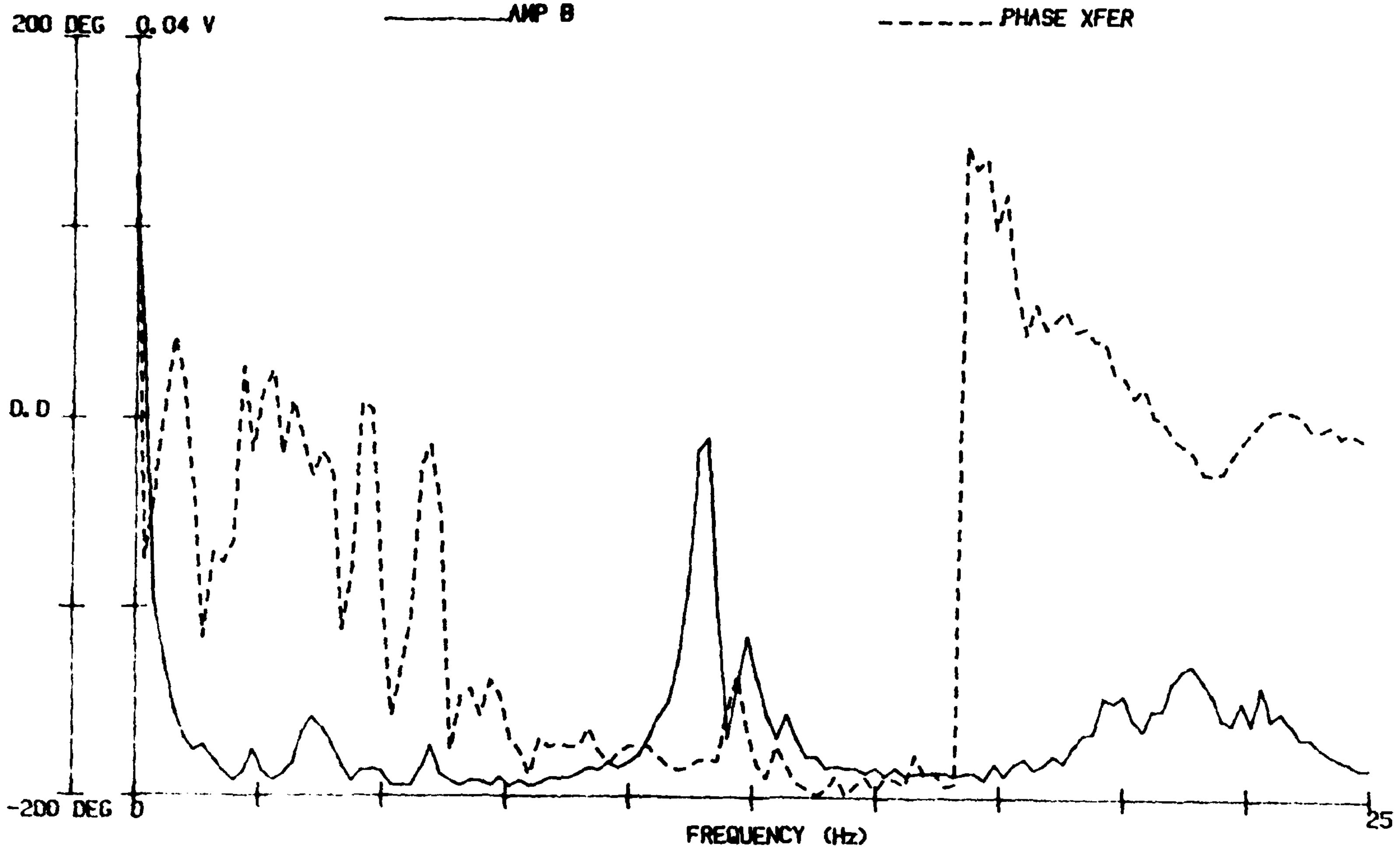


FIG.9 RESPONSE AT T.E. PORT WING

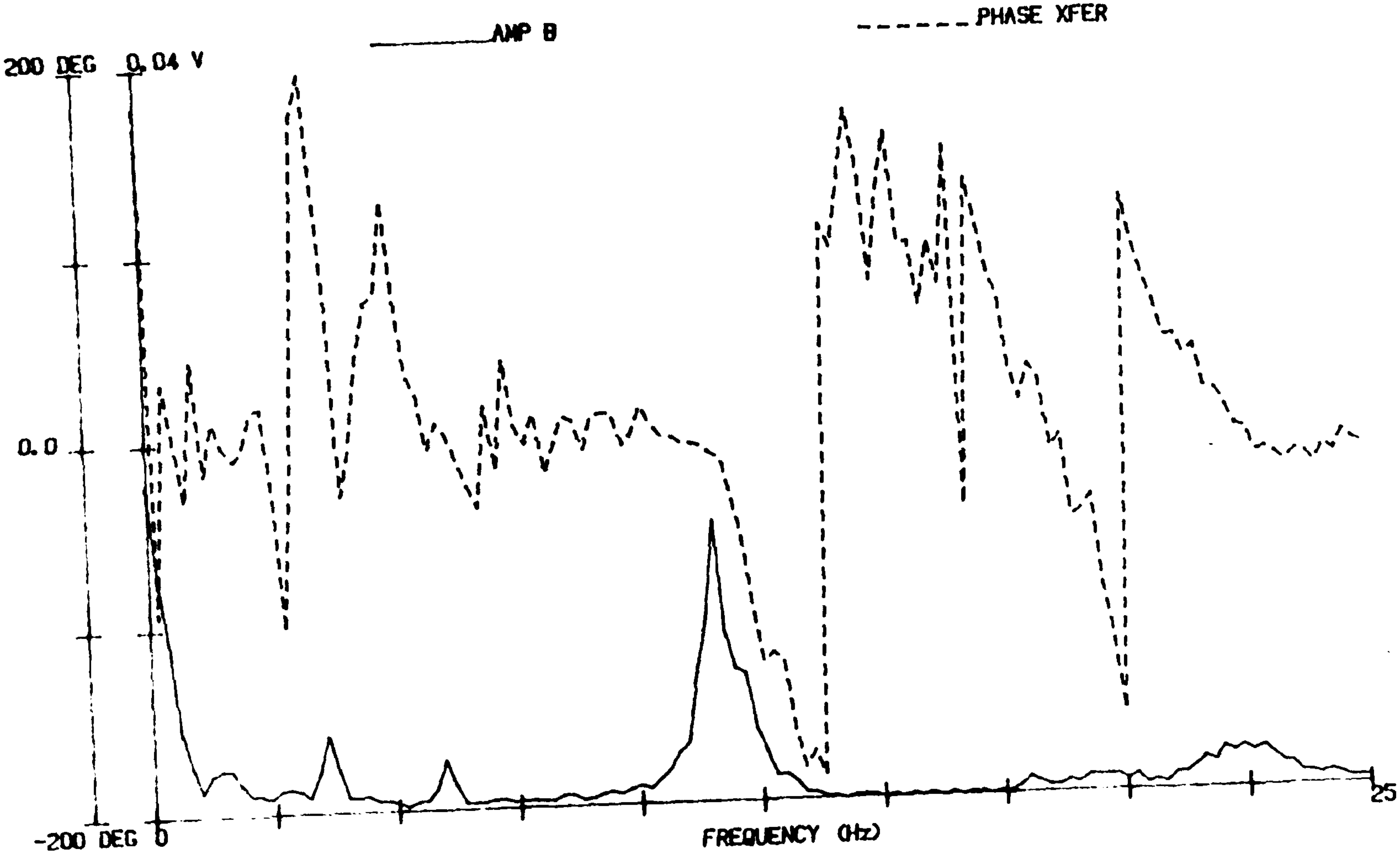


FIG.10 RESPONSE AT L.E. STBD WING

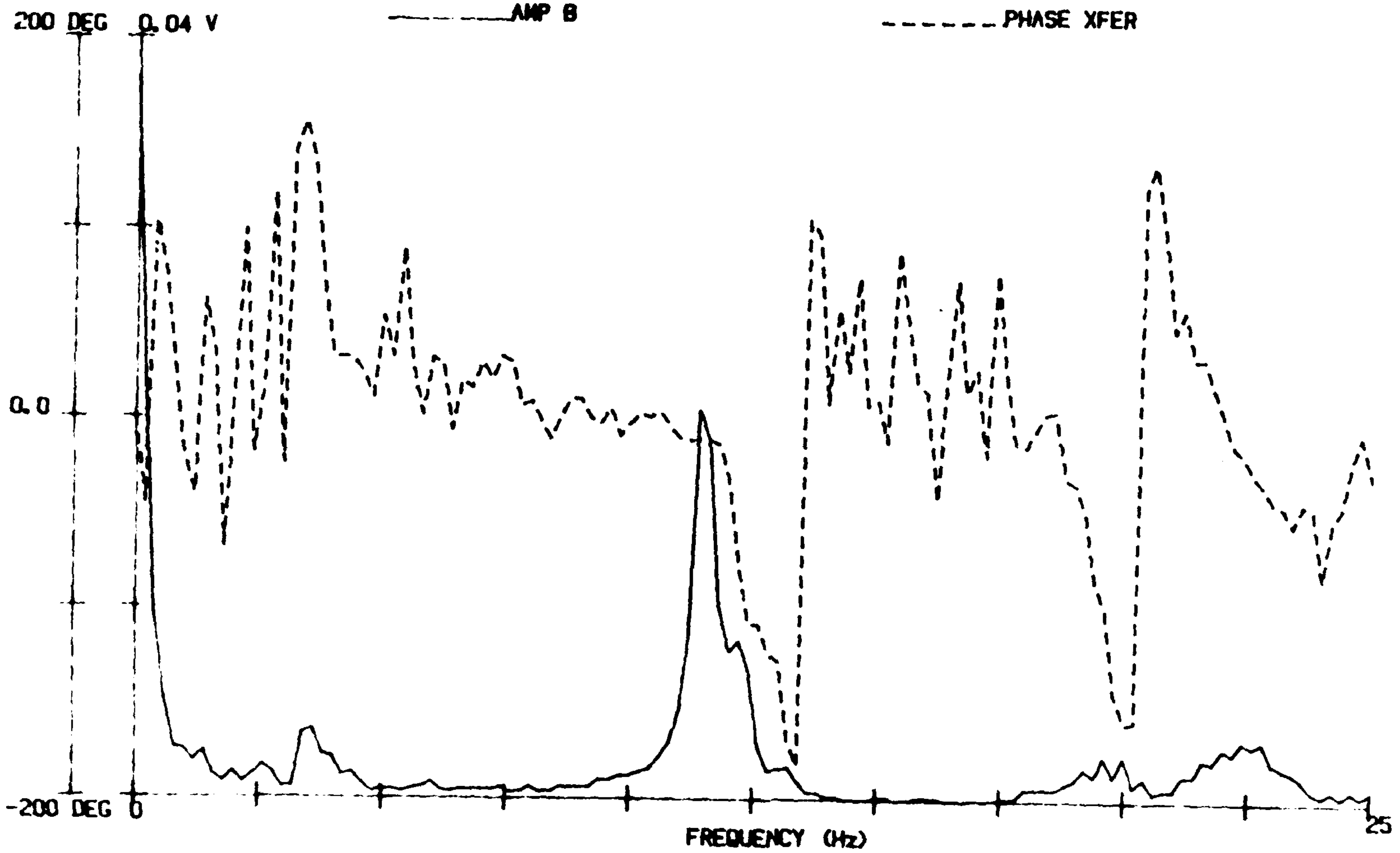


FIG.11 RESPONSE AT T.E. STBD WING

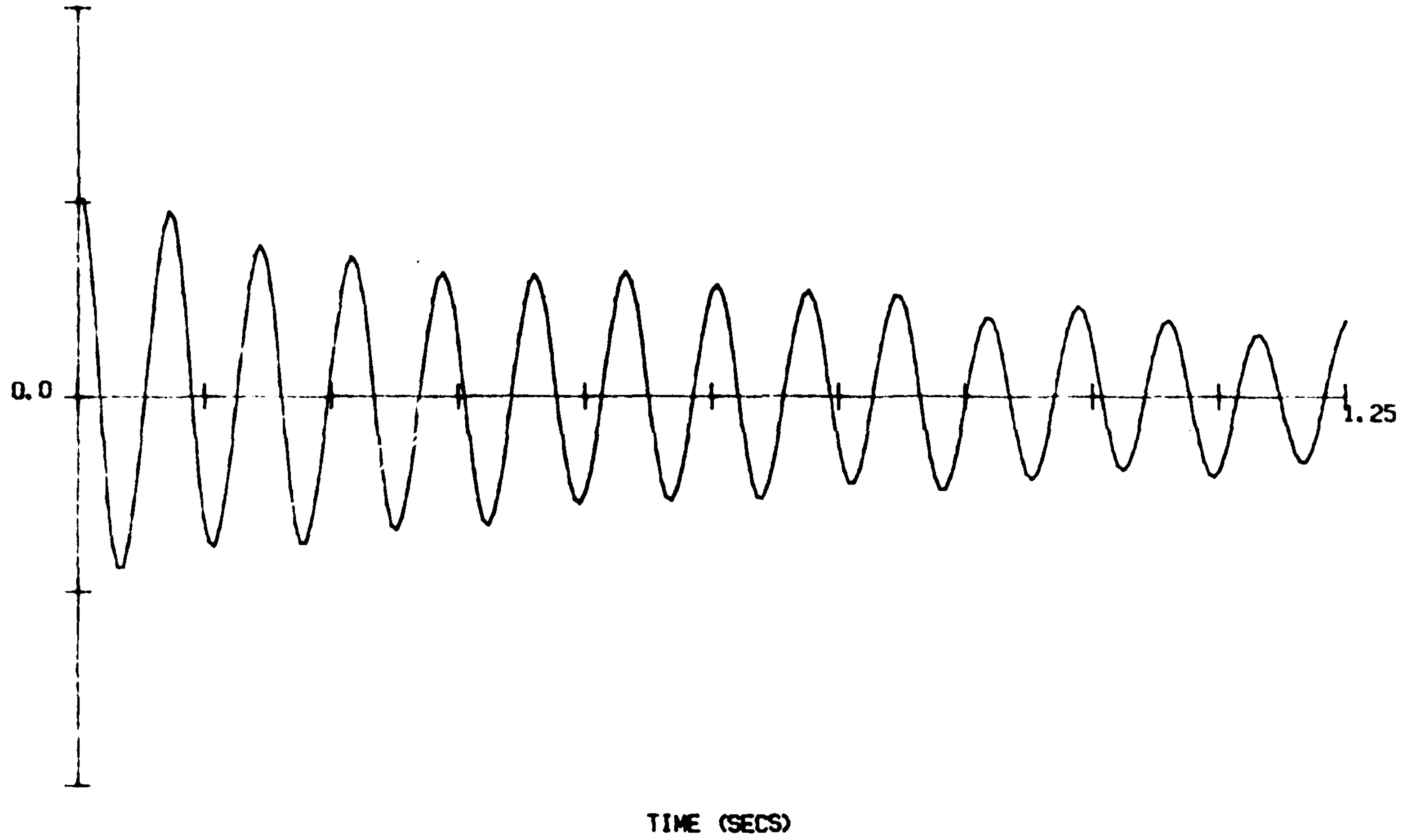
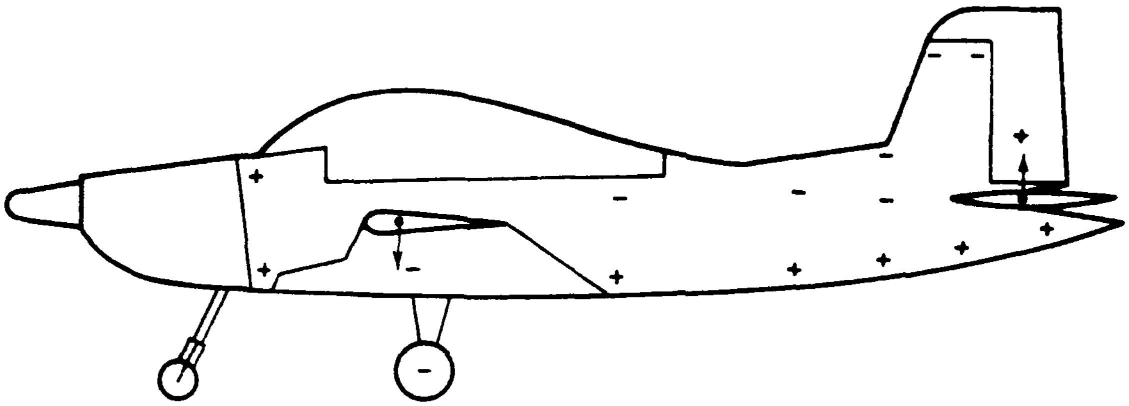


FIG.12 RESPONSE FILTERED AT 18 Hz



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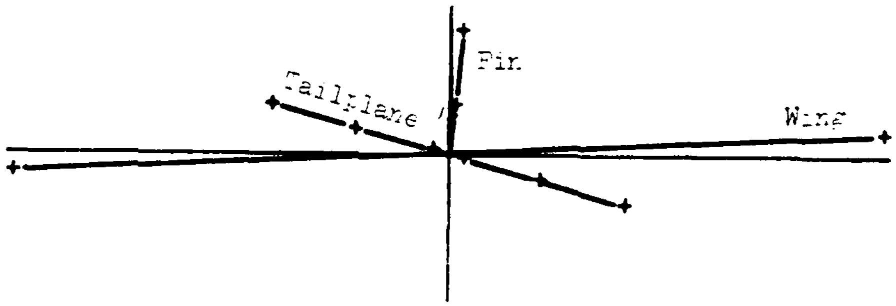

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15. COSATI Group

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16. Abstract

The fuselage torsion mode of a CT4 aircraft has been examined using an impulsive testing technique. The mode shape and natural frequency are presented.

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