WATTS ANTENNA COMPANY
270 Sunset Park Drive
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TECHNICAL SUMMARY: WA-TS 20.001

SUBJECT: *MONITOR CIRCUITRY FOR THE CAPTURE-EFFECT GLIDE SLOPE TO IMPROVE SYSTEM MONITORING AND REDUCE OUTAGES CAUSED BY WIDTH CHANNEL INSENSITIVITY TO MIDDLE ANTENNA DEPHASING AT ADVERSE SITES.*

January 30, 2000

The capture-effect glide slope system has long been the preferred solution for providing quality glide slope signals in adverse siting conditions. Principally this refers to short longitudinal ground planes and/or environments where the terrain beneath the approach path is rising. Quality guidance is provided by cancellation of course signals on the rising terrain and filling this region with “capture effect” clearance signals that provide a fly-up command at low elevations.

The capture-effect is referred to as an image system due to the requirement of adequate reflection plane to form the desired signal-in-space. Today’s requirement for antenna tower displacement allows for the antenna to be located closer to the runway than previously permissible. This leads to improved safety in the National Airspace (NAS) by allowing greater availability of precision guidance signals. Consequently, capture effect systems are being located throughout the NAS at sites that have rising terrain, limited longitudinal ground plane, and now increasingly at sites with lateral reflection plane truncations. As the siting conditions for the antenna system become less desirable, the signal-in-space begins to deviate from the ideal. In severe siting conditions, one could argue that methods to evaluate the signal-in-space must be adapted to evaluate the unique circumstances of the effects introduced by the undesirable terrain, and that the need for more sensitive monitor increases. In reality, the latter is the most desirable solution. Flight measurements are expensive, and considerable judgment would be required to determine if the antenna environment would warrant additional measurements on a case-by-case basis. A monitor capable of detecting small changes in the radiated signal, without imposing impractical limitations on the system hardware, would ensure that nominal flight measurements would be adequate in all cases. In addition, the industry typically begs for a simple solution to a complex problem. Such a monitor is presented here as an addition or modification to the existing hardware.

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OBJECTIVES: Two objectives are cited as the design goals of the modification: 1) Reduce width channel outages caused by tight tolerances required to detect small changes in the middle antenna phase; 2) Produce a means to permit tighter monitoring of SBO phase to ensure that below-path-clearances are met at the limits of the coverage area in a dephased condition.

BACKGROUND 1: All capture-effect integral monitors respond principally the same due to an established alignment procedure. However, it would be unreasonable to expect the monitor to representatively indicate the influence of the terrain on the signal-in-space. The monitor channel limits, therefore, are established by flight measurements and will vary from site-to-site depending on the terrain influence in a given fault condition.

One common variation is the necessary tolerance applied to the middle antenna phase as indicated in the width channel. The middle antenna greatly influences the amount of cancellation of multi-path signals from the low angle terrain. As the cancellation degrades, multi-path from the terrain begins to corrupt the glide path structure quality and influence the measured path angle and width. In the ideal sense, the allowable change in the middle antenna phase may be on the order of 15.0 degrees, but adverse sites may dictate a limit of perhaps only 10 degrees or less. The problem arises due to the incapability of the width channel to detect these small changes in the middle antenna while simultaneously permitting nominal and minor changes in other parameters without unnecessary outages. If the monitor alarms from changes in the middle antenna phase, it has provided a valuable service. The more likely event is an alarm resulting from a minor change in another parameter due to the tight limits required to monitor the middle antenna phase. The latter would remove the system from service while the glide path is within tolerance and an unnecessary injustice has occurred.

SOLUTION 1: Independently monitor the phase of the middle antenna

BACKGROUND 2: At sites with lateral ground plane truncations, the path angle lowers in the direction of the truncation. It is permissible today, given the present tolerances contained in the USFIM, to have a very low path angle outside of the localizer course sector as long as adequate fly-up guidance signals are present, a path is detectable, and greater than 150 uA of fly-down signal exists above the path. This has been determined to be a safe and acceptable condition.

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Flight measurements to establish monitor limits of the glide slope are, in most cases, made on the runway centerline. Centerline measurements at sites with longitudinal truncations provide sufficient indication of the effect of a given fault condition within the defined coverage area. At sites with lateral truncations, the signal relationships that exist on the runway centerline are not representative of those that exist in the direction of the truncation. Signal relationships that vary with azimuth will depend greatly on the severity of the truncation as indicated by the lowering of the path in a given direction or azimuth. These areas are evaluated in a nominal configuration but are not evaluated in all fault conditions to ensure that adequate fly-up signal exists for all faults. Flight measurements to evaluate these areas would be unnecessarily expensive, and the need to make additional measurements would be predicated on the results of the nominal measurements.

Examples of these fault conditions are the middle antenna advance and retard phase as discussed in design objective 1. Other examples are the main sideband (SBO) advance and retard phase faults. The limits for SBO phase are +/- 30 degrees when modern transmitting equipment is capable of maintaining the SBO output within +/- 5 degrees. A similar scenario exists to the middle antenna monitoring in the width channel for monitoring of the sideband phase. Width channel tolerances would produce outages if tight tolerances were applied to SBO phase as a result of flight measurements made in the direction of the ground plane truncation.

SOLUTION 2: Provide an alternate means to monitor SBO phase.

ADDITIONAL BENEFITS OF THE MONITOR MODIFICATION: Recent emphasis has been placed on reducing flight inspection costs by minimizing unnecessary commissioning and periodic monitor flight profiles or configurations. This would appear rational if two conditions would exist: 1) The methods to configure the monitor and set the limits are straightforward and verifiable by several means available at the site; 2) The limits established are considerably tighter than what has been necessary to ensure safe operation from a historical and worst case perspective.

The capability of the proposed monitor meets these two conditions with regard to the SBO phase tolerances. The nominal SBO phase tolerance is +/- 30 degrees but this monitor configuration will allow SBO phase monitoring as tightly as 10 degrees, or only 33 % of the present tolerance, with pronounced resolution.

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The initial reading will be 0 ddm which is verifiable by both an oscilloscope and the station portable ILS receiver (PIR). Dephasing readings to establish monitor limits can be verified by the PIR, graphically depicted by the oscilloscope, and confirmed by a very small change in the width channel reading. Confirmation of the proper setting of the limit can also be provided by inserting an N-fitting elbow, approximately 18 degrees electrical length at the operating frequency and only 60 % of the nominal setting, into the CSB and SBO line to determine that the channel deflection is well in excess of the limit setting. This straightforward method of evaluating the much tighter limit setting would yield the possibility of foregoing the flight measurements to establish the limit and to verify its effect to the signal-in-space with regard to SBO phase faults.

DESIGN ISSUES AND CONCEPTS: In order to preserve the integrity of the present monitor of the capture-effect, it is necessary to avoid altering the signal relationships in the path, width, and clearance monitor channels. This is successfully accomplished by the implementation of the proposed monitor concept.

An additional channel must be made available with the capability of precise monitoring of the middle antenna and SBO phase. Fortuitously for the application of this monitor concept, a spare monitor channel exists from the elimination of the near-field monitor antenna on the image glide slope systems in the United States. The near-field channel has executive fault capability and is used here to establish independent and conservative limits on the signals provided by the additional monitor hardware.

It is also fortuitous that the composite signal in the middle contains only course CSB and SBO signals and that no clearance signals exist. This inherent condition simplifies the circuitry required to derive only the middle antenna CSB signal to be used in the monitor channel. The initial composite signal is acquired from the middle antenna integral monitor by the use of a single 50-ohm power divider.

Power divider PD1 in the middle antenna monitor line will result in a 3 db loss, and compensating 3dB pads, AT3 and AT4 respectively, are placed in the upper and lower antenna integral monitor lines to reestablish the nominal amplitude ratios in the path, width, and clearance monitor channels. It is expected that enough signal level should still exist to adequately drive the path, width, and clearance monitor detectors.

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In order to provide the CSB only from the middle antenna integral monitor line, the monitor hardware must provide a means to cancel the SBO component from the composite signal. This is accomplished by a cancellation circuit comprised of combining hybrid HY1, Z1, AT1 and PD2. Phaser Z1 and attenuator AT1 allow the SBO cancellation signal to be adjusted to permit cancellation of various quantities and phases of the SBO signal in the middle antenna monitor line.

The SBO signal used for cancellation is provided by means of a 3-way power divider PD2 located in the main sideband output from the transmitting equipment. The device must have a power rating sufficient to allow CSB energy to be fed into the sideband input without damage. Ample transmitter SBO power output exists to reestablish the required SBO level to the transmit antennas. One port of the power divider will drive the transmit antennas, the second used for cancellation of the SBO in the middle antenna monitor line as referred to above, and the third is used to recombine with the middle antenna CSB signal to comprise the final monitor signal.

The near-field monitor channel has historically been designed a nominal reading of 0 ddm. The new monitor signal is comprised of the CSB only, derived from the middle antenna integral monitor signal, in quadrature phase (0 ddm) with a scalable portion of the SBO output from the station transmitting equipment.

Additional circuitry is required to combine a portion of the transmitter SBO output in quadrature phase with the CSB signal from the middle antenna monitor line. Recombining SBO signal is available from the output of PD2, is scaled by attenuator AT2, and feeds combining hybrid HY2 via phaser Z2. The circuitry provides adequate phase adjustment to establish the quadrature CSB/SBO phase condition. The magnitude of the SBO component is adjusted using attenuator AT2 to allow the desired resolution and nominal settings of the monitor readings in the fault conditions.

Scaling of the middle antenna CSB component is considered undesirable due to the requirement for adequate signal to drive the station near-field detector. The output of the circuitry is a middle antenna (MA) and SBO phase sensitive monitor signal, MA/SBO Phase Monitor, to drive the Near-Field detector and monitor channel.

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PARTS LIST:

QTY	Item Description
2	2-watt UHF hybrids or combiners
2	3dB 1 watt attenuators
1	3-way power divider 5 watts maximum
2	Trombone phasers (optional)
3	Attenuators (values to be determined)
-	Associated interconnecting cables
2	50-ohm loads
1	Station detector

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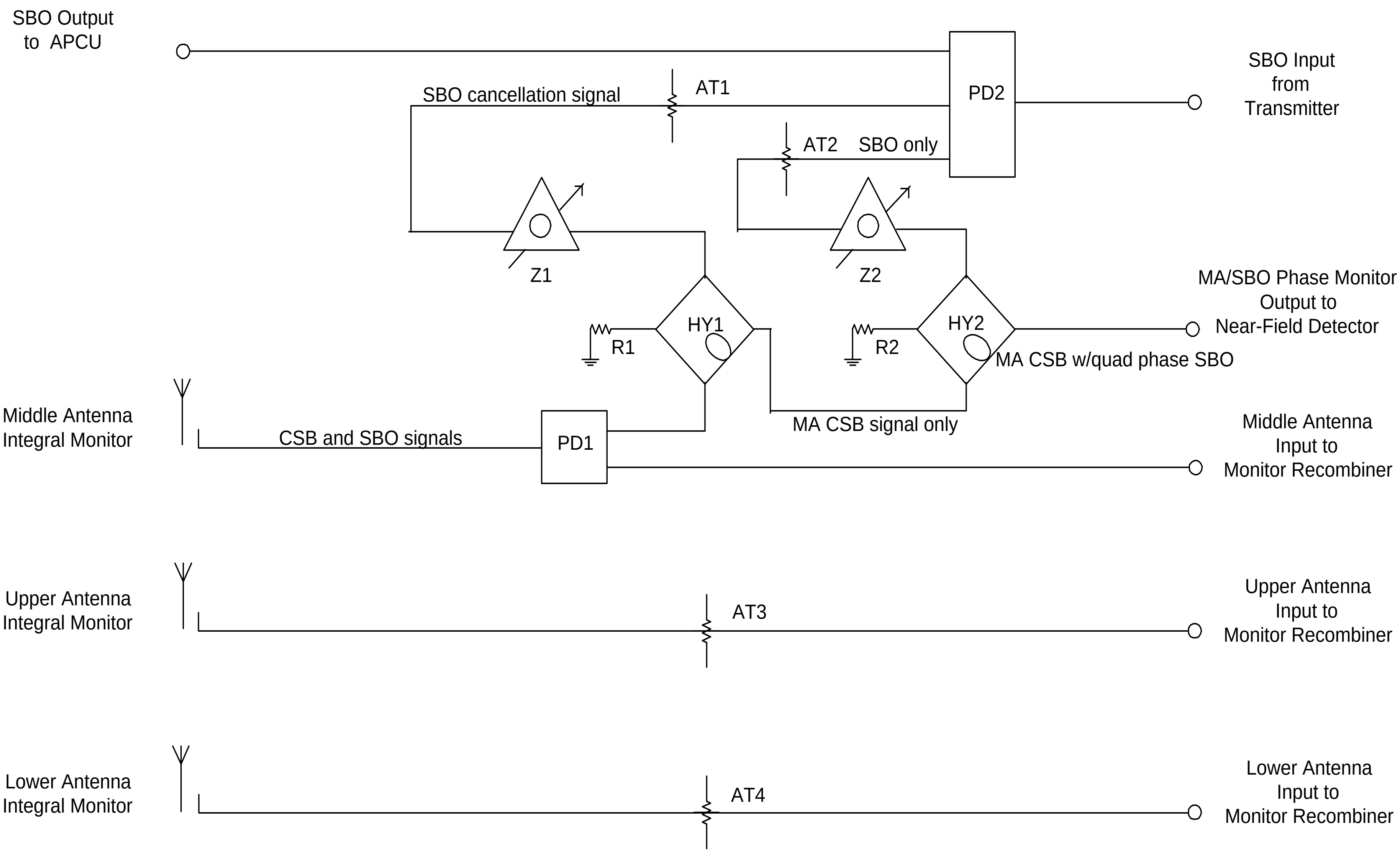
CAPTURE-EFFECT GLIDE-SLOPE
MIDDLE ANTENNA/SBO PHASE MONITOR
Block Diagram



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