WATTS ANTENNA COMPANY
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TECHNICAL SUMMARY: WA-TS 97.001

SUBJECT: ***METHODOLOGY TO RELAX THE SEPARATION CRITERIA FOR THE INSTRUMENT LANDING SYSTEM (ILS) LOCALIZER USING CAPTURE-EFFECT, AUDIO MODULATION PHASE CONTROL, AND A PRECISE TIMING REFERENCE***.

October 10, 1997

The concept of sustained use of the Instrument Landing System (ILS) has been burdened by a shortage of available channel frequency assignments. Extensive models, developed over the past decade, are used to determine if a new ILS could be installed without interference from other ILS or other sources of radio frequency interference. Using the present separation criterion of 23 decibels for *co-channel operating systems, it is, at a minimum, difficult to find non-interfering frequencies in large metropolitan areas. In fact, even with the appropriate separation, a disclaimer states "...this does not protect for audio clarity."

Research by Ohio University in the areas of ILS receiver capture-effect principles [1], minimizing multipath effects by audio modulation phase optimization [2], and minimizing ILS frequency spectrum constraints, have resulted in a concept to reduce the ILS separation criterion to 10 decibels with audio clarity. Application of the most beneficial techniques concluded from these FAA funded studies, in conjunction with a precise timing reference, offers a reasonable approach to significantly reduce ILS localizer separation distances.

Two-frequency localizer systems, also called capture-effect localizers, implement two carriers separated nominally by 8.0 KHz. The two signals enter the receiver simultaneously and are centered within a passband filter. Because of capture-effect, additional rejection is obtained from a second signal lower in level than the desired signal. Implementation of two-frequency ILS has been the key to the reduction of the effect of scattering from objects outside of a desired course line. The frequency separation of 8.0 KHz is necessary to prevent the beat frequency of the two carriers from producing an audible tone that would pass through the audio filter, without attenuation, and into the pilot's headset. Physical interconnections between transmitting equipment allow for relative frequency separation and modulation tone phase of the two signals. This concept can be expanded to two systems operating in a frequency-congested area and separated by large distances. A common oscillator timing reference is necessary to ensure proper frequency separation and modulation tone phase.

* co-channel operation implies two ILS operating at the "same" carrier frequency.

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Data from numerous bench measurements on ILS receivers indicate conclusively that manipulation of the relative audio modulation phase between two ILS signals can provide as much as 6.8 db of additional immunity. In fact, the in-phase relative audio employed in the current models of two-frequency systems is a most destructive condition. The benefits are realized when identical frequency modulation tones of an undesired signal, another localizer system for instance, is maintained in a quadrature or some out-of-phase condition with respect to the desired localizer modulation signals. Under these conditions, the summation of the undesired signal modulation with the desired signal is least destructive to the balance of the modulation tones from which the navigation information is derived.

A frequency separation of 9.0 KHz was necessary to ensure audio clarity at the lower separation criteria of 10 decibels. The beat frequency is intentionally produced further away from the receiver's audio passband for additional rejection. The amplitude of the resultant tone increases significantly as the two carriers approach equal amplitude. The level to the pilot's headset will vary with differences in the audio filters of various receiver designs. However, with 10-decibel separation at the limits of the service volumes, the condition would theoretically not exist.

CONCLUSIONS:

The implementation of capture-effect and audio phase optimization can be directly applied to two ILS separated by large distances. Application of both of these techniques could substantially reduce the required separation without detrimental effects to the guidance information.

In order for these benefits to be realized, a common timing reference must be used to control the RF frequency separation and the frequency and phase of the modulating tones.

If implemented over a broad scale, audio phase optimization should also reduce 1st, 2nd, and 3rd adjacent channel separation criteria.

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RECOMMENDATIONS:

An investigation should be conducted to determine the details of the implementation of the concepts contained herein. Consideration should be given to a site test to determine the efficacy of the fundamental design concept.

An appropriate timing reference should be determined. A physical connection, such as a landline or reference signals received from a Global Positioning or a Loran C system, might meet the requirements for such a reference.

Further studies should be conducted to determine potential adverse effects inherent in a dynamic environment, such as Doppler shift. Control of relative localizer service volume geometry will aid to minimize these effects.

REFERENCES:

1. Johnson, John H., Investigation of the Capture-Effect Phenomenon in ILS Localizer Receivers, March 1996, Avionics Engineering Center, School of Electrical Engineering and Computer Sciences, Ohio University. Prepared as Technical Task Directive 2.1 under Contract DTFA01-91-C-00020 for the U.S. Department of Transportation, Federal Aviation Administration.

2. Johnson, John H., Use of Audio Rephrasing To Minimize The Effect of Scattered Clearance Energy on a Dual-Frequency ILS Localizer, June 1996, Avionics Engineering Center, School of Electrical Engineering and Computer Sciences, Ohio University. Prepared as Technical Task Directive 2.10 under Contract DTFA01-91-C-00020 for the U.S. Department of Transportation, Federal Aviation Administration.

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