AERONAUTICAL MOBILE COMMUNICATIONS PANEL (AMCP)

EIGHTH MEETING

Montreal, 4 to 13 February 2003

Agenda Item 7: Future work

FEASIBILITY OF DSB-AM 8.33 KHZ CLIMAX OPERATION

(Presented by G. Dickhaut)

SUMMARY

The so-called climax-operation provides communication coverage for the ARNS within large areas (e.g. ATC-sectors), that cannot be provided by a single DSB-AM ground based transmitter. This is achieved by using transmitters at several locations adequately distributed to allow for a minimum field strength according to frequency planning requirements. Due to the fact that reception of multiple co-channel signals would interfere and therefore negatively affect demodulation in an airborne COM receiver a frequency offset between these signals is added. This transmission scheme (climax-operation) provides sufficient suppression of the weaker signal within nthe receiver demodulator circuit due to the capture effect.

Most sectors of the upper airspace in Europe have been converted from 25 kHz to 8.33 kHz channel spacing. Unfortunately those sectors, which require climax-operation due to coverage constraints, still use 25 kHz spacing. This was based on the fact, that up to now it has been assumed, that narrower IF filter used in the 8.33 kHz receivers compared to 25 kHz radios does not allow for adequate demodulation of a 8.33 kHz climax scheme signals.

Recently conducted bench tests at DFS labs showed that even with 8.33 kHz airborne equipage and a carrier offset of ±2.5 kHz climax implementation seems possible due to the acceptable voice quality at the DSB-AM airborne receiver. A separate mathematical analysis and simulation effort confirmed the feasibility of such a scheme.

In order to further investigate possible DSB-AM 8.33 kHz climax implementation additional bench and flight tests with a representative set of airborne radios are planned to be conducted by DFS mid 2003.

It is expected, that implementation of such a scheme would significantly improve

frequency efficiency of DSB-AM 8.33 kHz in Europe due to the wide usage of climax operation in that area.

Action by the AMCP is in paragraph 4.

1. INTRODUCTION

1.1 Introduction of 8.33 kHz channel spacing in the upper European airspace increased the availability of channels for very high frequency (VHF) communications. Unfortunately a large portion of the spectrum is blocked by 25 kHz climax operation.

1.2 Climax operation provides coverage of larger sectors by generating simultaneous transmission from more then one location. The so called capture effect allows the stronger signal to mask the weaker signals as long as a sufficient frequency offset between the signals can be provided to avoid harmful spectral overlap.

1.3 Recently conducted bench tests at Deutsche Flugsicherung GmbH (German Air Navigation Services) (DFS) labs showed that even with 8.33 kHz airborne equipage and a carrier offset of ±2.5 kHz climax implementation seems possible due to the acceptable voice quality at the DSB-AM airborne receiver. A separate mathematical analysis and simulation effort confirmed the feasibility of such a scheme.

2. BENCH TEST RESULTS

2.1 Lab testing at DFS facilities of the evaluation of the effects and the readability of 8.33 kHz climax operation has been conducted with two airborne radio types:

a) Dittel FSG-90 (General Aviation); and

b) Rockwell Collins VHF-920 (Air Transport).

2.2 Different values of frequency offsets have been considered:

a) 2.0 kHz, 2.5 kHz; and

b) 3 kHz.

2.3 Two signal generators (Rohde & Schwarz SME 03 and SMIQ 03) have been modulated either with 1 kHz test tones and a modulation depth of 80 per cent or with ATC-phraseology and an average modulation depth of 30 per cent corresponding to a peak value of 90 per cent.

2.4 Optimum results were achieved with a carrier offset of 2.5 kHz meaning that the heterodyne signal at Äf_T = 5 kHz could hardly be perceived. The ratio between the desired AF-signal and the heterodyne signal turned out to be 29 dB.

2.5 Test results showed, that if the first adjacent channel of any 8.33 kHz frequency is not deployed at radio sites in the same geographical area or mutual distance between transmitter site and any receiver site is at least 12 nmi, when using adjacent channels, implementation of 8.33 kHz climax scheme operation seems feasible.

3. MATHEMATICAL ANALYSIS AND SIMULATION RESULTS

3.1 Mathematical analysis and MATLAB simulation using equivalent baseband signal description as outlined in equation (1) showed, that 8.33 kHz climax operation is feasible.

3.2 For the climax DSB-AM signal the following equation hold:

$$\begin{aligned} y_{DSB\text{-}AM}(t) &= \mathrm{Re}\ \{[1 + m\cdot u(t)]e^{j(ù_T\ +\ Äù)t} + ñ\cdot[1 + m\cdot u(t)]e^{j(ù_T\ -\ Äù)t}\} \\ &= \mathrm{Re}\ \{\ y(t)\ e^{j(ù_T\ +\ Äù)t}\ \} \end{aligned} \qquad (1)$$

with “m” as the modulation depth and u(t) as the desired (useful) signal. y(t) is the so-called equivalent base band signal of $y_{DBS\text{-}AM}(t)$.

3.3 The narrowband IF-filter in a 8.33 kHz receiver more or less suppresses the upper sideband (USB) information of the DSB-AM signal component with the positive carrier offset and the lower sideband (LSB) of the DSB-AM signal component with the negative carrier offset (Figure 1). This leads as a first approximation to a transmission scheme using single sideband operation and spectrum distribution as shown in Figure 1. Mathematical analysis of such a scheme confirmed the feasibility.

3.4 MATLAB simulations based on mathematical description of equation (1) have been conducted using ATC-phraseology as desired signal u(t) to consider the impact of amplitude ratio ñ between the two DSB-AM components on readability. Very good voice quality could be achieved even in the critical case of having an amplitude ratio of ñ = 1.0.

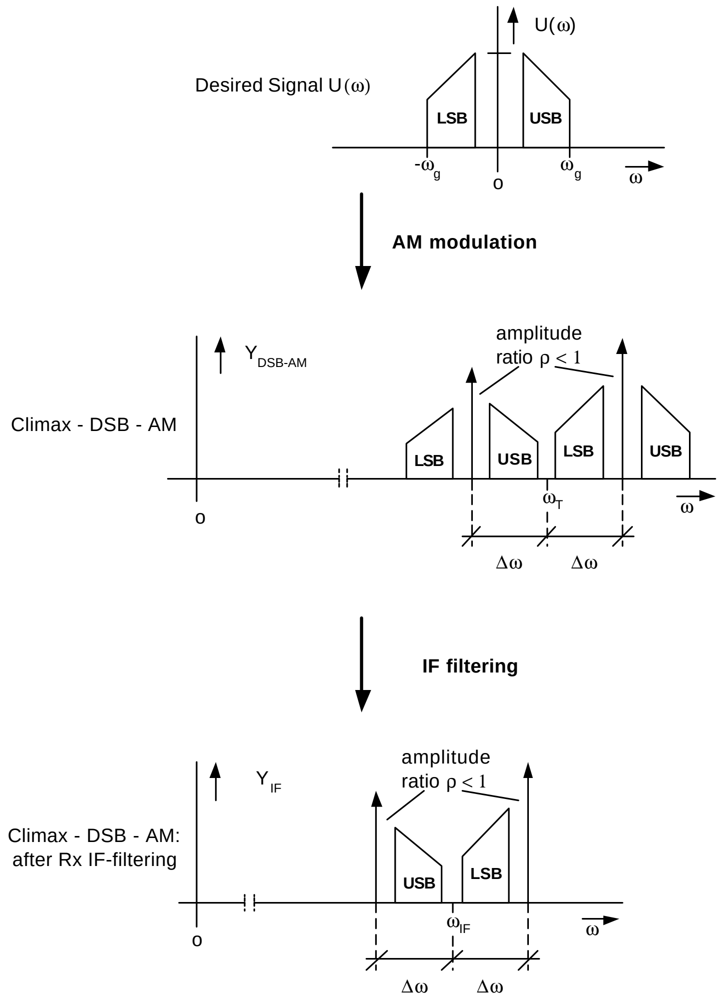

Figure 1. Spectral interpretation of 8.33 kHz climax operation

4. FURTHER WORK

4.1 It is planned to further investigate 8.33 kHz climax in bench tests using a representative set of 8.33 kHz DSB-AM airborne radios. In addition flight tests are planned to consider the feasibility in real environment. Both activities are foreseen for the time-frame mid 2003.

5. ACTION BY THE AMCP

5.1 The AMCP is invited to take note of the information outlined in this paper and add this issue to its work programme.

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