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ROTOR MODULATION STUDIES OF AN HF WIRE ANTENNA ON A CHSS-2 HELICOPTER

J. Y. WONG AND C. A MUILWYK

OTTAWA

JULY 1965

ABSTRACT

Model measurements carried out on an HF wire antenna on a CHSS-2 helicopter show that rotor modulation on the radiation patterns is significant between 6 and 12 mc/s. The signal strength varies by as much as 6 db between 8 and 9 mc/s because of half-wave excitation of the rotor blades. The significance of rotor modulation on the performance of the communications system is discussed.

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ROTOR MODULATION STUDIES OF AN HF WIRE ANTENNA ON A CHSS-2 HELICOPTER

- J.Y. Wong and C.A. Muilwyk* -

INTRODUCTION

The term "rotor modulation", as applied to a helicopter, refers to the variation in the antenna characteristics produced by the rotor blades. The effect is generally detrimental and tends to degrade the performance of the antenna system. The degree of degradation depends on a number of factors, the most significant of which are the antenna configuration and location, the operating frequency, and the characteristics of the antenna tuner and receiver.

The problem of rotor modulation on an HF antenna system for an HUS-1 U.S. Marine Corps helicopter is described in a report [1] by the Collins Radio Company. The type of antenna used was a tuned helix monopole. After the system was installed on the helicopter, a ground test was carried out, and the system was tuned without difficulty at a number of selected frequencies from 2 to 30 mc/s. A flight test was then made and it was found that the antenna could not be tuned from 7 to 10 mc/s. The difficulty was finally traced to rotor modulation. At about 8 mc/s the variation in antenna impedance caused by the rotor blades introduced discriminator errors in the tuner which rendered the system inoperative. It was reasoned that at this frequency the fuselage becomes half-wave resonant and any change in the configuration of the fuselage, such as in the position of the blades, will affect the antenna impedance. The report concludes by recommending that further attention be given to rotor modulation with regard to radiation pattern.

In a report [2] by Canadair Limited, results of a model pattern study are given for a number of proposed HF wire-antenna configurations on a Royal Canadian Navy CHSS-2 helicopter. The patterns were evaluated in accordance with USAF Military Specification MIL-9080; however, the problem of rotor modulation was given only a cursory examination owing to lack of contract funds. As a result, we were asked by DGA/RCN to investigate the effect of rotor modulation on a final antenna configuration for the CHSS-2 helicopter.

MEASUREMENTS

Radiation patterns were measured on a 1/24 scale model of the CHSS-2 helicopter which was supplied to us by the RCN. The antenna is a wire type approximately 45 feet long and is located on the port side of the fuselage. From the feed point (Sta. 405, W.L. 162) the antenna runs forward to the sponson and aft to a 10-inch standoff at Station 625. A sketch of the HF wire antenna is

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* NRC Summer Student, 1964

shown in Fig. 1 and a photograph of the model used in the study is given in Plate I.

In order to avoid pattern distortion caused by feed-cable effects, a small transistorized oscillator was designed and installed inside the helicopter fuselage. A schematic diagram of the oscillator is shown in Fig. 2. The receiving system consisted of a broad-band log-periodic dipole and a Scientific-Atlanta Model 1640 wide-range receiver. The system operated most satisfactorily.

RESULTS

In order to determine the effect of the rotor blades on the radiation patterns, measurements were carried out for two blade positions. In Fig. 3 azimuthal patterns for the E_ϕ component are given from 6 to 12 mc/s. The radial scale of the patterns is in terms of relative field strength (μv/meter). On examination, we observe that at the low and high ends of the band, the blade position changes only the relative amplitude of the radiation pattern — the pattern shape remains unaltered. However, between 8 and 9 mc/s both the shape and the amplitude of the pattern are changed and the effect appears to reach a maximum at about 8.5 mc/s. At this frequency, the rotor blades which are approximately a half-wavelength long, become excited, and it is the interaction between the fuselage and blade currents which produces the dramatic change in pattern shape. Off resonance, the coupling between blades and fuselage is very much reduced, and the variation in pattern amplitude can be attributed to a change in only the antenna impedance.

In Fig. 4, patterns are given for the E_θ component over the same band of frequencies. For this case, it is observed that the resonance phenomenon does not exist and the only change is one of pattern amplitude. This result is to be expected because the blades radiate essentially an E_ϕ component of field and the effect of rotor position on the E_θ patterns is small.

In order to appreciate whether or not rotor modulation presents a serious problem, it must be considered in the context of the over-all system. To illustrate, let us assume that at cruising, the rotor speed is about 200 rpm. From the results above, we know that the received (or transmitted) signal will have a 5-cycle variation for each revolution of the rotor. This is to say that the received signal will be modulated by the rotor at the rate of approximately 17 c/s. The amplitude of modulation is a function of the frequency of operation and of the bearing of the helicopter from the transmitting station. Whether or not rotor modulation is harmful will depend on the mode of transmission and the characteristics of the receiver.

Modulation studies were also carried out on a four-foot helix monopole which was installed at approximately Station 310 on the port side of the fuselage. The

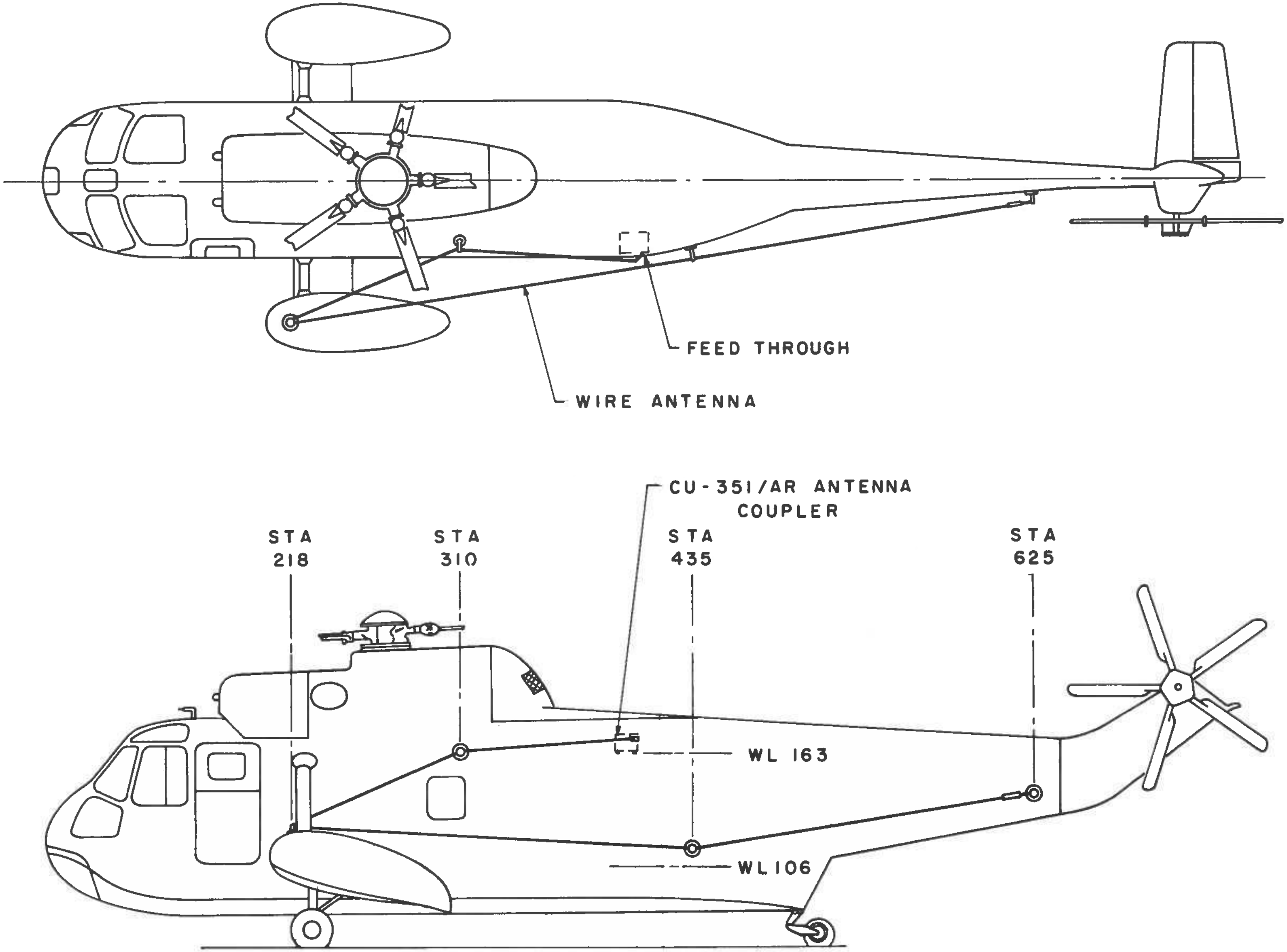
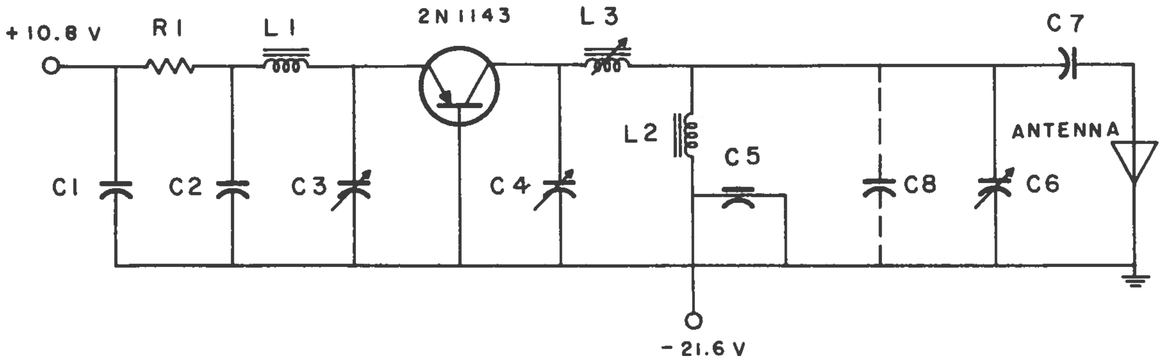


Fig. 1 HF wire antenna configuration on the CHSS-2 helicopter



60 mw, 100 - 400 mc OSCILLATOR

COMPONENTS:

R1- 1 KΩ RESISTOR
L1, L2- 1μH R.F. CHOKE
L3- 4 TURNS, 22 AWG, 1/4" I.D., 1/2" LONG, SLUG TUNED
C1, C2- 470 PF STAND-OFF CAPACITOR
C3, C4- 0-10 PF PISTON-TYPE VARIABLE CAPACITOR
C5- 100 PF FEED-THROUGH CAPACITOR
C6- 7-45 PF CERAMIC TRIMMER CAPACITOR
C7- 270 PF MICA CAPACITOR
C8- 22-33 PF MICA CAPACITOR (USE BELOW 120 mc)

FREQUENCY RANGE:

FUNDAMENTAL - 100-200 mc
SECOND HARMONIC 200-400 mc

Fig. 2 Schematic diagram of transistor oscillator used for modulation studies

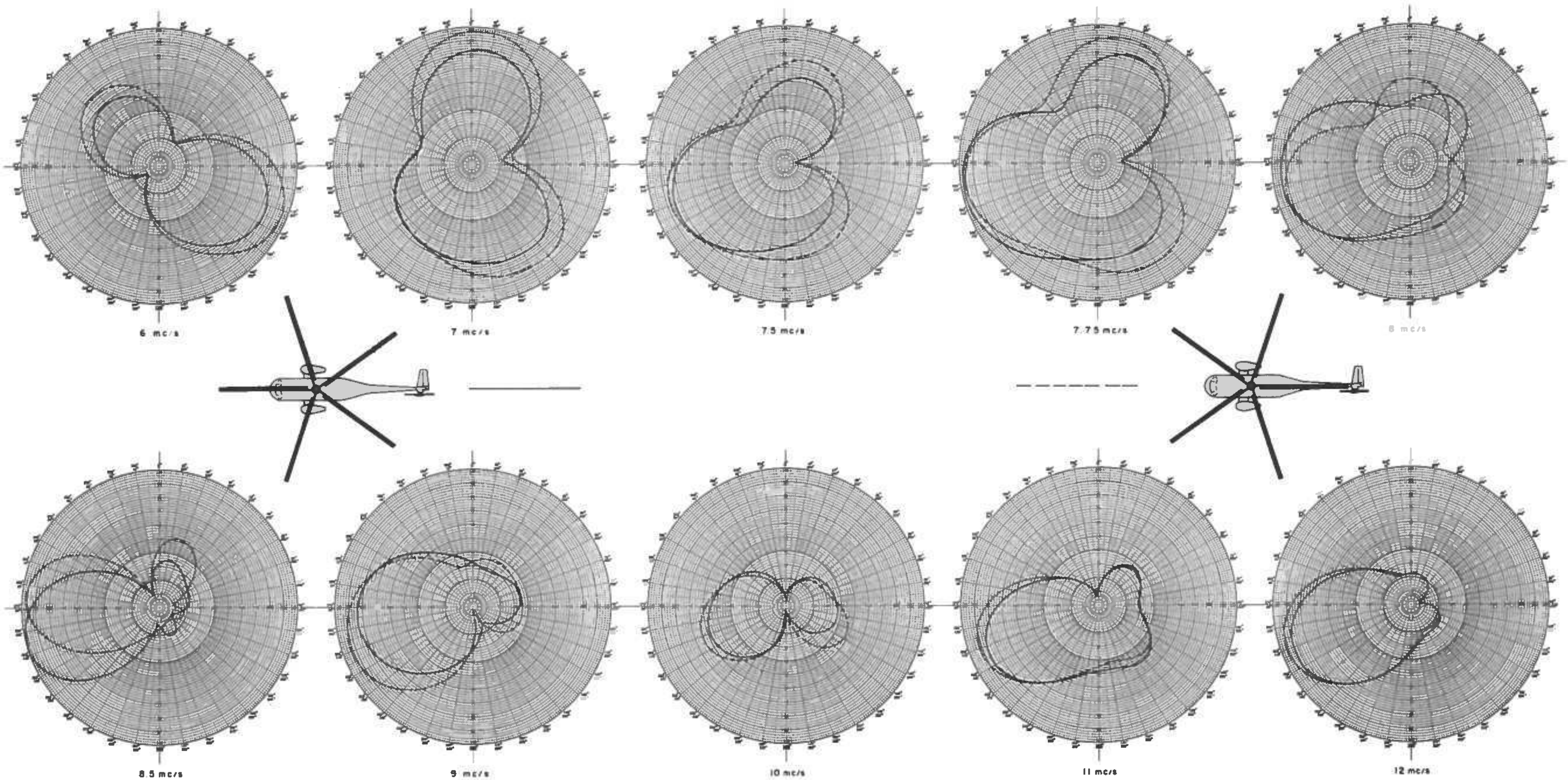


Fig. 3 Radiation patterns of E_{ϕ} component for two rotor positions

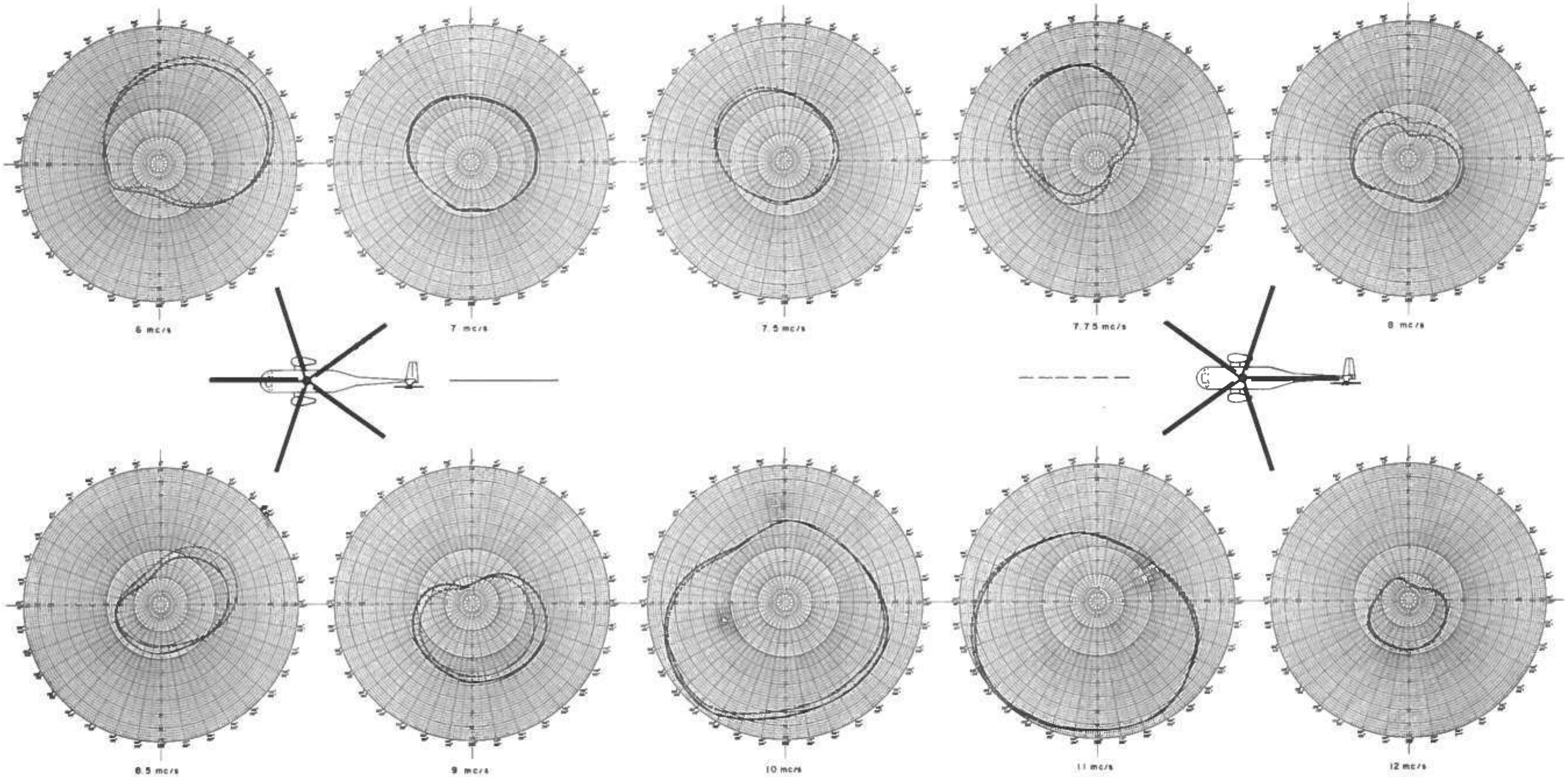


Fig. 4 Radiation patterns of E_θ component for two rotor positions

monopole was mounted vertically and canted aft by 30°. At about 8.5 mc/s, patterns for the two blade positions showed changes in both magnitude and shape, and the variation in the E_ϕ component was considerably greater than for the E_θ component.

CONCLUSIONS

Model measurements have shown that the effect of rotor modulation on the radiation patterns of an HF wire antenna on a CHSS-2 helicopter is significant between 6 and 12 mc/s. The greatest effect occurs between 8 and 9 mc/s and produces a change in both the amplitude and the shape of the pattern. At 8.5 mc/s the amplitude varies by as much as 6 db. Whether or not rotor modulation will degrade the communications performance will depend on the characteristics of the various components which comprise the system.

ACKNOWLEDGMENTS

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1. J. Andrews, "Final report on the investigation to develop an HF-SSB system for an HUS-1, USMC helicopter utilizing a tuned monopole antenna", Collins Radio Company, Cedar Rapids, Iowa, February 15, 1964
2. C.K. Adkar, "Radiation pattern measurements of 9 HF antennas for the Sikorsky CHSS-2 helicopter", Canadair Limited, Montreal, Que., Report No. RAR-00-103, April 16, 1964

Plate I — 1/24 scale model of CHSS-2 helicopter