Land Mobile Receiver RF Intermodulation Immunity Measurement Using Two Signal Generators

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SUMMARY The method proposed by DOC for measuring third order intermodulation performance of land mobile receivers is the IEC test procedure. The IEC test requires the availability of three signal generators. This communication describes a method of measuring third order receiver intermodulation performance using two signal generators. The new procedure provides measurement results *equivalent* to, and in some cases more accurate than, the IEC test.

1 INTRODUCTION

The IEC test [1] is the proposed new DOC method for measuring land mobile receiver intermodulation performance. This test employs three signal generators. It would be useful to have a method which provides results equivalent to those that would be obtained in an IEC test but which uses only two generators. Various methods are documented which measure receiver intermodulation characteristics and use two signal generators [2-7]. However, the results from one test cannot easily be related to those from another.

The basis of the IEC test procedure is to determine the performance of a receiver by measuring the output audio SINAD resulting from a modulated wanted on-channel signal and two off-channel unmodulated signals whose frequencies are adjusted to cause an on-channel intermodulation product. If the intermodulation performance of a receiver is measured in a region of its operating range where receiver noise and any desensitisation due to the introduced signals mixing with the local-oscillator sideband noise is not significant, then the level of distortion and hence the output SINAD may be calculated for various wanted level to intermodulation product level ratios [8]. If the product is approximately 5 dB below the wanted signal, then 12 dB SINAD will result for a typical receiver. This relationship is outlined in the appendix.

2 A NEW METHOD

Because receiver audio frequency responses vary and receiver noise is significant, the above result does not always hold for receivers. Especially the wanted level is near that required for reference sensitivity (see reference 1 for definition of reference sensitivity). A preliminary part of the new method, is the measurement of this parameter for the receiver under test as follows.

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Set one signal generator for a receivers input level of that required for reference sensitivity. Then increase the input by 3 dB and record the resulting output SINAD (x dB). Now introduce another on-channel unmodulated signal and increase its level until output SINAD is reduced back to 12 dB. Record the difference in the two input levels (y dB).

While keeping receiver input levels equal, the two generators are now used to cause a frequency modulated intermodulation product to fall on-channel. The input levels are adjusted to produce an intermodulation product which causes an output audio signal of x dB SINAD. From the former experiment we know that an unwanted on-channel signal y dB below the level of this intermodualtion product would reduce x dB SINAD to 12 dB.

For a receiver in which intermodulation is the only mechanism causing densitisation, these two signals (the intermodulation product and the unwanted signal) would represent the only on-channel signals present if the IEC test procedure was being used. Then in order to find the receiver input levels if the IEC test procedure was being used (i.e., the equi-level values would now produce an intermodulation product y dB below the wanted) the equi-level values used above should be reduced by y/3 dB. The division by three results from the third order intermodulation power relationship.

The intermodulation product may be frequency modulated with the standard index of 3 by either modulating (a) the inner frequency with an index of 1.5 or (b) the outer frequency with an index of 3.

3 EXPERIMENTAL RESULTS

Table 1 gives the results of an experiment using the two methods and a typical land mobile receiver. If this table is considered, then within experimental error (± 0.6 dB) the behaviour is as anticipated. The values for the 0.03 to 0.12 intermodulation pairs in the IEC intermodulation test appear to be in error due to the fact that the inner frequency also causes desensitisation of the receiver. It is only when the selectivity and intermodulation results differ by >10 dB that true intermodulation results are obtained. The proposed new method suffers much less from this source of error. The main reason for this, is that higher

Table 1

Comparison of the present IEC and proposed new method to measure intermodulation immunity for a typical VHF land mobile receiver

Inter-modulation Pair (MHz) (Inner offset/ Outer Offset)	Interference Rejection (dB)		
	IEC method		This study method
	Adjacent-signal selectivity (Using Inner)	Inter-modulation immunity	Inter-modulation immunity
0.03/0.06	70.6	66.7	76.2
0.06/0.12	73.3	70.9	74.8
0.12/0.24	78.1	73.3	74.5
0.24/0.48	84.3	75.2	75.1
0.48/0.96	90.4	76.3	75.7
0.96/1.92	94.1	75.4	74.8
1.92/3.84	94.4	72.8	72.3
3.84/7.68	95.5	74.9	74.4

levels are used in the proposed method. Because the growth in the intermodulation product is a third order mechanism, the noise generated by the inner frequency increases only 1/3 as fast as the product. Therefore, the proposed two generator method is more sencitive to intermodulation immunity than the IEC method. In certain situations the IEC method is unable to distinguish between a selectivity and an intermodulation test.

4 CONCLUSION

In 1975 [6] the IEC proposed a two-generator method and two three-generator methods for measuring land mobile receiver intermodulationperformance. The three-generator method was adopted for reasons thought to be: (a) simplicity, the three-generator method models the real situation and (b) general applicability, most equipment manufacturers already used the test for specifying their receivers.

A method of measuring the intermodulation immunity of a receiver which uses only two signal generators and gives results equivalent to, and in some cases more accurate than, the IEC test has been presented. The new method will enable laboratories to perform accurate intermodulation tests when their budgets do not allow for the provision of three signal generators.

5 ACKNOWLEDGMENT

The opinions contained herein are the private views of the author and may not reflect the current policy of the Department.

6 REFERENCES

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APPENDIX

The expression for the instantaneous frequency for common channel interference with the interfering signal unmodulated is [8]:

$$w_i(t) = w_1 + \Delta w \cos pt + \sum_{s=1}^{+\infty} \sum_{m=-\infty}^{+\infty} (-\rho)^s \frac{mp}{s} J_m(s\beta) \times \cos(mpt - s\psi_o)$$

where w_1 is the wanted carrier frequency,
Δw is the peak frequency deviation,
p is the modulating frequency,
ρ is the ratio of interference level to the wanted carrier level,
β is the modulation index, and
ψ_o is the phase difference

For the case where $\rho = -5$ dB, $p = 1000$ Hz, $\Delta w = 3000$ Hz and considering only components within the pass band (± 3 kHz), the output RMS signal-to-distortion ratio is 10.2 dB which corresponds to a SINAD of approximately 12 dB. For this calculation the audio frequency response was assumed to be a 6 dB/octave de-emphasis curve relative to the response at 1 kHz. The audio frequency response of individual receivers may vary.

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