Comparison of NRC prototype and CAL model of AFC chassis for AN/MPS-501B

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COMPARISON OF NRC PROTOTYPE AND CAL MODEL OF AFC CHASSIS FOR AN/MPS-501B

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SUMMARY

Some difficulties have arisen with the AFC chassis for the AN/MPS-501B radar, and the present report compares in detail the chassis as manufactured by Canadian Arsenals Limited, and the prototype designed by the Radio and Electrical Engineering Division of the National Research Council in 1954. The prototype design is described in Report ERA-264.

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COMPARISON OF NRC PROTOTYPE AND CAL MODEL OF AFC CHASSIS FOR AN/MPS-501B

- A.C. Hudson and R.L. Westby -

INTRODUCTION

This chassis is required to track the radar local oscillator while the tunable magnetron is being tuned, with sufficient accuracy to permit the radar to function satisfactorily during the tuning.

When the radar is first turned on, the local oscillator must also search the complete band and lock on the correct sideband.

To be useable in the field, the above functions must be performed without readjustment of controls, regardless of variations in the level of the magnetron sample which may change owing to several causes.

COMPARISON OF NRC AND CAL CHASSIS IN THE LABORATORY

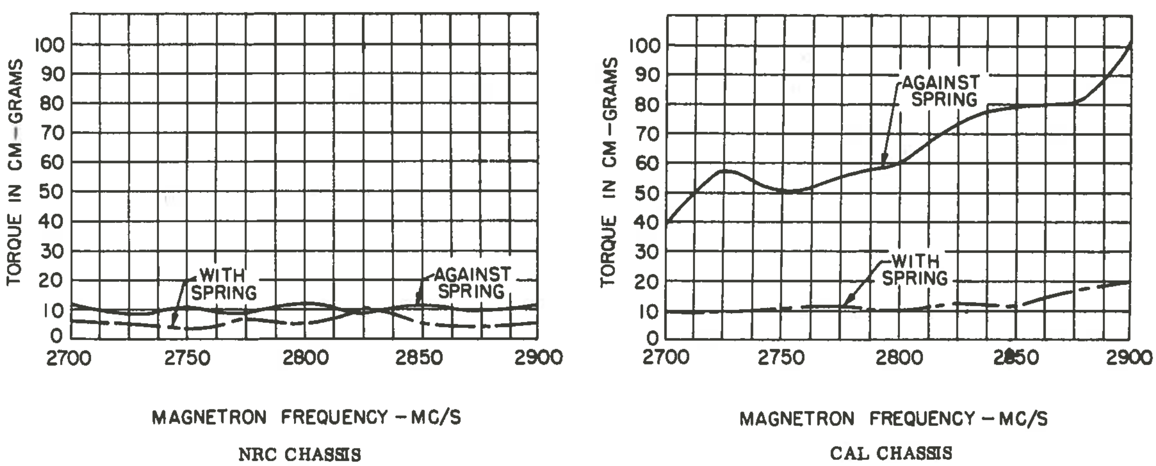


FIG. 1 TORQUE REQUIRED TO MOVE SERVOMECHANISM

Gearbox

Fig. 1 compares the NRC and CAL chassis from the point of view of torque required to start the mechanical servomechanism, as a function of local oscillator setting. The CAL gearbox has been redesigned in such a way as to increase the number of moving parts. The spring has also been altered.

Mechanical Servomechanism Performance

TABLE I

VOLTAGE CHANGE AT REFLECTOR REQUIRED TO ACTUATE MECHANICAL SERVOMECHANISM

NRC Chassis	2 volts
CAL Chassis	13.5 volts

The voltage shown is the change necessary at the klystron reflector to operate the mechanical correcting servomechanism, assuming that the previous mechanical correction was of the opposite sign.

Maximum Static Frequency Error

The maximum static frequency error is the error just before the mechanical servomechanism operates. Reference to Fig. 3 of ERA-264 shows that this should be the maximum voltage from Table I herein, divided by the slope of the discriminator curve. This is the basis of the calculated values in Table II.

The IF amplifier presently in use in the AN/MPS-501B is 3 db down at 0.25 mc/s off frequency, and hence a static frequency error of greater than about 100 kc/s will cause loss of echoes.

TABLE II

MAXIMUM STATIC FREQUENCY ERROR

Remarks	NRC Chassis (kc/s)	CAL Chassis (kc/s)
Calculated from data of Table I	(2 ÷ ·037 =) 54	(13.5 ÷ .031 =) 435
Measured with spectrum analyser	40	440
Typical residual error after search	25	380

Maximum Dynamic Frequency Error

This error is measured with a spectrum analyser while the RF signal generator is frequency modulated by means of a cyclic motor. It might be mentioned that a certain small frequency lag is desirable, since the echo from a distant target which beats with the local oscillator at a given time is at a magnetron frequency corresponding to an earlier time. For example, for a target at a range of 200,000 yards, the optimum "error" at maximum tuning rate is 0.2 mc/s.

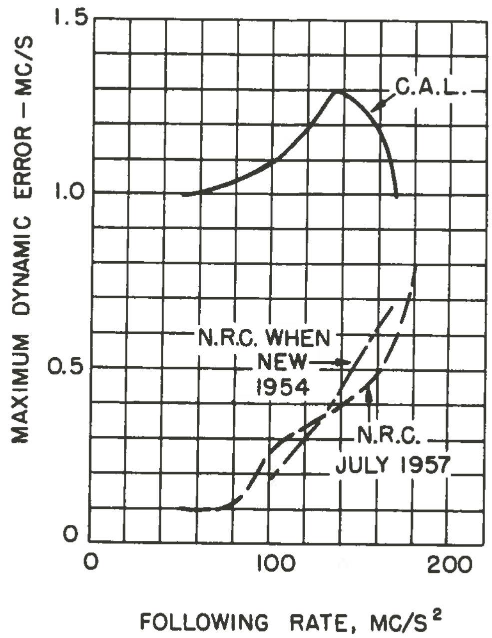


FIG. 2 FREQUENCY ERROR WHILE FOLLOWING

Dynamic Range for Satisfactory Locking

For this test the system is thrown into search, and locking is observed. This is repeated at higher levels of magnetron sample, until locking on the wrong sideband occurs. The level is then reduced until locking fails to occur. The dynamic range is the difference between these two levels, and is shown in Table III.

TABLE III

DYNAMIC RANGE

Frequency (mc/s)	NRC Chassis (db)	CAL Chassis (db)
2700	16	13
2800	19	13
2900	14	14

Limiter Characteristic

The limiter characteristic (measured from the cold end of the 180 K resistor in Fig.27 of ERA-264 to the discriminator cathode) is shown in Fig. 3, for the NRC and CAL chassis. It can be seen that considerable difference in d-c level exists, and also that there would seem to be very little limiting in the CAL chassis.

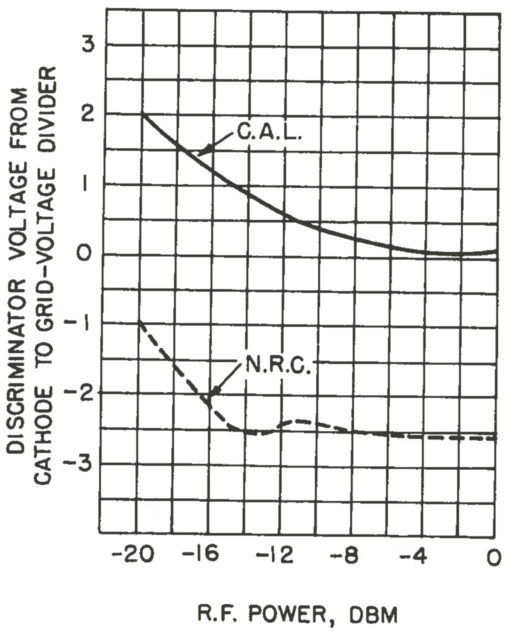
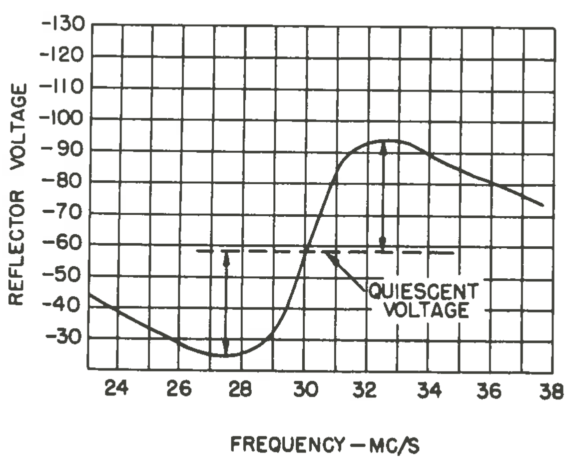
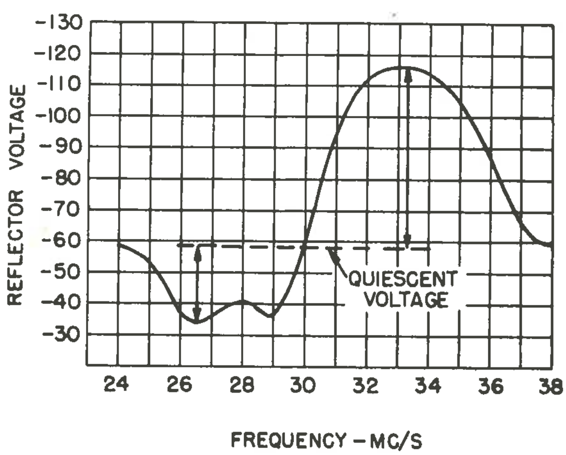


FIG. 3 LIMITER CHARACTERISTIC

Discriminator Characteristic



(a) NRC CHASSIS

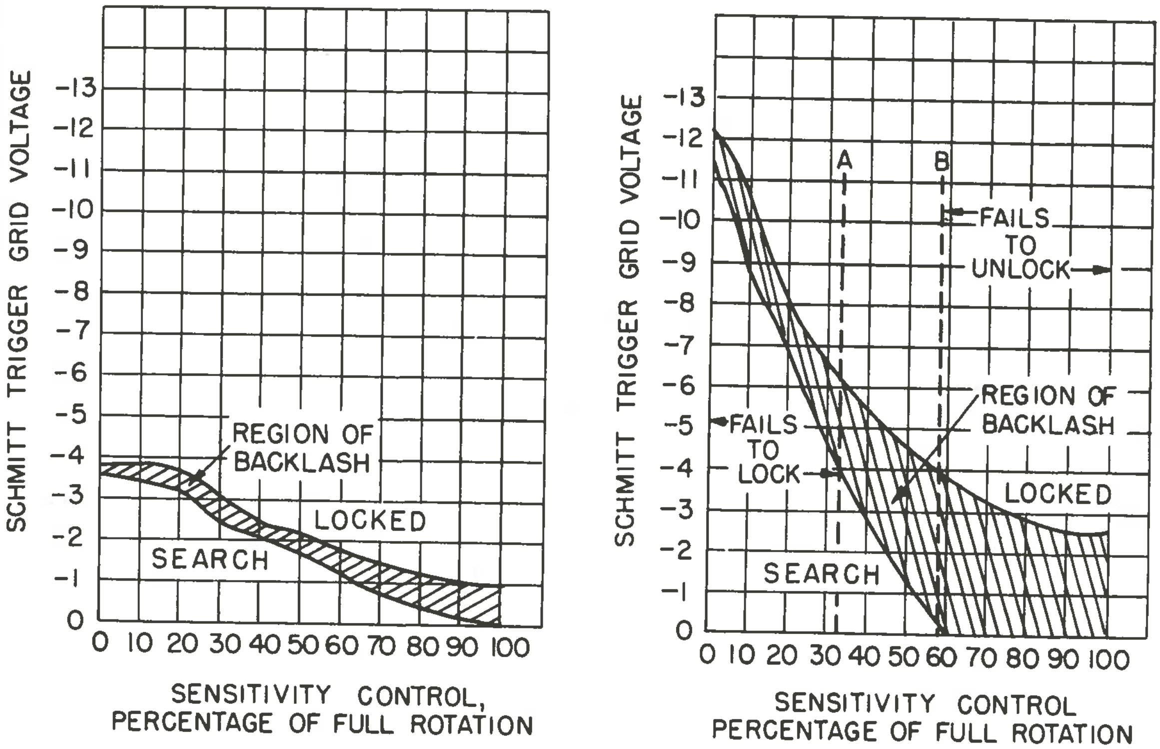


(b) CAL CHASSIS

FIG. 4 DISCRIMINATOR CHARACTERISTIC

Fig. 4 (b) represents the best characteristics which could be obtained in the CAL model. The primary trimmer (see Fig. 27 of ERA-264), the function of which is to equalize the peaks, failed to do so in the CAL chassis.

Schmitt Trigger Operation



NRC CHASSIS　　　CAL CHASSIS

FIG. 5　SCHMITT TRIGGER OPERATION

On the CAL model, operation is possible only in the region A to B of Fig. 5.

OPERATION IN THE RADAR

We were not able to obtain satisfactory locking or following by the CAL chassis in the radar, owing generally to the extremely critical settings of lock sensitivity and reflector voltage controls. Another defect was a frequent sustained oscillation of the mechanical servo.

Owing to the substitution of DC for AC in the servo-amplifier, this oscillation was able to feed back through the radar 300-volt supply to the PPI, and destroy the display.

LIST OF DIFFERENCES BETWEEN NRC PROTOTYPE AND CAL MODEL

(The component numbers refer to Fig. 2 of ERA-264.)

1. 39 pfd capacitor removed from input circuit of AFC preamplifier. This capacitor may have been mistaken for a redundant coupling capacitor, but its actual function was to protect the circuit consisting of R_8 and the capacitor in parallel with it from any interference, hum, or ground currents, which might appear on the cable from the AFC preamplifier.

2. 3.3 K resistor across L_1 removed.

3. 330 K resistor added in parallel with 220 K plate resistor in one section of V_2.

4. 56 K resistor from -555 volt supply to Motor Zero Control changed to 120 K resistor.

5. 0.15 μF capacitor from Motor Zero Control center tap to ground added.

6. 470 K resistor from center tap of Motor Zero Control to modulator bridge changed to 1 megohm resistor. This would appear to increase the impedance level at the grid of V_4, and hence its sensitivity to hum disturbance, without any appreciable effect on the gain.

7. 330 K resistor in series with lock light changed to 100 K resistor.

8. Value of cathode resistor of V_5 changed from 330 ohms to 820 ohms.

9. 1 megohm resistor from lock sensitivity control to one grid of V_5 changed to 680 K resistor.

10. 1 megohm resistor in search voltage input to V_4 changed to 270 K resistor.

11. 270 K resistor from secondary of search voltage transformer to V_6B changed to 470 K resistor.

12. Plate voltage for servo-amplifier output tubes (V_7 and V_8) changed from 300 V AC to 300 V DC. It is felt that this has the following disadvantages:

    1) Extra load on the tubes; the observed bulb temperature rises were: NRC 99°C; CAL 126°C.
    2) Unnecessary loading on the 300 V supply. NRC + 300 drain = 43 ma. CAL + 300 drain = 122 ma.
    3) Feedback of hash to the display during servo operation. (At times this would completely distort the PPI display).

13. Value of filter capacitor in 300 V input changed from 2.0 μF to 1.0μF.

14. Change from One-way to Two-way Search: This change was made to reduce the cost of the squint-correcting modifications. It is not believed to have caused any appreciable degradation of performance, although this cannot be determined in the presence of the many other changes.

CONCLUSIONS

The factor which seems to have had the greatest effect in degrading the performance is the design change which has resulted in the increased torque required by the local oscillator gearbox (see Fig. 1).