CHAPTER 1.

1. INTRODUCTION TO ILS.

1.1 NAVIGATIONAL AIDS :

Navigation is the 'ART' of determining the position of an aircraft over earth's surface and guiding its progress from one place to another.

To accomplish this ART, some sort of 'aids' are required by the PILOTS. In the early days, voyages were accomplished by the navigators through the knowledge of Terrain or movements of sun stars and winds. As the time progressed, some instruments such as Compass, Chronometer and Theodolite came on the scene.

In the twentieth century, electronics also entered in the Aviation field. Direction finders and other navigational aids enabled the navigators to obtain 'Fixes' using electronic aids only. Hence such aids became more and more popular and came into extensive use.

TYPES OF NAVIGATION

The methods of navigation can be divided into four categories:

1. Visual
2. Astronomical (Celestial)
3. Navigation by dead reckoning
4. Radio navigation

a. **Visual navigation:** In this method the navigator `fixes' his position on a map by observing known visible landmarks, such as rivers, railway lines, mountains, coast lines etc,. During night. 'light beacons from cities and towns can provide information about the position of aircraft. However this is possible only under good visibility conditions.

b. **Astronomical navigation:** This is accomplished by measuring the angular position of celestial bodies with a sextant and noting the precise time at which the measurement is made with a chronometer! The position of celestial bodies at various times are given in almanacs. With two or three observations, the position (‘Fix ‘) of the aircraft can be obtained. The advantage of celestial navigation is its relative independence of external aids. But good visibility is required to take elevation angles of heavenly . Under favorable conditions, this method gives position with an accuracy of 1 NM.

c. **Dead reckoning:** The term 'Dead Reckoning' abbreviated as `DR' stands for deduced calculation. In this method the ground 'Position' of an aircraft at any instant is calculated from its previously determined position, the speed of its motion with respect to earth along with the direction of motion (i.e. velocity vector) and the motion time elapsed. For navigation by dead reckoning, direction of motion is provided by magnetic compass and speed by air-speed indicator. Navigation would be straight forward if the medium, in which the aircraft is moving, is stationary. But, while flying, the wind speed and the direction from which it blows affects the aircraft's speed and may also drift the aircraft from the direction to which its nose is pointing. Hence the ground position of an aircraft is determined from the knowledge of its speed. Direction of the fore and aft axis and the prevailing wind conditions, using the principle of triangle of velocities.

d. **Radio Navigation:** This method is based on the use of Radio Transmitter, Radio Receiver, and propagation of electromagnetic waves to find navigational parameters such as direction, distance etc., required to find the position of the aircraft. The Radio navigational aids provide information to a pilot regarding the position of his/her aircraft in azimuth and/or elevation at any instant of time. Radio communication and navigational aids also provide useful information to Air Traffic Control Officers for effective control of air traffic.

CLASSIFICATION OF RADIO NAVIGATIONAL AIDS :

Radio navigational Aids can he classified in different ways. The classification helps in identifying the usefulness of a given facility. All navigational aids, which provide guidance by using Radio Waves, are called Non-visual aids.

According to service range, the radio navigational aids are broadly classified into three categories:

a. Long range
b. Medium range
c. Short range

a. **Long Range Navigational Aids:** Some of the aids operating world-wide in, this category are OMEGA and Long Range Aid to Navigation (LORAN).
They are operate in the Very Low Frequency (VLF) and Low Frequency (LF) bands of the frequency spectrum. i.e. 10 KHz, 50-100 KHz and 100- 200 KHz respectively to give very long ranges of the order of 7000 Kms, and 700 Kms respectively. They are based on hyperbolic system of navigation. These aids are not, provided by Airports Authority of India (AAI), although aircraft equipped with corresponding receiving equipment can use these facilities while flying over Indian air space.

b. **Medium Range Navigational Aids:** NDB (non directional beacon) falls in this category . It operates in the LF/MF band of frequency spectrum with a nominal range of 150-250 nautical miles, and even up to 350 NM over high seas.

c. **Short Range Radio Navigational Aids:** Some of the important and widely used short range aids are : VHF DF, VOR, DME, ILS and RADARS. These aids operate in and above the VHF bands and hence the coverage is dependant upon line-of-sight phenomenon.

Factors affecting coverage of medium range navigational aids.

a. Transmitter power
b. Frequency in use
c. Geographical location
d. Atmospheric conditions

The factor which affects the coverage area of a short range navigational aids.

a. Transmitter power
b. Height of transmitter and receiver
c. Site/terrain conditions
d. Sensitivity of the receiver

The inter-relationship between Transmitted Power, Frequency and Range of different -medium/short range navigational aids are shown in Table below.

Short Range Aids:

NAME OF THE EQUIPMENT	SYSTEM	FREQUENCY BAND	POWER (IN WATTS)	RANGE (NM)
NDB	Locator	200 – 450 KHz	<50	45
VOR	Terminal VOR	108 – 112 MHz	13	25
Localizer	ILS	108 – 112 MHz	10	25
Glide Path	ILS	328 – 336 MHz	10	10
DME	ILS - DME	960 – 1215 MHz	100	25

Medium Range Aids:

NAME OF THE EQUIPMENT	SYSTEM	FREQUENCY BAND	POWER (IN WATTS)	RANGE (NM)
NDB	Homing & En-route	200 – 450 KHz	500 & >1KW	150 & >250
VHF D/F	Homing	118 – 136 MHz	--	150
VOR	Homing & En-route	112 – 118 MHz	100	200
DME	Homing & En-route	960 – 1215 MHz	1KW	200

Inter relationship in terms of Frequency, Power, Range and system

1.2 EVOLUTION OF LANDING AIDS :

Modern I.L.S. is the result of the evolution of landing aids leading from signal strength monitors known as ISOPTENTIAL systems, through the LORENTZ and STANDARD BEAM APPROACH (S.B.A .) SYSTEMS, to the present. Of course evolution continues with MICROWAVE LANDING SYSTEMS, known as M.L.S.

The present system saw its conception in the U.S.A. The carrier frequencies were chosen to provide a reasonable aerial size with adequate performance .The “state of the art “ at the time of development provided reasonable efficiency from components at these frequencies A system of tone modulation was chosen using 90 Hz and 150 Hz, both frequencies being directly derivable from the U.S. mains frequency of 60 Hz . The harmonics of these frequencies are not inter related until 450 Hz and the use of low modulating frequencies allows for close channel spacing.

Future Navigation System:

For navigation purposes, the FANS Committee developed the concept of required navigation performance (RNP), where the performance of the system would be specified. This avoids the need for ICAO to select a navigation system, and it allows aircraft operators to choose the equipment most suitable to their needs in meeting the navigation performance requirement. The RNP concept supports the development of more flexible route systems and area navigation environments. The FANS Committee was confident that the global navigation satellite system (GNSS) will evolve to the point where it is suitable as a sole means of navigation meeting the required navigation performance (RNP) for most phases of flight and eventually replacing the current large variety of short range navigational aids (See Fig. 1)

Fig.1.FANS -Navigation

The GNSS is now deployed through navigation satellites of the United States' global positioning system (GPS) and the Russian Federations' global orbiting navigation satellite system (GLONSS), together with various augmentation systems to provide the necessary integrity and accuracy improvements. In accordance with the current ICAO transition plan, the microwave landing system (MLS) and instrument landing system (ILS) will for the near future, be the standard system for precision approach and landing. Eventually, most ground- based navigation aids will be withdrawn from service.

In 1980, the International Civil Aviation Organization (ICAO) recognized that the existing air traffic system had many problems and limitations. ICAO setup a committee to investigate the situation, and to find out a solution. The committee was called the Special Committee on Future Air Navigation Systems. It is known as FANS phase I committee. The FANS committee was set up in 1983. After lot of study and discussion, the committee recommended a new approach, which uses satellites, digital networks and computers, as well as some existing methods. The new approach is called CNS/ATM.

CNS/ATM was endorsed by the member states of ICAO in 1991. It should be in full operation by **2010**.

The new system:

CNS / ATM is going to change the way pilots and controllers communicate .Communication will be based on data link (digital data) .Voice communication will be used as backup and will gradually becomes less important. Data based communication has many advantages over voice communication especially on oceanic routes and over continental land mass where there are few navigational aids.

Satellite based navigation....

The main feature of navigation will be the use of satellite based

- Aircraft use **signals** from a minimum of 4 satellites to calculate their position
- **There are two sets of** satellites to choose from. These sets each consists of 21 satellites (and 3 spares) which orbit at an altitude of about 20,000 Kms. One is operated by the United States Department of Defense. This system is called GPS (Global Positioning System). The other, operated by Russia, is called GLONASS (Global Orbiting Navigation Satellite System).
- These satellite systems are accurate to within 100 mtrs. (on a horizontal plane). They provide a common time reference to all users.
- The whole system of satellite based navigation (including satellites, receivers, Ground Earth Stations and monitoring) is called GNSS - Global Navigation Satellite System.
- New aviation maps need to be produced for GNSS. The old maps were based on regional datum points. The GNSS maps are based on WGS 84, which uses a single datum point (the center of the Earth).

Precision approach aids....

In its standard form GPS is not precise enough for precision approaches.

There are two approach methods available under CNS/ATM.

1. You can enhance the accuracy of GPS so it can be used for landing approach
2. MLS-Microwave landing system

This is likely to be overtaken by improvements in satellite systems.

1.3 Purpose and use of ILS:

The Instrument Landing System (ILS) provides a means for safe landing of aircraft at airports under conditions of low ceilings and limited visibility. The use of the system materially reduces interruptions of service at airports resulting from bad weather by allowing operations to continue at lower weather minimums. The ILS also increases the traffic handling capacity of the airport under all weather conditions.

The function of an ILS is to provide the PILOT or AUTOPILOT of a landing aircraft with the guidance to and along the surface of the runway. This guidance must be of very high integrity to ensure that each landing has a very high probability of success.

1.4 COMPONENTS OF ILS:

The basic philosophy of ILS is that ground installations, located in the vicinity of the runway, transmit coded signals in such a manner that pilot is given information indicating position of the aircraft with respect to correct approach path.

To provide correct approach path information to the pilot, three different signals are required to be transmitted. Se first signal gives the information to the pilot indicating the aircraft's position relative to the center line of the runway. The second signal gives the information indicating the aircraft's position relative to the required angle of descent, where as the third signal provides distance information from some specified point.

These three parameters which are essential for a safe landing are Azimuth Approach Guidance, Elevation Approach Guidance and Range from the touch down point. These are provided to the pilot by the three components of the ILS namely Localizer, Glide Path and Marker Beacons respectively. At some airports, the Marker Beacons are replaced by a Distance Measuring Equipment (DME).

This information is summarized in the following table.

ILS Parameter	ILS Component
a. Azimuth Approach Guidance	Provided by Localizer
b. Elevation Approach Guidance	Provided by Glide Path
c. Fixed Distances from Threshold	Provided by Marker Beacons
d. Range from touch down point	Provided by DME

Localizer unit:

The localizer unit consists of an equipment building, the transmitter equipment, a platform, the antennas, and field detectors. The antennas will be located about 1,000 feet from the stop end of the runway and the building about 300 feet to the side. The detectors are mounted on posts a short distance from the antennas.

Glide Path Unit :

The Glide Path unit is made up of a building, the transmitter equipment, the radiating antennas and monitor antennas mounted on towers. The antennas and the building are located about 300 feet to one side of the runway center line at a distance of approximately 1,000 feet from the approach end of the runway.

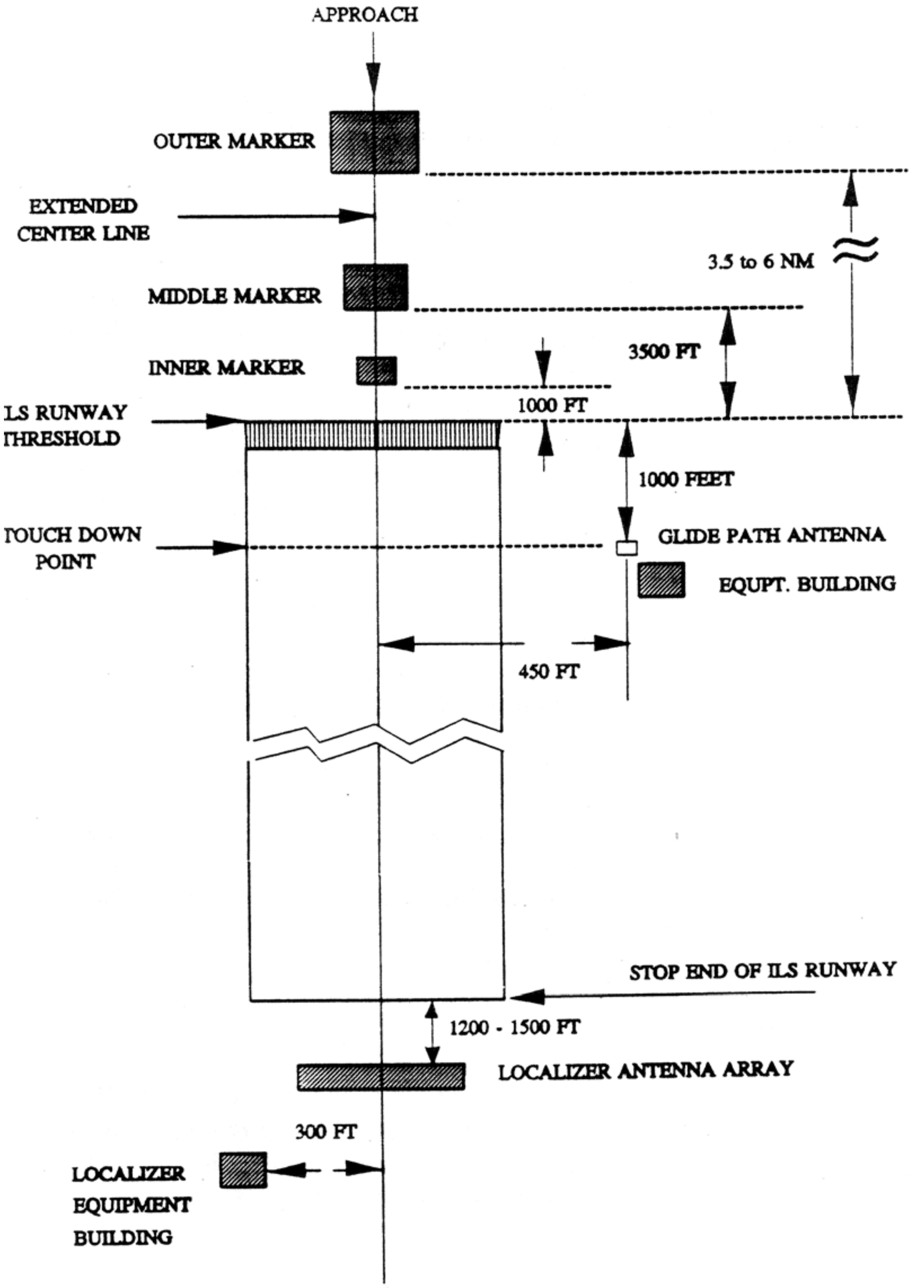


Figure 2. shows the typical locations of ILS components Marker

Units :

Three Marker Units are provided. Each marker unit consists of a building, transmitter and directional antenna array. The system will be located near the runway center line, extended. The transmitters are 75 MHz, low power units with keyed tone modulation. The units are controlled via lines from the tower.

The outer marker will be located between 4 and 7 miles in front of the approach end of the runway, so the pattern crosses the glide angle at the intercept altitude. The modulation will be 400 Hz keyed at 2 dashes per second.

The middle marker will be located about 3500 feet from the approach end of the runway, so the pattern intersects the glide angle at 200 feet. The modulation will be a 1300 Hz tone keyed by continuous dot, dash pattern.

Some ILS runways have an inner marker located about 1.000 feet from the approach end of the runway, so the pattern intersects the glide angle at 100 feet. The transmitter is modulated by a tone of 3000 Hz keyed by continuous dots.

Distance Measuring Equipment (DME):

Where the provision of Marker Beacons is impracticable, a DME can be installed co-located with the Glide Path facility.

The ILS should be supplemented by sources of guidance information which will provide effective guidance to the desired course. Locator Beacons, which are essentially low power NDBs, installed at Outer Marker and Middle Marker locations will serve this purpose.

Aircraft ILS Component :

The Azimuth and Elevation guidance are provided by the Localizer and Glide Path respectively to the pilot continuously by an on-board meter called the Cross Deviation Indicator (CDI).Range information is provided continuously in the form of digital readout if DME is used with ILS. However range information is not presented continuously if Marker Beacons are used. In this condition aural and visual indications of specific distances when the aircraft is overhead the marker beacons are provided by means of audio coded signals and lighting of appropriate colored lamps in the cockpit.

FUNCTIONS OF ILS COMPONENTS :

A brief description of each of the ILS components is given in this section.

Function of Localizer unit :

The function of the Localizer unit is to provide, within its coverage limits, a vertical plane – of c our s e al i g ned with the extended center-line of the runway for azimuth guidance to landing aircraft. In addition, it shall provide information to landing aircraft as to whether the aircraft is offset towards the left or right side of this plane so as to enable the pilot to align with the course.

Function of Glide Path unit :

The function of the Glide Path unit is to provide, within its coverage limits, an inclined plane aligned with the glide path of the runway for providing elevation guidance to landing aircraft. In addition, it shall provide information to landing aircraft as to whether the aircraft is offset above or below this plane so as to enable the pilot to align with the glide path.

Function of marker Beacon / DME :

The function of the marker beacons,/DME is to provide distance information from the touch down point to a landing aircraft.

The marker beacons, installed at fixed distances from the runway threshold, provide specific distance information whenever a landing aircraft is passing over any of these beacons so that the pilot can check his altitude and correct it if necessary.

The DME, installed co-located with the Glide Path unit, will provide a continuous distance information from the touch down point to landing aircraft.

Function of Locators:

The function of locators, installed co-located with the marker beacons, is to guide aircraft coming for landing to begin an ILS approach.

1.5 Different models used in AAI:

Different models of ILS used in AAI are as follows:

1. GCEL ILS :In this ILS mechanical modulator is used and both the near field monitoring system is utilized.
2. NORMARC ILS :In this system advance technology is used and for monitoring purpose along with near field monitoring integral monitoring has been utilized .Now a days 2 models viz. NM 3000 series and NM 7000 series are mostly used in AAI.
3. ASI ILS : In Mumbai and Delhi airport these ILS are used under modernization programme. One of the ILS model at Delhi is a CAT III ILS.

1.6 CONTROL AND INDICATIONS IN AIRBORNE RECEIVER :

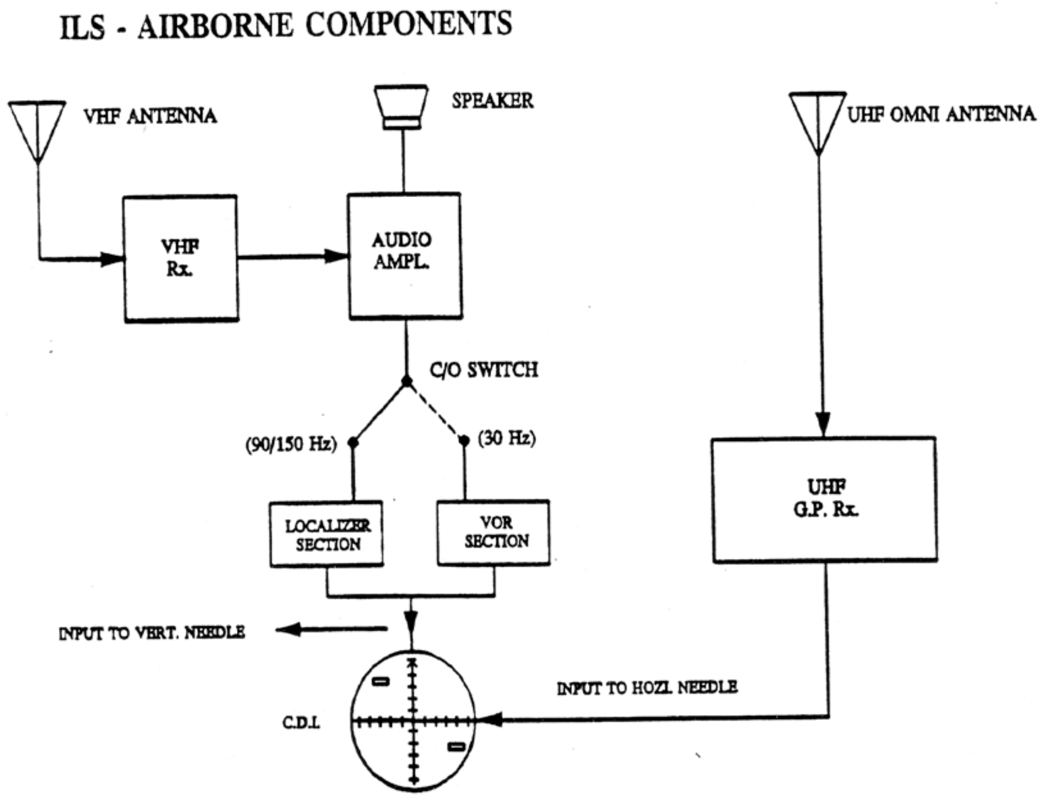


Figure 3. Block Diagram ILS Airborne Receiver

The basic block diagram of ILS airborne receiver is shown in Fig.3 The basic airborne display unit appears as shown in Fig. 4

The salient features of the airborne display unit are as below:

a) There are two needles (vertical needle for localizer and the horizontal one for glide path).
b) There are two lines, vertical and horizontal, crossing each other at the center of the meter and graduated by a series of dots. There are four dots above and four below the central dot on the vertical line. Similarly there are four dots left and four dots right of the central dot on the horizontal line.
c) The Localizer and Glide Path needles are driven by the DDM of respective radiation.

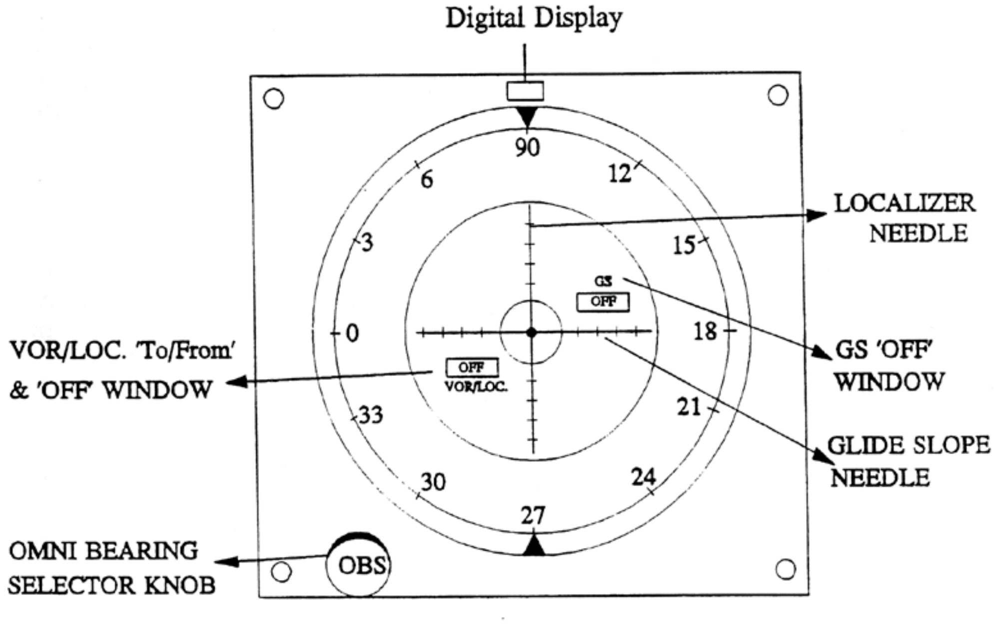


FIG 4 .LOC GLIDE SLOPE INDICATOR AND RECEIVER

Chapter 2

Communication Principles in relation to ILS

NOTE: ***Please refer to the Communication Principles (General) Volume***

Article No.
Comm. Principles

2.1 Modulation techniques

2.1.1 Basic Concepts (1.1)

- Need & definition (1.1.1)
- Categorization - CWI pulse, Analog/Digital, Linear/Non-linear. (1.1.2)
- Types of CW modulation. (1.1.3)

2.1.2 Amplitude Modulation (1.2)

- Basic theory of AM - Came·, message & information (1.2.1)
- Definition of carrier & modulating signal (1.2.2)
- Power relations (1.2.3)
- Instantaneous frequency, spectrum (1.2.4)
- TSB & DSBSC (1.2.5)
- Mode of emission (1.2.11)
- Phasor representation (1.2.6)
- RF / Audio phase (1.2.7)
- Effect of RF misphase (1.2.8)
- Transmitter modulation (1.2.9)
- Space modulation. (1.2.10)

2.2 Transmission Lines

2.2.1 Properties of Electrical lines. (2.1)

2.2.2 Distributed Impedance & Characteristic Impedance. (2.2)

2.2.3 Wave velocity, Propagation constant, Velocity factor(2.3)

2.2.4 Characteristics of Un-terminated / terminated lines with different loads of different lengths. (2.4)

2.2.5 Nodes and Anti-nodes of voltage and current, Impedance curve, Input Impedance. (2.5)

CHAPTER 3.

PRINCIPLES OF ILS

3.1 Guidance tones:

ILS employs amplitude modulation of a radio frequency carrier to provide the guidance information. The modulating signals used in ILS are pure sine waves of 90 Hz and 150 Hz frequency. This handout deals with the characteristic features of signals radiated by Localizer and Glide Path.

Audio modulation frequencies of 90 and 150 Hz are used to provide right and left indication. When approaching for a landing, the 150 signal predominates on the right-hand side of the course and the 90 on the left,

The system uses Amplitude Modulation and hence the aircraft receiver must measure the difference in amplitudes of the detected tones to determine the aircraft position. This leads to the term Difference in Depth of Modulation (DDM). When the DDM is zero, the aircraft is correctly positioned. When a DDM exists, the pilot must correct the aircraft's position until the DDM is zero. The pointer needles of the CDI instrument are driven by the DDM.

Audio modulation frequencies of 90 and 150 Hz are used to provide up and down indication. When approaching for a landing, the 150 signal predominates below the glide path and the 90 above.

3.2 Radio frequency clearance and DDM:

ILS theory is founded on the concept of Difference in Depth of Modulation (DDM), which applies both to Localizer course theory and to glide path theory. As already stated, the intelligence of the radiated signal depends upon a comparison of the two frequencies, 90 and 150 Hz. By comparing the magnitude of these two frequencies, the aircraft receiver can determine how far and in what direction the aircraft has deviated from a prescribed Localizer course or Glide Path. There are two ways by which the relationship between the two frequencies can be expressed; as a difference in magnitudes, or as a ratio of the magnitudes. While the difference relationship is called the DDM, the ratio relationship is called the Radio Frequency Clearance (RFC).

DDM is the standard that is used to evaluate an ILS facility, both in the air and on the ground. However, RFC is of prime interest for monitoring purposes.

3.3 Localizer coverage ,Azimuth and Elevation :

Azimuth:

The localizer shall provide signals sufficient to allow satisfactory operation of a typical aircraft installation within the localizer and glide path coverage sectors. The localizer coverage sector shall extend from the center of the localizer antenna system to distances of:

46.3 km (25 NM) within plus or minus 10 degrees from the front course line;
31.5 km (17 NM) between 10 degrees and 35 degrees from the front course line;
18.5 km (10 NM) outside of plus or minus 35 degrees if coverage is provided;

except that, where topographical features dictate or operational requirements permit, the limits may be reduced to 33.3 km (18 NM) within the plus or minus 10-degree sector and 18.5 km (10 NM) within the remainder of the coverage when alternative navigational facilities provide satisfactory coverage within the intermediate approach area.

Elevation:

The localizer signals shall be receivable at the distances specified at and above a height of 600 m (2 000 ft) above the elevation of the threshold, or 300 m (I 000 ft) above the elevation of the highest point within the intermediate and final approach areas, whichever is the higher. Such signals shall be receivable, to the distances specified, up to a surface extending outward from the localizer antenna and inclined at 7 degrees above the horizontal.

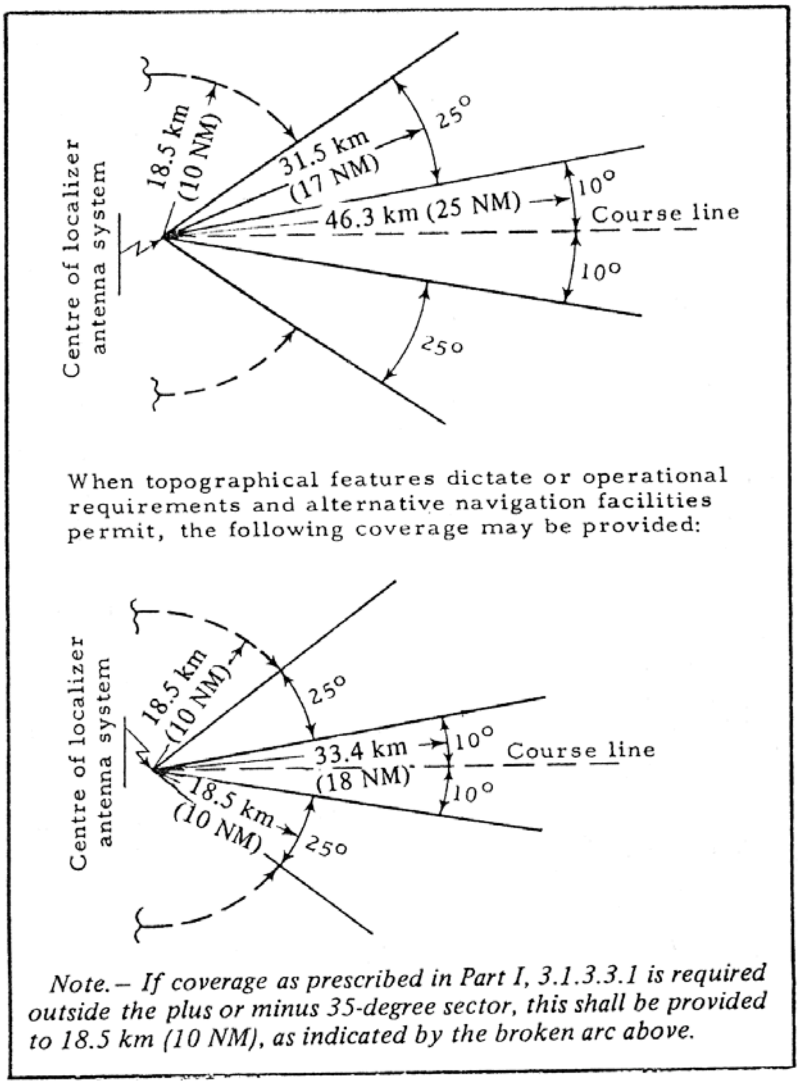


FIG.5 Localizer coverage in respect to azimuth

3.3.1 Azimuth Coverage

As stated in the ILS specifications, the Localizer azimuth coverage is restricted to ±35°. It should be mentioned at this stage that one of the paramount problems with LL.S. is reflections, from objects in areas of High DDM, on the runway centre line. This can be illustrated using figure 6.

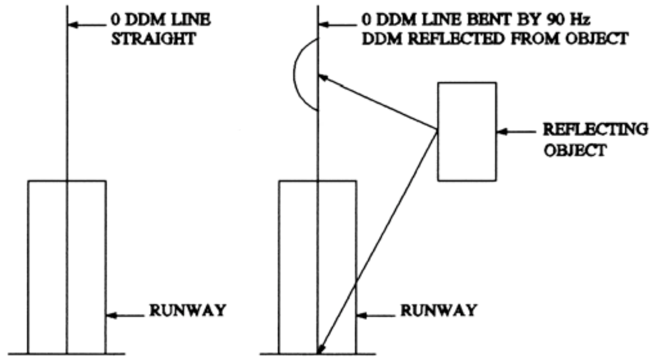


Figure 6. Effect of Reflection on Localizer Course.

One reason why coverage is restricted to only ± 35° is to eliminate the effects of objects outside this area. However there remains the problem of reflection from objects sited within the coverage area. To reduce this problem the coverage area is divided into two areas namely the COURSE and CLEARANCE areas.

COURSE area is defined as the area within ± 10 degree from the runway centre line. CLEARANCE area includes the area from ± 10° to ± 35°.

Signals in clearance areas are often transmitted on a different frequency or on a different phase from course signals to reduce the effect of reflections.

I. Course Coverage.

Let us first consider Azimuth guidance in course area. This guidance is provided by radiating following two signals:

a. CSB/CL (Carrier with side band/course).
b. SBO/CL (Side band only/Course).

CSB/CL signal is fed to central five pairs of aerial (i.e. 1B-IY, 2B-2Y, 3B-3Y, 4B-4Y and 5B-5Y). Across the length of the aerial array the distribution of CSB/CL signal gives a maximum in the centre falling to zero at ends. The CSB/CL signal is fed in RF phase to the required pairs. The amplitude and phase relationship of RF feed to various aerials are as shown in figure 7. The idea of doing this is to obtain the required radiation pattern consisting of single narrow major LOBE falling to zero at 11.5° from the centre line and having minimum side lobes. Radiation pattern due to CSB/CL fed to various antenna elements as described above, is shown in figure 8.

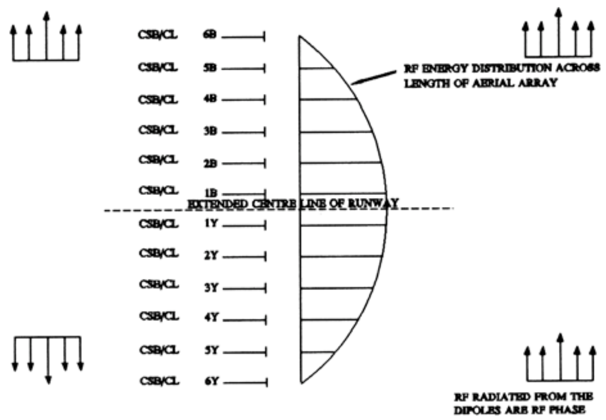


Figure 7. CSB/CL Signal Distribution

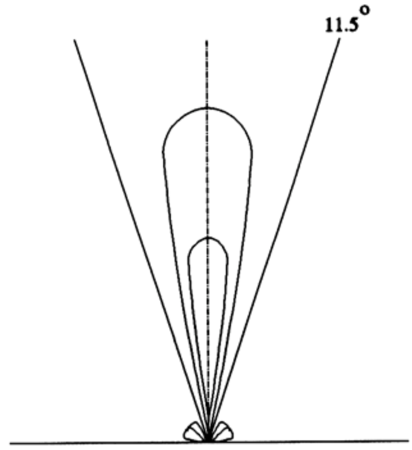


Figure 8. CSB/CL Radiation Pattern

Since the depth of modulation due to 150 Hz and 90 Hz is set equal to 20 % in the CSB/CL signal, ZERO DDM will result everywhere within the pattern.

SBO/CL signal is fed to all six pairs of aerials. The distribution of SBO energy, across the length of aerial array gives a maximum an either side of the centre line with zero in the centre and at both ends. Amplitude and RF feed of SBO/CL is as shown in figure 9.. Radiation pattern due to SBO/CL is as shown in figure 10.

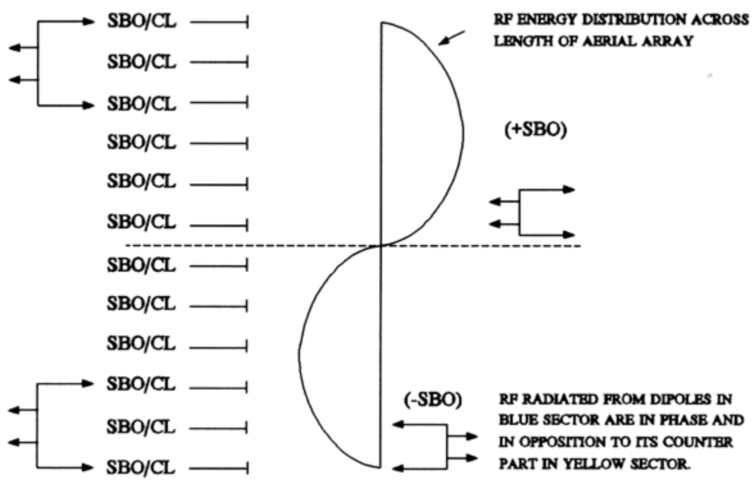


Figure 9. SBO/CL Signal Distribution

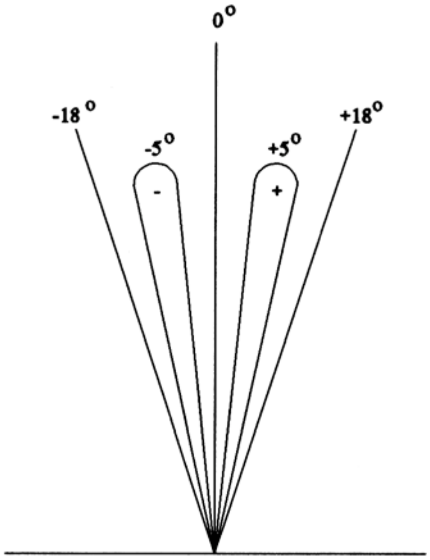


Figure 10. SBO/CL Radiation Pattern

If the CSB and SBO signals are combined, a polar diagram as shown in figure 11 results.

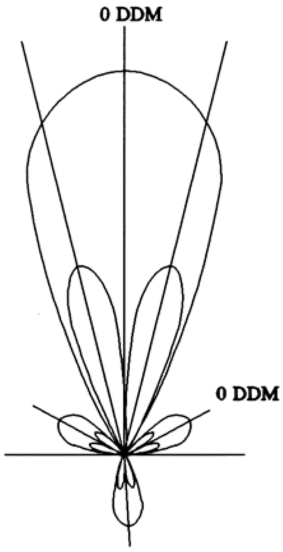


Figure 11.Combined CSB/CL and SBO/CL Radiation Pattern.

Because the signals are all in RF phase, the sidebands will add or subtract, depending on the polarity to produce the tone predominance on each side of the runway. It can be seen that patterns are very similar to those achieved with 3 elements localizer array system except the signal is now concentrated in a smaller area and displacement sensitivity is linear out to 18 °lo DDM. The same criteria which was applicable to the 3 element localizer also apply in this case.

a. The relative phase of SBO signals set the tone predominance.
b. The SBO power will set the displacement sensitivity.

II. Clearance Coverage.

The basic Course Coverage pattern suffers from two drawbacks:

a. Main lobe beamwidth does not provide the coverage specified by ICAO (±35°at17NM).
b. The course pattern has side lobes which give false guidance information.

The objectives of clearance radiation are intended to overcome these difficulties. There are three methods by which the Clearance coverage can be obtained. These are:

a. In Phase Clearance.
b. Two Frequency Clearance.
c. Quadrature Clearance.

In-Phase Clearance employs signals at the same frequency and in phase with the course transmission, but fed only to the centre antenna elements so giving greater coverage. In this case the antenna elements are highly directive, thus suppressing side lobes.

Quadrature Clearance employs signals at the same frequency but at a audio and RF phase quadrature from the course transmission, fed to only the inner antenna element pairs. STAN/GCEL Localizer employs this method of clearance.

Two Frequency Clearance employs signals displaced approx. 10 KHz from the course transmission fed to only the centre antenna elements. The NORMARC Localizer employs this method of clearance

3.3.2 Elevation Coverage

The elevation coverage of Localizer Antenna Array can be explained based on the Image Antenna Theory.

Image Antenna Theory.

Consider an isotropic horizontally polarized antenna above a perfectly conducting plane as shown in figure 12.

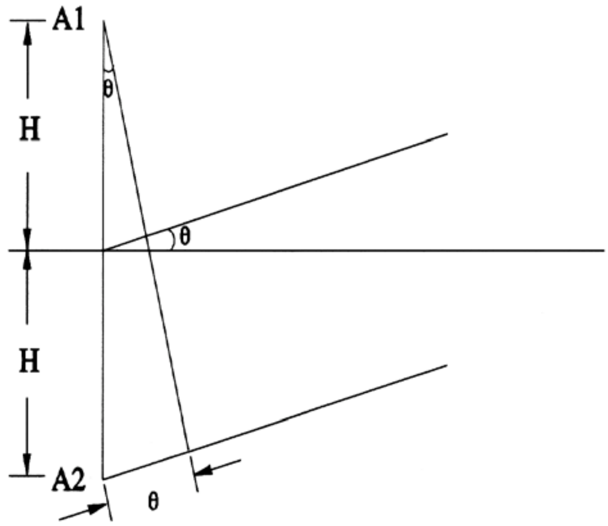


Figure 12. Image Antenna Concept

The electric field intensity received at any point will consist of two components namely:

a. that due to direct wave from the antenna and
b. that due to the reflected wave from the conducting surface.

Since the antenna is horizontally polarized, E field will reverse its direction upon reflection. The same can be applied to any antenna placed above the ground. Ground can be considered a perfect conducting plane for all practical purposes. Hence it follows, from the simple geometry, that an antenna at a height H above the ground may be considered as two radiating elements, A1 and A2 , spaced 2H, part and radiating in antiphase. Now a maximum signal will be received when the signal from antennas A1 and A2 arrive at the receiver in phase. For this to happen, the path difference in the two path lengths must be equal to λ/2. This results in the maximum radiation at an angle θ which is related to the height H as given the formula:

$$E = A_{\theta} \sin (H \sin \theta)$$

$$\sin (\lambda \sin \theta) = 1 = \sin \lambda/4$$

or $\lambda \sin \theta = \lambda/4$

or $\sin \theta = 1/4$

or $\theta = 14.5''$

Our desired direction of radiation is typically 3° in elevation; at which localizer coverage should be available; however to cater to such low elevation angles, the localizer antenna array will have to be placed abnormally high, becoming a source of obstruction for landing and take off aircrafts. For this reason, as a compromise between the obstruction clearance and desired angle of radiation, the height of localizer antenna array is usually kept as one wavelength, which is a height of approx. three meters at localizer frequency.

The antenna and its image form an out of phase antenna pair spaced 2 λ apart, and hence there will be an additional lobe at a higher angle.

Localizer Antenna :

The Localizer antenna array is mounted at a height λ above the ground and hence maximum radiation occurs at 14.5 degrees with respect to ground. As aircraft approach a runway typically at 3°, it can be seen that only the lowest portion of the lobe is used. Now, the regulations state that the field strength in a section between 2000 feet and 7° from the horizontal must be of useable amplitude. Therefore, the power of the transmissions must be increased considerably. Of course, use of a reflector screen helps but if the antenna elements are mounted in a 60° corner reflector, the following two main results occur:

a. The energy is concentrated into one lobe at approximately 11.5° .
b. The gain increases to about 11 dB over an isotropic radiator.

3.4 Glide path Coverage :

The glide path equipment shall provide signals sufficient to allow satisfactory operation of a typical aircraft installation in sectors of 8 degrees in azimuth on each side of the center line of the ILS glide path, to a distance of at least 18.5 km (10 NM) up to 1.75 θ and down to 0.45 θ above the horizontal or to such lower angle, down to 0.30 θ, as required to safeguard the promulgated glide path intercept procedure.

In order to provide coverage for glide path performance specified above, the minimum field strength within this coverage sector shall be 400 micro volts per meter (minus 95 dBW/m^2). For Facility Performance Category I glide paths, this field strength shall be provided down to a height of 30 m (100 ft) above the horizontal plane containing the threshold. For facility Performance Categories II and III glide paths, this field strength shall be provided down to a height of 15 m (50 It) above the horizontal plane containing the threshold.

Note 1.- The requirements in the *foregoing* paragraphs are *based on the assumption* that the aircraft is heading directly toward *the* facility.

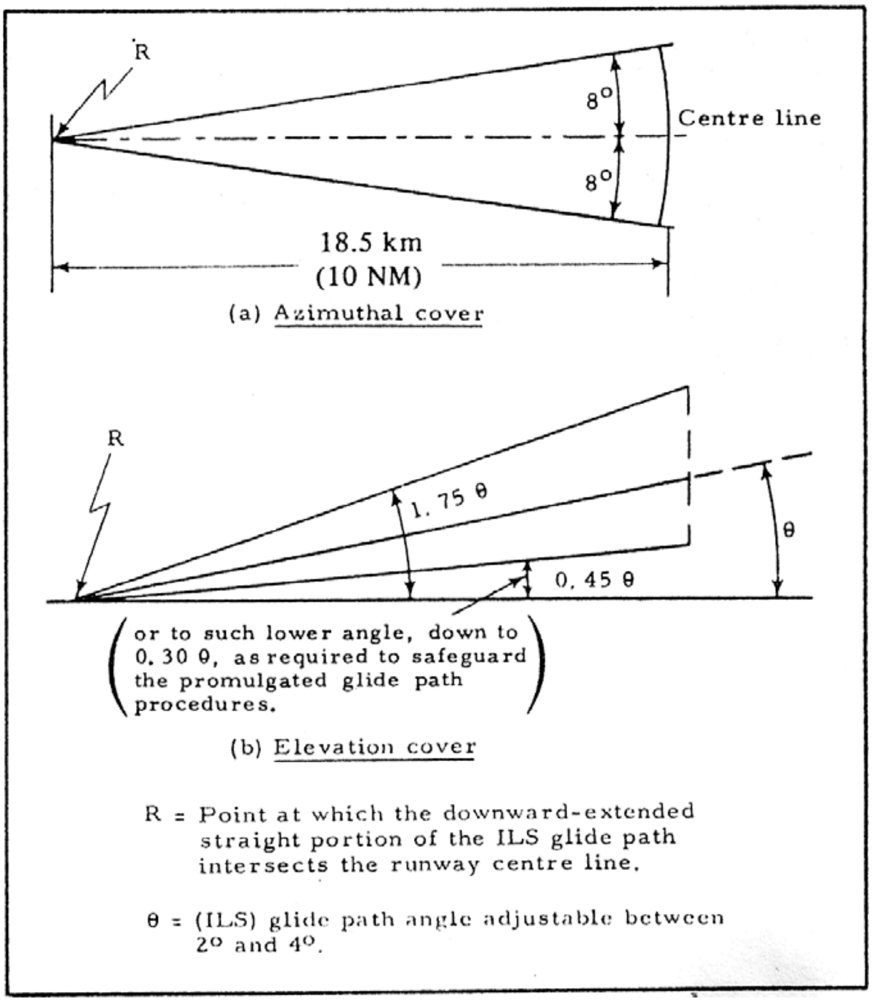


Figure 13 Glide path coverage.

CHAPTER 4

ILS SIGNAL FORMAT

4.1 Localizer :

4.1.1 LLZ signal format with reasoning of its requirement :

To obtain the required coverage for localizer and Glide Path , two RF signals need to be radiated. These two signals are defined as:

a. CSB Signal; and

b. SBO Signal.

CSB Signal

This is an RF signal in which the RF carrier is amplitude modulated simultaneously by the audio frequencies of 90 HZ and 150 Hz. If V_cSin ω_ct is the carrier signal, the resultant CSB signal is expressed by

$$V_{CSB}=V_{cCSB}Sin\omega_c t+mV_{cCSB}Sin\omega_{90}tSin\omega_c t+mV_{cCSB}Sin\omega_{150}tSin\omega_c t$$

$$V_{CSB}=V_{cCSB}Sin\omega_c t+\frac{mV_{cCSB}}{2}Cos(\omega_c-\omega_{90})\,t-\frac{mV_{cCSB}}{2}Cos(\omega_c+\omega_{90})\,t$$

$$+\frac{mV_{cCSB}}{2}Cos(\omega_c-\omega_{150})\,t-\frac{mV_{cCSB}}{2}Cos(\omega_c+\omega_{150})\,t$$

This equation gives the following frequency components:

a. a radio frequency carrier f_c,

b. a 90Hz lower sideband f_c - 90Hz,

c. a 90Hz upper sideband f_c + 90Hz,

d. a 150Hz lower sideband f_c - 150Hz and

e. a 150Hz upper sideband f_c + 150Hz.

This signal, when viewed on a CRO, looks like the waveform shown in figure 14; when viewed on a spectrum analyzer looks like the diagram shown in figure 15; and the vector representation of this signal is as shown in figure 16.

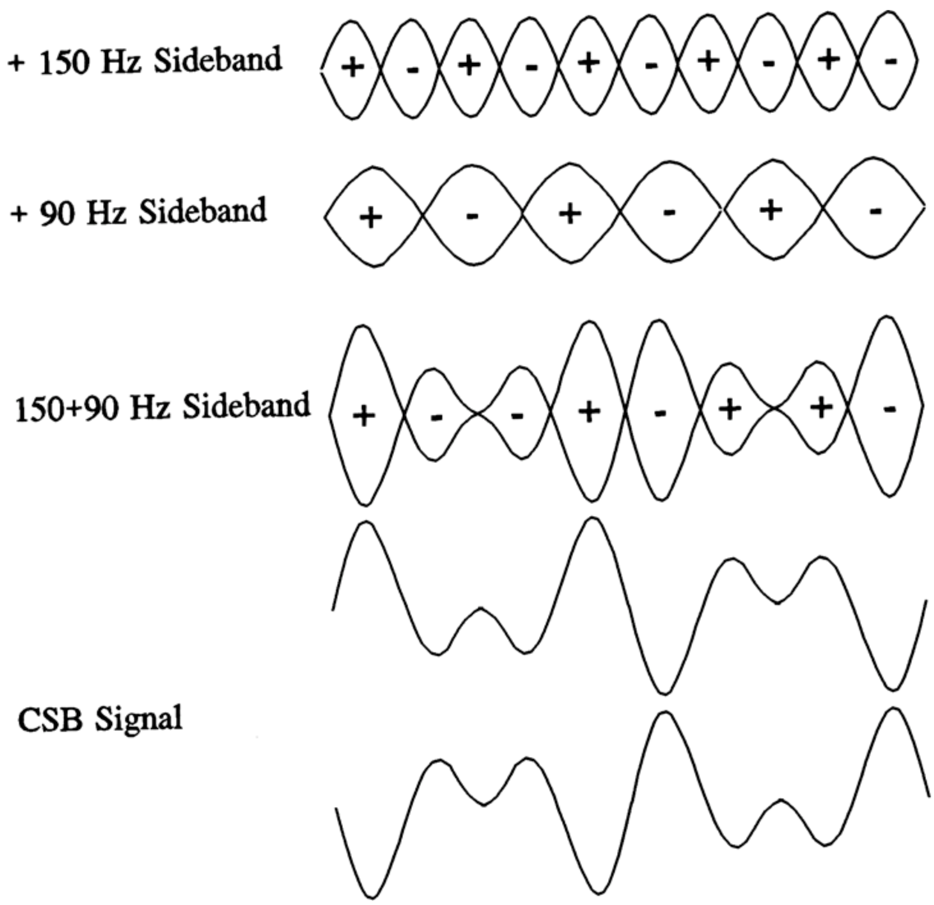


Figure 14.The waveform of CSB Signal

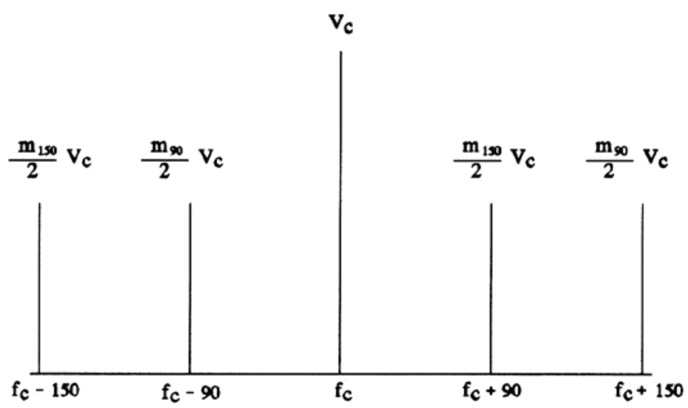


Figure 15. The Frequency Spectrum of CSB Signal

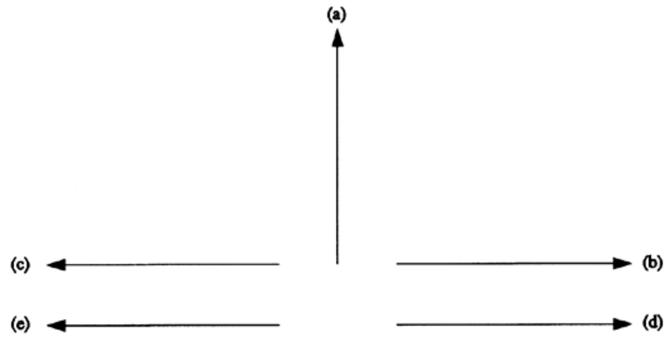


Figure 16. vector representation of CSB signal

SBO Signal:

This is an RF signal in which the RF carrier is amplitude modulated simultaneously by the audio frequencies of 90 Hz and 150 Hz with the carrier component removed. If V_c Sin $w_c t$ is the carrier signal, the resultant SBO signal is expressed by:

$$V_{SBO}=V_{cSBO}[-Sin\omega_{90}tSin\omega_{c}t+Sin\omega_{150}tSin\omega_{c}t]$$

$$V_{SBO}=-\frac{mV_{cSBO}}{2}Cos(\omega_{c}-\omega_{90})\,t+\frac{mV_{cSBO}}{2}Cos(\omega_{c}+\omega_{90})\,t+\frac{mV_{cSBO}}{2}$$

$$Cos(\omega_{c}-\omega_{150})\,t-\frac{mV_{cSBO}}{2}Cos(\omega_{c}+\omega_{150})\,t$$

This equation gives the following frequency components:

a. a 90Hz lower sideband f_c - 90Hz,

b. a 90Hz upper sideband f_c + 90Hz,

c. a 150Hz lower sideband f_c - 150Hz,and

d. a 150Hz upper sideband f_c + 150 Hz

This signal, when viewed on a CRO, looks like the waveform shown in figure 17 ,when viewed on a spectrum analyzer looks like the diagram shown in figure 18 and the vector representation of this signal is as shown in figure 19.

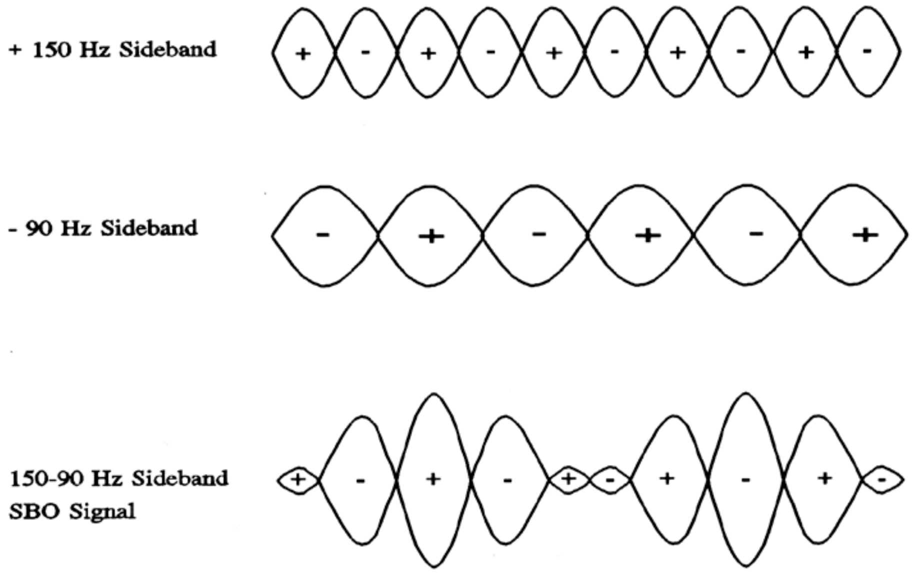


Figure 17. The waveform of SBO signal

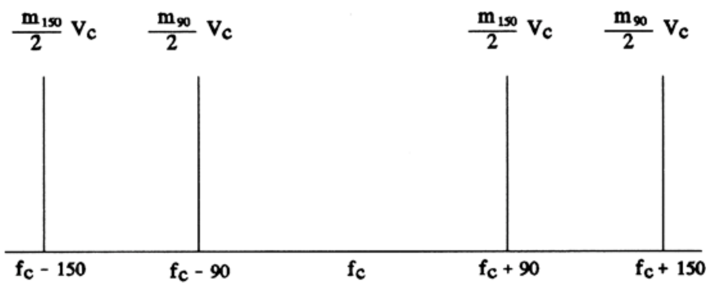


Figure 18 .The Frequency Spectrum of SBO Signal

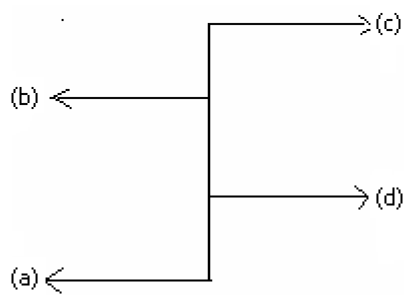


Figure 19.The Vector Representation of SBO Signal

ANTENNA ARRAY CONCEPTS

An antenna array is an arrangement of several individual antennas so spaced and phased that their individual contributions combine in one preferred direction and cancel in undesired directions to get directivity. Thus an antenna array is a method of combining the radiations from a group of similar antennas.

An antenna array is said to be linear if the individual antennas of the array are equally spaced along a straight line. Individual antennas of an antenna array are also called Elements of the antenna array. These elements can either be λ/2 antenna elements or any other complex radiating antenna elements like Log Periodic Antenna Array.

The total field produced by an antenna array system is equal to the vector sum of the fields produced by individual antennas of the array system. Hence the amplitude and phase of the signals fed to each of the elements of the array is of great significance as it influences the total field produced.

The ILS antenna array consists of a number of pairs of antennas. In order to understand the radiation pattern of these arrays, it is essential to consider the radiation pattern produced by one pair of antennas and then the combined radiation pattern is obtained by phasor addition. In this lesson we shall adopt some standard notations, namely:

$$I = I_m \, \mathrm{Sin}\,(\omega t+\varphi)$$

Since the antennas in given array will be supplied energy from a single RF source, the term containing frequency (ωt) may be omitted when writing the polar form:

In the polar form, φ expresses the initial phase angle of the current and the bar above I indicates that it is a phasor quantity.

The ILS antenna arrays can be easily analyzed on the basis of two specific types of antenna pairs namely:

a. those fed currents of equal amplitude that are in phase (SIP); and
b. those that are fed currents with equal amplitude but of opposite phase (SOP).

Before going into the details of these, the effect of separation between antennas will be discussed.

The Effect of Separation between two Antennas

In general, the effect of increasing the separation between antennas of an array is two fold:

a. the number of lobes in the pattern will increase; and
b. the major lobe will decrease in width.

Since the array is considered to be composed of isotropic radiators, each lobe will be of the same magnitude. It should be noted that the pattern of figure 20 b. would not be adversely affected even if the radiators were composed of antenna elements. In the discussion to follow, the lobe of this figure is considered the major lobe.

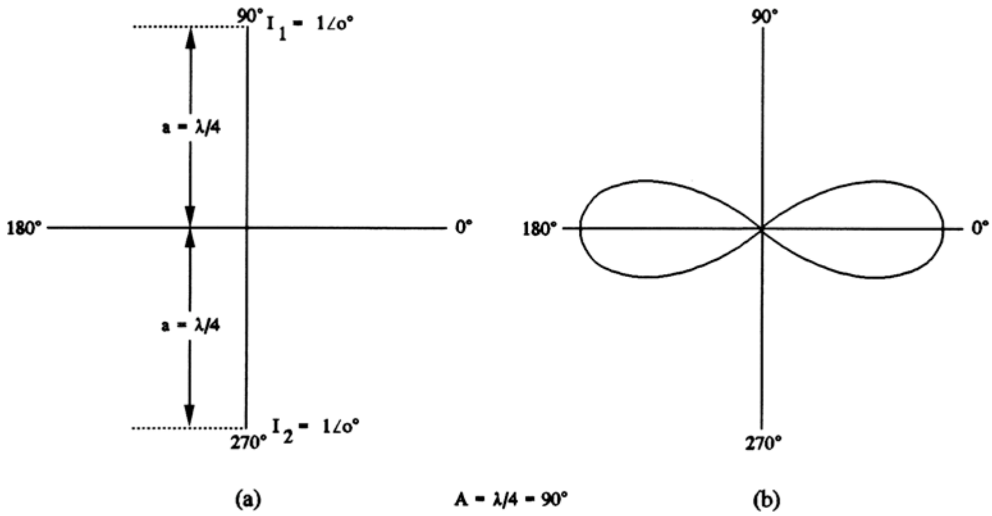


Figure 20. The Basic two Element Antenna Array.

The Reference Array of Two Isotropic Radiators is shown in (a) and the Resultant Pattern is shown in (b) above.

Figure 21a. extends the separation between the antenna of the basic array to λ and Figure21 b indicates the resultant radiation pattern Notice that the number of lobes has now increased to four, and the major lobe has decreased in width.

It is not necessary to solve for the resultant field intensity at all angles in order to sketch a radiation pattern. A sketch, while not accurate at all points in the pattern; does present the critical points (i.e. the maximum and nulls), which are usually the main points of interest. The critical points of a pattern can usually be determined by inspection of the array diagram, and furthermore, because of the symmetry of a pattern, the critical points need to be determined only in one hemisphere.

Since these two antennas have equal current amplitudes and equal current phases of 0°, it is apparent that the maximum resultant field intensity occurs on the reference line (θ = 0°). As the point of observation is moved from the reference line (a change in the angle θ) the individual antenna phasors rotate in opposite directions by an amount given by the quantity (a sin θ). Since 90° of phasor rotation is required for an oppositely phased condition between the two antenna phasors (remember, both phasors rotate at the same rate, but in opposite directions) the angle θ at which the out-of phase condition occurs in quadrant I can be determined as follows:

a Sin θ = Phasor rotation where a = λ /4 = 90° a

Sin θ =90°

or Sin θ = 90°/90° = 1,or θ = 90°

Therefore, the first maximum is at θ = 0° and the first null is at θ = 90°.

Refer again to Figure 21. The two diagrams are divided into quadrants I, II, III, and IV. Since it is only necessary to determine critical points in one hemisphere, quadrants I and IV are used, and furthermore, the 0° bisector of these two quadrants becomes the reference line. After the radiation pattern for quadrants I and IV is determined, quadrants II and III are drawn in as the minor image of I and IV.

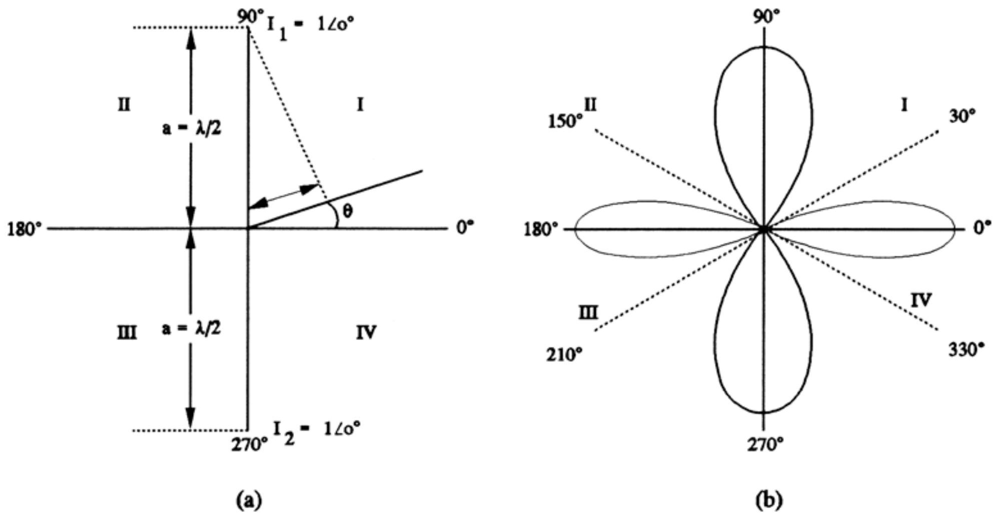


Figure 21 A Variation in the Basic Two-Element Array.

The Configuration of Figure 21(a) represents an increased separation between the elements of Figure 20(b). The resultant pattern of the Array is shown in Figure 21(b).

Since these two antennas have equal current amplitudes and equal current phases of 0°. it is apparent that the maximum resultant field intensity occurs on the reference line (θ = 0°). As the point of observation is moved from the reference line (a change in the angle θ) the individual antenna phasors rotate in opposite directions by an amount given by the quantity (a sin θ). Since 90° of phasor rotation is required for an oppositely phased condition between the two antenna phasors (remember, both phasors rotate at the same rate, but in opposite directions) the angle θ at which the out-of phase condition occurs in quadrant I can be determined as follows:

a sin θ = phasor rotation where a = λ/2 or 180°

a sin θ = 90°

sin θ = 90°/180°

θ = $\sin^{-1}.5$

θ = 30°

The first critical point of quadrant 1 is located at θ = 30° and because the phasors are diametrically opposed and of equal magnitude, this critical point is a null.

The maximum amount of phasor rotation possible in any quadrant is given by the value of a. Since only 90° of phasor rotation has been considered so far (resulting in a null) another 90° of rotation is possible, and of course will result in the phasors returning to an in-phase condition.

The value of θ at which this occurs is again determined by: a

sin θ = phasor rotation

a sin θ = 180°

$$\sin \theta = 180°/180°$$

$$\theta = 90°$$

Hence, the second critical point is a maximum and occurs at θ = 90°. Since θ = 90° is the limit of quadrant I, there can be no other critical points in the first quadrant.

The critical points of quadrant IV are yet to be determined. To do so requires, first of all, a return to the initial condition, or θ = 0°, and then an investigation of the critical points in quadrant IV. Again, each phasor will rotate as the point of observation is moved into quadrant IV. Since 180° of phasor rotation is possible, and both phasors are initially in phase, there will be a null and a maximum in the fourth quadrant, just as in the first quadrant. The astute observer will note, however, that the critical points of quadrants I and IV occur at respective values of angle (B) only because the relative phase of the exciting currents is 0°. Also, it should be noted that the minimums are complete nulls only because the magnitudes of the exciting currents are equal.

In the final analysis, we can say that when the separation between the isotopic radiators was λ/2 or 180°, there was one lobe in the I & IV quadrants, and the first nulls occurred at ± 90°. As against this, when the separation was increased to I or 360°, there were two lobes in the I & IV quadrants and the first nulls occurred at ± 30°. We can therefore conclude that the effect of increasing the separation between antennas of an array is two fold:

a. the number of lobes in the pattern will increase; and
b. The major lobe will decrease in width.

In-Phase Pair

Here, we will discuss a particular type of antenna pair, the Specific In-Phase, or SIP, pair, i.e., those fed currents of equal amplitude that are in phase. We will be limited to discussion of the horizontal radiation from SIPs.

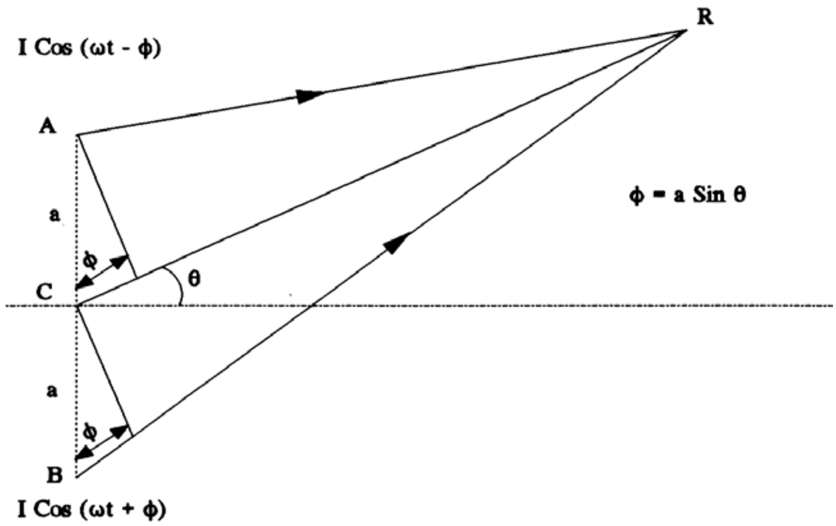


Figure 22. SIP antenna pair

Figure 22 shows the SIP. The resultant radiation at R due to antenna feeds of I Cos (ωt-φ) at A and I Cos ((ωt+φ)) at B is:

I_R = I Cos (ωt-φ)+ I Cos (ωt+ φ)

= I Cos ωt Cos Φ + I Sin ωt Sin Φ + I Cos ωt Cos Φ - I Sin ωt Sin Φ

= 2 I Cos ωt Cos Φ

= 2 I Cos ωt Cos (a Sin θ) since Φ = a Sin θ

= k Cos (a Sin θ); where k = 2I Cos ωt

From the above equations, the directions of Maximum radiations are always at θ = 0 and 180 degrees and also when:

$\theta = \text{Sin}^{-1}$ (n*180/a)

The directions of null will be:

$\theta = \text{Sin}^{-1}$(n*180+90)/a}

Thus we can conclude that when the isotropic elements of a two-element array are fed with signals in phase, the total field produced will have the following characteristics:

a. Maximum field on the Center Line.
b. Production of a number of Lobes. The number of lobes produced per quadrant will be equal to the number of wavelengths of separation between the elements.
c. Alternate lobes are always in antiphase.

For example aerials spaced 2 λ apart, will produce two lobes per quadrant as shown in figure 23.

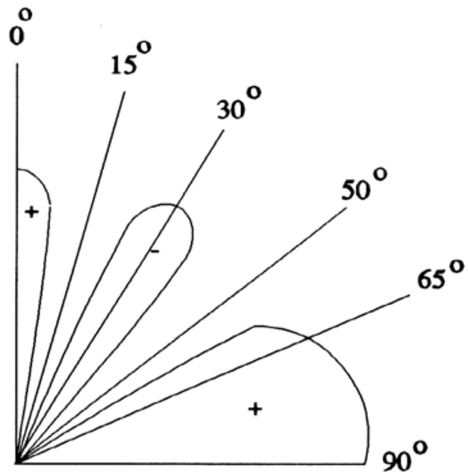


Figure 23

The Oppositely-phased Pair

Here, we will discuss a particular type of antenna pair, the Specific Out of Phase, or SOP, pair, i.e., those fed currents of equal amplitude that are in phase. We will be limited to discussion of the horizontal radiation from SOPs.

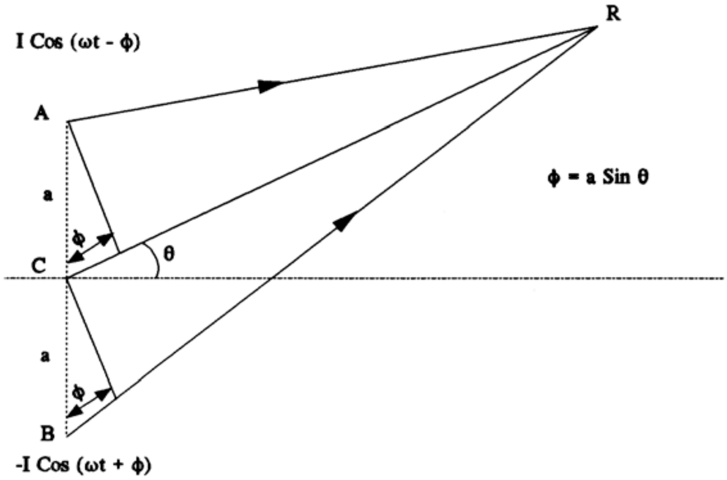


Figure 24 SOP antenna pair

Figure 24 shows the SIP. The resultant radiation at R due to antenna feeds of I Cos (ωt-φ) at A and -I Cos (ωt+φ) at B is:

$$
\begin{aligned}
I_R &= I \cos(\omega t - \Phi) - I \cos(\omega t + \Phi) \\
&= I \cos \omega t \cos \Phi + I \sin \omega t \sin \Phi - I \cos \omega t \cos \Phi + I \sin \omega t \sin \Phi \\
&= 2 I \sin \omega t \sin \Phi \\
&= 2 I \sin \omega t \sin(a \sin \theta); \qquad \text{since } \Phi = a \sin \theta \\
&= k \sin(a \sin \theta); \qquad k = 2 I \sin \omega t
\end{aligned}
$$

From the above equations, the directions of Maximum radiations occurs at:

$\theta = \text{Sin}^{-1}(n*180+90)/a\}$

The directions of null will be at 0 and 180 degrees as well as at:

$\theta = \text{Sin}^{-1}\{ (n*180)/a\}$

Thus we may conclude that when the isotropic elements of a two element array are fed with signals in anti-phase, the total field produced will have the following characteristics:

a. Zero radiation on the Center Line.
b. Production of a number of Lobes. The number of lobes produced per quadrant will -be equal to the number of wavelengths of separation between the elements.
c. Alternate lobes are always in antiphase.
d. The phase of radiation changes as the centerline is crossed.

For example aerials spaced λ apart, will produce one lobe per quadrant as shown in

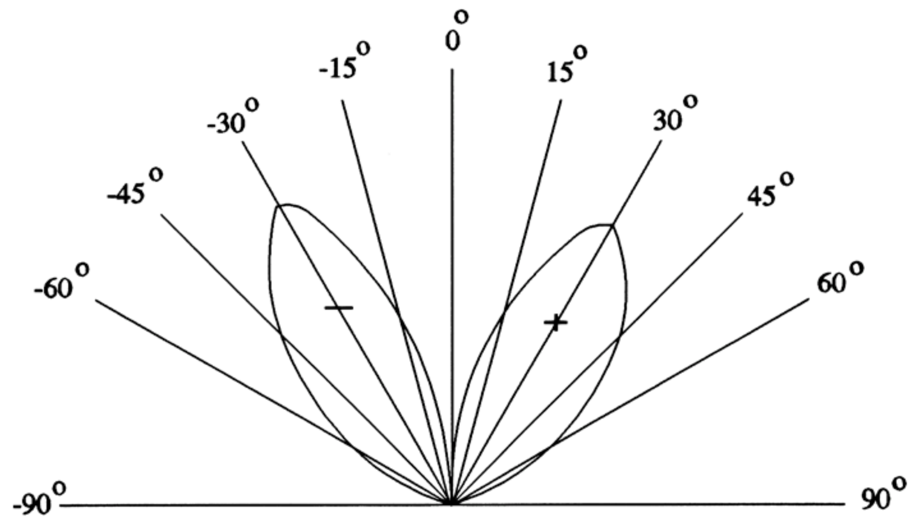


figure 25.

Figure 25

Combined Radiation from Two or more Antenna Pairs:

When an array contains two or more antenna pairs, and all the pairs are either fed in phase or in phase opposition, the combined radiation pattern from such an array in a particular direction could be obtained by simple algebraic addition of field strength magnitudes due to individual pairs.

All normally operating ILS antenna arrays consists of various combinations of in-phase and oppositely phased pairs. If an array consists of an in-phase pair and an oppositely phased pair, particular current phasing conditions must be chosen if the combined fields from each pair are to add algebraically in all directions. It can be proved that if the currents in one pair is in quadrature with the other pair, then the fields will add algebraically. This fact is made use of in the Localizer array where the sideband antenna pairs are fed currents with relative phase angles of 0 and 180 degrees while the carrier pairs are fed currents at the relative phase angle of 90 degrees, so that the effective radiation in any direction is readily obtained by simple algebraic addition of the various combined fields.

Enhancing Radiation Pattern of Arrays - Principle of pattern multiplication:

If the isotropic antennas in an array are replaced by directional antennas like dipole, the resultant radiation pattern of the array becomes more directional. The total field pattern of an array of non-isotropic but similar sources is the product of the individual source pattern and the pattern of an array of isotropic point sources each located at the phase center of the individual source and having the same relative amplitude and phase, while the total phase pattern is the sum of the phase patterns of the individual source and the an-ay of isotropic point sources.

As discussed earlier, by feeding equal signals to all the elements of an array, in addition to the principal or major lobe, secondary or minor lobes are also produced. The minor lobes are usually undesirable, because not only considerable amount of power is wasted in the directions of the minor lobes but also unnecessary interference is caused in these areas.

By using a reflector behind the aerials, the back radiation will be eliminated and the forward radiation is enhanced.

All these techniques are employed in the design of ILS antennas.

4.1.2. LOCALIZER ANTENNA ARRAY

The ILS Localizer antenna array consists of a number of antenna elements mounted in line, at right angles to the runway and symmetrical with respect to the runway centerline.

To understand the Localizer antenna array's basic principle of working, a simple three-element array is discussed first.

4.1.2.1 Three Element Localizer Array

Figure 26. shows the configuration of a three element Localizer antenna array.

Aerial B is located at the extended centerline of runway. Where as aerial A and C are displaced by an equal distance from aerial B.

Aerial B radiates CSB signal while aerial A radiates + SBO and aerial C radiates- SBO signal. The vector representation of these signal are shown in the figure 26.

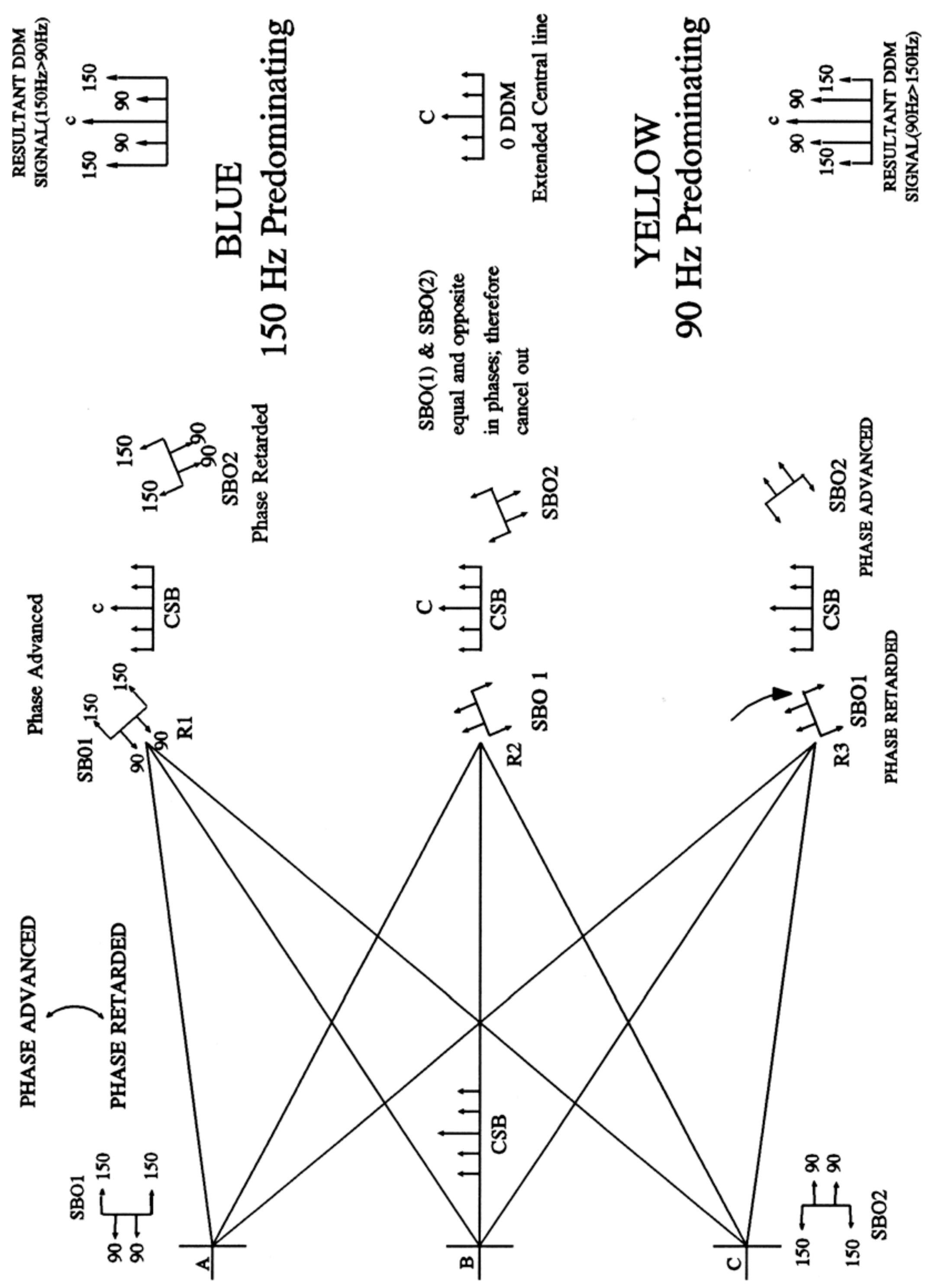


Figure 26. Three-element Localizer antenna array.

If an aircraft is located in Blue Sector (which falls right side of runway while approaching) say at point R1, then it receives three signals (CSB, +SBO and -SBO) through three different paths (AR1 , BR1 and CR1).

Since the path lengths are not equal, the relative phases of the signals at point R1 will not be the same as it was at points A, B and C. The phase of the +SBO signal will advance in phase with respect to CSB signal at point R1 because of shorter path length (AR1 < BR1). Similarly the phase of the -SBO signal will retard in phase with respect to CSB signal at point R1 due to longer path length (CR1 > BR1). Advancing in phase of SBO signal is shown as a rotation in anti-clockwise direction and phase retarding of -SBO signal is shown as clockwise rotation in the figure 26. If, we now add all these three signals vectorially, we may observe that 150 Hz sideband is strengthened where as 90 Hz sideband is reduced. This creates difference in depth of modulation where 150 Hz tone is greater than 90 Hz tone.

At any point (say O) at the extended centre line of the runway, the path traveled by SBO (AO) and -SBO (CO) are equal in length and are greater than the path traveled by CSB (BO) signal by the same amount. Thus SBO signal and -SBO signal are phase retarded by the same amount and hence are 180° out of phase at point O. Hence SBO signals are cancelled out and only CSB signal remains present at point O. As the depth of modulation by 150 Hz and 90 Hz are equal in CSB (20 percent each), 0 DDM results at any point on the centre line of runway.

By similar arguments and vectorial addition of SBO, -SBO and CSB signals in Yellow Sector, it can be proved that the difference in depth of modulation of 90 Hz tone is greater than 90 Hz tone.

From the above discussion, the following important points emerge:

I. CSB is the only signal existing on the centre line because SBO signals cancel. Hence at all points on the centre line of runway DDM (Difference in depth of modulation) is zero.
II. 150 Hz tone modulation predominates in Blue Sector.
III. 90 Hz tone modulation predominates in Yellow Sector.

This, so far presents to us qualitative analysis of tone predominance at various places. But it is quite evident from the vectorial addition of CSB, -SBO and +SBO signals that the resultant signal will have depth of modulation by 150 Hz and 90 Hz which depends upon relative strength of SBO signals with respect to CSB signal and also on angle of phase advance or phase retard. From the above we may say that value of DDM depends upon:

a. Relative strength of SBO with respect to CSB signal.

b. Azimuth angle (where DDM is being measured). DDM increases if azimuth angle increases. 15.5% DDM is adjusted at 105 meters from the runway centre line at the landing threshold in order to meet specification of displacement sensitivity. This can be achieved by adjusting SBO Power.

While discussing earlier we have assumed that SBO signal, CSB signal and -SBO signal are being radiated from aerials, A, B and C respectively. In other words, we may say that signal with specific phase relationship is being radiated from various antenna elements. Imagine what would have happened if SBO signals were interchanged. Certainly then tone predominance is Blue sector and Yellow sector would also have changed in a manner where 90 Hz > 150 Hz in BLUE SECTOR and 150 Hz > 90 Hz in YELLOW SECTOR, which is totally undesirable. Hence, we may state that the correct tone predominance is set by proper phasing of the SBO signals relative to CSB.

4.1.1 Limitations of Three elements- use of 12 and 24 elements

The basic concept of localizer with the help of three aerial system, does not, unfortunately provide required coverage and displacement sensitivity. Also it does not remain linear out to 18% DDM. CSB signal fed to dipole B (in fig.26), located on the extended centre line of runway provide excess coverage and reflections due to objects like tall building, hills and bridges located in this wider coverage area may create complications in localizer radiation (such as course bending etc.). Hence practical Localizer antenna array system consists of more number of antenna elements. These antenna array systems not only restrict the localizer azimuth coverage within the specified limit but also meet the requirement of displacement sensitivity.

Practical Localizer Antenna Array

The practical ILS Localizer antenna array will consist of either 12 or 24 elements depending on the local requirements. Figure 27shows a schematic diagram of a Localizer array containing 12 antenna elements.

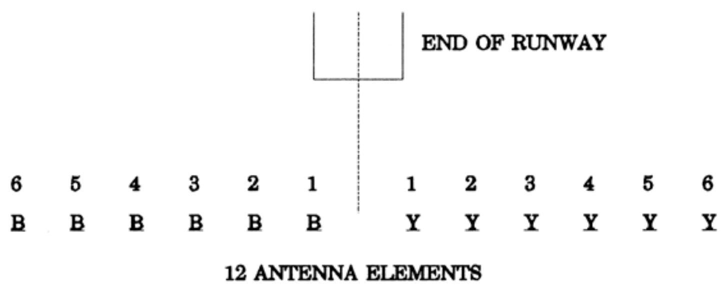


Figure 27 12 Element Localizer Array

The antenna elements are treated as pairs. The antenna elements are numbered from the centre outwards and assigned a code of Yellow (Y) or Blue (B) depending on their position. Y is used for antenna elements positioned on the left of the runway centre line as seen by a landing aircraft and B is used for antenna elements positioned on the right. Hence MB form the first pair, 2Y2B form the next pair and so on. consists of a 12 or 24 antenna elements depending on the local requirements. The spacing between the antenna elements is of the order of 3/4 λ (0.75λ).

4.1.4 Typical radiation pattern of LLZ antenna, Back Beam.

If the CSB and SBO signals of course radiation are combined, a polar diagram as shown in figure 28 results.

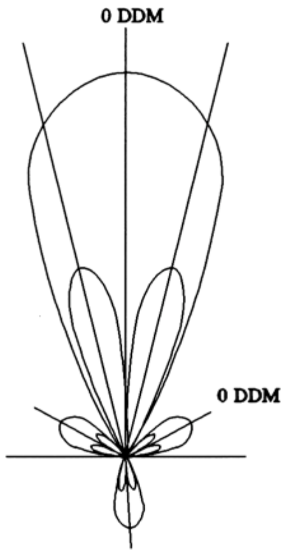


Figure 28 Combined CSB/CL and SBO/CL Radiation Pattern.

Because the signals are all in RF phase, the sidebands will add or subtract, depending on the polarity to produce the tone predominance on each side of the runway. It can be seen that patterns are very similar to those achieved with 3 elements localizer array system except the signal is now concentrated in a smaller area and displacement sensitivity is linear out to 18 % DDM. The same criteria which was applicable to the 3 element localizer also apply in this case:

- The relative phase of SBO signals set the tone predominance.
- The SBO power will set the displacement sensitivity.

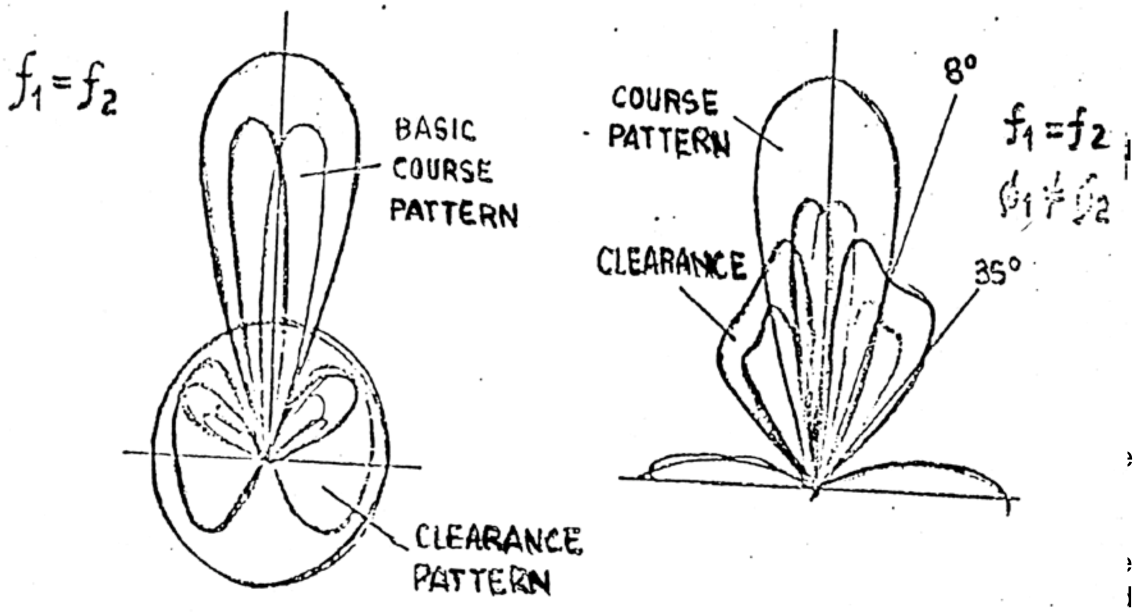
When CSB and SBO signal of Clearance radiations are combined together with the radiation of course signals a radiation pattern of figure 29 results.

Clearance radiation employs signals displaced approx. 10 KHz from the course transmission fed to only the centre antenna elements. The NORMARC Localizer employs this method of clearance.

During radiation a back beam is also formed which is shown in the combined radiation pattern of figure 29. By using reflector screen the gain can be increased.

:

- that due to direct wave from the antenna and
  - that due to the reflected wave from the



by 5 KHz from the assigned frequency .The aircraft receiver uses the well known capture effect to lock into larger signal. This can be demonstrated as follows;

150Hz

a. Detector output on right hand side of runway, no interfering clearance signal.

10 KHz beat between carriers

b. Detector output on right hand side of runway, with interfering clearance signal.

The aircraft a.f. circuits will reject the beat provided it is above 4KHz. It can be seen that it is important that the tolerances, of the two transmitters are strictly controlled, for if the frequency difference is too large the transmissions may interfere with the adjacent channels and if it is too small the beat frequency will pass through the aircraft receiver circuits and upset the DDM -measurements. The tolerance for the transmitters, in this case is ± 0.002% instead of ± 0.005% allowed for signal frequency system.

4.2 GLIDE PATH

4.2.1 Glide Path Signal Format with reasoning of its requirement:

Glide path operates in the UHF band on a predetermined frequency between 328 MHz and 336 MHz. As in the case of Localizer, the glide path radiation pattern is formed by an antenna array. Some of the typical antenna arrays used are the Null Reference, Side Band Reference and M-array. The antenna systems are dependent upon ground reflections for forming the course structure, which means that the terrain in front of the facility must be reasonably level.

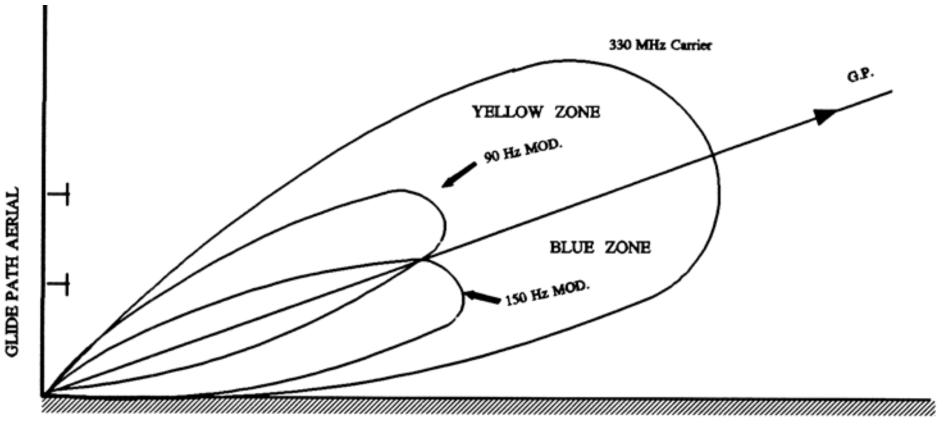


Figure 30. Basic Glide path Coverage

Glide path antenna array:

The glide path aerial system provides the means for transmitting the ILS elevation guidance information. This is achieved by transmitting combinations of glide path CSB and SBO signals in the proper amplitude and phase relation from two or three radiating elements raised at critical heights above the ground. These elements are mounted on a common mast , sited at safe distance from the runway, adjacent to touchdown.

The following are the basic specifications for an ILS glide path:

Carrier frequency:	predetermined between 328 MHz and 336 MHz
Navigation tones:	90 Hz AND 150 Hz, modulated on the RF carrier at 40 % each tone on the glide path. Offset, one tone must predominate. The 150 Hz tone modulation predominates below the glide angle and the 90 Hz above the glide angle.
Glide angle (θ):	Set at a predetermined value between 2 degrees and 4 degrees.
Displacement Sensitivity:	The DDM should be 0.0875 (8.75%) at ± 0.12 θ and 0.175 (17.5%) at ± 0.24 θ
Coverage, Azimuth:	10 NM AT ± 8 degrees from the course line .
Coverage, Elevation:	10 NM between 1.75 θ and 0.45 θ or to such low angles as 0.3 θ if required as per the promulgated ILS let down procedures.

There are three types of Glide Path antenna arrays in use. These are:

a. Null Reference Array

b. Side Band Reference Array

c. M - array

The principle of operation of a Glide path array can be explained using the Null Reference Array.

4.2. 2 Null Reference Array

The principle of operation of a null reference array is based on the Image Antenna theory. Based on the Image theory, a dipole placed at a height of H above the ground can be considered as an antiphase antenna pair with a spacing of 2H. If the distance 2H is made equal to λ then one lobe of radiation is produced in the quadrant above the ground and the radiated field is proportional to:

$\sin (H \sin \theta)$; $[E = A_o \text{Sin} (H \text{ Sin } \theta)]$

where θ is the elevation angle. Hence it can be easily seen that the maximum radiation occurs at the angle θ given by the formula:

$\theta = \sin^{-1} (\lambda/4H)$

Conversely, for a given elevation angle of maximum radiation, the height of the antenna above ground H is given by the formula:

$H = \lambda /(4 \sin \theta)$

From the above equation, it can be easily shown that for three degree elevation angle of maximum radiation, the height of the antenna above ground H is 5λ.In this case although there will be ten lobes of radiation (because 2H = 10λ), the first lobe will have a maximum radiation at three degrees as shown in figure 31.

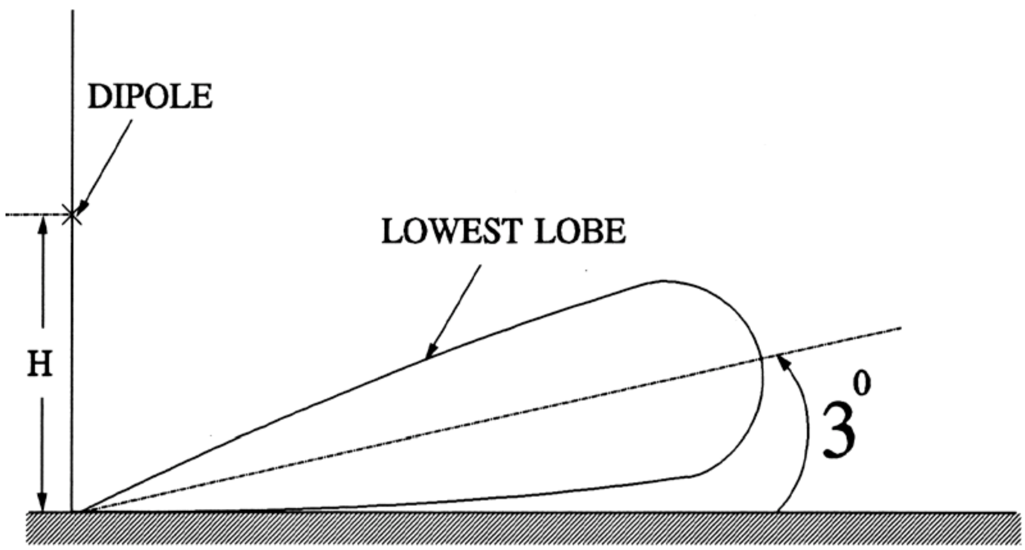


Figure 31

By similar argument, if the antenna is kept at the height of 10λ, there will be twenty lobes and the first two lobes will be so formed that there will be a null at 3 degrees as shown in figure 32. (Amplitude of signal fed to upper antenna is much less as compared to lower antenna).

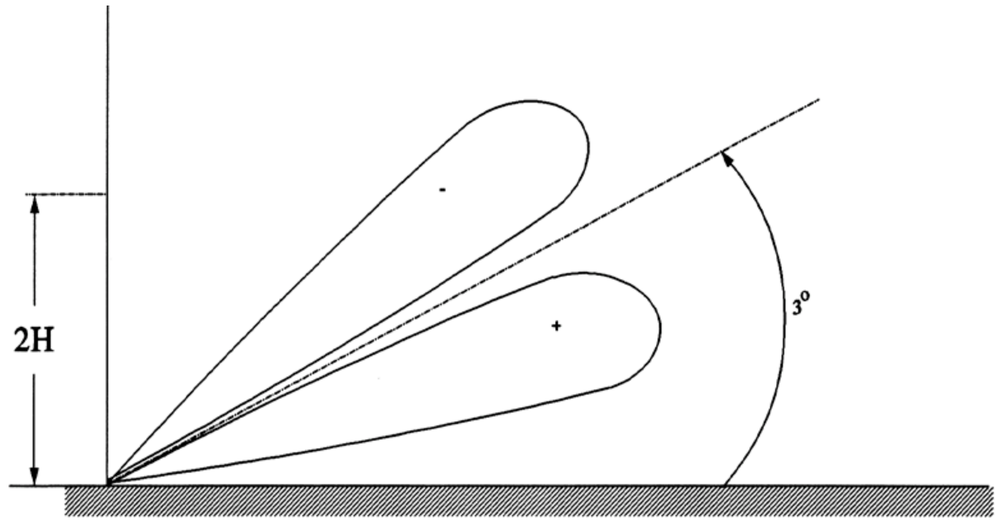


Figure 32

A combination of the above two radiation patterns will result in the null reference glide path. This is achieved by the antenna array consisting of two antennas placed above the ground as shown in figure 33.

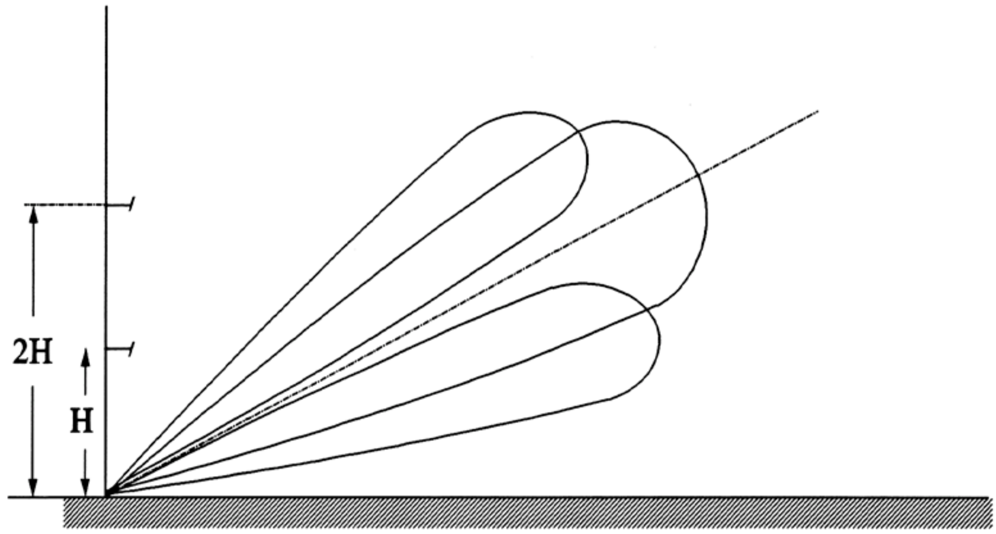


Figure 33

The lower antenna is placed at a height H above the ground and radiates the CSB signal. The upper antenna is placed at a height 2H above the ground and radiates the SBO signal. The CSB signal will have carrier and sidebands in phase and the modulation depth of each tone is 40%. The SBO signal is having sidebands in anti-phase. The combination of the two signals will produce a glide path as shown in figure 34.

Below glide angle , the vector addition of CSB and SBO signal will result in difference in depth of modulation where 150 Hz is greater than 90 Hz. At glide angle only CSB signal exists hence DDM will be zero as depth of modulation in CSB signal by 150 Hz and 90 Hz are equal (40% each). Above glide angle 90 Hz is greater than 150 Hz.

Figure 34 illustrates the radiation pattern in rectangular coordinates. Examination of the situation at 3 θ will reveal that a false glide angle exists having reversed guidance information.

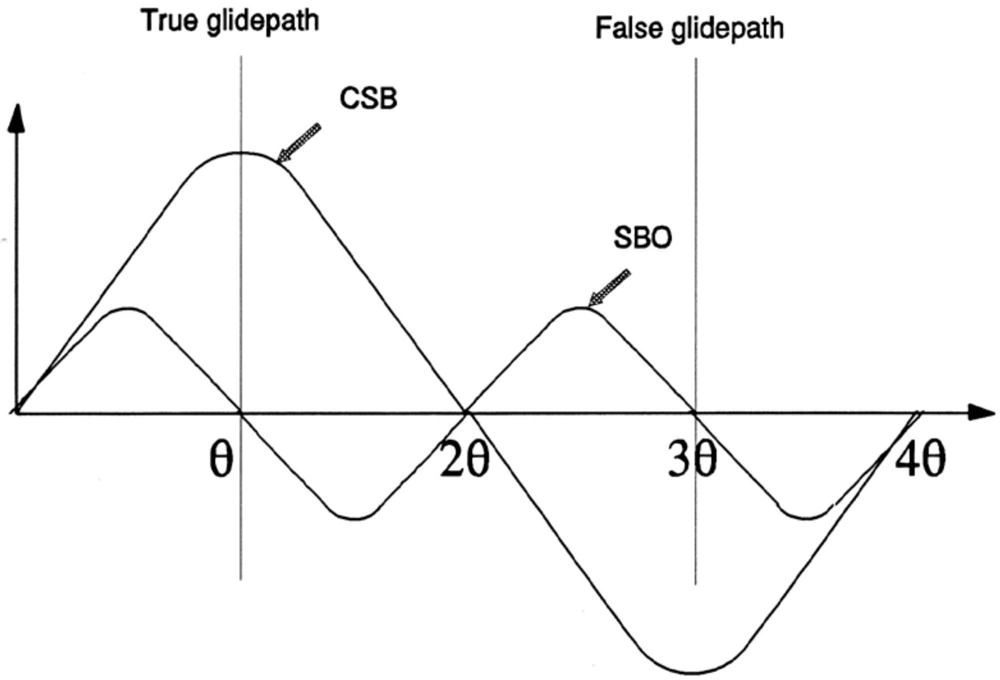


Figure 34

The configuration discussed so for is known as the NULL REFERENCE GLIDE PATH. It is, perhaps, the simplest option and easiest to maintain as the height of the top aerial determines the glide angle (assuming CSB is set to 0 DDM). Electrical adjustment of the glide angle can be made by adjusting the DDM of the CSB signal but this is not recommended as it complicates maintenance. Additionally, the displacement sensitivity may be adjusted by means of the SBO power, as in the case of the localizer. Increasing the SBO power increases sensitivity and reduces the half sector width, is the angle between θ and the angle where 8.75 % DDM is achieved. Reducing the SBO power does first the reverse.

The fact that false glide angle information is given at 3 θ should not concern aircraft operators because the aircraft normally approaches an airfield below θ (due to the range). Therefore the receiver will capture the lowest lobe. For a glide angle of 2.5° and a height of 2000 to 5000 feet, the range at which this occurs is about 10 Nautical miles. The false glide angle will have a height of 4000 to 5000 feet, at this range the aircraft will therefore only uses the lowest (correct) lobe for guidance. If the second lobe is captured the guidance information is reversed. So it will not be "flyable". The null reference glide path requires rather special circumstances for optimum operation. Firstly, there is the subject of aerial height. Typical value for 3°.

Height of lower antenna $H = 5\lambda = 4.5$ meters.

Height of upper antenna $2H = 10\lambda = 9.0$ meters.

It can be seen that aerial mast requirement for this case, is at least 9 meters. In many cases a mast of this height is an unacceptable obstruction, so an alternative system must be used. additionally, because of the aerial height, it requires reasonably flat ground free from modules out to at least 360 meters and thereafter no substantial obstruction out to ± 10 ° each side of the course line. Obstructions will create reflections resulting in distortion of the elevation guidance information (beam bends).

It is therefore required that an alternative system should have lower aerials and some immunity from reflectors. This has resulted in the development of two more glide path antenna systems namely:

a. Sideband Reference System; and

b. Quadrature clearance or M array system.

4.2.3 Sideband Reference System

In the sideband reference system the antenna heights are h/2 and 3h/2 thereby resulting in a reduction of about 2.25 meters from the null reference mast working with the same value of H. Since the heights of the aerials are lower, the effects of irregularities in ground level are more pronounced but the area required for beam formation is less than that for the null reference system.

The sideband reference system employs two transmitting aerials, mounted one above the other at h/2 and 3h/2

$$\text{where } h = \frac{\lambda}{4\sin\theta}$$

.

If $h = 5\lambda$ provides a maximum at 3 ° , then $h/2 = 2.5\lambda$ will provide a maximum at 6°.

$$2.5\lambda = \frac{\lambda}{4\sin\theta}$$

$$\sin\theta = \frac{\lambda}{4 * 2.5\lambda} = \frac{1}{10}$$

$$\theta = 6°$$

So if a signal is fed to an aerial of height 2.5λ (h/2) the lobe maximum will be at approximately 6 °.

Consider an aerial at 3h/2 .For each lobe produced from an aerial at h/2; there will be three lobes produced from the aerial at 3h/2.

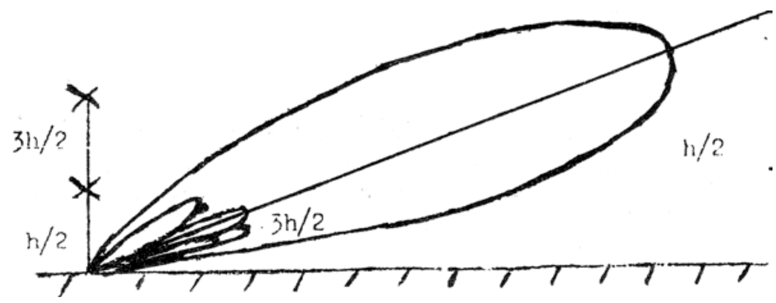


FIG. 35

I f C. S. B & S . B .O. i s f e d to the lower aerial and S.B.O. to the top aerial phased as shown:

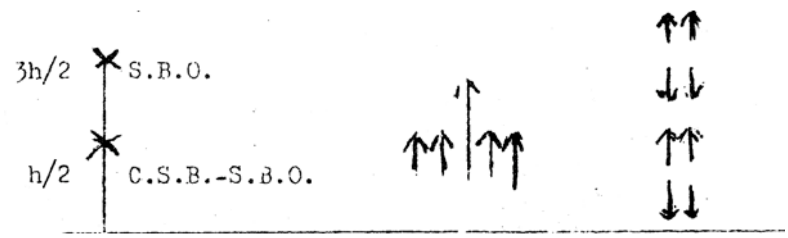


FIG . 36

a glide path will result at θ as shown in Figure 37(a) & (b). It will be noted that maximum carrier exists at 2θ, so there is le signal on the glide path. There is correspondingly less signal glide path so there is less to reflect from obstructions. In fact the reduction of signal on the glide path is in the order of -6dB and the immunity from reflections is of the order of -2.3 dB over the null reference system. The coverage and DDM and predominance specifications are met.

Because the top aerial is at 3h/2, it can be seen that the mast height is now of the order of

$$\frac{3 \times 4.5m}{2} = 6.75m.$$

taking h = 4.5m.

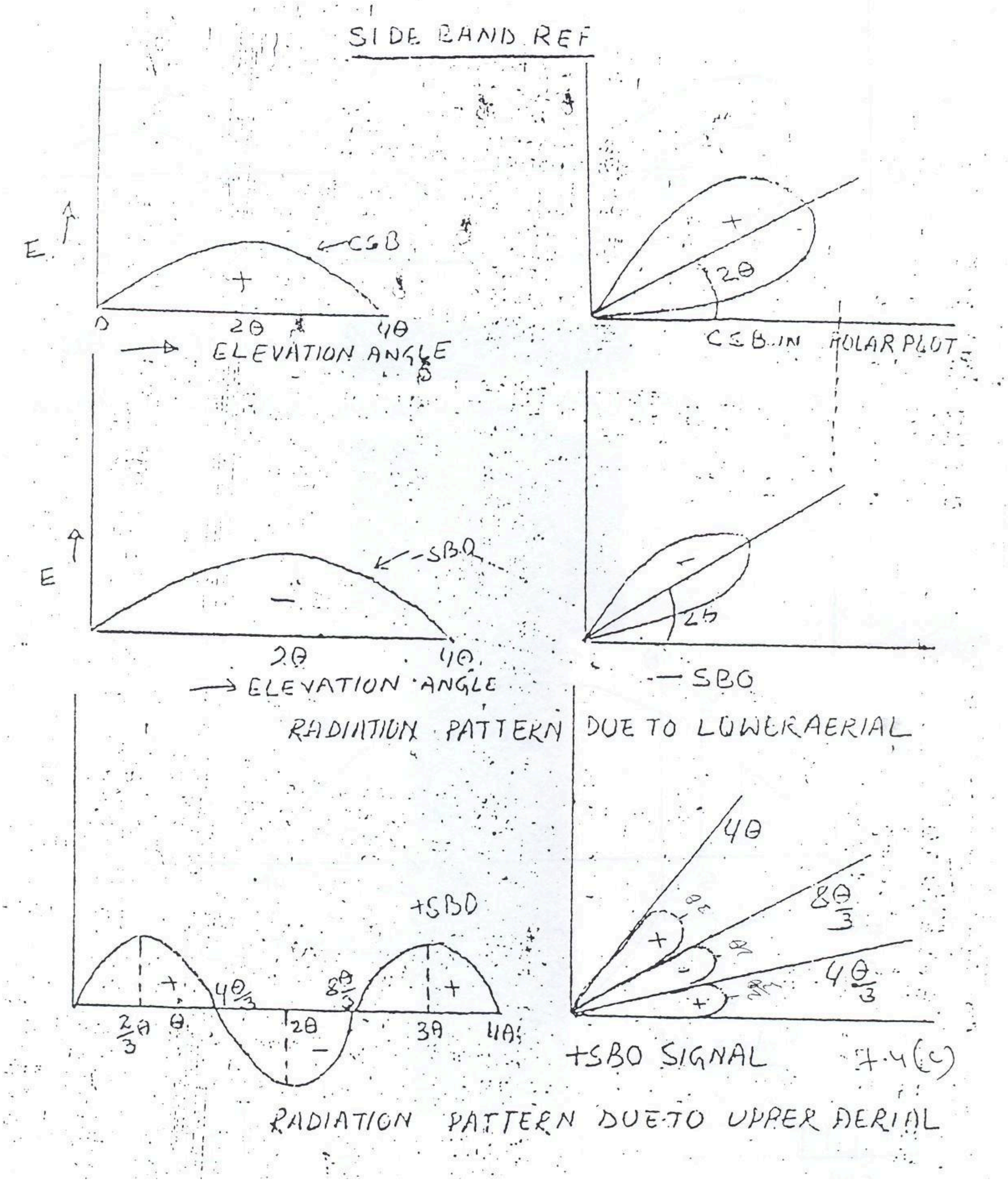

SIDE BAND REF
E
CSB
+
0
2θ
4θ
ELEVATION ANGLE
+
2θ
CSB IN POLAR PLOT
E
-SBO
−
2θ
4θ
ELEVATION ANGLE
−
2θ
-SBO
RADIATION PATTERN DUE TO LOWER AERIAL
+SBO
+
4θ/3
8θ/3
+
2/3θ
θ
2θ
−
3θ
4θ
4θ
8θ/3
4θ/3
+
−
+
+SBO SIGNAL
7.4(c)
RADIATION PATTERN DUE TO UPPER AERIAL

FIG. 37(a)

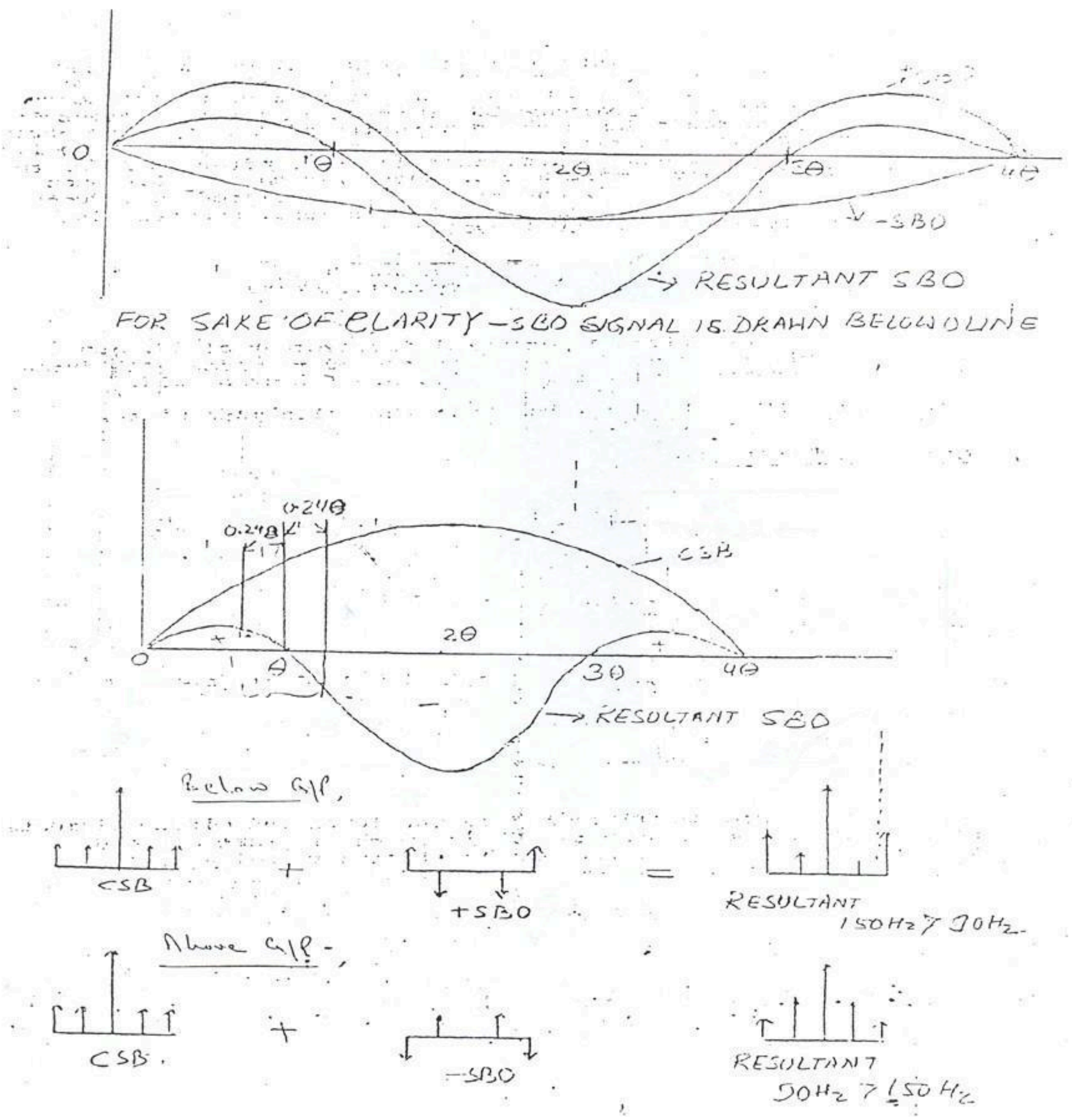


FIG. 37(b)

This gives a reduction of 2.25m from the null reference mast, working with the same value of h. Since the aerials are lower , the affects of irregularities' in ground level are More pronounced but the area required for beam - forming is less than that for the null reference system. The sideband reference system is therefore often used where the ground falls away beyond the landing threshold.

4.2.4 M Array System

Some sites require a system which provides a very high immunity from reflections, even at the expense of other factors. The answer for this is the Quadrature clearance or M array system which is widely used with Normarc Installations.

This array consists of three aerial elements mounted vertically one above the other at heights H, 2H and 3H above the ground as shown in figure 38.

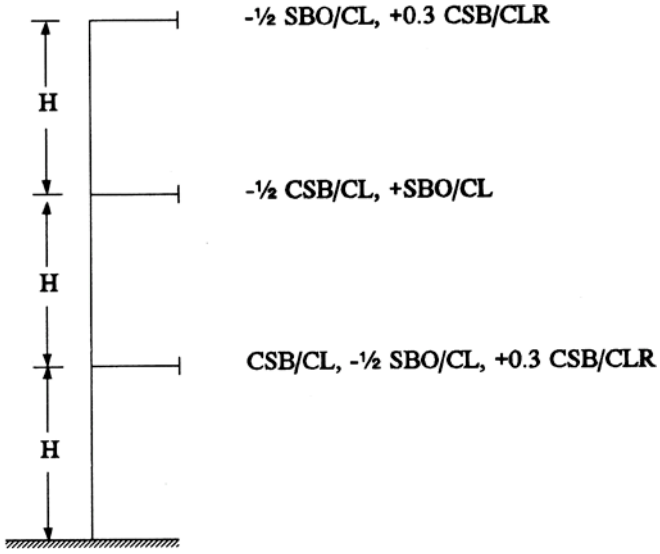


Figure 38

Each element is fed with the proportions of course CSB, course SBO and clearance CSB signals in order to transmit the glide path radiation pattern with the minimum of interference from the obstructions and rising ground lying directly in the glide path field. The clearance radiation is phase advanced 90° on the course radiation to create a crossover region at ± 0.66 about the angle of elevation 9, and also being modulated to a depth of 60 % with 150 Hz tone and 20 % with 90 Hz tone, ensures high values of FLY UP DDM at low elevations.

Here

$$H = \frac{\lambda}{4\sin\theta}$$

λ = Operating Wavelength

θ = Glide Angle

The array offers a potential improvement of 27.5 dB over the null reference array, with regard to glide path interference, assuming an overall reflection factor of 10%.

The DDM is linear throughout the glide path width, being 17.5% at ± 0.24 θ.

The amplitude and phases of the various drives to the aerials of the array are detailed in the following table.

SIGNAL	LOWER AERIAL AMP.	PHASE	MIDDLE AERIAL AMP.	PHASE	UPPER AERIAL AMP.	PHASE
COURSE CSB						
CARRIER	1.0	0^0	0.5	180^0	---	---
150 Hz DSB	0.4	0^0	0.2	180^0	---	---
90 Hz DSB	0.4	0^0	0.2	180^0	---	---
COURSE SBO						
150 Hz DSB	0.071	180^0	0.142	0^0	0.071	180^0
90 Hz DSB	0.071	0^0	0.142	180^0	0.071	0^0
CLEARANCE CSB						
CARRIER	0.3	90^0	---	---	0.3	90^0
150 Hz DSB	0.223	53.8^0	---	---	0.233	53.8^0
90 Hz DSB	0.074	53.8^0	---	---	0.074	53.8^0

COURSE CSB RADIATION :

The course CSB/CL is fed to the lower and middle elements, so that the lower element signal is twice as great as, and in RF antiphase with, the middle element signal. The Course CSB radiation pattern is shown in figure 39.

The height H is calculated from the equation

$$H = \lambda / (4 \sin \theta)$$

where θ is the required glide path angle.

The lower course CSB signal has a sinusoidal distribution, the field strength being given by the equation

$$F \propto \sin (H \sin (\varphi)$$

The middle course CSB signal has sinusoidal distribution at twice the frequency , the field strength being given by the equation.

$$F \propto -1/2 \sin (2H \sin (\varphi)$$

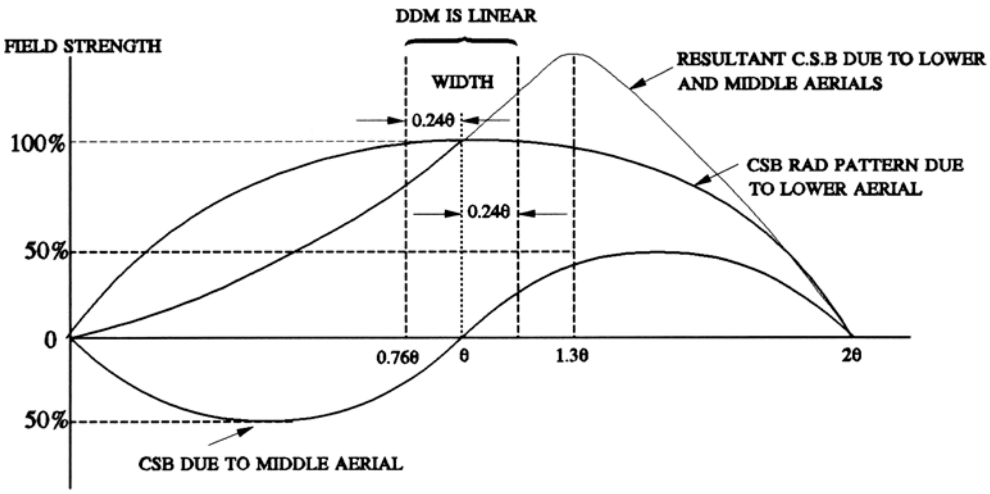


Figure 39

The resultant CSB distribution , obtained by vectorial addition of the two CSB signals has low values at low elevations and rises to maximum at about 1.3 θ , the DDM distribution being linear within the glide path width angle ± 0.24θ.

COURSE SBO RADIATION :

The course SBO signal is fed to all three aerial elements, so that the upper and the lower elements signals are half the amplitude of, and in R.F. antiphase with , the middle element signal. Figure 40 shows the Course SBO radiation.

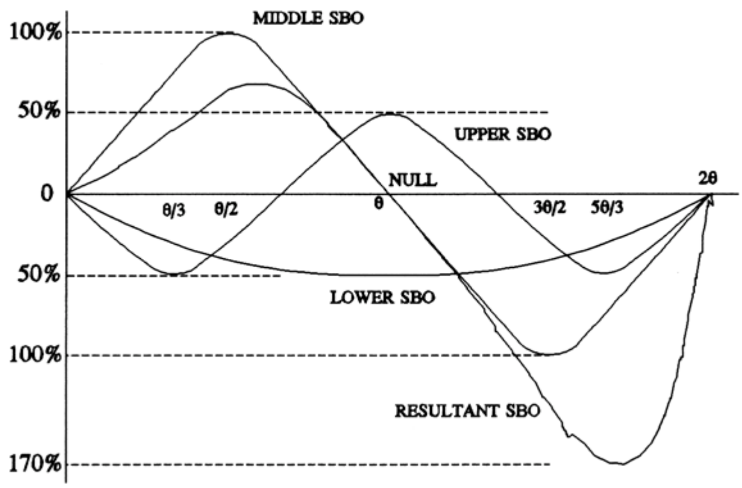


Figure 40

The lower course SBO signal has sinusoidal distribution the field strength being given by the equation

$$F \propto -1/2 \sin (H \sin (\varphi)$$

The middle course SBO signal has sinusoidal distribution at twice the frequency of the lower SBO signal, the field strength being given by equation

$$F \propto \sin(2H\sin(\varphi)$$

The upper course SBO signal has sinusoidal distribution at the three times the frequency of the lower SBO signal, the field strength being given by the equation

$$F \propto -1/2 \sin(3H \sin \varphi)$$

The resultant course SBO pattern is obtained by vectorial addition of the lower, middle and upper SBO distribution and has low values at low elevations, the first lobe maximum occurring at about 0.7θ.The resultant has a null at the glide angle and rises to a second lobe maximum at about 1.6 θ. The distribution through the glide path width of ± 0.24 θ is linear.

CLEARANCE CSB RADIATION

The clearance CSB is fed to the upper and lower aerial elements at a relative signal level of 30 % of the course CSB signal, and in quadrature with it. Figure 41 shows the clearance CSB radiation.

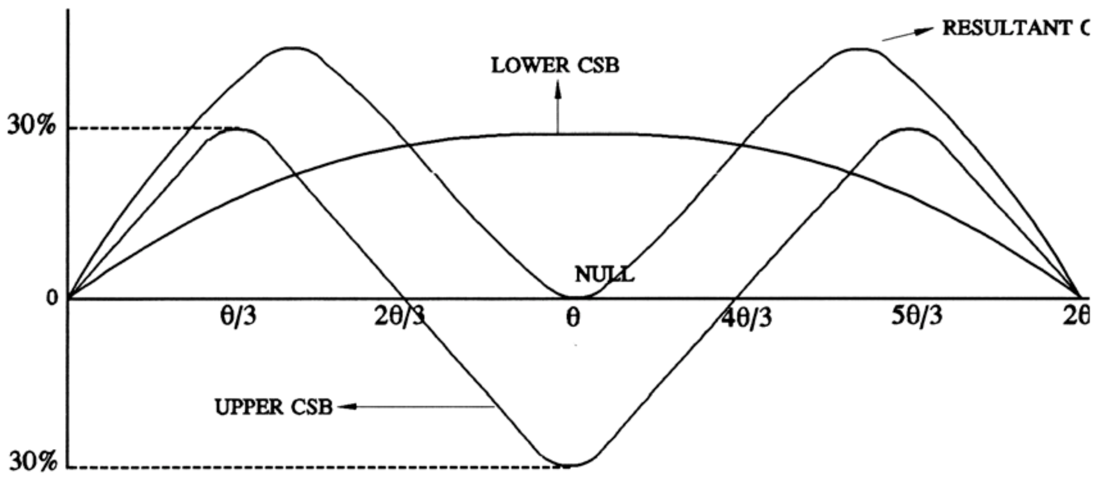


Figure 41

The clearance CSB signal applied to the lower aerial element has sinusoidal distribution , the distribution being given by the equation

$$F \propto 0.3\sin(H \sin\varphi)$$

The clearance CSB signal applied to the upper aerial element has a sinusoidal distribution at three times the frequency of the lower element , the distribution being given by the equation

$$F \propto 0.3\sin(3H\sin\varphi)$$

The distribution of the resultant CSB/CLR signal is symmetrical about the glide path angle, giving a null on the glide path angle and having maxima at 0.4 θ and

1.6 θ.

The resultant clearance CSB signal being modulated to 60 % depth with 150 Hz tone and to 20 % with 90 Hz tone gives a depth of 40 % DDM indication at the aircraft receiver at lower angles than the cross-over angle of 0.6θ . This signal therefore produces a full scale FLY UP indication at the aircraft receiver as required. At the cross-over angle, the relative amplitude of the course CSB carrier and the clearance CSB carrier become equal, but are phased in quadrature. Because of the high rate of change of the course CSB and clearance CSB through the cross-over region, the aircraft receiver will capture the stronger signal, ensuring that spurious indications are completely eliminated.

COMBINED RADIATION PATTERN OF M-ARRAY:

The combined radiation pattern of the M-Array is given in figure 42.

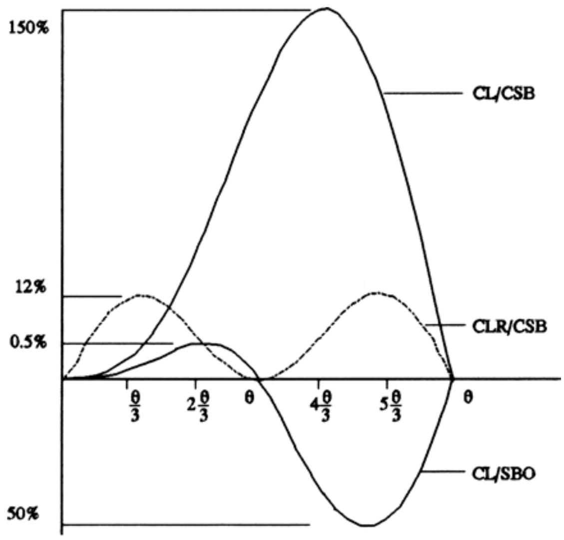


Figure 42 Combined Radiation Pattern

4.2.5. Comparison of different GP system:

Sr.No	System	Advantages	Disadvantages
1	Null reference	stable	1.Aerial height of order of 9m. 2.Suffers from reflections from objects 3.Requires flat foreground out to 360m.
2	Sideband reference	1. Reduced aerial height (now of order of 6.75 m). 2. Some freedom from reflections, 3. Foreground requirement reduced to 300 m.	1. Glide angle depends on electrical balance between signal from two aerials. 2. Ground flatness more critical.
3	Type M	1.Freedom from reflections.	1. Aerial very high (of order of 13.5m). 2. Increased foreground requirement . 3. Glide angle depends on electrical balance between 3 aerials .

ILS RADIATION PATTERN AND DDM

Localizer Course Width

Localizer receivers CPI are calibrated such that 150 µa, FSD corresponds to a DDM value of 0.155. The area between the two edges-of-course is defined as the localizer course sector.

Localizer course widths are adjusted according to runway length. This is referred to as a "tailored course width". The course width is adjusted to be 700 feet wide at the runway threshold. It should be apparent that the longer the runway, the smaller the angular course width.

There are limits on initial localizer course widths. They can be no wider than 6° and no narrower than 3°. If the runway length is long enough that the angular course width calculates to less than 3° when using 700 feet at the runway threshold. The course width is set for 3°. If the tailored width calculates to more than 6°, the course width is set for 6°, on a short runway.

Course Width vs. RF Phase

Proper RF phasing cannot be over emphasized. It is a very important concept that must be understood. It has been discussed before. It must be remembered that for maximum space modulation the rf phase of the separate sideband must be correct. Any change from optimum will cause DDM to decrease and cause the course width to widen.

Glide Path Width

Glide path receiver CPI are calibrated such that 150 microampere of deflection current corresponds to a value of DDM equal to 0.1775. The edge-of-path is defined as a point where the cross pointer current is exactly 150 microamperes. Therefore, a DDM value of 0.178 also corresponds to the edge-of-path. There are two angles where DDM is

0.178, one above the glide angle and the other below the glide angle. The area between these angles is defined as the glide path sector. The path sector is always adjusted for an angular sector width of 1.4 degrees.

Another term, path envelope, is used to define a path sector that is 0.7 degree wide, which is one half of the sector width previously described.

CHAPTER 05

PHASE ERROR IN ILS

5.1 Reasons of phase errors(PROXIMITY EFFECT) :

In previous discussions of radiation patterns, it was assumed that the distance from an antenna array to points of reception was very much greater than the spacing between the antennas in the array. This justifies the assumption that the paths of radiation from antennas in an array to a point of reception in far field are parallel and the distance of travel equal. In effect, the array appears as a "point source" antenna with energy radiating from one antenna. As points of reception are moved closer to the array (near field), the "point source" analogy is no longer valid. The physical spacing between antennas in the array becomes more apparent and the paths of radiation are no longer parallel. As a result, the distance of travel from each antenna of a pair becomes unequal and causes the resultant received energy in near field to be misphased with respect to the resultant in far field. This misphasing is called proximity error and is a very normal effect in both localizers and glide slopes. As misphasing of signals occurs in near field, a widening of course or path results. This causes insensitive cross pointer indications and is potentially dangerous. This is not a serious consequence for a localizer as an aircraft would have landed prior to the near field point. However, facility monitoring and ground checking are performed in near field and this necessitates an understanding of proximity error.

As an aircraft lands in the glide slope near field, proximity error becomes a major consideration and a method to control it for aircraft indications has been developed. Proximity error can be compensated for by off setting antennas.

5.2 Rayleigh distance(Near and far field, Fresnel and Fraunhofer region)

Analysis

Figure 43.shows an antenna array with an aperture of length L and two receivers, one of which (Rx1) is kept in the near field and the other (Rx2) in the far field.

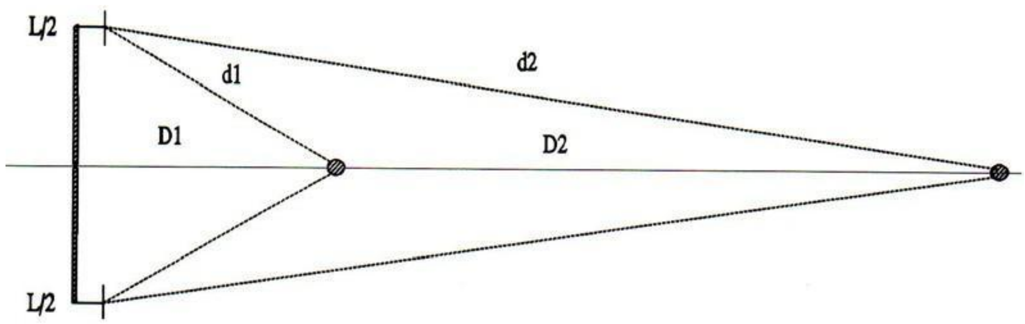


Figure 43.

It can be seen in the case of RX1 , distance D1 is less than dl, implying that, if signals are radiated from the center of the array and extremities of the array in phase, the signal received at Rx1 from the center of the array will be different to that received from the extremities. This could lead to distortion of the signal received at Rx1. In the case of Rx2, D2 is almost the same distance as d2 so there will be only a very small phase difference between the signals received. The greater the distance to the Receiver from the array, the lesser will be the phase error. The distance at which the correct signals may be received will depend on the size of the array and the operating wavelength. The near field region where unrealistic signals are received is known as the RAYLEIGH region. The distance from which correct signals are received is known as the RAYLEIGH DISTANCE and can be found by:

$D = L^2 / \lambda$

Where L = Aperture Length

D = RAYLEIGH Distance

λ = Operating Wavelength

In the case of the NULL REFERENCE glide path system, the maximum height of the antennas may be say 9 meters above the ground but the effective aperture is twice that length i.e., 18 meters because of the image theory. Using the above formula we have:

$D = L^2/\lambda$

$=(18)^2/0.9 = 360$ Meters

From this distance CORRECT information is received. In the case of the M array glide path system, the antenna height may be 13.5 meters, giving an effective aperture of 27 meters. Using the same formula we get:

$D = L^2/\lambda$

$= 729/0.9 = 810$ Meters.

These distances are evidently unacceptable because, accurate glide path data is required down on the runway to a distance of the order of 120 meters (400 feet) from the transmitter. This means that the phase errors have to be minimized in the near field.

Phase error in a NULL REFERENCE glide path system and antenna offset:

Figure 44. shows an aircraft within the near field of a null reference glide path system.

Figure 44.

The RF radiated from the upper dipole B reaches the aircraft located at point C (on glide path) through the path BC, whereas from dipole A, it is through path AC. The difference in lengths of path will create a phase error as shown in figure 44. The phase error will upset the phase relationship between RF radiated from antenna elements A and B, when it reaches point C.

This Phase Error can be expressed as:

$$\varphi = \frac{(H_u)^2 - (H_l)^2}{2D}$$

For 3° Glide Path, $H_u = 10\lambda$ and $H_l = 5\lambda$

Hence for 360° phase error $\varphi = \lambda$. Therefore the distance at which this happens is:

$$D = \frac{H_u^2 - H_l^2}{2\varphi} = \frac{(10\lambda)^2 - (5\lambda)^2}{2\lambda} = \frac{75\lambda^2}{2\lambda} = 37.5\lambda$$

By similar calculations, the values of D for different phase errors are determined and tabulated in the following table:

S. No.	Phase error	Distance from the antenna
1	λ	37.5λ
2	3λ/4	50λ
3	λ/2	75λ
4	λ/4	150λ

Table

It can be seen from the above table that the phase error doubles as the distance is halved from the receiving point. This means that when an aircraft approaches to land, the phase error starts to increase from 0° to 360° and this process repeats as it comes closer and closer.

It is interesting to consider what happens to the guidance information when certain critical phase errors exist i.e. at critical distances from the transmitter. First consider a point where the phase error is 0°, at this point there will be no change in the relative phase, so the guidance information will be correct. Now consider what happens at the point where the phase error is 90° or 270°. Here it is observed that the relative phase of CSB and SBO has changed at the aircraft and by phaser addition of these signals it can be established that 0 DDM results. Hence, we may say that at all points where phase error is 90° or 270°, 0 DDM will result irrespective of aircraft's vertical position (either on glide angle or above or below the glide angle). When phase error is 180°, an inverted glide path results. It can be seen that an aircraft approaching the near field, will receive consecutively correct guidance, 0 DDM, inverted guidance, 0 DDM and correct guidance etc.

Hence the overall effect of the phase error is the widening of glide path. The approaching aircraft instruments would appear less sensitive to changes in height. It can also be proved that increase in the path width is very small at the Middle Marker and is much larger at the Threshold. Hence for all practical purposes, the Middle Marker can be used as the dividing point between the near field and far field.

The situation arising out of phase errors in the near field is obviously unsatisfactory as the glide path will be UNFLYABLE at these close ranges. So modifications must be carried out to minimize the phase errors. The method used to minimize the phase errors on the runway centerline is called antenna offset.

Antenna Offset

It is clear that the phase error is caused by the sideband signals differing in phase with the carrier signals. If a point is chosen directly opposite the glide slope array on the runway center line, the conditions shown in figure 45.

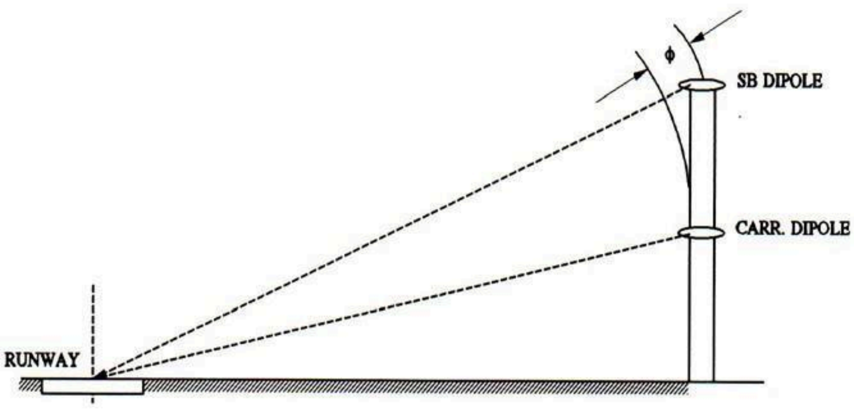


Figure 45.

PROXIMITY PHASE EFFECTS OPPOSITE THE ARRAY

Referring to figure 45, if the signal path lengths were measured from the sideband dipole and the carrier dipole to the runway centerline, it would be found that the sideband signals have to travel a farther distance than the carrier signals. This would cause the sideband signals to lag the carrier signals, as previously stated, resulting in the phase error φ

If we were to move the sideband dipole laterally towards the runway while keeping the carrier dipole centered on the tower, we could make the sideband and carrier signal path lengths equal, thereby, eliminating the phase error on the runway centerline opposite the array. This condition is depicted in figure 46.

Figure 46.

The distance we move the sideband dipole is defined as the antenna offset. At the landing threshold the effect of the offset aerials is reduced. The result is that an aircraft receives correct guidance from the coverage extremities down to the runway. The antennas are offset in a similar manner for the side band reference and M - array glide path systems.

5.4 Placement of Monitor antennas(LLZ and GP)

The monitoring of ILS systems is mandatory. The monitor system must detect system changes that would cause an unsafe condition to exist at a facility. If an equipment parameter were to exceed a prescribed tolerance the monitor system must initiate an equipment transfer or shutdown.

5.4.1 GLIDE PATH MONITORING

The four main parameters that are monitored to prescribed tolerance in a glide path are the glide angle, path width, RF level and Modulation percentage.

There are two methods of sampling the radiated signals for input to the monitor. They are integral and near field monitoring. As the name implies, near field monitoring is accomplished by placing a receiving antenna in the near field in front of the array. Integral monitoring is accomplished by placing pickup loops or dipoles in very close proximity to the radiating element.

In the early days of glide path, a monitor mast was positioned in front of the array and one antenna was placed at a height that intersected the glide angle. This was the method of monitoring the glide angle. Another detector antenna was then positioned at a height not on the glide angle. This antenna was used for monitoring changes in path width. The transmitter RF output, which equated to usable distance, and modulation percentage was sampled off either or both the detector antennas.

The method of monitoring the glide angle has not changed, however, the method of monitoring path width changes has been changed to integral monitor detection. Again RF level and modulation percentage will be sampled and fed back to the monitor system by either method or a combination of both.

Integral Width Monitoring

The path width of a null reference glide slope (NRGS) is a function of the sideband to carrier ratio for various glide angles. This ratio is simply called the A ratio.

In the integral width monitor network the carrier and sideband signals are sampled by probes that are in close proximity to the antenna radiator, coupling factors of -25 dB being typical.

The sampled signals are combined in a combining and phasing unit and fed to the width detector through a double stub tuner. The double stub tuner is used to match the impedance of the bridge port to the monitor input detector.

Near Field Monitoring

In order to monitor the glide angle it should be a simple matter to calculate the glide angle height above ground at a certain distance by using the trigonometric expression of:

$$(\tan\theta)\ (\text{adjacent side}) = \text{opposite side}$$

Where θ is the glide angle, the adjacent side is the distance from the Glide path antenna, and opposite side would be the height of the monitor antenna. See following example:

At Q = 3° the height of the glide angle in feet at a distance of 220 feet from the base of an antenna array is (tan 3°)(220) = 11.53 feet.

So in order to monitor the glide angle it would appear that mounting the antennas at the calculated height and distance from the array would be sufficient. However, in near field we know proximity error exists directly in front of the array; we need to take this into consideration.

Placement of the Field Monitor Antenna

The distances where the phase error due to the proximity effect is -360 degrees and - 180 degrees would be the most logical place to position the near field monitor pole. The two positions duplicate the far field path width conditions. The only difference at 180 degrees phase error is reverse sensing.

Normally the monitor pole is positioned at the -180 degree phase error point, rather than the -360 degree point, for stability in monitoring.

We can use quadrature phasing to locate the actual phase error position of an existing monitor pole. We require this information so we can set the alarm points on the monitor. If the monitor pole were not placed at exactly -180 phase error point then the 0.051 DDM figure must be modified by the cosine of misphasing.

5.4.2 LOCALIZER MONITORING

The localizer monitoring system must be stable, duplicate far field conditions and cause an equipment transfer to standby equipment or a facility shutdown when prescribed tolerances are exceeded.

The parameters that must be monitored in any localizer are course alignment, course width, modulation percent, transmitter RF output level, and identification.

The early antenna arrays used two field detectors to monitor the on course and width signals. The on course detector was located on centerline approximately 150 feet in front of the array at an azimuth of 0°. The off course or width detector was also located approximately 150 feet in front of the array, but at an azimuth of about + 5°. Localizer radiated signals were received, detected to audio levels and fed back to the monitors. The modulation percent, the transmitter RF output level, and identification level are usually sampled from the on course detector signals. Since the detectors are only 150 feet from the antenna array, proximity error must be considered.

Modern antenna systems such as the traveling wave, dipole and log periodic array use the integral monitor system. In the integral monitoring system, a sample of the radiated energy is fed back to a monitor combining circuit and then to the monitor equipment.

Course Alignment

In an ideal localizer system, transmitter modulation would be 20 percent each frequency; also, the composite sideband null would be exactly on runway centerline. Slight errors in the physical placement of the array and individual antennas will cause the sideband null not to be exactly on runway centerline. Also, small differences in the phase of antenna currents of a pair will cause the on course 0 DDM to be slightly displaced off the runway centerline when the modulation factor m90 and m150 are equal.

To correct for these slight differences the modulation equality of the m90 and m150 is unbalanced. So the ILS receiver on centerline will indicate "0" DDM.

With the localizer centerline established, the monitoring of this parameter is of considerable importance. Course alignment is the most important parameter monitored and consequently if not closely checked could allow an aircraft to fly into an obstruction. Course alignment for Category I localizers has a "standard" tolerance of 5% of the commissioned course width. In other words, a facility with a width of 5.0° could have a maximum alignment change of ±. 25°.

Course Width

As stated previously all localizers will be tailored to a course width of 700 feet at threshold as long as the angular width is between 3° and 6°.

Tolerance for course width is ± 17 percent of the normal width. Therefore, the tailored course width at runway threshold will be 700 feet ± 119 feet and the edge of course can shift ± 59.5 feet.

In the early localizer arrays the off course or width detector was located at about 150 feet from the array at an angle of + 5°. When integral monitoring was introduced, the off course detector was simulated. In some systems the simulated DDM reading into the monitor was set to 0.155/150 Hz, the same reading one would have if he had a detector placed at the right edge of course.

Integral Monitoring

Integral monitoring (monitoring of unradiated signals) is used to sense out-of-tolerance conditions in the radiated signals. A sample of the radiated RF signals from each antenna are recombined to develop:

a. A course data signal that will sense changes in course alignment, RF level and modulation.
b. A width data signal that will sense changes in course width.

Recombination circuits are used to combine the sideband and carrier signals from all antennas. The outputs of the recombination circuits were routed to bridge circuits to form the final output signals to the monitors.

CHAPTER 06

SPECIFICATIONS FOR RADIO NAVIGATION AIDS

Note.— Specifications concerning the siting and construction of equipment and installations on operational areas aimed at reducing the hazard to aircraft to a minimum are contained in Annex 14, Chapter 8.

3.1 Specification for ILS

3.1.1 Definitions

Angular displacement sensitivity. The ratio of measured DDM to the corresponding angular displacement from the appropriate reference line.

Back course sector. The course sector which is situated on the opposite side of the localizer from the runway.

Course line. The locus of points nearest to the runway centre line in any horizontal plane at which the DDM is zero.

Course sector. A sector in a horizontal plane containing the course line and limited by the loci of points nearest to the course line at which the DDM is 0.155.

DDM — Difference in depth of modulation. The percentage modulation depth of the larger signal minus the percentage modulation depth of the smaller signal, divided by 100.

Displacement sensitivity (localizer). The ratio of measured DDM to the corresponding lateral displacement from the appropriate reference line.

Facility Performance Category I — ILS. An ILS which provides guidance information from the coverage limit of the ILS to the point at which the localizer course line intersects the ILS glide path at a height of 60 m (200 ft) or less above the horizontal plane containing the threshold.

Note.— This definition is not intended to preclude the use of Facility Performance Category I — ILS below the height of 60 m (200 ft), with visual reference where the quality of the guidance provided permits, and where satisfactory operational procedures have been established.

Facility Performance Category II — ILS. An ILS which provides guidance information from the coverage limit of the ILS to the point at which the localizer course line intersects the ILS glide path at a height of 15 m (50 ft) or less above the horizontal plane containing the threshold.

Facility Performance Category III — ILS. An ILS which, with the aid of ancillary equipment where necessary, provides guidance information from the coverage limit of the facility to, and along, the surface of the runway.

Front course sector. The course sector which is situated on the same side of the localizer as the runway.

Half course sector. The sector, in a horizontal plane containing the course line and limited by the loci of points nearest to the course line at which the DDM is 0.0775.

Half ILS glide path sector. The sector in the vertical plane containing the ILS glide path and limited by the loci of points nearest to the glide path at which the DDM is 0.0875.

ILS continuity of service. That quality which relates to the rarity of radiated signal interruptions during any approach. The level of continuity of service of the localizer or the glide path is expressed in terms of the probability of not losing the radiated guidance signals.

ILS glide path. That locus of points in the vertical plane containing the runway centre line at which the DDM is zero, which, of all such loci, is the closest to the horizontal plane.

ILS glide path angle. The angle between a straight line which represents the mean of the ILS glide path and the horizontal.

ILS glide path sector. The sector in the vertical plane containing the ILS glide path and limited by the loci of points nearest to the glide path at which the DDM is 0.175.

Note.— The ILS glide path sector is located in the vertical plane containing the runway centre line, and is divided by the radiated glide path in two parts called upper sector and lower sector, referring respectively to the sectors above and below the glide path.

ILS integrity. That quality which relates to the trust which can be placed in the correctness of the information supplied by the facility. The level of integrity of the localizer or the glide path is expressed in terms of the probability of not radiating false guidance signals.

ILS Point "A". A point on the ILS glide path measured along the extended runway centre line in the approach direction a distance of 7.5 km (4 NM) from the threshold.

ILS Point "B". A point on the ILS glide path measured along the extended runway centre line in the approach direction a distance of 1 050 m (3 500 ft) from the threshold.

ILS Point "C". A point through which the downward extended straight portion of the nominal ILS glide path passes at a height of 30 m (100 ft) above the horizontal plane containing the threshold.

ILS Point "D". A point 4 m (12 ft) above the runway centre line and 900 m (3 000 ft) from the threshold in the direction of the localizer.

ILS Point "E". A point 4 m (12 ft) above the runway centre line and 600 m (2 000 ft) from the stop end of the runway in the direction of the threshold.

Note.— See Attachment C to Part I, Figure C-1.

ILS reference datum (Point "T"). A point at a specified height located vertically above the intersection of the runway centre line and the threshold and through which the downward extended straight portion of the ILS glide path passes.

Two-frequency glide path system. An ILS glide path in which coverage is achieved by the use of two independent radiation field patterns spaced on separate carrier frequencies within the particular glide path channel.

Two-frequency localizer system. A localizer system in which coverage is achieved by the use of two independent radiation field patterns spaced on separate carrier frequencies within the particular localizer VHF channel.

3.1.2 Basic requirements

3.1.2.1 The ILS shall comprise the following basic components:

a) VHF localizer equipment, associated monitor system, remote control and indicator equipment;

b) UHF glide path equipment, associated monitor system, remote control and indicator equipment;

c) VHF marker beacons, associated monitor systems, remote control and indicator equipment, except as provided in 3.1.7.6.6 below.

Note.— It is intended that the air traffic services unit involved in the control of aircraft on the final approach be one of the designated control points receiving without delay information on the operational status of the ILS as derived from the monitors.

3.1.2.1.1 Facility Performance Categories II and III — ILS also shall comprise remote indicator and control equipment, which shall provide indications at designated remote control points of the operational status of all ILS ground system components.

Note.— It is intended that the air traffic system is likely to call for additional provisions which may be found essential for the attainment of full operational Category III capability, e.g. to provide additional lateral and longitudinal guidance during the landing roll-out, and taxiing, and to ensure enhancement of the integrity and reliability of the system.

3.1.2.2 The ILS shall be constructed and adjusted so that, at a specified distance from the threshold, similar instrumental indications in the aircraft represent similar displacements from the course line or ILS glide path as appropriate, irrespective of the particular ground installation in use.

3.1.2.3 The localizer and glide path components specified in 3.1.2.1 a) and b) above which form part of a Facility Performance Category I — ILS shall comply at least with the Standards in 3.1.3 and 3.1.5 below respectively, excepting those in which application to Facility Performance Category II — ILS is prescribed.

3.1.2.4 The localizer and glide path components specified in 3.1.2.1 a) and b) above which form part of a Facility Performance Category II — ILS shall comply with the Standards applicable to these components in a Facility Performance Category I — ILS, as supplemented or amended by the Standards in 3.1.3 and 3.1.5 below in which application to Facility Performance Category II — ILS is prescribed.

3.1.2.5 The localizer and glide path components and other ancillary equipment specified in 3.1.2.1.1 above, which form part of a Facility Performance Category III — ILS, shall otherwise comply with the Standards applicable to these components in Facility Performance Categories I and II — ILS, except as supplemented by the Standards in 3.1.3 and 3.1.5 below in which application to Facility Performance Category III — ILS is prescribed.

3.1.2.6 To ensure an adequate level of safety, the ILS shall be so designed and maintained that the probability of operation within the performance requirements specified is of a high value, consistent with the category of operational performance concerned.

Note.— The specifications for Facility Performance Categories II and III — ILS are intended to achieve the highest degree of system integrity, reliability and stability of operation under the most adverse environmental conditions to be encountered. Guidance material to achieve this objective in Categories II and III operations is given in 2.8 of Attachment C to Part I.

3.1.2.7 At those locations where two separate ILS facilities serve opposite ends of a single runway, an interlock shall ensure that only the localizer serving the approach direction in use shall radiate, except where the localizer in operational use is Facility Performance Category I — ILS and no operationally harmful interference results.

3.1.2.7.1 **Recommendation.—** *At those locations where two separate ILS facilities serve opposite ends of a single runway and where a Facility Performance Category I — ILS is to be used for auto-coupled approaches and landings in visual conditions an interlock should ensure that only the localizer serving the approach direction in use radiates, providing the other localizer is not required for simultaneous operational use.*

Note.— If both localizers radiate there is a possibility of interference to the localizer signals in the threshold region. Additional guidance material is contained in 2.1.9 and 2.13 of Attachment C to Part I.

3.1.2.7.2 At locations where ILS facilities serving opposite ends of the same runway or different runways at the same airport use the same paired frequencies, an interlock shall ensure that only one facility shall radiate at a time. When switching from one ILS facility to another, radiation from both shall be suppressed for not less than 20 seconds.

Note.— Additional guidance material on the operation of localizers on the same frequency channel is contained in 4.2.6 of Part II and 2.1.9 of Attachment C to Part I.

3.1.3 VHF localizer and associated monitor

Introduction.— The specifications of this 3.1.3 cover ILS localizers providing either positive guidance information over 360 degrees of azimuth, or providing such guidance only within a specified portion of the front coverage (see 3.1.3.7.4 below). Where ILS localizers providing positive guidance information in a limited sector are installed, information from some suitably located navigation aid, together with appropriate procedures, will generally be required to ensure that any misleading guidance information outside the sector is not operationally significant.

3.1.3.1 *General*

3.1.3.1.1 The radiation from the localizer antenna system shall produce a composite field pattern which is amplitude modulated by a 90 Hz and a 150 Hz tone. The radiation field pattern shall produce a course sector with one tone predominating on one side of the course and with the other tone predominating on the opposite side.

3.1.3.1.2 When an observer faces the localizer from the approach end of a runway, the depth of modulation of the radio frequency carrier due to the 150 Hz tone shall predominate on his right hand and that due to the 90 Hz tone shall predominate on his left hand.

3.1.3.1.3 All horizontal angles employed in specifying the localizer field patterns shall originate from the centre of the localizer antenna system which provides the signals used in the front course sector.

3.1.3.2 *Radio frequency*

3.1.3.2.1 The localizer shall operate in the band 108 MHz to 111.975 MHz. Where a single radio frequency carrier is used, the frequency tolerance shall not exceed plus or minus 0.005 per cent. Where two radio frequency carriers are used, the frequency tolerance shall not exceed 0.002 per cent and the nominal band occupied by the carriers shall be symmetrical about the assigned frequency. With all tolerances applied, the frequency separation between the carriers shall not be less than 5 kHz nor more than 14 kHz.

3.1.3.2.2 The emission from the localizer shall be horizontally polarized. The vertically polarized component of the radiation on the course line shall not exceed that which corresponds to a DDM error of 0.016 when an aircraft is positioned on the course line and is in a roll attitude of 20 degrees from the horizontal.

3.1.3.2.2.1 For Facility Performance Category II localizers, the vertically polarized component of the radiation on the course line shall not exceed that which corresponds to a DDM error of 0.008 when an aircraft is positioned on the course line and is in a roll attitude of 20 degrees from the horizontal.

3.1.3.2.2.2 For Facility Performance Category III localizers, the vertically polarized component of the radiation within a sector bounded by 0.02 DDM either side of the course line shall not exceed that which corresponds to a DDM error of 0.005 when an aircraft is in a roll attitude of 20 degrees from the horizontal.

3.1.3.2.3 For Facility Performance Category III localizers, signals emanating from the transmitter shall contain no components which result in an apparent course line fluctuation of more than 0.005 DDM peak to peak in the frequency band 0.01 Hz to 10 Hz.

3.1.3.3 *Coverage*

3.1.3.3.1 The localizer shall provide signals sufficient to allow satisfactory operation of a typical aircraft installation within the localizer and glide path coverage sectors. The localizer coverage sector shall extend from the centre of the localizer antenna system to distances of:

46.3 km (25 NM) within plus or minus 10 degrees from the front course line;

31.5 km (17 NM) between 10 degrees and 35 degrees from the front course line;

18.5 km (10 NM) outside of plus or minus 35 degrees if coverage is provided;

except that, where topographical features dictate or operational requirements permit, the limits may be reduced to 33.3 km (18 NM) within the plus or minus 10-degree sector and 18.5 km (10 NM) within the remainder of the coverage when alternative navigational facilities provide satisfactory coverage within the intermediate approach area. The localizer signals shall be receivable at the distances specified at and above a height of 600 m (2 000 ft) above the elevation of the threshold, or 300 m (1 000 ft) above the elevation of the highest point within the intermediate and final approach areas, whichever is the higher. Such signals shall be receivable, to the distances specified, up to a surface extending outward from the localizer antenna and inclined at 7 degrees above the horizontal.

3.1.3.3.2 In all parts of the coverage volume specified in 3.1.3.3.1 above, other than as specified in 3.1.3.3.2.1, 3.1.3.3.2.2 and 3.1.3.3.2.3 below, the field strength shall be not less than 40 microvolts per metre (minus 114 dBW/m²).

Note.— This minimum field strength is required to permit satisfactory operational usage of ILS localizer facilities.

3.1.3.3.2.1 For Facility Performance Category I localizers, the minimum field strength on the ILS glide path and within the localizer course sector from a distance of 18.5 km (10 NM) to a height of 60 m (200 ft) above the horizontal plane containing the threshold shall be not less than 90 microvolts per metre (minus 107 dBW/m²).

3.1.3.3.2.2 For Facility Performance Category II localizers, the minimum field strength on the ILS glide path and within the localizer course sector shall be not less than 100 microvolts per metre (minus 106 dBW/m²) at a distance of 18.5 km (10 NM) increasing to not less than 200 microvolts per metre (minus 100 dBW/m²) at a height of 15 m (50 ft) above the horizontal plane containing the threshold.

3.1.3.3.2.3 For Facility Performance Category III localizers, the minimum field strength on the ILS glide path and within the localizer course sector shall be not less than 100 microvolts per metre (minus 106 dBW/m²) at a distance of 18.5 km (10 NM), increasing to not less than 200 microvolts per metre (minus 100 dBW/m²) at 6 m (20 ft) above the horizontal plane containing the threshold. From this point to a further point 4 m (12 ft) above the runway centre line, and 300 m (1 000 ft) from the threshold in the direction of the localizer, and thereafter at a height of 4 m (12 ft) along the length of the runway in the direction of the localizer, the field strength shall be not less than 100 microvolts per metre (minus 106 dBW/m²).

Note.— The field strengths given in 3.1.3.3.2.2 and 3.1.3.3.2.3 above are necessary to provide the signal-to-noise ratio required for improved integrity.

3.1.3.3.3 **Recommendation.—** *Above 7 degrees, the signals should be reduced to as low a value as practicable.*

Note 1.— The requirements in 3.1.3.3.1, 3.1.3.3.2.1, 3.1.3.3.2.2 and 3.1.3.3.2.3 above are based on the assumption that the aircraft is heading directly toward the facility.

Note 2.— Guidance material on significant airborne receiver parameters is given in 2.2.2 and 2.2.4 of Attachment C to Part I.

3.1.3.3.4 When coverage is achieved by a localizer using two radio frequency carriers, one carrier providing a radiation field pattern in the front course sector and the other providing a radiation field pattern outside that sector, the ratio of the two carrier signal strengths in space within the front course sector to the coverage limits specified at 3.1.3.3.1 above shall not be less than 10 dB.

Note.— Guidance material on localizers achieving coverage with two radio frequency carriers is given in the Note to 3.1.3.11.2 below and in 2.7 of Attachment C to Part I.

3.1.3.4 *Course structure*

3.1.3.4.1 For Facility Performance Category I localizers, bends in the course line shall not have amplitudes which exceed the following:

Zone	*Amplitude (DDM) (95% probability)*
Outer limit of coverage to ILS Point "A"	0.031
ILS Point "A" to ILS Point "B"	0.031 at ILS Point "A" decreasing at a linear rate to 0.015 at ILS Point "B"
ILS Point "B" to ILS Point "C"	0.015

3.1.3.4.2 For Facility Performance Categories II and III localizers, bends in the course line shall not have amplitudes which exceed the following:

Zone	*Amplitude (DDM) (95% probability)*
Outer limit of coverage to ILS Point "A"	0.031
ILS Point "A" to ILS Point "B"	0.031 at ILS Point "A" decreasing at a linear rate to 0.005 at ILS Point "B"
ILS Point "B" to the ILS reference datum	0.005
and, for Category III only:	
ILS reference datum to ILS Point "D"	0.005
ILS Point "D" to ILS Point "E"	0.005 at ILS Point "D" increasing at a linear rate to 0.010 at ILS Point "E"

Note 1.— The amplitudes referred to in 3.1.3.4.1 and 3.1.3.4.2 above are the DDMs due to bends as realized on the mean course line, when correctly adjusted.

Note 2.— Guidance material relevant to the localizer course structure is given in 2.1.4, 2.1.6 and 2.1.7 of Attachment C to Part I.

3.1.3.5 *Carrier modulation*

3.1.3.5.1 The nominal depth of modulation of the radio frequency carrier due to each of the 90 Hz and 150 Hz tones shall be 20 per cent along the course line.

3.1.3.5.2 The depth of modulation of the radio frequency carrier due to each of the 90 Hz and 150 Hz tones shall be within the limits of 18 and 22 per cent.

3.1.3.5.3 The following tolerances shall be applied to the frequencies of the modulating tones:

a) the modulating tones shall be 90 Hz and 150 Hz within plus or minus 2.5 per cent;

b) the modulating tones shall be 90 Hz and 150 Hz within plus or minus 1.5 per cent for Facility Performance Category II installations,

c) the modulating tones shall be 90 Hz and 150 Hz within plus or minus 1 per cent for Facility Performance Category III installations;

d) the total harmonic content of the 90 Hz tone shall not exceed 10 per cent; additionally, for Facility Performance Category III localizers, the second harmonic of the 90 Hz tone shall not exceed 5 per cent;

e) the total harmonic content of the 150 Hz tone shall not exceed 10 per cent.

3.1.3.5.3.1 **Recommendation.—** *For Facility Performance Category I — ILS, the modulating tones should be 90 Hz and 150 Hz within plus or minus 1.5 per cent where practicable.*

3.1.3.5.3.2 For Facility Performance Category III localizers, the depth of amplitude modulation of the radio frequency carrier at the power supply frequency or its harmonics, or by other unwanted components, shall not exceed 0.5 per cent. Harmonics of the supply, or other unwanted noise components that may intermodulate with the 90 Hz and 150 Hz navigational tones or their harmonics to produce fluctuations in the course line, shall not exceed 0.05 per cent modulation depth of the radio frequency carrier.

3.1.3.5.3.3 The modulation tones shall be phase-locked so that within the half course sector, the demodulated 90 Hz and 150 Hz wave forms pass through zero in the same direction within:

a) for Facility Performance Categories I and II localizers: 20 degrees; and

b) for Facility Performance Category III localizers: 10 degrees,

of phase relative to the 150 Hz component, every half cycle of the combined 90 Hz and 150 Hz wave form.

Note 1.— The definition of phase relationship in this manner is not intended to imply a requirement to measure the phase within the half course sector.

Note 2.— Guidance material relative to such measurement is given at Figure C-6 of Attachment C to Part I.

3.1.3.5.3.4 With two-frequency localizer systems, 3.1.3.5.3.3 above shall apply to each carrier. In addition, the 90 Hz modulating tone of one carrier shall be phase-locked to the 90 Hz modulating tone of the other carrier so that the demodulated wave forms pass through zero in the same direction within:

a) for Categories I and II localizers: 20 degrees; and

b) for Category III localizers: 10 degrees,

of phase relative to 90 Hz. Similarly, the 150 Hz tones of the two carriers shall be phase-locked so that the demodulated wave forms pass through zero in the same direction within:

1) for Categories I and II localizers: 20 degrees; and

2) for Category III localizers: 10 degrees,

of phase relative to 150 Hz.

3.1.3.5.3.5 Alternative two-frequency localizer systems that employ audio phasing different from the normal inphase conditions described in 3.1.3.5.3.4 above shall be permitted. In this alternative system, the 90 Hz to 90 Hz phasing and the 150 Hz to 150 Hz phasing shall be adjusted to their nominal values to within limits equivalent to those stated in 3.1.3.5.3.4 above.

Note.— This is to ensure correct airborne receiver operation in the region away from the course line where the two carrier signal strengths are approximately equal.

3.1.3.5.3.6 **Recommendation.—** *The sum of the modulation depths of the radio frequency carrier due to the 90 Hz and 150 Hz tones should not exceed 95 per cent within the required coverage.*

3.1.3.5.3.7 When utilizing a localizer for radiotelephone communications, the sum of the modulation depths of the radio frequency carrier due to the 90 Hz and 150 Hz tones shall not exceed 65 per cent within 10 degrees of the course line and shall not exceed 78 per cent at any other point around the localizer.

3.1.3.6 *Course alignment accuracy*

3.1.3.6.1 The mean course line shall be adjusted and maintained within limits equivalent to the following displacements from the runway centre line at the ILS reference datum:

a) for Facility Performance Category I localizers: plus or minus 10.5 m (35 ft), or the linear equivalent of 0.015 DDM, whichever is less;

b) for Facility Performance Category II localizers: plus or minus 7.5 m (25 ft);

c) for Facility Performance Category III localizers: plus or minus 3 m (10 ft).

3.1.3.6.2 **Recommendation.—** *For Facility Performance Category II localizers, the mean course line should be adjusted and maintained within limits equivalent to plus or minus 4.5 m (15 ft) displacement from runway centre line at the ILS reference datum.*

Note 1.— It is intended that Facility Performance Categories II and III installations be adjusted and maintained so that the limits specified in 3.1.3.6.1 and 3.1.3.6.2 above are reached on very rare occasions. It is further intended that *design and operation of the total ILS ground system be of sufficient integrity to accomplish this aim.*

Note 2.— It is intended that new Category II installations are to meet the requirements of 3.1.3.6.2 above.

Note 3.— Guidance material on measurement of localizer course alignment is given in 2.1.4 of Attachment C to Part I.

3.1.3.7 *Displacement sensitivity*

3.1.3.7.1 The nominal displacement sensitivity within the half course sector at the ILS reference datum shall be 0.00145 DDM/m (0.00044 DDM/ft) except that for Category I localizers, where the specified nominal displacement sensitivity cannot be met, the displacement sensitivity shall be adjusted as near as possible to that value. For Facility Performance Category I localizers on runway codes 1 and 2, the nominal displacement sensitivity shall be achieved at the ILS Point "B". The maximum course sector angle shall not exceed 6 degrees.

Note.— Runway codes 1 and 2 are defined in Annex 14.

3.1.3.7.2 The lateral displacement sensitivity shall be adjusted and maintained within the limits of plus or minus:

a) 17 per cent of the nominal value for Facility Performance Categories I and II;

b) 10 per cent of the nominal value for Facility Performance Category III.

3.1.3.7.3 **Recommendation.**— *For Facility Performance Category II — ILS, displacement sensitivity should be adjusted and maintained within the limits of plus or minus 10 per cent where practicable.*

Note 1.— The figures given in 3.1.3.7.1 and 3.1.3.7.2 above are based upon a nominal sector width of 210 m (700 ft) at the appropriate point, i.e. ILS Point "B" on runway codes 1 and 2, and the ILS reference datum on other runways.

Note 2.— Guidance material on the alignment and displacement sensitivity of localizers using two radio frequency carriers is given in 2.7 of Attachment C to Part I.

Note 3.— Guidance material on measurement of localizer displacement sensitivity is given in 2.9 of Attachment C to Part I.

3.1.3.7.4 The increase of DDM shall be substantially linear with respect to angular displacement from the front course line (where DDM is zero) up to an angle on either side of the front course line where the DDM is 0.180. From that angle to plus or minus 10 degrees, the DDM shall not be less than 0.180. From plus or minus 10 degrees to plus or minus 35 degrees, the DDM shall not be less than 0.155. Where coverage is required outside of the plus or minus 35 degrees sector, the DDM in the area of the coverage, except in the back course sector, shall not be less than 0.155.

Note 1.— The linearity of change of DDM with respect to angular displacement is particularly important in the neighbourhood of the course line.

Note 2.— The above DDM in the 10-35 degree sector is to be considered a minimum requirement for the use of ILS as a landing aid. Wherever practicable a higher DDM, e.g. 0.180, is advantageous to assist high speed aircraft to execute large angle intercepts at operationally desirable distances.

3.1.3.8 *Voice*

3.1.3.8.1 Facility Performance Categories I and II localizers may provide a ground-to-air radiotelephone communication channel to be operated simultaneously with the navigation and identification signals, provided that such operation shall not interfere in any way with the basic localizer function.

3.1.3.8.2 Category III localizers shall not provide such a channel, except where extreme care has been taken in the design and operation of the facility to ensure that there is no possibility of interference with the navigational guidance.

3.1.3.8.3 If the channel is provided, it shall conform with the following Standards:

3.1.3.8.3.1 The channel shall be on the same radio frequency carrier or carriers as used for the localizer function, and the radiation shall be horizontally polarized. Where two carriers are modulated with speech, the relative phases of the modulations on the two carriers shall be such as to avoid the occurrence of nulls within the coverage of the localizer.

3.1.3.8.3.2 The peak modulation depth of the carrier or carriers due to the radiotelephone communications shall not exceed 50 per cent but shall be adjusted so that:

a) the ratio of peak modulation depth due to the radiotelephone communications to that due to the identification signal is approximately 9:1;

b) the sum of modulation components due to use of the radiotelephone channel, navigational signals and identification signals shall not exceed 95 per cent.

3.1.3.8.3.3 The audio frequency characteristics of the radiotelephone channel shall be flat to within 3 dB relative to the level at 1 000 Hz over the range 300 Hz to 3 000 Hz.

3.1.3.9 *Identification*

3.1.3.9.1 The localizer shall provide for the simultaneous transmission of an identification signal, specific to the runway and approach direction, on the same radio frequency carrier or carriers as used for the localizer function. The transmission of the identification signal shall not interfere in any way with the basic localizer function.

3.1.3.9.2 The identification signal shall be produced by Class A2A modulation of the radio frequency carrier or carriers using a modulation tone of 1 020 Hz within plus or minus 50 Hz. The depth of modulation shall be between the limits of 5 and 15 per cent except that, where a radiotelephone communication channel is provided, the depth of modulation shall be adjusted so that the ratio of peak modulation depth due to radiotelephone communications to that due to the identification signal modulation is approximately 9:1 (see 3.1.3.8.3.2 above). The emissions carrying the identification signal shall be horizontally polarized. Where two carriers are modulated with identification signals, the relative phase of the modulations shall be such as to avoid the occurrence of nulls within the coverage of the localizer.

3.1.3.9.3 The identification signal shall employ the International Morse Code and consist of two or three letters. It may be preceded by the International Morse Code signal of the letter "I", followed by a short pause where it is necessary to distinguish the ILS facility from other navigational facilities in the immediate area.

3.1.3.9.4 The identification signal shall be transmitted at a speed corresponding to approximately seven words per minute, and shall be repeated at approximately equal intervals, not less than six times per minute, at all times during which the localizer is available for operational use. When the transmissions of the localizer are not available for operational use, as, for example, after removal of navigational components, or during maintenance or test transmissions, the identification signal shall be suppressed.

3.1.3.10 *Siting*

3.1.3.10.1 The localizer antenna system shall be located on the extension of the centre line of the runway at the stop end, and the equipment shall be adjusted so that the course lines will be in a vertical plane containing the centre line of the runway served. The antenna system shall have the minimum height necessary to satisfy the coverage requirements laid down in 3.1.3.3 above, and the distance from the stop end of the runway shall be consistent with safe obstruction clearance practices.

3.1.3.11 *Monitoring*

3.1.3.11.1 The automatic monitor system shall provide a warning to the designated control points and cause one of the following to occur, within the period specified in 3.1.3.11.3.1 below, if any of the conditions stated in 3.1.3.11.2 below persists:

a) radiation to cease;

b) removal of the navigation and identification components from the carrier;

c) reversion to a lower category in the case of Facility Performance Categories II and III localizers where the reversion requirement exists.

Note.— It is intended that the alternative of reversion offered in 3.1.3.11.1 above may be used only if:

1) the safety of the reversion procedure has been substantiated; and

2) the means of providing information to the pilot on the change of category has adequate integrity.

3.1.3.11.2 The conditions requiring initiation of monitor action shall be the following:

a) for Facility Performance Category I localizers, a shift of the mean course line from the runway centre line equivalent to more than 10.5 m (35 ft), or the linear equivalent to 0.015 DDM, whichever is less, at the ILS reference datum;

b) for Facility Performance Category II localizers, a shift of the mean course line from the runway centre line equivalent to more than 7.5 m (25 ft) at the ILS reference datum;

c) for Facility Performance Category III localizers, a shift of the mean course line from the runway centre line equivalent to more than 6 m (20 ft) at the ILS reference datum;

d) in the case of localizers in which the basic functions are provided by the use of a single-frequency system, a reduction of power output to less than 50 per cent of normal, provided the localizer continues to meet the requirements of 3.1.3.3, 3.1.3.4 and 3.1.3.5 above;

e) in the case of localizers in which the basic functions are provided by the use of a two-frequency system, a reduction of power output for either carrier to less than 80 per cent of normal, except that a greater reduction to between 80 per cent and 50 per cent of normal may be permitted, provided the localizer continues to meet the requirements of 3.1.3.3, 3.1.3.4 and 3.1.3.5 above;

Note.— It is important to recognize that a frequency change resulting in a loss of the frequency difference specified in 3.1.3.2.1 above may produce a hazardous condition. This problem is of greater operational significance for Categories II and III installations. As necessary, this problem can be dealt with through special monitoring provisions or highly reliable circuitry.

f) change of displacement sensitivity to a value differing by more than 17 per cent from the nominal value for the localizer facility.

Note.— In selecting the power reduction figure to be employed in monitoring referred to in 3.1.3.11.2 e) above, particular attention is directed to vertical and horizontal lobe structure (vertical lobing due to different antenna heights) of the combined radiation systems when two carriers are employed. Large changes in the power ratio between carriers may result in low clearance areas and false courses in the off-course areas to the limits of the vertical coverage requirements specified in 3.1.3.3.1 above.

3.1.3.11.2.1 **Recommendation.—** *In the case of localizers in which the basic functions are provided by the use of a two-frequency system, the conditions requiring initiation of monitor action should include the case when the DDM in the required coverage beyond plus or minus 10 degrees from the front course line, except in the back course sector, decreases below 0.155.*

3.1.3.11.3 The total period of radiation, including period(s) of zero radiation, outside the performance limits specified in a), b), c), d), e) and f) of 3.1.3.11.2 above shall be as short as practicable, consistent with the need for avoiding interruptions of the navigation service provided by the localizer.

3.1.3.11.3.1 The total period referred to under 3.1.3.11.3 above shall not exceed under any circumstances:

10 seconds for Category I localizers;

5 seconds for Category II localizers;

2 seconds for Category III localizers.

Note 1.— The total time periods specified are never-to-be-exceeded limits and are intended to protect aircraft in the final stages of approach against prolonged or repeated periods of localizer guidance outside the monitor limits. For this reason, they include not only the initial period of outside tolerance operation but also the total of any or all periods of outside tolerance radiation including period(s) of zero radiation, which might occur during action to restore service, for example, in the course of consecutive monitor functioning and consequent change-over(s) to localizer equipment(s) or elements thereof.

Note 2.— From an operational point of view, the intention is that no guidance outside the monitor limits be radiated after the time periods given, and that no further attempts be made to restore service until a period in the order of 20 seconds has elapsed.

3.1.3.11.3.2 **Recommendation.—** *Where practicable, the total period under 3.1.3.11.3.1 above should be reduced so as not to exceed two seconds for Category II localizers and one second for Category III localizers.*

3.1.3.11.4 Design and operation of the monitor system shall be consistent with the requirement that navigation guidance and identification will be removed and a warning provided at the designated remote control points in the event of failure of the monitor system itself.

Note.— Guidance material on the design and operation of monitor systems is given in 2.1.8 of Attachment C to Part I.

3.1.3.11.5 Any erroneous navigation signals on the carrier occurring during removal of navigation and identification components in accordance with 3.1.3.11.1 b) above shall be suppressed within the total periods allowed in 3.1.3.11.3.1 above.

Note.— To prevent hazardous fluctuations in the radiated signal, localizers employing mechanical modulation equipment may require suppression of navigation components during modulator rundown.

3.1.4 Interference immunity performance for ILS localizer receiving systems

3.1.4.1 After 1 January 1998, the ILS localizer receiving system shall provide adequate immunity to interference from two signal, third-order intermodulation products caused by VHF FM broadcast signals having levels in accordance with the following:

$$2N_1 + N_2 + 72 \leq 0$$

for VHF FM sound broadcasting signals in the range 107.7 – 108.0 MHz

and

$$2N_1 + N_2 + 3\,(24 - 20 \log \frac{\Delta f}{0.4}) \leq 0$$

for VHF FM sound broadcasting signals below 107.7 MHz,

where the frequencies of the two VHF FM sound broadcasting signals produce, within the receiver, a two signal, third-order intermodulation product on the desired ILS localizer frequency.

N_1 and N_2 are the levels (dBm) of the two VHF FM sound broadcasting signals at the ILS localizer receiver input. Neither level shall exceed the desensitization criteria set forth in 3.1.4.2 below.

$\Delta f = 108.1 - f_1$, where f_1 is the frequency of N_1, the VHF FM sound broadcasting signal closer to 108.1 MHz.

3.1.4.2 After 1 January 1998, the ILS localizer receiving system shall not be desensitized in the presence of VHF FM broadcast signals having levels in accordance with the following table:

Frequency (MHz)	*Maximum level of unwanted signal at receiver input*
88-102	+15 dBm
104	+10 dBm
106	+ 5 dBm
107.9	−10 dBm

The relationship is linear between adjacent points designated by the above frequencies.

Note.— Guidance material on immunity criteria to be used for the performance quoted in 3.1.4.1 and 3.1.4.2 above is contained in Attachment C to Part I, 2.2.10.

3.1.4.3 After 1 January 1995, all new installations of airborne ILS localizer receiving systems shall meet the provisions of 3.1.4.1 and 3.1.4.2 above.

3.1.4.4 **Recommendation.—** *Airborne ILS localizer receiving systems meeting the immunity performance standards of 3.1.4.1 and 3.1.4.2 above should be placed into operation at the earliest possible date.*

3.1.5 UHF glide path equipment and associated monitor

Note.— θ is used in this paragraph to denote the nominal glide path angle.

3.1.5.1 *General*

3.1.5.1.1 The radiation from the UHF glide path antenna system shall produce a composite field pattern which is amplitude modulated by a 90 Hz and a 150 Hz tone. The pattern shall be arranged to provide a straight line descent path in the vertical plane containing the centre line of the runway, with the 150 Hz tone predominating below the path and the 90 Hz tone predominating above the path to at least an angle equal to 1.75 θ.

3.1.5.1.2 **Recommendation.—** *The UHF glide path equipment should be capable of adjustment to produce a radiated glide path from 2 to 4 degrees with respect to the horizontal.*

3.1.5.1.2.1 **Recommendation.—** *The ILS glide path angle should be 3 degrees. ILS glide path angles in excess of 3 degrees should not be used except where alternative means of satisfying obstruction clearance requirements are impracticable.*

3.1.5.1.2.2 The glide path angle shall be adjusted and maintained within:

a) 0.075 θ from θ for Facility Performance Categories I and II — ILS glide paths;

b) 0.04 θ from θ for Facility Performance Category III — ILS glide paths.

Note 1.— Guidance material on adjustment and maintenance of glide path angles is given in 2.4 of Attachment C to Part I.

Note 2.— Guidance material on ILS glide path curvature, alignment and siting, relevant to the selection of the height of the ILS reference datum is given in 2.4 of Attachment C to Part I and Figure C-5.

3.1.5.1.3 The downward extended straight portion of the ILS glide path shall pass through the ILS reference datum at a height ensuring safe guidance over obstructions and also safe and efficient use of the runway served.

3.1.5.1.4 The height of the ILS reference datum for Facility Performance Categories II and III — ILS shall be 15 m (50 ft). A tolerance of plus 3 m (10 ft) is permitted.

3.1.5.1.5 **Recommendation.—** *The height of the ILS reference datum for Facility Performance Category I — ILS should be 15 m (50 ft). A tolerance of plus 3 m (10 ft) is permitted.*

Note 1.— In arriving at the above height values for the ILS reference datum, a maximum vertical distance of 5.8 m (19 ft) between the path of the aircraft glide path antenna and the path of the lowest part of the wheels at the threshold was assumed. For aircraft exceeding this criterion, appropriate steps may have to be taken either to maintain adequate clearance at threshold or to adjust the permitted operating minima.

Note 2.— Appropriate guidance material is given in 2.4 of Attachment C to Part I.

3.1.5.1.6 **Recommendation.—** *The height of the ILS reference datum for Facility Performance Category I — ILS used on short precision approach runway codes 1 and 2 should be 12 m (40 ft). A tolerance of plus 6 m (20 ft) is permitted.*

3.1.5.2 *Radio frequency*

3.1.5.2.1 The glide path equipment shall operate in the band 328.6 MHz to 335.4 MHz. Where a single radio frequency carrier is used, the frequency tolerance shall not exceed 0.005 per cent. Where two carrier glide path systems are used, the frequency tolerance shall not exceed 0.002 per cent and the nominal band occupied by the carriers shall be symmetrical about the assigned frequency. With all tolerances applied, the frequency separation between the carriers shall not be less than 4 kHz nor more than 32 kHz.

3.1.5.2.2 The emission from the glide path equipment shall be horizontally polarized.

3.1.5.2.3 For Facility Performance Category III — ILS glide path equipment, signals emanating from the transmitter shall contain no components which result in apparent glide path fluctuations of more than 0.02 DDM peak to peak in the frequency band 0.01 Hz to 10 Hz.

3.1.5.3 *Coverage*

3.1.5.3.1 The glide path equipment shall provide signals sufficient to allow satisfactory operation of a typical aircraft installation in sectors of 8 degrees in azimuth on each side of the centre line of the ILS glide path, to a distance of at least 18.5 km (10 NM) up to 1.75 θ and down to 0.45 θ above the horizontal or to such lower angle, down to 0.30 θ, as required to safeguard the promulgated glide path intercept procedure.

3.1.5.3.2 In order to provide the coverage for glide path performance specified in 3.1.5.3.1 above, the minimum field strength within this coverage sector shall be 400 microvolts per metre (minus 95 dBW/m²). For Facility Performance Category I glide paths, this field strength shall be provided down to a height of 30 m (100 ft) above the horizontal plane containing the threshold. For Facility Performance Categories II and III glide paths, this field strength shall be provided down to a height of 15 m (50 ft) above the horizontal plane containing the threshold.

Note 1.— The requirements in the foregoing paragraphs are based on the assumption that the aircraft is heading directly toward the facility.

Note 2.— Guidance material on significant airborne receiver parameters is given in 2.2.5 of Attachment C to Part I.

Note 3.— Material concerning reduction in coverage outside 8 degrees on each side of the centre line of the ILS glide path appears in 2.4 of Attachment C to Part I.

3.1.5.4 *ILS glide path structure*

3.1.5.4.1 For Facility Performance Category I — ILS glide paths, bends in the glide path shall not have amplitudes which exceed the following:

Zone	*Amplitude (DDM) (95% probability)*
Outer limit of coverage to ILS Point "C"	0.035

3.1.5.4.2 For Facility Performance Categories II and III — ILS glide paths, bends in the glide path shall not have amplitudes which exceed the following:

Zone	*Amplitude (DDM) (95% probability)*
Outer limit of coverage to ILS Point "A"	0.035
ILS Point "A" to ILS Point "B"	0.035 at ILS Point "A" decreasing at a linear rate to 0.023 at ILS Point "B"
ILS Point "B" to ILS reference datum	0.023

Note 1.— The amplitudes referred to in 3.1.5.4.1 and 3.1.5.4.2 above are the DDMs due to bends as realized on the mean ILS glide path correctly adjusted.

Note 2.— In regions of the approach where ILS glide path curvature is significant, bend amplitudes are calculated from the mean curved path, and not the downward extended straight line.

Note 3.— Guidance material relevant to the ILS glide path course structure is given in 2.1.5 of Attachment C to Part I.

3.1.5.5 *Carrier modulation*

3.1.5.5.1 The nominal depth of modulation of the radio frequency carrier due to each of the 90 Hz and 150 Hz tones shall be 40 per cent along the ILS glide path. The depth of modulation shall not deviate outside the limits of 37.5 per cent to 42.5 per cent.

3.1.5.5.2 The following tolerances shall be applied to the frequencies of the modulating tones:

a) the modulating tones shall be 90 Hz and 150 Hz within 2.5 per cent for Facility Performance Category I — ILS;

b) the modulating tones shall be 90 Hz and 150 Hz within 1.5 per cent for Facility Performance Category II — ILS;

c) the modulating tones shall be 90 Hz and 150 Hz within 1 per cent for Facility Performance Category III — ILS;

d) the total harmonic content of the 90 Hz tone shall not exceed 10 per cent: additionally, for Facility Performance Category III equipment, the second harmonic of the 90 Hz tone shall not exceed 5 per cent;

e) the total harmonic content of the 150 Hz tone shall not exceed 10 per cent.

3.1.5.5.2.1 **Recommendation.**— *For Facility Performance Category I — ILS, the modulating tones should be 90 Hz and 150 Hz within plus or minus 1.5 per cent where practicable.*

3.1.5.5.2.2 For Facility Performance Category III glide path equipment, the depth of amplitude modulation of the radio frequency carrier at the power supply frequency or harmonics, or at other noise frequencies, shall not exceed 1 per cent.

3.1.5.5.3 The modulation shall be phase-locked so that within the ILS half glide path sector, the demodulated 90 Hz and 150 Hz wave forms pass through zero in the same direction within:

a) for Facility Performance Categories I and II — ILS glide paths: 20 degrees;

b) for Facility Performance Category III — ILS glide paths: 10 degrees,

of phase relative to the 150 Hz component, every half cycle of the combined 90 Hz and 150 Hz wave form.

Note 1.— The definition of phase relationship in this manner is not intended to imply a requirement for measurement of phase within the ILS half glide path sector.

Note 2.— Guidance material relating to such measures is given at Figure C-6 of Attachment C to Part I.

3.1.5.5.3.1 With two-frequency glide path systems, 3.1.5.5.3 above shall apply to each carrier. In addition, the

90 Hz modulating tone of one carrier shall be phase-locked to the 90 Hz modulating tone of the other carrier so that the demodulated wave forms pass through zero in the same direction within:

a) for Categories I and II — ILS glide paths: 20 degrees;

b) for Category III — ILS glide paths: 10 degrees,

of phase relative to 90 Hz. Similarly, the 150 Hz tones of the two carriers shall be phase-locked so that the demodulated wave forms pass through zero in the same direction, within:

1) for Categories I and II — ILS glide paths: 20 degrees;

2) for Category III — ILS glide paths: 10 degrees,

of phase relative to 150 Hz.

3.1.5.5.3.2 Alternative two-frequency glide path systems that employ audio phasing different from the normal inphase condition described in 3.1.5.5.3.1 above shall be permitted. In these alternative systems, the 90 Hz to 90 Hz phasing and the 150 Hz to 150 Hz phasing shall be adjusted to their nominal values to within limits equivalent to those stated in 3.1.5.5.3.1 above.

Note.— This is to ensure correct airborne receiver operation within the glide path sector where the two carrier signal strengths are approximately equal.

3.1.5.6 *Displacement sensitivity*

3.1.5.6.1 For Facility Performance Category I — ILS glide paths, the nominal angular displacement sensitivity shall correspond to a DDM of 0.0875 at angular displacements above and below the glide path between 0.07 θ and 0.14 θ.

Note.— The above is not intended to preclude glide path systems which inherently have asymmetrical upper and lower sectors.

3.1.5.6.2 **Recommendation.—** *For Facility Performance Category I — ILS glide paths, the nominal angular displacement sensitivity should correspond to a DDM of 0.0875 at an angular displacement below the glide path of 0.12 θ with a tolerance of plus or minus 0.02 θ. The upper and lower sectors should be as symmetrical as practicable within the limits specified in 3.1.5.6.1 above.*

3.1.5.6.3 For Facility Performance Category II — ILS glide paths, the angular displacement sensitivity shall be as symmetrical as practicable. The nominal angular displacement sensitivity shall correspond to a DDM of 0.0875 at an angular displacement of:

a) 0.12 θ below path with a tolerance of plus or minus 0.02 θ;

b) 0.12 θ above path with a tolerance of plus 0.02 θ and minus 0.05 θ.

3.1.5.6.4 For Facility Performance Category III — ILS glide paths, the nominal angular displacement sensitivity shall correspond to a DDM of 0.0875 at angular displacements above and below the glide path of 0.12 θ with a tolerance of plus or minus 0.02 θ.

3.1.5.6.5 The DDM below the ILS glide path shall increase smoothly for decreasing angle until a value of 0.22 DDM is reached. This value shall be achieved at an angle not less than 0.30 θ above the horizontal. However, if it is achieved at an angle above 0.45 θ, the DDM value shall not be less than 0.22 at least down to 0.45 θ or to such lower angle, down to 0.30 θ, as required to safeguard the promulgated glide path intercept procedure.

Note.— The limits of glide path equipment adjustment are pictorially represented in Figure C-11 of Attachment C to Part I.

3.1.5.6.6 For Facility Performance Category I — ILS glide paths, the angular displacement sensitivity shall be adjusted and maintained within plus or minus 25 per cent of the nominal value selected.

3.1.5.6.7 For Facility Performance Category II — ILS glide paths, the angular displacement sensitivity shall be adjusted and maintained within plus or minus 20 per cent of the nominal value selected.

3.1.5.6.8 For Facility Performance Category III — ILS glide paths, the angular displacement sensitivity shall be adjusted and maintained within plus or minus 15 per cent of the nominal value selected.

Note.— Explanatory material on ILS glide path adjustment and maintenance values appears at 2.1.5 of Attachment C to Part I.

3.1.5.7 *Monitoring*

3.1.5.7.1 The automatic monitor system shall provide a warning to the designated control points and cause radiation to cease within the periods specified in 3.1.5.7.3.1 below if any of the following conditions persist:

a) shift of the mean ILS glide path angle equivalent to more than 0.075 θ from θ;

b) in the case of ILS glide paths in which the basic functions are provided by the use of a single-frequency system, a reduction of power output to less than 50 per cent, provided the glide path continues to meet the requirements of 3.1.5.3, 3.1.5.4 and 3.1.5.5 above;

c) in the case of ILS glide paths in which the basic functions are provided by the use of two-frequency systems, a reduction of power output for either carrier to less than 80 per cent of normal, except that a greater reduction to between 80 per cent and 50 per cent of normal may be permitted, provided the glide path continues to meet the requirements of 3.1.5.3, 3.1.5.4 and 3.1.5.5 above;

Note.— It is important to recognize that a frequency change resulting in a loss of the frequency difference specified in 3.1.5.2.1 above may produce a hazardous condition. This problem is of greater operational significance for Categories II and III installations. As necessary, this problem can be dealt with through special monitoring provisions or highly reliable circuitry.

d) for Facility Performance Category I — ILS glide paths, a change of the angle between the glide path and the line below the glide path (150 Hz predominating) at which a DDM of 0.0875 is realized by more than plus or minus 0.0375 θ;

e) for Facility Performance Categories II and III — ILS glide paths, a change of displacement sensitivity to a value differing by more than 25 per cent from the nominal value;

f) lowering of the line beneath the ILS glide path at which a DDM of 0.0875 is realized to less than 0.7475 θ from horizontal;

g) a reduction of DDM to less than 0.175 within the specified coverage below the glide path sector.

Note 1.— The value of 0.7475 θ from horizontal is intended to ensure adequate obstacle clearance. This value was derived from other parameters of the glide path and monitor specification. Since the measuring accuracy to four significant figures is not intended, the value of 0.75 θ may be used as a monitor limit for this purpose. Guidance on obstacle clearance criteria is given in PANS-OPS (Doc 8168).

Note 2.— Subparagraphs f) and g) are not intended to establish a requirement for a separate monitor to protect against deviation of the lower limits of the half sector below 0.7475 θ from horizontal.

Note 3.— At glide path facilities where the selected nominal angular displacement sensitivity corresponds to an angle below the ILS glide path which is close to or at the maximum limits specified in 3.1.5.6 above, it may be necessary to adjust the monitor operating limits to protect against sector deviations below 0.7475 θ from horizontal.

Note 4.— Guidance material relating to the condition described in g) appears in 2.4.13 of Attachment C to Part I.

3.1.5.7.2 **Recommendation.—** *Monitoring of the ILS glide path characteristics to smaller tolerances should be arranged in those cases where operational penalties would otherwise exist.*

3.1.5.7.3 The total period of radiation, including period(s) of zero radiation, outside the performance limits specified in a), b), c), d), e) and f) of 3.1.5.7.1 above shall be as short as practicable, consistent with the need for avoiding interruptions of the navigation service provided by the ILS glide path.

3.1.5.7.3.1 The total period referred to under 3.1.5.7.3 above shall not exceed under any circumstances:

6 seconds for Category I — ILS glide paths;

2 seconds for Categories II and III — ILS glide paths.

Note 1.— The total time periods specified are never-to-be-exceeded limits and are intended to protect aircraft in the final stages of approach against prolonged or repeated periods of ILS glide path guidance outside the monitor limits. For this reason, they include not only the initial period of outside tolerance operation but also the total of any or all periods of outside tolerance radiation, including period(s) of zero radiation, which might occur during action to restore service, for example, in the course of consecutive monitor functioning and consequent changeover(s) to glide path equipment(s) or elements thereof.

Note 2.— From an operational point of view, the intention is that no guidance outside the monitor limits be radiated after the time periods given, and that no further attempts be made to restore service until a period in the order of 20 seconds has elapsed.

3.1.5.7.3.2 **Recommendation.—** *Where practicable, the total period specified under 3.1.5.7.3.1 above for Categories II and III — ILS glide paths should not exceed 1 second.*

3.1.5.7.4 Design and operation of the monitor system shall be consistent with the requirement that radiation shall cease and a warning shall be provided at the designated remote control points in the event of failure of the monitor system itself.

Note.— Guidance material on the design and operation of monitor systems is given in 2.1.8 of Attachment C to Part I.

3.1.6 Localizer and glide path frequency pairing

3.1.6.1 The pairing of the runway localizer and glide path transmitter frequencies of an instrument landing system shall be taken from the following list in accordance with the provisions of Part II, 4.2:

Localizer (MHz)	*Glide path (MHz)*	*Localizer (MHz)*	*Glide path (MHz)*
108.1	334.7	109.5	332.6
108.15	334.55	109.55	332.45
108.3	334.1	109.7	333.2
108.35	333.95	109.75	333.05
108.5	329.9	109.9	333.8
108.55	329.75	109.95	333.65
108.7	330.5	110.1	334.4
108.75	330.35	110.15	334.25
108.9	329.3	110.3	335.0
108.95	329.15	110.35	334.85
109.1	331.4	110.5	329.6
109.15	331.25	110.55	329.45
109.3	332.0	110.7	330.2
109.35	331.85	110.75	330.05

Localizer (MHz)	Glide path (MHz)	Localizer (MHz)	Glide path (MHz)
110.9	330.8	111.5	332.9
110.95	330.65	111.55	332.75
111.1	331.7	111.7	333.5
111.15	331.55	111.75	333.35
111.3	332.3	111.9	331.1
111.35	332.15	111.95	330.95

3.1.6.1.1 In those regions where the requirements for runway localizer and glide path transmitter frequencies of an instrument landing system do not justify more than 20 pairs, they shall be selected sequentially, as required, from the following list:

Sequence number	Localizer (MHz)	Glide path (MHz)
1	110.3	335.0
2	109.9	333.8
3	109.5	332.6
4	110.1	334.4
5	109.7	333.2
6	109.3	332.0
7	109.1	331.4
8	110.9	330.8
9	110.7	330.2
10	110.5	329.6
11	108.1	334.7
12	108.3	334.1
13	108.5	329.9
14	108.7	330.5
15	108.9	329.3
16	111.1	331.7
17	111.3	332.3
18	111.5	332.9
19	111.7	333.5
20	111.9	331.1

3.1.6.2 Where existing ILS localizers meeting national requirements are operating on frequencies ending in even tenths of a megahertz, they shall be re-assigned frequencies, conforming with 3.1.6.1 or 3.1.6.1.1 above as soon as practicable and may continue operating on their present assignments only until this re-assignment can be effected.

3.1.6.3 Existing ILS localizers in the international service operating on frequencies ending in odd tenths of a megahertz shall not be assigned new frequencies ending in odd tenths plus one twentieth of a megahertz except where, by regional agreement, general use may be made of any of the channels listed in 3.1.6.1 above (see Part II, 4.2).

3.1.7 VHF marker beacons

3.1.7.1 *General*

a) There shall be two marker beacons in each installation except as provided in 3.1.7.6.6 below. A third marker beacon may be added whenever, in the opinion of the Competent Authority, an additional beacon is required because of operational procedures at a particular site.

b) The marker beacons shall conform to the requirements prescribed in this 3.1.7. When the installation comprises only two marker beacons, the requirements applicable to the middle marker and to the outer marker shall be complied with.

c) The marker beacons shall produce radiation patterns to indicate predetermined distance from the threshold along the ILS glide path.

3.1.7.1.1 When a marker beacon is used in conjunction with the back course of a localizer, it shall conform with the marker beacon characteristics specified in 3.7.1 below.

3.1.7.1.2 Identification signals of marker beacons used in conjunction with the back course of a localizer shall be clearly distinguishable from the inner, middle and outer marker beacon identifications, as prescribed in 3.1.7.5.1 below.

3.1.7.2 *Radio frequency*

3.1.7.2.1 The marker beacons shall operate at 75 MHz with a frequency tolerance of plus or minus 0.01 per cent and shall utilize horizontal polarization. As from 1 January 1985 all newly installed marker beacons shall have a frequency tolerance of plus or minus 0.005 per cent. After 1 January 1990 this provision applies for all marker beacons.

3.1.7.2.2 **Recommendation.**— *Marker beacons should operate with a frequency tolerance of plus or minus 0.005 per cent.*

3.1.7.3 *Coverage*

3.1.7.3.1 The marker beacon system shall be adjusted to provide coverage over the following distances, measured on the ILS glide path and localizer course line:

a) *inner marker (where installed):* 150 m plus or minus 50 m (500 ft plus or minus 160 ft);

b) *middle marker:* 300 m plus or minus 100 m (1 000 ft plus or minus 325 ft);

c) *outer marker:* 600 m plus or minus 200 m (2 000 ft plus or minus 650 ft).

3.1.7.3.2 The field strength at the limits of coverage specified in 3.1.7.3.1 above shall be 1.5 millivolts per metre (82 dBW/m²). In addition, the field strength within the coverage area shall rise to at least 3.0 millivolts per metre (76 dBW/m²).

Note 1.— In the design of the ground antenna, it is advisable to ensure that an adequate rate of change of field strength is provided at the edges of coverage. It is also advisable to ensure that aircraft within the localizer course sector will receive visual indication.

Note 2.— Satisfactory operation of a typical airborne marker installation will be obtained if the sensitivity is so adjusted that visual indication will be obtained when the field strength is 1.5 millivolts per metre (82 dBW/m²).

3.1.7.4 *Modulation*

3.1.7.4.1 The modulation frequencies shall be as follows:

a) *inner marker (when installed):* 3 000 Hz;

b) *middle marker:* 1 300 Hz;

c) *outer marker:* 400 Hz.

The frequency tolerance of the above frequencies shall be plus or minus 2.5 per cent, and the total harmonic content of each of the frequencies shall not exceed 15 per cent.

3.1.7.4.2 The depth of modulation of the markers shall be 95 per cent plus or minus 4 per cent.

3.1.7.5 *Identification*

3.1.7.5.1 The carrier energy shall not be interrupted. The audio frequency modulation shall be keyed as follows:

a) *inner marker (when installed):* 6 dots per second continuously;

b) *middle marker:* a continuous series of alternate dots and dashes, the dashes keyed at the rate of 2 dashes per second, and the dots at the rate of 6 dots per second;

c) *outer marker:* 2 dashes per second continuously.

These keying rates shall be maintained to within plus or minus 15 per cent.

3.1.7.6 *Siting*

3.1.7.6.1 The inner marker, when installed, shall be located so as to indicate in low visibility conditions the imminence of arrival at the runway threshold.

3.1.7.6.1.1 **Recommendation.—** *If the radiation pattern is vertical, the inner marker, when installed, should be located between 75 m (250 ft) and 450 m (1 500 ft) from the threshold and at not more than 30 m (100 ft) from the extended centre line of the runway.*

Note 1.— It is intended that the inner marker pattern should intercept the downward extended straight portion of the nominal ILS glide path at the lowest decision height applicable in Category II operations.

Note 2.— Care must be exercised in siting the inner marker to avoid interference between the inner and middle markers. Details regarding the siting of inner markers are contained in 2.10 of Attachment C to Part I.

3.1.7.6.1.2 **Recommendation.—** *If the radiation pattern is other than vertical, the equipment should be located so as to produce a field within the course sector and ILS glide path sector that is substantially similar to that produced by an antenna radiating a vertical pattern and located as prescribed in 3.1.7.6.1.1 above.*

3.1.7.6.2 The middle marker shall be located so as to indicate the imminence, in low visibility conditions, of visual approach guidance.

3.1.7.6.2.1 **Recommendation.—** *If the radiation pattern is vertical, the middle marker should be located 1 050 m (3 500 ft) plus or minus 150 m (500 ft), from the landing threshold at the approach end of the runway and at not more than 75 m (250 ft) from the extended centre line of the runway.*

Note.— See 2.2.2 of Attachment A to Part I, regarding the siting of inner and middle marker beacons.

3.1.7.6.2.2 **Recommendation.—** *If the radiation pattern is other than vertical, the equipment should be located so as to produce a field within the course sector and ILS glide path sector that is substantially similar to that produced by an antenna radiating a vertical pattern and located as prescribed in 3.1.7.6.2.1 above.*

3.1.7.6.3 The outer marker shall be located so as to provide height, distance and equipment functioning checks to aircraft on intermediate and final approach.

3.1.7.6.3.1 **Recommendation.—** *The outer marker should be located 7.2 km (3.9 NM) from the threshold except that, where for topographical or operational reasons this distance is not practicable, the outer marker may be located between 6.5 and 11.1 km (3.5 and 6 NM) from the threshold.*

3.1.7.6.4 **Recommendation.—** *If the radiation pattern is vertical, the outer marker should be not more than 75 m (250 ft) from the extended centre line of the runway. If the radiation pattern is other than vertical, the equipment should be located so as to produce a field within the course sector and ILS glide path sector that is substantially similar to that produced by an antenna radiating a vertical pattern.*

3.1.7.6.5 The positions of marker beacons, or where applicable, the equivalent distance(s) indicated by the DME when used as an alternative to part or all of the marker beacon component of the ILS, shall be published in accordance with the provisions of Annex 15.

3.1.7.6.6 Where the provision of VHF marker beacons is impracticable, a suitably located DME, together with associated monitor system and remote control and indicator equipment shall be an acceptable alternative to part or all of the marker beacon component of the ILS.

Note.— Guidance material relative to the use of DME as an alternative to the marker beacon component of the ILS is contained in Attachment C to Part I, 2.11.

3.1.7.6.6.1 When so used, the DME shall provide distance information operationally equivalent to that furnished by marker beacon(s).

3.1.7.6.6.2 When used as an alternative for the middle marker, the DME shall be frequency paired with the ILS localizer and sited so as to minimize the error in distance information.

3.1.7.6.6.3 The DME in 3.1.7.6.6 above shall conform to the specification in 3.5 below.

3.1.7.7 *Monitoring*

3.1.7.7.1 Suitable equipment shall provide signals for the operation of an automatic monitor. The monitor shall transmit a warning to a control point if either of the following conditions arise:

a) failure of the modulation or keying;

b) reduction of power output to less than 50 per cent of normal.

3.1.7.7.2 **Recommendation.—** *For each marker beacon, suitable monitoring equipment should be provided which will indicate at the appropriate location a decrease of the modulation depth below 50 per cent.*

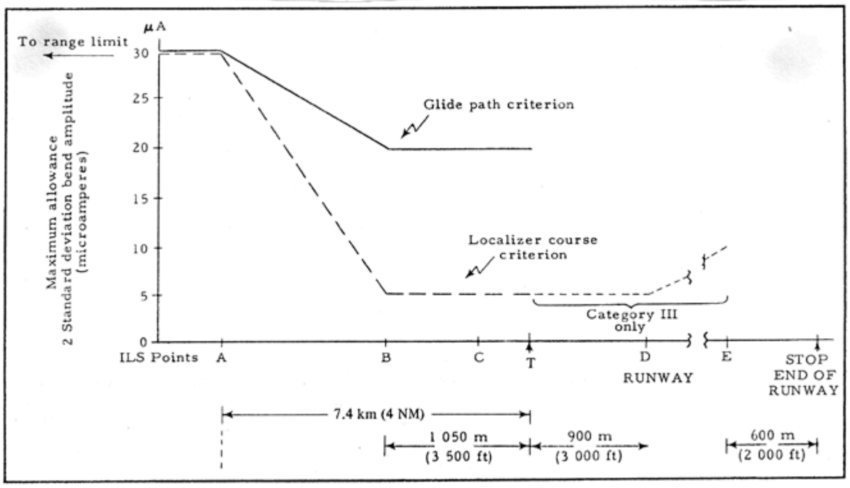


Figure C-I. Categories II and III localizer course and glide path maximum bend amplitude criteria

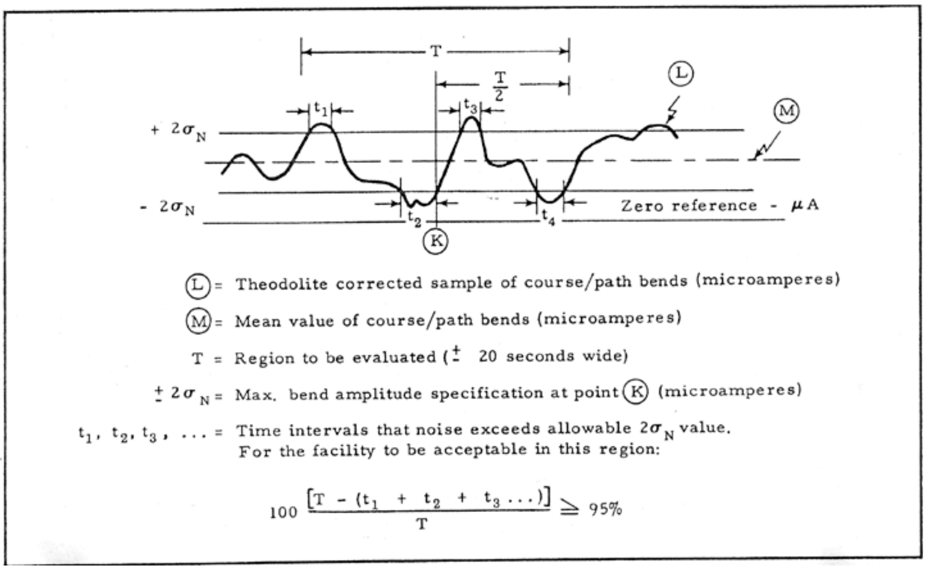
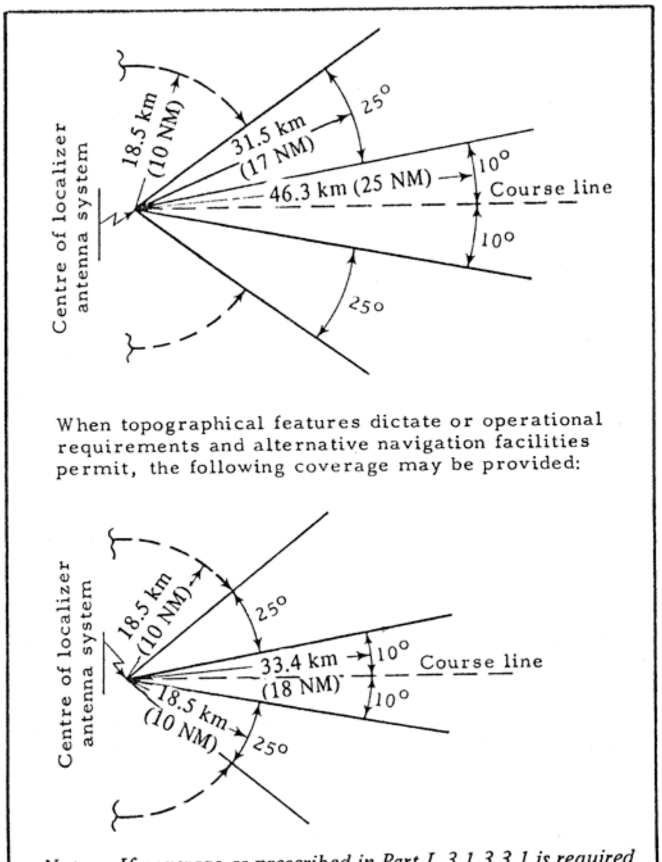


Figure C-2. Evaluation of course/path bend amplitude



Note.— If coverage as prescribed in Part I, 3.1.3.3.1 is required outside the plus or minus 35-degree sector, this shall be provided to 18.5 km (10 NM), as indicated by the broken arc above.

Figure C-7. I,ocalizer coverage in respect to azimuth

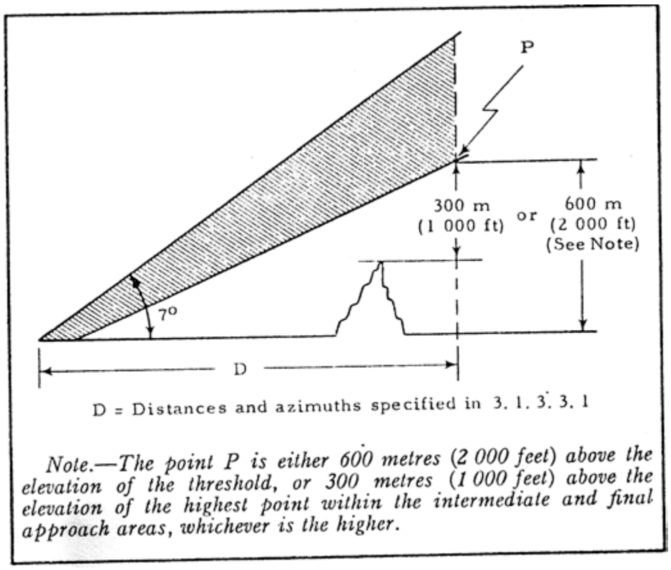


Figure C-8. Localizer coverage with respect to elevation

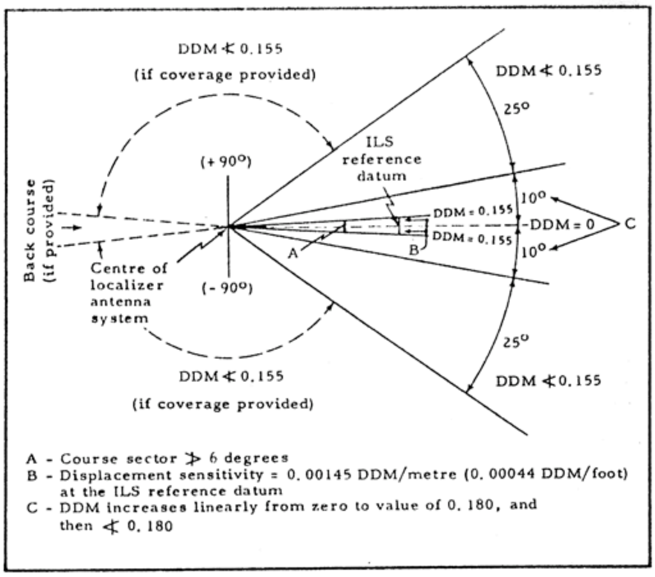


Figure C-9. Difference in depth of modulation and displacement sensitivity

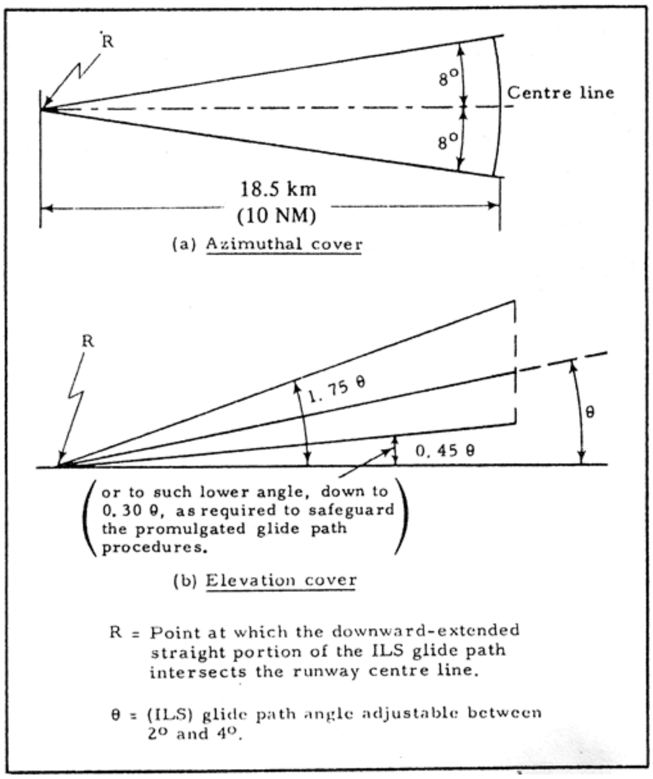
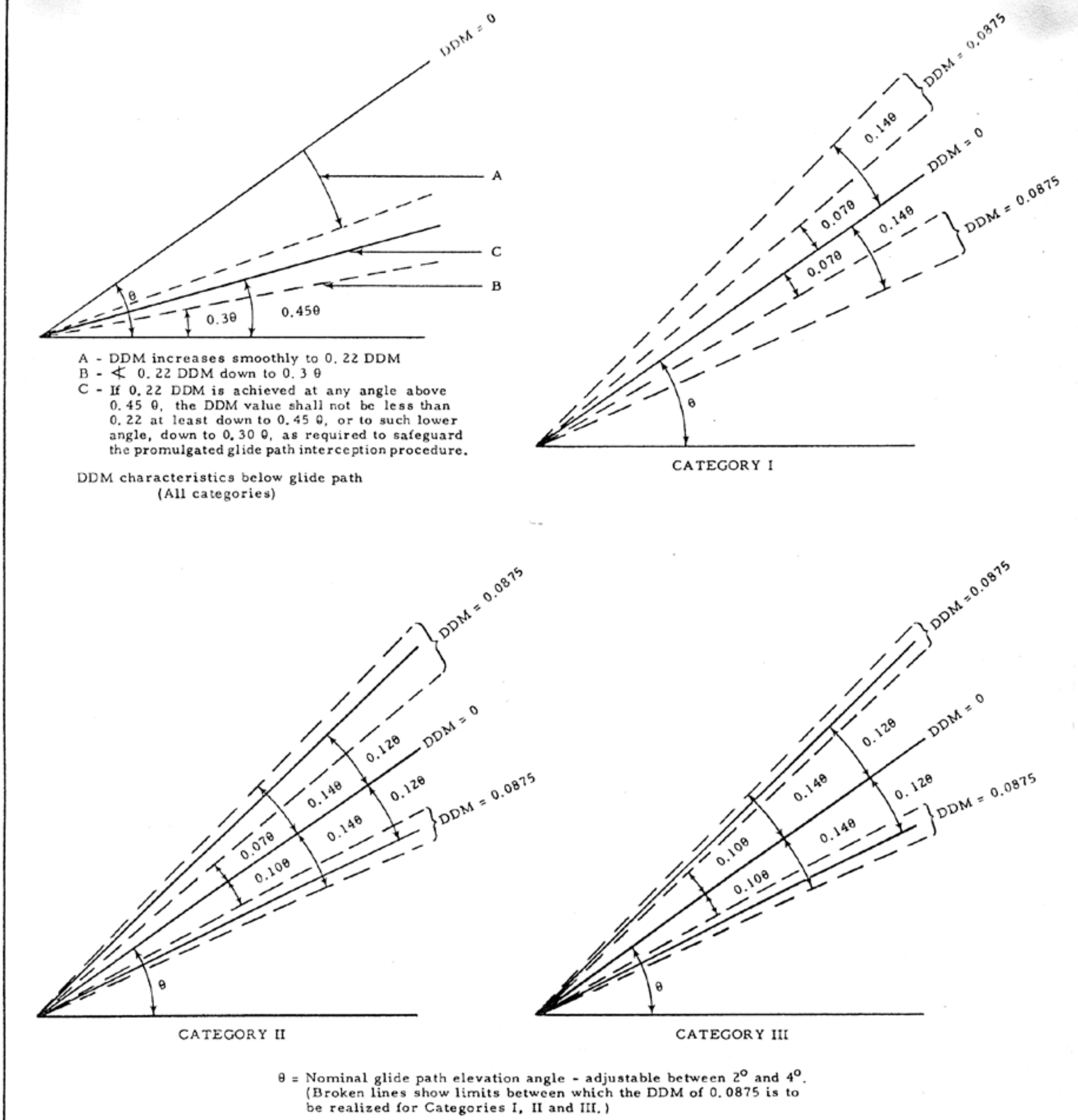
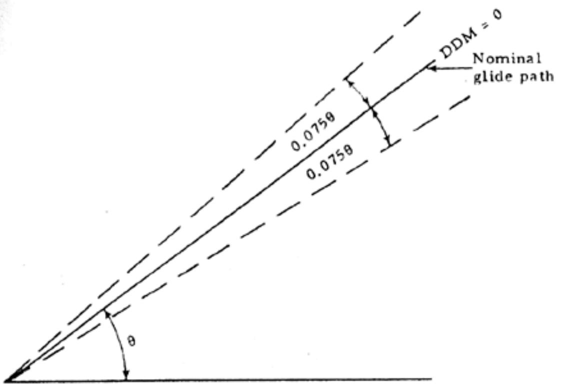


Figure C-10. Glide path coverage

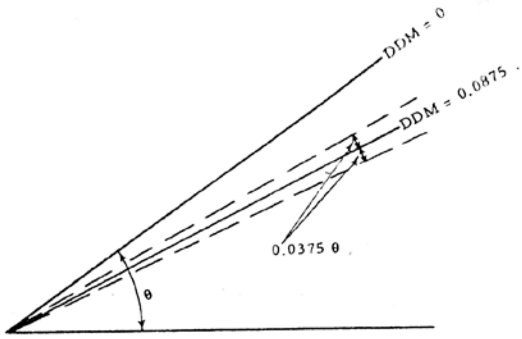


Note.— Figure C-11 depicts the tolerances for the radiated space pattern specified in Part I, 3.1.5.6; however, this space pattern should not be interpreted as being representative of any one particular ground equipment. In this connexion, it should be noted that there are several known types of ILS glide path ground equipment having different characteristics but which can satisfy the requirements of Part I, 3.1.5.6. Therefore, wherever there is a requirement to know the tolerances applicable to a specific equipment, reference should be made to the manufacturer's technical data rather than the ICAO systems specification.

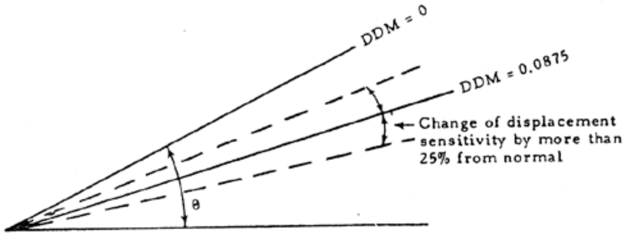
Figure C-11. Glide path - Difference in depth of modulation



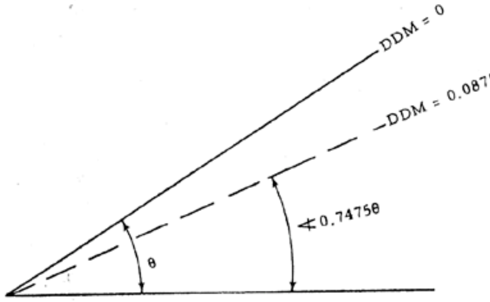
Monitoring provisions of 3.1.5.7.1 a)



Monitoring provisions of 3.1.5.7.1 d)



Monitoring provisions of 3.1.5.7.1.e)



Monitoring provisions of 3.1.5.7.1 f)

Note.—The broken lines represent the permissible limits of deviation before monitoring action is required.

Parameter	Annex 10, Volume I, reference	Doc 8071 Volume I, reference	Measurand	Tolerance (See Note 1)	Uncertainty	Periodicity
Orientation	3.1.3.1		Orientation	Correct		Annual
Frequency	3.1.3.2.1	4.2.12	Frequency	Frequency single: 0.005% Dual: 0.002% Separation: >5 kHz <14 kHz.	0.001% 0.0005%	Annual
Spurious modulation	3.1.3.2.3		DDM, Deviation	<0.005 DDM peak-to-peak	0.001 DDM	Quarterly
Coverage (usable distance)	3.1.3.3.1	4.2.13	Power	As set at commissioning. See Note 2.	1 dB	Quarterly
Course structure (Category III only)	3.1.3.4	4.2.8, 4.2.9	DDM	As described in Annex 10.	0.001 DDM	Quarterly
Carrier modulation — Balance — Depth	3.1.3.5.1	4.2.15	DDM, Depth	Within 10 μA of the modulation balance value. 18-22%	0.001 DDM 0.2%	Quarterly
Carrier modulation frequency	3.1.3.5.3	4.2.14	Frequency	Cat I: ±2.5% Cat II: ±1.5% Cat III: ±1%	0.1%	Annual
Carrier modulation harmonic content (90 Hz)	3.1.3.5.3 d)	4.2.17	Total 2nd harmonic	<10% <5% (Cat III)	0.5%	Annual
Carrier modulation harmonic content (150 Hz)	3.1.3.5.3 e)	4.2.17	Total 2nd harmonic	<10% <5% (Cat III)	0.5%	Annual
Unwanted modulation	3.1.3.5.3.2		Ripple	Modulation depth <0.5%	0.1%	Semi-annual
Phase of modulation tones	3.1.3.5.3.3	4.2.18 to 4.2.20	LF phase	Cat I, II: <20° Cat III: <10°	4° 2°	Annual
Phase of modulation tones dual frequency systems (each carrier and between carriers)	3.1.3.5.3.4	4.2.18 to 4.2.20	LF phase	Cat I, II: <20° Cat III: <10°	4° 2°	Annual
Phasing of alternative systems	3.1.3.5.3.5	4.2.18 to 4.2.20	LF phase	Cat I, II, nominal: ±20° Cat III nominal: ±10°	4° 2°	Annual
Sum of modulation depths	3.1.3.5.3.6	4.2.15	Modulation depth	Modulation depth <95%	2%	Quarterly
Sum of modulation depths when using radiotelephony communications	3.1.3.5.3.7	4.2.15	Modulation depth	Modulation depth <65% ±10°, <78% beyond 10°	2%	Monthly

Parameter	Annex 10, Volume I, reference	Doc 8071 Volume I, reference	Measurand	Tolerance (See Note 1)	Uncertainty	Periodicity
Course alignment	3.1.3.6.1	4.2.8, 4.2.9	DDM, Distance	Cat I: <10.5 m. See Note 2. Cat II: <7.5 m Cat III: < 3 m	0.3 m	I — Quarterly II— Monthly III — Weekly
Displacement sensitivity	3.1.3.7	4.2.10	DDM/metre	0.00145 nominal. See Note 2. Cat I, II: ±17% Cat III: ±10%	±3% ±2%	I, II — Quarterly III — Monthly
Peak modulation depth	3.1.3.8.3.2		Modulation depth	<50%	2%	Quarterly
Audio frequency characteristic	3.1.3.8.3.3		Modulation depth	±3dB	0.5 dB	Annual
Identification tone frequency	3.1.3.9.2		Tone frequency	1 020 ±50 Hz	5 Hz	Annual
Identification modulation depth	3.1.3.9.2	4.2.16	Modulation depth	As commissioned.	1 %	Quarterly
Identification speed	3.1.3.9.4		Tone frequency	1 020 ±50 Hz	1 %	
Identification repetition rate	3.1.3.9.4		Time	As commissioned.		
Phase modulation	3.1.3.5.4	4.2.21 to 4.2.23	Peak deviation	Limits given in FM Hz/PM radians: see Note 5. 90 Hz / 150 Hz / (Difference Hz) Cat I: 135/1.5 / 135/0.9 / 45 Cat II: 60/0.66 / 60/0.4 / 20 Cat III: 45/0.5 / 45/0.3 / 15	10 Hz 5 Hz 5 Hz	3 years
Monitoring — Course shift	3.1.3.11.2	4.2.25	DDM, Distance	See Note 2. Monitor must alarm for a shift in the main course line from the runway centre line equivalent to or more than the following distances at the ILS reference datum. Cat I: 10.5 m (35 ft) Cat II: 7.5 m (25 ft) Cat III: 6.0 m (20 ft)	2 m 1 m 0.7 m	I — Quarterly II — Monthly III — Weekly See Notes 3 and 4
— Change in displacement sensitivity	3.1.3.11.2 f)	4.2.26	DDM, Distance	Monitor must alarm for a change in displacement sensitivity to a value differing from the nominal value by more than: Cat I: 17% Cat II: 17% Cat III: 17%	±3% ±3% ±3%	
— Clearance signal	3.1.3.11.2.1		DDM	Required only for certain types of localizer. Monitor must alarm when the off-course clearance cross-pointer deflection falls below 150 µA anywhere in the off course coverage area	±5 µA	

Parameter	*Annex 10, Volume I, reference*	*Doc 8071 Volume I, reference*	*Measurand*	*Tolerance (See Note 1)*	*Uncertainty*	*Periodicity*
— Reduction in power	3.1.3.11.2 d) and e)	4.2.27	Power field strength	Monitor must alarm either for a power reduction of 3 dB, or when the coverage falls below the requirement for the facility, whichever is the smaller change.	±1 dB relative	
— Total time, out-of-tolerance radiation	3.1.3.11.3	4.2.24	Time	For two-frequency localizers, the monitor must alarm for a change of ±1dB in either carrier, unless tests have proved that use of the wider limits above will not cause unacceptable signal degradation (>150 μa in clearance sector). Cat I: 10 s Cat II: 5 s Cat III: 2 s	±5 μA 0.2 s	

Notes:

1. *In general, the equipment settings should not be modified if the listed parameters are within 50 per cent of tolerance. See 4.2.54 and 4.2.55.*
2. *After the commissioning, flight check for the localizer, ground measurements of course alignment, displacement sensitivity, and power output should be made, both for normal and monitor alarm conditions. These measurements should be noted and used as reference in subsequent routine check measurements.*
3. *The periodicity for monitor tests may be increased if supported by an analysis of integrity and stability history.*
4. *These tests also apply to those parameters measured by the far-field monitor, if installed.*
5. *This measurement applies to the difference in peak frequency deviation between the separate measurements of the undesired 90 Hz FM (or equivalent PM) and the 150 Hz FM, using the filters specified in the table in 4.2.23.*

Table I-4-5. **Ground test requirements for ILS performance Categories I, II and III glide paths**

Parameter	*Annex 10, Volume I, reference*	*Doc 8071 Volume I, reference*	*Measurand*	*Tolerance (See Note 1)*	*Uncertainty*	*Periodicity*
Orientation	3.1.5.1.1		Orientation	Correct		Annual
Path angle	3.1.5.1.2.2	4.2.29 to 4.2.31	DDM, Angle	See Note 2. Cat I: Within 7.5% of nominal angle Cat II: Within 7.5% of nominal angle Cat III: Within 4% of nominal angle	Cat I: 0.75% Cat II: 0.75% Cat III: 0.4%	Quarterly
Frequency	3.1.5.2.1	4.2.34	Frequency	Single 0.005% Dual 0.002% Separation >4 kHz, <32 kHz	0.001% 0.0005% 0.0005%	Annual
Unwanted modulation	3.1.5.2.3		DDM	±0.02 DDM peak-to-peak	0.004 DDM	Semi-annual
Coverage (usable distance)	3.1.5.3	4.2.35	Power	As commissioned.	1 dB	Quarterly
Carrier modulation (See Note 3) — Balance — Depth	3.1.5.5.1	4.2.37	Modulation depth	0.002 DDM 37.5% to 42.5% for each tone	0.001 DDM 0.5%	Quarterly
Carrier modulation frequency	3.1.5.5.2 a), b), and c)	4.2.36	Frequency of modulation tones	Cat I: 2.5% Cat II: 1.5% Cat III: 1%	0.01%	Annual
Carrier modulation harmonic content (90 Hz)	3.1.5.5.2 d)	4.2.38	Total 2nd harmonic	<10% <5% (Cat III)	1%	Annual
Carrier modulation harmonic content (150 Hz)	3.1.5.5.2 e)	4.2.38	Total 2nd harmonic	<10% < 5% (Cat III)	1%	Annual
Unwanted amplitude modulation	3.1.5.5.2.2		Ripple	<1%		Annual
Phase of modulation tones	3.1.5.5.3	4.2.39	Phase	Cat I, II: <20° Cat III: <10°	4° 2°	Annual
Phase of modulation tones, dual frequency systems (each carrier and between carriers)	3.1.5.5.3.1	4.2.39	Phase	Cat I, II: <20° Cat III: <10°	4° 2°	Annual
Phase of modulation tones, alternative systems	3.1.5.5.3.2	4.2.39	Phase	Cat I, II: Nominal ± 20° Cat III: Nominal ± 10°	4° 2°	Annual
Displacement sensitivity	3.1.5.6	4.2.32	DDM, Angle	Refer to Annex 10, Volume I, 3.1.5.6 See Note 2.	Cat I: 2.5% Cat II: 2.0% Cat III: 1.5%	Quarterly Quarterly Monthly

Parameter	Annex 10, Volume I, reference	Doc 8071 Volume I, reference	Measurand	Tolerance (See Note 1)	Uncertainty	Periodicity
Phase modulation	3.1.5.5.4		Peak deviation	Limits given in FM Hz / PM radians: See Note 5. 90 Hz 150 Hz Difference (Hz) Cat I: 150/1.66 150/1.0 50 Cat II, III: 90/1.0 90/0.6 30	10 Hz 10 Hz	3 years
Monitoring (See Note 4) — Path angle	3.1.5.7.1 a)	4.2.42	DDM, Angle	See Note 2. Monitor must alarm for a change in angle of 7.5% of the promulgated angle.	±4 µA	Cat I, II — Quarterl Cat III — Monthly
— Change in displacement sensitivity	3.1.5.7.1 d), e)	4.2.43	DDM, Angle	Cat I: Monitor must alarm for a change in the angle between the glide path and the line below the glide path at which 75 µA is obtained, by more than 3.75% of path angle. Cat II: Monitor must alarm for a change in displacement sensitivity by more than 25%. Cat III: Monitor must alarm for a change in displacement sensitivity by more than 25%.		
— Reduction in power	3.1.5.7.1 b), c)	4.2.44	Power	Monitor must alarm either for a power reduction of 3 dB, or when the coverage falls below the requirement for the facility, whichever is the smaller change.	±1 dB	
				For two-frequency glide paths, the monitor must alarm for a change of ±1dB in either carrier, unless tests have proved that use of the wider limits above will not cause unacceptable signal degradation.	±0.5 dB	
— Clearance signal	3.1.5.7.1 g)		DDM, Angle	Monitor must alarm for DDM <0.175 below path clearance area		
— Total time of out-of-tolerance radiation	3.1.5.7.3.1	4.2.24	Time	Cat I: 6 s Cat II, III: 2 s		

Notes:

1. In general, the equipment settings should not be modified if the listed parameters are within 50 per cent of the given tolerances. See 4.2.54 and 4.2.55.

2a) After the commissioning, flight check for the glide path, ground measurements of glide path angle, displacement sensitivity, and clearance below path, may be made, both for normal and monitor alarm conditions. These measurements may be used as reference in subsequent routine check measurements.

2b) After the commissioning, flight check for the glide path and ground measurements of the glide path power should be made, both for normal and monitor alarm conditions. These measurements may be used as reference in subsequent routine check measurements.

3. The tolerances given are for routine checks only. All parameters should be set to nominal values at the time of commissioning.

4. The periodicity for monitor tests may be increased if supported by an analysis of integrity and stability history.

5. This measurement applies to the difference in peak frequency deviation between the separate measurements of the undesired 90 Hz FM (or equivalent PM) and the 150 Hz FM, using the filters specified in the table in 4.2.23.

Table I-4-6. Ground test requirements for ILS marker beacons

Parameter	*Annex 10, Volume I, reference*	*Doc 8071 Volume I, reference*	*Measurand*	*Tolerance (see Note 1)*	*Uncertainty*	*Periodicity*
Frequency	3.1.7.2.1	4.2.45	Frequency	±0.01% (0.005% recommended)	0.001%	Annual
RF output power		4.2.46	Power	±15%	5%	Quarterly
Carrier modulation	3.1.7.4.2	4.2.47	Modulation depth	91-99%	2%	Quarterly
Carrier modulation frequency	3.1.7.4.1	4.2.48	Frequency of tone	Nominal ±2.5%	0.01%	Semi-annual
Carrier modulation harmonic content		4.2.49	Modulation depth	Total <15%	1%	Annual
Keying	3.1.7.5.1	4.2.50	Keying	Proper keying, clearly audible OM: 400 Hz, 2 dashes per second continuously. MM: 1 300 Hz, alternate dots and dashes continuously. The sequence being repeated once per second. IM: 3 000 Hz, 6 dots per second continuously.	 ±0.1 s ±0.1 s ±0.03 s	Quarterly
Monitor system — Carrier power — Modulation depth — Keying	3.1.7.7.1	4.2.51	 Power Percent Presence	Alarm at: -3 dB >50 % Loss or continuous	 1 dB 2%	Quarterly See Note 2.

Notes:

1. The tolerances given are for routine checks only. All parameters should be set to nominal values at the time of commissioning.
2. The periodicity for monitor tests may be increased if supported by an analysis of integrity and stability history.

Table I-4-7. Flight inspection requirements and tolerances for localizer Category (Cat) I, II and III

Parameter	*Annex 10, Volume I, reference*	*Doc 8071, Volume I, reference*	*Measurand*	*Tolerance*	*Uncertainty*	*Inspection type*		
						S	*C, C*	*P*
Identification	3.1.3.9	4.3.12	Morse code	Proper keying, clearly audible to the limit of the range.	Subjective assessment		x	x
Voice feature	3.1.3.8	4.3.13	Audibility, DDM	Clear audio level similar to identification, no effect on course line.	Subjective assessment		x	x
Modulation	N/A		DDM, Modulation, Depth	See Note 1.				x
— Balance	3.1.3.5	4.3.14		0.002 DDM	0.001 DDM	x	x	
— Depth		4.3.15		18% to 22%	±.5%	x	x	x
Displacement sensitivity	3.1.3.7	4.3.16 to 4.3.20	DDM	Cat I: Within 17% of the nominal value Cat II: Within 17% of the nominal value Cat III: Within 10% of the nominal value See Note 2.	±3 μA ±3 μA ±2 μA For nominal 150 μA input	x	x	x
Off-course clearance	3.1.3.7.4	4.3.21, 4.3.22	DDM	On either side of course line, linear increase to 175 μA, then maintenance of 175 μA to 10°. Between 10° and 35°, minimum 150 μA. Where coverage required outside of ±35°, minimum of 150 μA except in back course sector.	±5 μA For nominal 150 μA input	x	x	x
High-angle clearance	N/A	4.3.23 to 4.3.25	DDM	Minimum of 150 μA.	±5 μA For nominal 150 μA input	x	x	
Course alignment accuracy	3.1.3.6	4.3.26 to 4.3.28	DDM, Distance, Angle	Equivalent to the following displacements at the ILS reference datum: Cat I: ±10.5 m (35 ft) Cat II: ±7.5 m (25 ft) [±4.5 m (15 ft) for those Cat II localizers which are adjusted and maintained within ±4.5 m] Cat III: ±3 m (10 ft)	Cat I: ±2 m Cat II: ±1 m Cat III: ±0.7m	x	x	x
Phasing		4.3.39, 4.3.40	DDM	≤10 μA of the modulation balance value. See Note 3.	±1 μA	x	x	x
DDM increase linear	3.1.3.7.4		DDM	>180 μA (Linear increase from 0 to >180 μA)			x	x
Voice no interference to basic function	3.1.3.8		DDM, Speech	No interference.			x	x
Phase to avoid voice null on dual frequency systems	3.1.3.8.3.1		Speech	No nulls.			x	x

Parameter	Annex 10, Volume I, reference	Doc 8071, Volume I, reference	Measurand	Tolerance	Uncertainty	Inspection type S	Inspection type C, C	Inspection type P
Course structure	3.1.3.4 See Annex 10, Volume I, Attachment C, Note to 2.1.3	4.3.29 to 4.3.33	DDM	Outer limit of coverage to Point A: 30 µA all categories Point A to Point B: Cat I: Linear decrease to 15 µA Cat II: Linear decrease to 5 µA Cat III: Linear decrease to 5 µA Beyond Point B: Cat I: 15 µA to Point C Cat II: 5 µA to Reference datum Cat III: 5 µA to Point D, then linear increase to 10 µA at Point E. See Note 4 for application of tolerances.	See Annex 10, Volume I, Att. C, 2.1.5. From Point A to B, 3 µA decreasing to 1 µA From Point B to E, 1 µA	x	x	x
Coverage (usable distance)	3.1.3.3 See Annex 10, Volume I, Attachment C, Figures C-7 and C-8	4.3.34 to 4.3.36	Flag current, DDM	From the localizer antenna to distances of: 46.3 km (25 NM) within ±10° from the course line. 31.5 km (17 NM) between 10° and 35° from the course line. 18.5 km (10 NM) beyond ±35° if coverage is provided. (See detailed procedure for exceptions.)		x	x	x
— Field strength			Field strength	>40 microvolts/metre (−114 dBW/m2)	±3 dB			
Polarization	3.1.3.2.2	4.3.37	DDM	For a roll attitude of 20° from the horizontal: Cat I: 15 µA on the course line Cat II: 8 µA on the course line Cat III: 5 µA within a sector bounded by 20 µA either side of the course line.	± 1 µA	x	x	
Back course		4.3.41 to 4.3.43	DDM, Angle	Not less than 3°.	0.1 °		x	x
— Sector width	N/A							
— Alignment	N/A		DDM, Distance	Within 60 m of the extended centre line at 1 NM.	±6 m		x	x
— Structure	N/A		DDM	Limit of coverage to final approach fix: ±40 µA FAF to 1.85 km (1 NM) from threshold: ±40 µA Decreasing at a linear rate to: ±20 µA	Annex 10, Volume I, Attachment C, 2.1.4		x	x
— Modulation depth	N/A		Modulation depth	18% to 22% approximately 9 km (5 NM) from the localizer. See Note 1.	±0.5%		x	x

Parameter	Annex 10, Volume I, reference	Doc 8071, Volume I, reference	Measurand	Tolerance	Uncertainty	Inspection type S	Inspection type C, C	Inspection type P
Monitor system	3.1.3.11	4.3.38		See Note 2.				
— Alignment			DDM, Distance	Monitor must alarm for a shift in the main course line from the runway centre line equivalent to or more than the following distances at the ILS reference datum. Cat I: 10.5 m (35 ft) Cat II: 7.5 m (25 ft) Cat III: 6.0 m (20 ft)	 2 m 1 m 0.7 m		x	x
— Displacement sensitivity			DDM, Distance	Monitor must alarm for a change in displacement sensitivity to a value differing from the nominal value by more than: Cat I: 17% Cat II: 17% Cat III: 17%	 ±4% ±4% ±2%		x	x
— Off-course clearance			DDM	Required only for certain types of localizer. Monitor must alarm when the off-course clearance cross-pointer deflection falls below 150 μA anywhere in the off-course coverage area.	±5 μA ±1 dB relative		x	x
— Power			Power field strength	Monitor must alarm either for a power reduction of 3 dB, or when the coverage falls below the requirement for the facility, whichever is the smaller change. For two-frequency localizers, the monitor must alarm for a change of ±1 dB in either carrier, unless tests have proved that use of the wider limits above will not cause unacceptable signal degradation (>150 μa in clearance sector)	± 5 μA		x	

Notes:

1. *Recommended means of measurement is by ground check.*
2. *Recommended means of measurement is by ground check, provided that correlation has been established between ground and air measurements.*
3. *Optional, at the request of the ground technician, unless good correlation between airborne and ground phasing techniques has not been established.*
4. *Course structure along the runway may be measured by flight inspection or by ground vehicle. Refer to 4.3.79 for guidance on structure analysis.*

Legend: N/A = *Not applicable*
S = *Site*
C, C = *Commissioning, Categorization*
P = *Periodic — Nominal periodicity 180 days*

Table I-4-8. Flight inspection requirements and tolerances for glide path Categories (Cat) I, II and III

Parameter	Annex 10, Volume I, reference	Doc 8071, Volume I, reference	Measurand	Tolerance	Uncertainty	Inspection type S	C,C	P
Angle — Alignment	3.1.5.1.2.2	4.3.45, 4.3.46	DDM, Angle	Cat I: Within 7.5% of nominal angle Cat II: Within 7.5% of nominal angle Cat III: Within 4% of nominal angle	Cat I: 0.75% Cat II: 0.75% Cat III: 0.3% of nominal angle	x	x	x
— Height of reference datum	3.1.5.1.5 3.1.5.1.6 3.1.5.1.4		DDM	Cat I: 15 m (50 ft) + 3 m (10 ft) (See Note 3) Cat II: 15 m (50 ft) + 3 m (10 ft) (See Note 3) Cat III: 15 m (50 ft) + 3 m (10 ft) (See Note 3)	0.6 m		x	
Displacement sensitivity — Value — Symmetry	3.1.5.6	4.3.47 to 4.3.49	DDM, Angle	Refer to Annex 10, Volume I, 3.1.5.6	Cat I: 2.5% Cat II: 2.0% Cat III: 1.5%	x	x	x
Clearance — Below path	3.1.5.6.5	4.3.50	DDM, Angle	Not less than 190 µA at an angle above the horizontal of not less than 0.3θ. If 190 µA is realized at an angle greater than 0.45θ, a minimum of 190 µA must be maintained at least down to 0.45θ.	±6 µA for a nominal 190 µA input	x	x	x
— Above path	3.1.5.3.1			Must attain at least 150 µA and not fall below 150 µA until 1.75θ is reached.				
Glide path structure	3.1.5.4	4.3.52	DDM	See Note 5. Cat I: From coverage limit to Point C: 30 µA. Cat II and III: From coverage limit to Point A: 30 µa From Point A to Point B: linear decrease from 30 µA to 20 µA. From Point B to reference datum: 20 µA.	Cat I: 3 µA Cat II: 2 µA Cat III: 2 µA	x	x	x
Modulation — Balance — Depth	3.1.5.5.1	4.3.3.53 4.3.54	Modulation depth	See Note 1. 0.002 DDM 37.5% to 42.5% for each tone.	0.001 DDM 0.5%	x x	x x	x x
Obstruction — Clearance	N/A	4.3.55	DDM	Safe clearance at 180 µa (Normal), or at 150 µa (wide alarm).	Subjective assessment	x	x	x
Coverage — Usable distance	3.1.5.3	4.3.56	Flag current	Satisfactory receiver operation in sector 8° azimuth either side of the localizer centre line for at least 18.5 km (10 NM) up to 1.75θ and down to 0.45θ above the horizontal, or to a lower angle, down to 0.3θ as required to safeguard the glide path intercept procedure.	±3 dB	x	x	x
— Field strength			Field strength	>400 µV/m (−95 dBW/m²) (Refer to Annex 10 for specific signal strength requirements.)				

Parameter	Annex 10, Volume I, reference	Doc 8071, Volume I, reference	Measurand	Tolerance	Uncertainty	Inspection type S	C,C	P
Monitor system	3.1.5.7	4.3.57, 4.3.58		See Note 2.				
— Angle			DDM, Angle	Monitor must alarm for a change in angle of 7.5% of the promulgated angle	±4 µA		x	x
— Displacement sensitivity			DDM, Angle	Cat I: Monitor must alarm for a change in the angle between the glide path and the line below the glide path at which 75 µA is obtained, by more than 0.037θ. Cat II: Monitor must alarm for a change in displacement sensitivity by more than 25%. Cat III: Monitor must alarm for a change in displacement sensitivity by more than 25%.	±4 µA ±1 dB		x	x
— Power			Power	Monitor must alarm either for a power reduction of 3 dB, or when the coverage falls below the requirement for the facility, whichever is the smaller change. For two-frequency glide paths, the monitor must alarm for a change of ±1 dB in either carrier, unless tests have proved that use of the wider limits above will not cause unacceptable signal degradation.	±0.5 dB			
Phasing	N/A	4.3.59 to 4.3.65		No fixed tolerance. To be optimized for the site and equipment. See Note 4.	N/A		x	x

Notes:

1. *Recommended means of measurement is by ground check.*
2. *Recommended means of measurement is by ground check, provided that correlation has been established between ground and air measurements.*
3. *This requirement only arises during commissioning and categorization checks. The method of calculating the height of the extended glide path at the threshold is described in 4.3.81, Analysis — Reference datum height (RDH). For Category I approaches on Code 1 and 2 runways, refer to 3.1.5.1.6 of Annex 10, Volume I.*
4. *Optional, at the request of the ground technician.*
5. *Tolerances are referenced to the mean course path between Points A and B, and relative to the mean curved path below Point B.*

Legend: *S* = *Site*
C,C = *Commissioning, Categorization*
P = *Periodic — Nominal periodicity is 180 days*
N/A = *Not applicable*

Parameter	Annex 10, Volume I, reference	Doc 8071, Volume I, reference	Measurand	Tolerance	Uncertainty	Inspection type		
						S	C,C	P
Keying	3.1.7.4 3.1.7.5	4.3.66	Keying	Proper keying, clearly audible OM: 400 Hz, 2 dashes per second continuously. MM: 1 300 Hz alternate dots and dashes continuously. The sequence being repeated once per second. IM: 3 000 Hz, 6 dots per second continuously.	 ±0.1 s ±0.1 s ±0.03 s		x	x
Coverage — Indications — Field strength	3.1.7.3 3.1.7.3.2	4.3.67 to 4.3.71	Signal level distance Field strength	Proper indication over the beacon or other defined point. When checked while flying on localizer and glide path, coverage should be: OM: 600 m ±200 m (2 000 ft ±650 ft) MM: 300 m ±100 m (1 000 ft ±325 ft) IM: 150 m ±50 m (500 ft ±160 ft) On a normal approach, there should be a well-defined separation between the indications from the middle and inner markers. Measurement should use the Low sensitivity setting on receiver. (Refer to Annex 10 for specific field strength requirements)	 ±40 m ±20 m ±10 m ±3 dB	x	x	x
Monitor system	3.1.7.7	4.3.72, 4.3.73		An operationally usable indication should be obtained for a reduction in power output of 50%, or a higher power at which the equipment will be monitored. See Note.	±1 dB		x	x
Standby equipment	.	4.3.74		Same checks and tolerances as main equipment.			x	x

Note.— Alternatively, this can be checked by analysing the field strength recording.

Legend: S = *Site*
C,C = *Commissioning, Categorization*
P = *Periodic — Nominal periodicity is 180 days*
N/A = *Not applicable*

CHAPTER 07

I.L.S. SITING CRITERIA

LOCALIZER LOCATION:

The I.L.S. Localizer consists of an antenna array monitor field detectors and equipment array. The Localizer is normally located near the end of the runway opposite the threshold. However, the antenna array is the prime consideration and will to a certain extent, fix the location of the building , of field detectors,

SITING REQUIREMENTS:

The Localizer antenna system must be symmetrically positioned about the extended centerline of runway with the longitudinal axis of the array perpendicular to the extended runway centerline.

The optimum distance from the stop end of the runway to the Localizer array for each Site is determined by consideration of several factors. Few of them are as under:

1) Required obstruction clearance criteria,
2) Usable distance and signal coverage requirements
3) Presence of reflecting or reradiating object in the vicinity,
4) Safety considerations.
5) Back course requirements.
6) Anticipated facility upgrading and/or airport expansion.
7) Establishment costs.

The criteria for minimum antenna distance from stop end of runway is as follows:

1) The distance chosen shall preclude penetration of the approach surface plane by the localizer plane,
2) Where a clear or graded area extending to distance of 1250 feet or more from the stop end of the runway is provided, the Localizer shall not be located less than 1000 ft, from the stop end of the runway or beyond the paved overrun if present,
3) Where site conditions preclude adherence to the approach surface plan, waivers of this criteria will be considered on individual basis. Approval of such waiver requests will be contingent on the relative antenna, height, transmitter power, the distance being considered etc.

Localizer will not be located at a distance less than 300 ft, from the stop end of the runway to insure minimum protection from the effects of the aircraft engine jet blasts, at airports where commercial jet aircrafts are in operation. Where siting conditions preclude adherence to the 300 ft. limitation, consideration shall be given to the locating the array beyond the maximum distance limit or to an offset location,

The maximum standard distance from the stop end of the runway to the Localizer array shall be 2000 ft. However location of the array beyond this distance is permissible where significant advantages can be obtained.

1) Where the Localizer will serve a relatively short runway requiring a wide course width (5-6 degrees) to provide the 700 ft. tailored width at the threshold, the array may be located beyond the 2000ft. This will permit the use of the

additional sideband power greater than that of an array located at a lesser distance, thereby providing additional off course clearance signals. The greater distance will also provide an increased safety margin for the aircraft, When this type of siting condition is encountered, the maximum distance from the array to the approach threshold shall not exceed 13,370. ft, for category I Localizer.

2) Location of Localizer array beyond the 2000 ft, permissible where airport expansion plans include extension of the runway which necessitates future Localizer relocation, Taxi track& and building planned the near future should also be taken into consideration.

The elevation of the array shall be considered conjunction with the distance requirements. Majority of the airports require ground mounted array. In some selected airports elevated antenna array may become necessary to meet the required minimum, signal coverage. This may occur due to hump in the runway or the presence of hills and other obstructions in the vicinity which causes a shadow effect. The array shall be mounted so that antenna radiating element is in line of sight the threshold crossing height at the approach end runway. The maximum height of the antenna shall not exceed 35 feet-above, immediate terrain.

The presence of signal reflecting or reradiating acts in the vicinity may place an additional restriction on the location of the localizer antenna system.

The terrain between the antennas and the end of runway shall contain no severe irregularities or obstructions that may affect the Localizer signal quality.
Existing obstructions shall be removed and the area graded.

The longitudinal grade of area A as shown in Fig.47. shall be constant within plus one percent to minus one percent of the runway centerline extended. The transverse grade area A shall be constant and within + 1 and - 3 percent of extended centre line and the transition between area A & B shall be smooth.

At some runways terrain may prevent the Localizer antennas from being positioned on the runway centerline extended. The Localizer antenna array may be off set so that course does not lie along the runway centerline but rather intercepts the centerline at a point determined by the amount of angular off set. The maximum Localizer offset angle shall be 3.0 degrees. The Localizer offset angle (refer fig. 50) is formed by vertical plane containing both the decision height paint and the point on the runway centerline that is 1150 feet inbound from the decision height point. The criteria for standard Localizer facilities shall apply also to an offset Localizer with the following exceptions or amendments:

i) The antenna array shall be offset in the direction that will offer the least signal interference from the movement or obstructions. The distance from the array to the approach threshold shall not exceed the perpendicular extension of 2000 feet distance limit from the stop end of the runway that applies to the normal Localizer configurations.

ii) The offset Localizer shall comply with the minimum distance of 0 the array from the atop end et the runway and from the runway centerline and ILS runway obstruction criteria.

iii) No element of the array shall penetrate a 10:1 surface originating at a point on the runway centerline nearest the array.

iv) No antenna array shall be sited to provide vertical and horizontal clearance to taxing aircraft on adj acent taxi ways.

v) The criteria for location of equipment shelter are:

a) The shelter shall not be located between any portion of the permissible antenna location and the runway.

b) The shelter shall not be located within 250 ft of the extended runway centerline.

c) The shelter may be located within 100 ft. of the array centre or the extended back course line or within ±30 degrees of the longitudinal axis of the array,

d) If an elevated array is installed, the shelter may be located directly behind the platform, provided the elevation of the top of shelter does not exceed the level of the platform.

7.2 Siting criteria for Glide Path

General

The glide slope antenna system is located in a line parallel to the runway centerline and offset from the runway centerline. The glide slope site may be located on either side of the runway. The most reliable operation will occur when it is located on the side that provides, the least interference from building, power lines. moving vehicles and aircraft and which has greatest extent of smooth terrain outbound from the antennas.

The glide slope depends on the terrain conditions due to inherent image antenna concept; radiation from an antenna located at above a reflecting surface (the ground terrain in the case of glide slope) travels to different paths to the receiving antenna, a direct path and an indirect path via the reflecting surface, The reflected signal appears to emanate from and image antenna along the same vertical plane as the real antenna and at a distance below the reflecting surface equal to the distance of the real antenna above the surface,

Siting of glide slope is limited by the terrain irregularity or roughness in front of the antenna, The degrading effect of the rough terrain results from the random dispersion and/or phase shift of the ground plane signal, which precludes formation of the desired glide slope pattern.

Criteria for Roughness:

Terrain is considered to be rough if the phase shift in ground reflected signal caused by the change in average path length would result in an out of tolerances glide- path. The l imitation of terrain irregularity is

$$Z < (0.0117)\ T/H$$

Where

Z = Height of irregularity (in feet)
T = Distance from glide path antenna to irregularity (in feet),
H = Height of sideband antenna in wavelengths,

From the above formula i t can be seen that roughness limit for 3.0 degree glide angle would be 1.22 feet, per 1000 feet.

Extent of Roughness :

The terrain reflects the ground signal in a specular manner, slight departures from the smooth terrain ' for small distances (about 10 feet or lees) wil I not usually have an adverse effect on the glide path signal. The smooth terrain terminates when it encounters extensive roughness or singular roughness of a large magnitude such as a wide ditch, or a hill or a valley. The reflected signal contribution must be continuous for a terrain to be considered smooth therefore the smooth surface terminates at a- point where roughness is encountered even though a smooth reflecting surface exists beyond the roughness.

Site Preparation

It is desirable to provide an ideal site for glide slope facility with no obstruction in the first Fresnel zone but ft becomes cost prohibitive at most of the locations, Thus the site preparation is compromised between theoretical and practical requirements. When preparing a site, following criteria are considered,

The first Fresnel zone extends from the Glide Path antenna outward for 300 ft, and up to 130 ft. wide, Ideally whole area comprising of first Fresnel zone should be graded. However, at most locations, first Fresnel zone extends beyond the airport boundary which puts a limit on the area to be graded.

Use of Null Reference Type glide path is limited by the unavailability of graded area up to 3000 ft., first Fresnel zone, grading of which may require extensive land filling or cutting of hills, a very costly affair. In such event, other alternative image type systems can be used, A side band reference system is used at places where the smooth terrain extends for a distance up to 2000 ft. Type M array with clearance can be used at a place which have severe roughness throughout first Fresnel zone, to determine the type of glide slope to be used for various terrain conditions.

The presence of signal interference sources such as power lines, buildings, fences and other metal structures which may reflect or reradiate the glide slope signal into the useable sector should be considered before selecting the type of G.P. serial system. When feasible all such structures should be removed especially in approach zone, If removal is impossible and the interference source in sufficiently low, a capture effect system will partially overcome the effects of the low angle reflection.

LOCATING THE GLIDE SLOPE FACILITY

When planning a glide slope, the first step is to determine where the facility should be located in relation to the runway. In addition to considering the terrain conditions on either aide of the runway, the location of potential glide slope interferences should be considered. Of primary importance in this regard is the location of taxi-ways, aircraft holding apron and parking ramps, The Glide Path should be located on the side of runway which is free from all such obstructions. If terrain or other factors preclude locating the facility away from these areas, it may be necessary to restrict the flow of ground traffic to prevent glide slope interference.

Lateral-Distance Criteria

The glide slope antenna masts shall be located on a longitudinal reference line that is parallel to runway centerline and laterally displaced at a distance which meets the obstacle free zone criteria. See Fig. 51 for these obstacle criteria. The glide slope shall be located at optimum distance which will be determined by site analysis. Normally Glide Path is installed at a distance from 400 ft. displaced laterally from centerline of the runway.

The required height of the mast along with the siting conditions shall be considered before selecting particular site for installation. The glide slope antenna mast height shall comply with the lateral distance obstruction criteria. When applying lateral distance criteria, the elevation of the runway centerline directly a beam of the antenna mast shall be used as the vertical reference point. See fig. 51 & 52 for lateral distance criteria details.

Longitudinal Distance Requirements

Glide Path antenna is offset longitudinally from the landing threshold and this longitudinal offset-has to be determined along with the lateral offset to locate the Glide Path side, Various factors affect longitudinal offset and they are:

1. Glide Path angle.
2. I.L.S. reference datum.
3. Required obstructions clearance.
4. Slope of terrain along the longitudinal reference line,
5. The extent of smooth terrain in the side area beyond the threshold.

If there is limited amount of smooth terrain in front of the ideal location, the longitudinal distance should be increased with a corresponding adjustment in the remaining parameters* within their defined limits to provide greatest extent of smooth terrain. In addition, where the smooth terrain is limited, a sideband reference or capture effect s y s t em w i l l be u s ed. I f sideband reference system is used the lower antenna height requirements may permit a reduction in the lateral distance, thereby, a possible decrease in the extent of smooth terrain, Since a capture effect system requires a higher antenna mast than a null reference system, a greater lateral distance may be required,

If the terrain encompassing the glide slope site is flat (zero terrain slope) longitudinal displacement 'd' is .determined by the following formula :

$$d = h / \tan \theta$$

where

d = longitudinal offset of Glide path from runway threshold h
= I.L S reference datum = 50 ft.
θ = Glide Angle

If the runway is sloping , then d is found as fellows d

$$= h / \tan(\theta + \alpha)$$

where

α = Runway gradient, it is taken as the + ve in event of up gradient and -ve in case of down gradient.

Longitudinal offset ‘d' of Glide path aerial from landing threshold for various values of θ, glide angle, considering ideal runway and reflection plane is given as follows :

For

θ = 2.50 degree	d = 1273	ft
θ = 2.75 degree	d = 1157	ft
θ = 3.00 degree	d = 1060	ft
θ = 3.25 degree	d = 978	ft
θ = 3.50 degree	d = 909	ft

Marker Beacon and Locator:

The primary function, of ILS Markers is to designate specific point in the ILS approach path. Marker radiate a highly directional vertical pattern at 75 MHZ which is elliptical in horizontal plane. ILS approach path passes through minor axis of the beacon antenna pattern. Aircraft determines its fix from the touchdown point, at predetermined distance, at which markers are positioned, as the modulation of beacon equipment causes a particular colour of light to glow in the panel indication of aircraft .

For category I & II two markers Middle and Outer are normally required,

OUTER MARKER

This beacon is located at a distance of 4 to 7 miles from landing threshold, It marks glide path procedure turn altitude intercept point, Modulation frequency is 400Hz , and code is 2 dashes/second continuously .This beacon causes blue light to flash in the aircraft instrument panel.

MIDDLE MARKER

Interception of the beacon makes decision height point and causes amber light to flash in the aircraft instrument panel . This is situated at a distance of 3500 feet nominal from the threshold.. Modulation frequency is 1300 Hz and its code- is alternate dots and dashes at a rate of 95 combinations per minute.

LOCATION TOLERANCES

This following permissible variations in the location of beacons is outlined as it not always possible to locate these beacon at exact points:

Outer Marker = ± 250 Feet lateral and 3.5 to 6. 0 Nm longitudinal Middle

Marker = ± 3500 Feet longitudinal and 250 feet lateral

Compass Locators:

If operationally required non –directional compass locators may be installed at the middle and outer marker sites as an auxiliary aid to ILS . These facilities are normally designated as LOM (Locate Outer Marker) and LMM(Locate Middle Marker). Locator beacon transmit a 1020 Hz identification tone which modulates a two letter Morse code signal . The LOM is identified by the first two letters of three letter ILS identification and LMM by the last two letters .

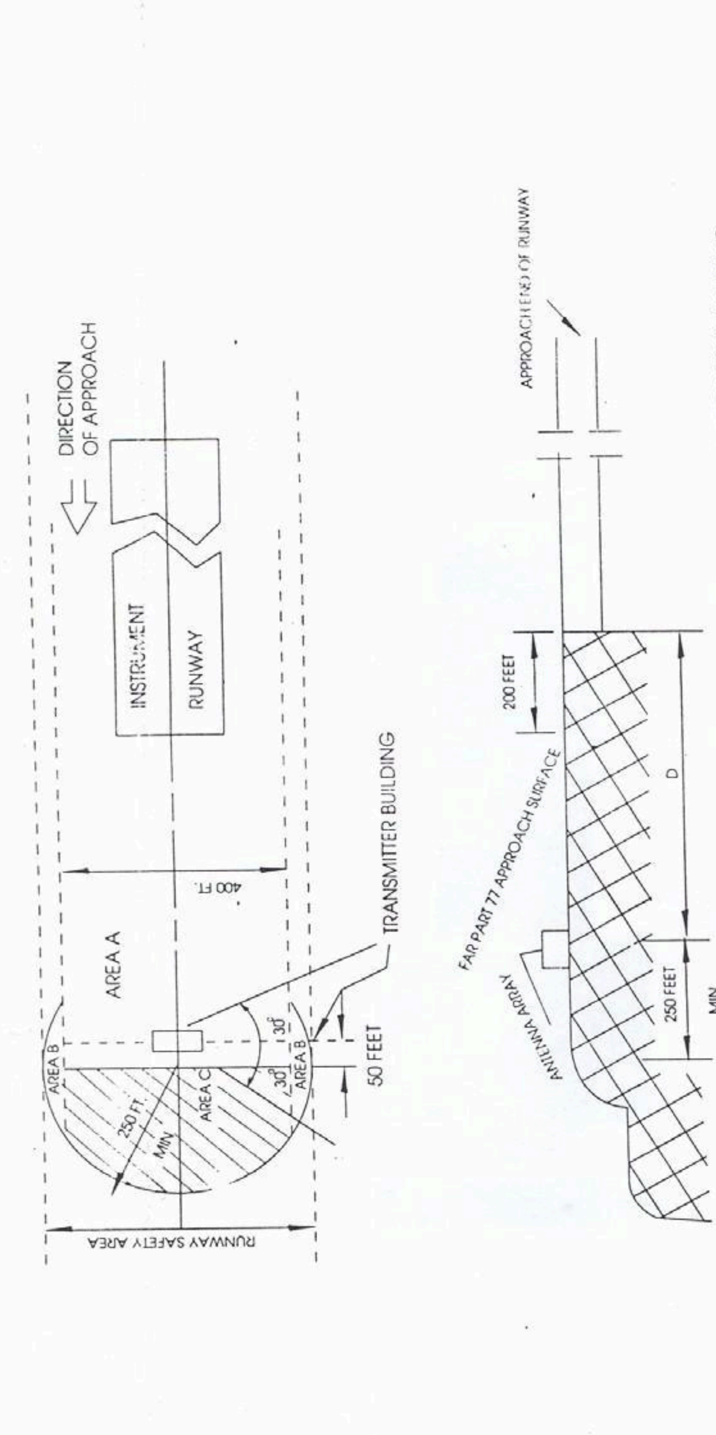
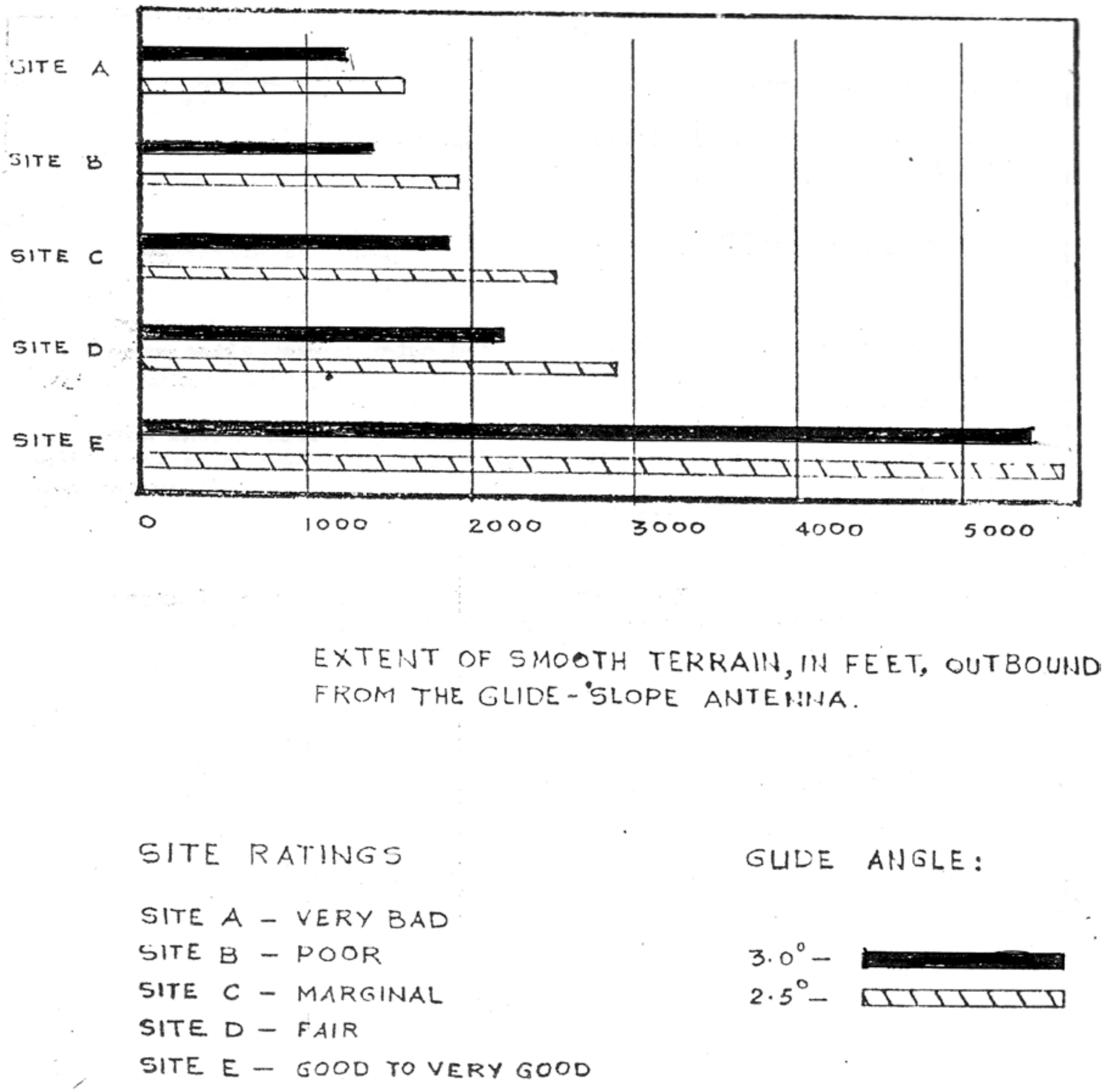


FIG. 1.1 TYPICAL LOCALIZER PLOT LAYOUT AND SITE GRADING REQUIREMENTS

NOTES

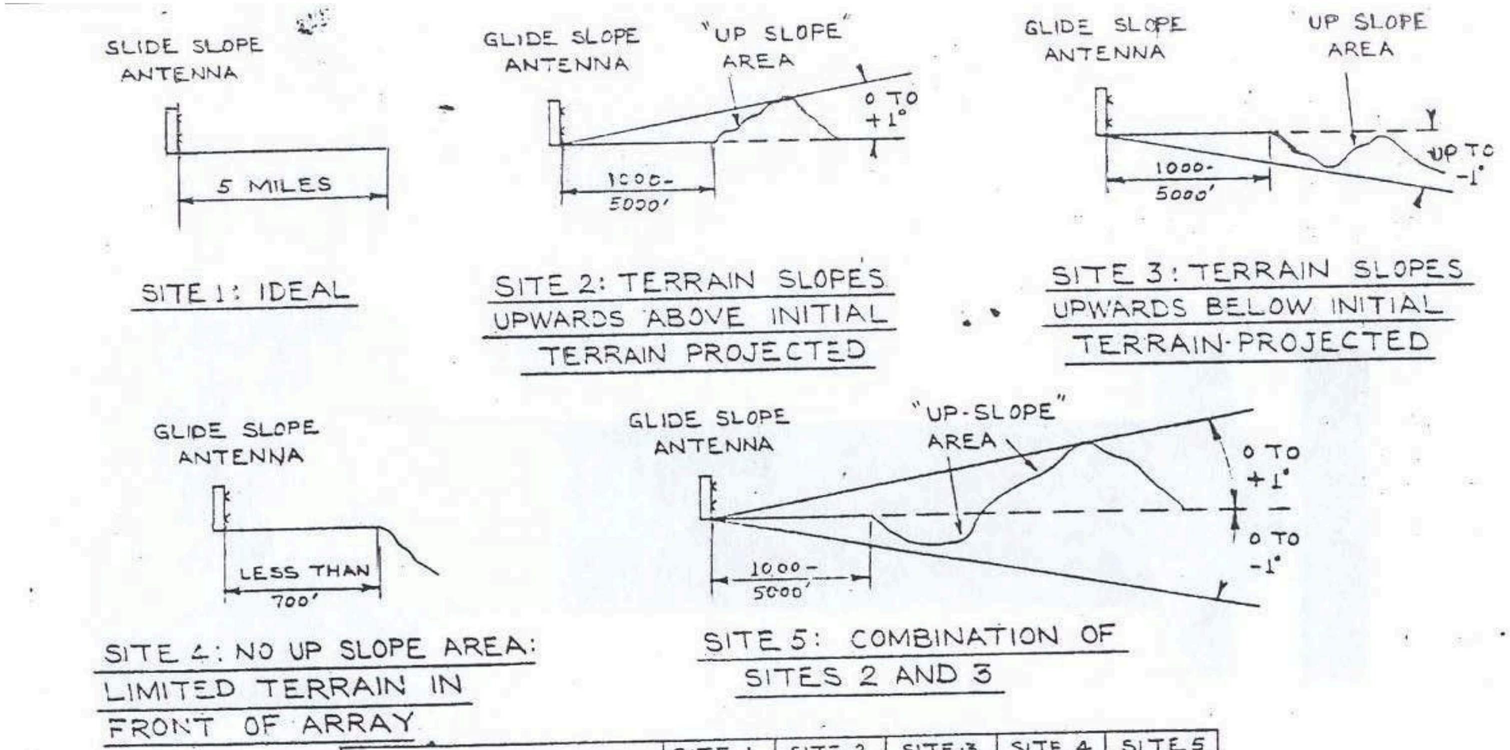
1. AREAS A AND B SHOULD BE FREE OF LOCALIZER INTERFERENCE SOURCES (TREES, BUILDINGS, FENCES, ETC.)
2. GRADING MAY BE LIMITED TO REMOVAL OF INTERFERENCE SOURCES IN AREAS A AND B.
3. THE SIZE AND CONFIGURATION OF AREAS A AND B ARE APPLICABLE TO ALL FACILITIES EXCEPT THAT AREA C (SHADED AREA CONTAINING PORTIONS OF AREAS A AND B) MAY BE DELETED AT FACILITIES THAT HAVE UNIDIRECTIONAL ANTENNAS; i.e, LOG- PERIODIC DIPOLE ARRAYS OR TRAVELLING WAVE ANTENNA ARRAYS.
4. DISTANCE D, DETERMINED BY TERRAIN AND SITING CONDITIONS, WITH MINIMUM DISTANCE LIMITED BY THE LOCALIZER ANTENNA ARRAY AND TRANSMITTER SHELTER'S COMPLIANCE WITH OBSTRUCTION CLEARANC CRITERIA. THE ANTENNA SHOULD BE LOCATED BEYOND 1000 FEET FROM THE STOP END OF THE RUNWAY.
5. TRANSMITTER SHELTER SHALL BE LOCATED AT A MINIMUM DISTANCE OF 250 FEET FROM THE RUNWAY CENTERLINE AND CENTERLINE EXTENDED. THE TRANSMITTER SHELTER SHOULD BE LOCATED WITHIN ± 30 DEGREES OF THE ANTENNA'S LONGITUDINAL AXIS.

FIG.47



GLIDE-SLOPE SITE RATING AS A FUNCTION OF THE EXTENT OF SMOOTH TERRAIN

FIG. 48 (a)



	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5
PERCENT OF TOTAL SITES	5	20	15	15	45
NULL REFERENCE	ALL	VERY FEW	FEW	NONE	VERY FEW
SIDEBAND REFERENCE	ALL	FEW	MANY	VERY FEW	FEW
CAPTURE EFFECT	ALL	MOST	MOST	NONE	MOST
END FIRE	ALL	MANY	ALL	ALL	MANY

EXPECTED APPLICABILITY OF GLIDE SLOPE SYSTEMS TO DIFFERENT SITING CONDITIONS

FIG. 48 (b)

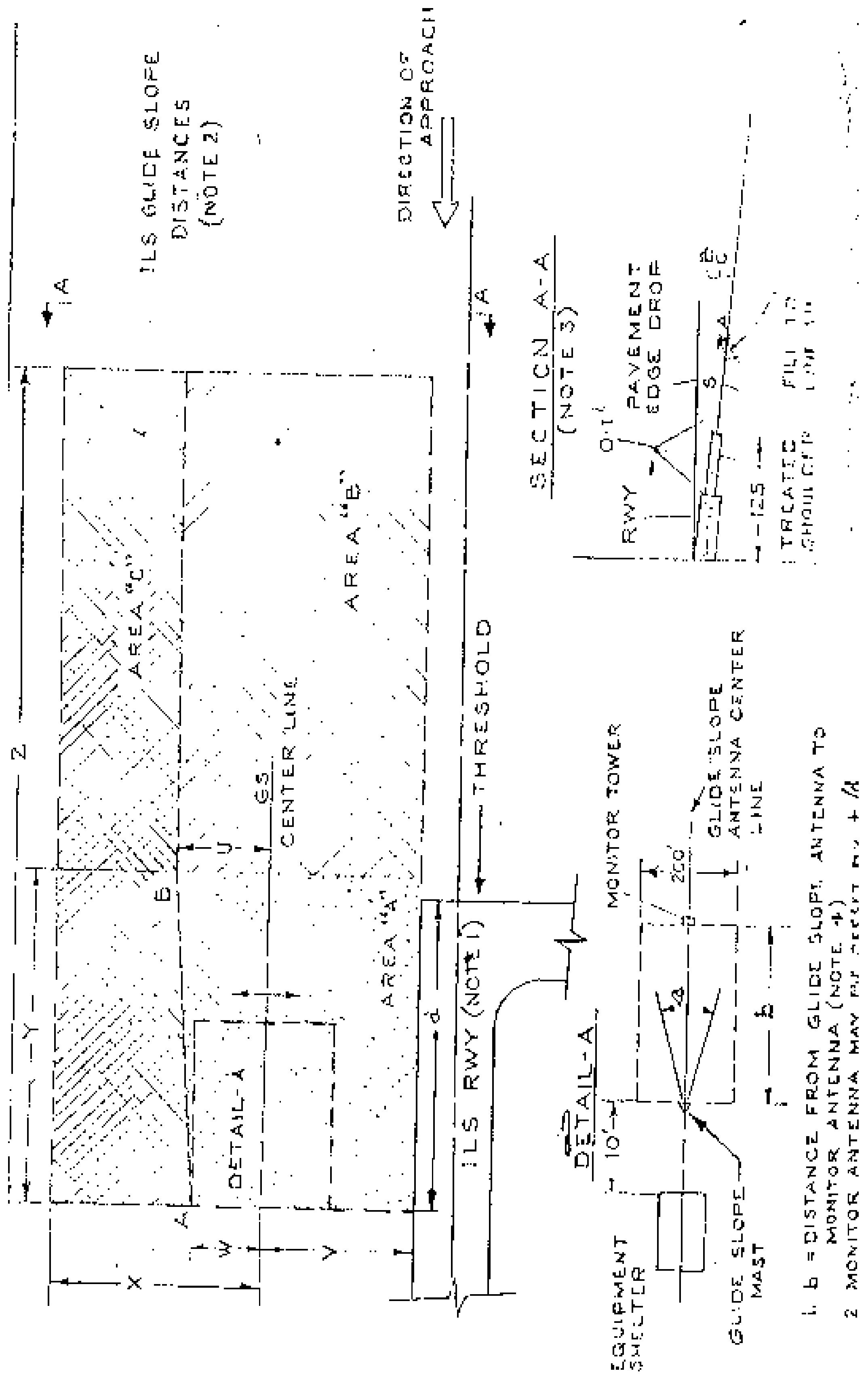

ILS GLIDE SLOPE DISTANCES (NOTE 2)
DIRECTION OF APPROACH
SECTION A-A (NOTE 3)
RWY
PAVEMENT EDGE DROP
TREATED SHOULDER
AREA "C"
AREA "B"
AREA "A"
GS CENTER LINE
THRESHOLD
ILS RWY (NOTE 1)
DETAIL-A
MONITOR TOWER
GLIDE SLOPE ANTENNA CENTER LINE
EQUIPMENT SHELTER
GLIDE SLOPE MAST
1. b = DISTANCE FROM GLIDE SLOPE ANTENNA TO MONITOR ANTENNA (NOTE 4)

FIG. 49

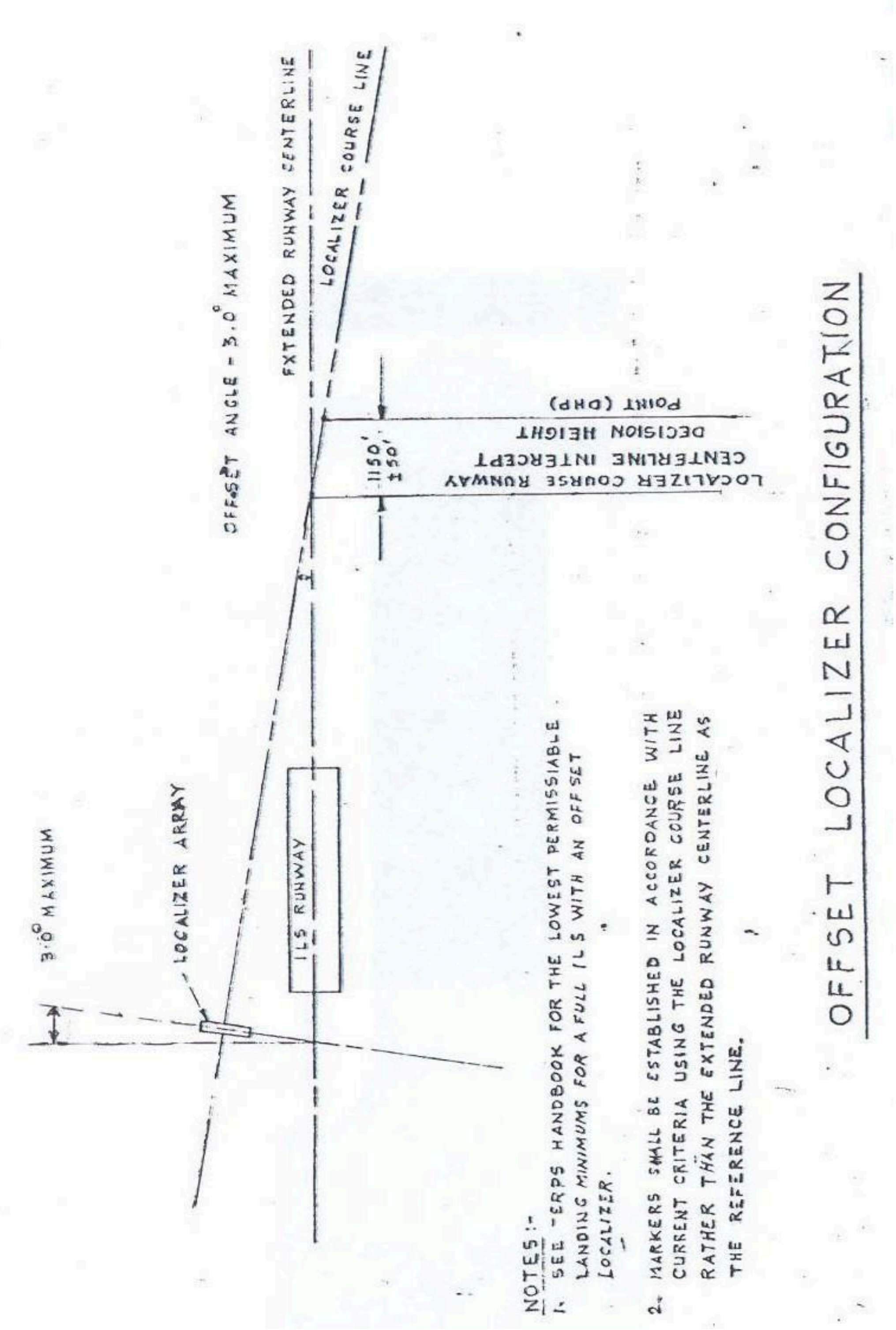

3.0° MAXIMUM
LOCALIZER ARRAY
ILS RUNWAY
OFFSET ANGLE - 3.0° MAXIMUM
EXTENDED RUNWAY CENTERLINE
LOCALIZER COURSE LINE
1150' ±50'
LOCALIZER COURSE RUNWAY CENTERLINE INTERCEPT DECISION HEIGHT POINT (DHP)
NOTES:-
1. SEE "ERPS HANDBOOK FOR THE LOWEST PERMISSIABLE LANDING MINIMUMS FOR A FULL ILS WITH AN OFF SET LOCALIZER.
2. MARKERS SHALL BE ESTABLISHED IN ACCORDANCE WITH CURRENT CRITERIA USING THE LOCALIZER COURSE LINE RATHER THAN THE EXTENDED RUNWAY CENTERLINE AS THE REFERENCE LINE.
OFFSET LOCALIZER CONFIGURATION

Fig. 50

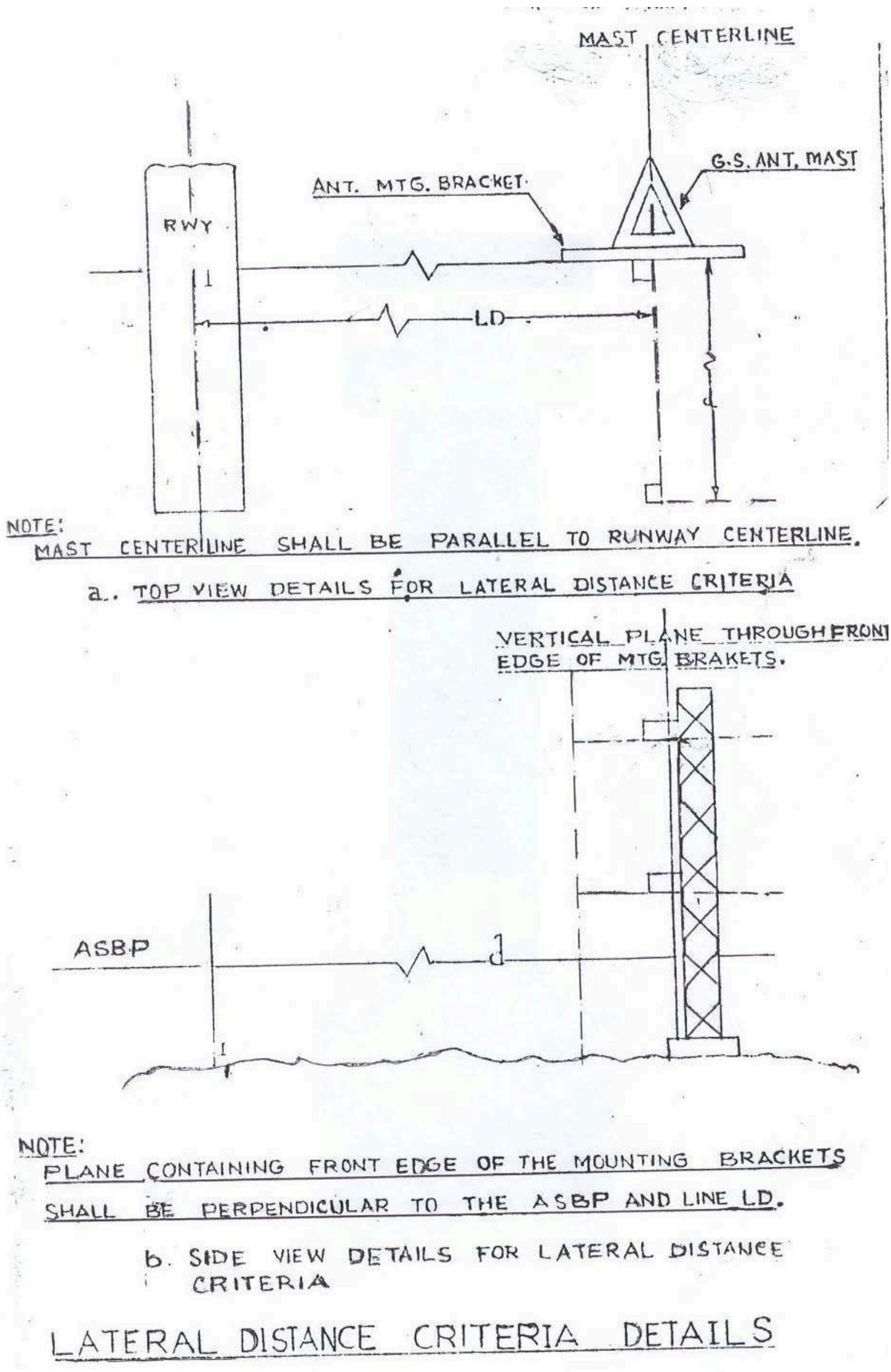
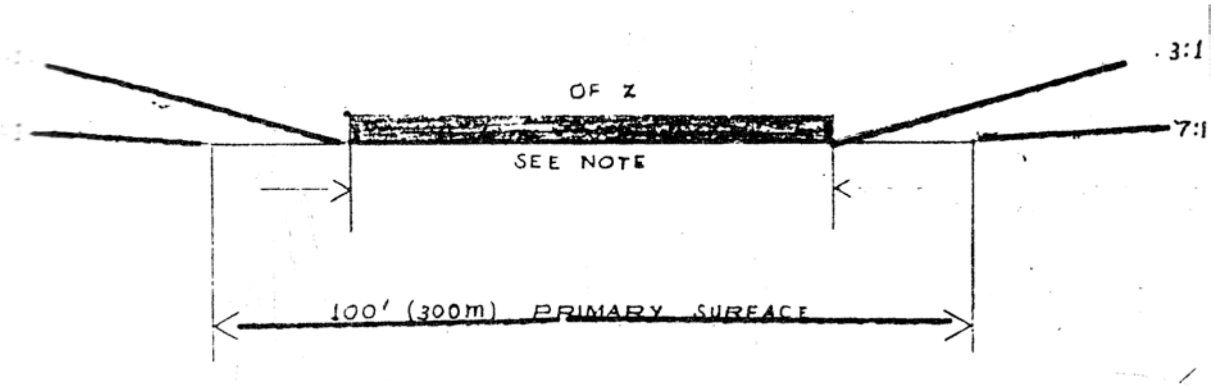

MAST CENTERLINE
G.S. ANT. MAST
ANT. MTG. BRACKET
RWY
LD
d
NOTE:
MAST CENTERLINE SHALL BE PARALLEL TO RUNWAY CENTERLINE.
a. TOP VIEW DETAILS FOR LATERAL DISTANCE CRITERIA
VERTICAL PLANE THROUGH FRONT EDGE OF MTG. BRAKETS.
ASBP
d
NOTE:
PLANE CONTAINING FRONT EDGE OF THE MOUNTING BRACKETS SHALL BE PERPENDICULAR TO THE ASBP AND LINE LD.
b. SIDE VIEW DETAILS FOR LATERAL DISTANCE CRITERIA
LATERAL DISTANCE CRITERIA DETAILS

FIG. 51



NOTE:-

THE RUNWAY OF Z AND APPROACH OF Z WIDTHS ARE THE GREATER OF: 180 FEET (54 m.), PLUS THE WINGSPAN OF THE MOST DEMANDING AIRPLALE, PLUS 20 FEET (6m.) PER 1000 FEET (300m) OF AIRPORT ELEVATION; OR, 400 FEET (120 m.).

THE MAST SHALL NOT VIOLATE THE 3:1 PLANE.

GLIDE SLOPE MAST LATER DISTANCE CRITERIA

FIG. 52

7.3 GROUND INSPECTION

PROCEDURE SCOPE

This chapter provides the basic philosophy of ground inspection. However, for formalizing the detailed inspection procedure for individual type of equipment the suggested procedure by the supplier should also be referred.

GENERAL

The following are suggestions for conducting ground inspection of those parameters which are listed in ANNEX 10 Volume 1. The procedures given, generally provide guidance in the methods of measuring various parameters, However, the actual procedure adopted should be finalized based on the suppliers recommendations also. It is also intended that the checks are made at the points which more realistically represent the signal condition in the far field. Also field monitor should not be used for taking field measurements but the observations on field monitors should be corroborated by the ground check observations.

When corroborative checks are made on monitor indications, by portable test equipments, following effects should be taken into account.

(a) Aperture Effect:

Following should be taken into account :-

i. Localizer: Negligible error due to near field effect will be introduced if measurements are made at points beyond 10 aperture distance from the localizer antenna for aperture up to 100 ft. For larger aperture a minimum distance of 20 aperture should be used, Any measurements taken closer than these distance will not be true representation of signal structure in the field.
ii. Glide Path: Individual antenna is offset around the vertical passing through the centre of system in such a way that signal path phase relationship existing on ILS reference datum is correct. Since it is not possible to continuously monitor the performance of GLIDE PATH at this point, a suitable offset position is located where representative measurements are made, However, a good correlation between the measurements thus made and the signal structure at Reference Datum should exist.

(b) Ground Constant::

In the near field, the measurements accuracy will depend greatly on the reflecting terrain condition which should be carefully controlled. Varying ground conducting condition will also effect the measurements. To effectively control this varying condition a counter-poise designed and located at a suitable point in reflecting terrain will help a lot.

(c) Tolerances:-

The tolerances specified are the deviations from the optimum performance values. It is therefore desired that at the time of commissioning the facility should be set for the nominal values.

The test equipments utilized should not have inherent errors more than one fifth the tolerance specified. Also the equipment setting should not be modified if the listed parameters are within 50 percent of given tolerances. After the commissioning flight check, ground measurements of course alignments, displacements sensitivity and power would be made. For glide path, measurements of glide angle displacements sensitivity, minimum clearance below glide angle and power should be noted down for reference.

LOCALIZER

Localizer Course Alignment

The measurements on localizer must not be carried out in the near field region. The method which is widely used employs field test equipments with measurements carried out on pre-surveyed points. The course structure at the positions selected for these measurements must be known to be stable. By use of this test equipment, the position of course Line relative to centre Line is determined,

Displacement Sensitivity

Displacement sensitivity is similarly measured on a line perpendicular to runway centre line at pre surveyed positions. It should however be ascertained that the course structure at these position is stable. The displacement sensitivity is given by the difference of the two DDM divided by the Linear distance between the two pre surveyed points. It should be linear. Normally the DDM at width position should maintain.

Off Course Clearance

Pre-surveyed points are provided up to at least 40 degree. Off course clearance signals are recorded, Particular care has to be taken for the points where the course predominance changes to clearance signal.

Polarization

Normally this measurement is not to be carried out in a routine manner. However in the even of any suspected effect change in the DDM when antenna is tilted by 20^0 will give the effect of polarization.

Carrier Frequency

This can be measured at the transmitter output signal using a dummy, load tap or in RF Socket. In monitor position with all the modulating signals with drawn two frequency system the frequencies should be offset, symmetrically about the assigned frequency. Checks on both the frequencies should be made.

Output Power

The output power into the antenna system may be measured using a wattmeter preferably of through line type which indicates the direct and reflected power. During installations it will be convenient to relate this power to the field strength at some pre-surveyed point in the air field. At the same time the out put of the transmitter and field strength should be recorded. Similarly the field strengths is observed with 3db reduction in the transmitter output. Thus within the relationship established between the transmitter power and observed field strength at pre surveyed points the power can be predicted.

Tone Frequency

Measurement of tone frequency is made by taking the “time period measurements" for individual tone frequencies on a counter. In case the signals are generated from the same source, monitoring the frequency of this source should be recorded.

Modulation Depths (90/150 Hz)

The technique used to measure the modulation depth should preferably be one, which analyses with both modulating tone present.

Measurement of modulation depth of 1020 Hz identification tone can either be made by switching Off 90 Hz, 150Hz tone and generating a continuous 1020 Hz Tone. Modulation depth measurement then will give the Mod Depth for ident tone.

The measurement can also be made by comparing the reading for 9O/150 Hz and1020 Hz on wave analyzer.

Harmonic Content Of The - 90 and 150 Hz Tones

This is measured at the detected transmitter output and level (where detector itself should not produce any directions) with the help of a wave analyzer. The value is obtained on calculation basis.

90/150 Hz Phasing

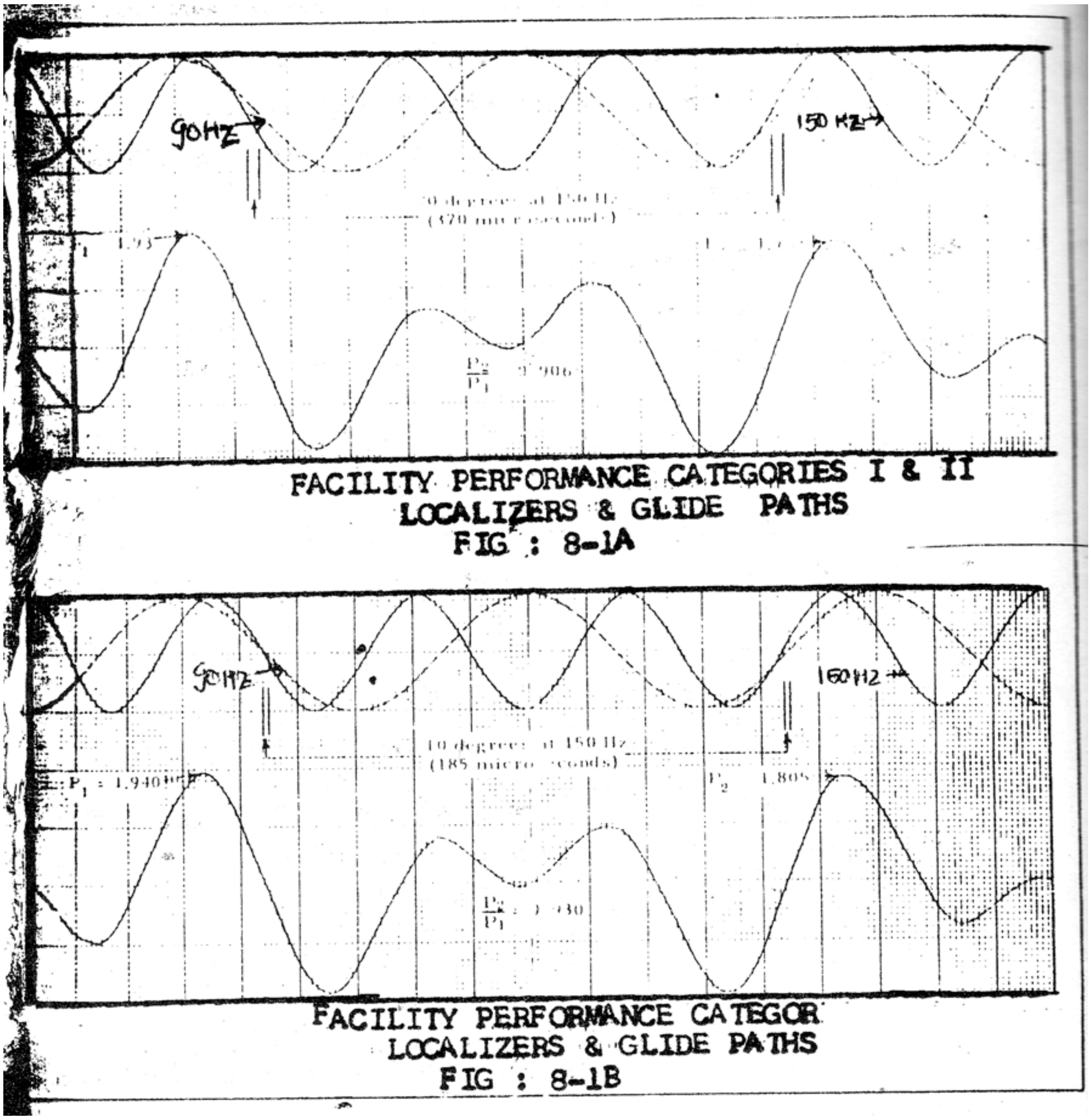
One of the method recommended for checking of the relative phasing between 90Hz& 150 Hz tones is as follows:

1) The detected audio CSB can be displayed on an oscilloscope, Lock the display by varying time base.
2) Remove one tone and adjust oscilloscope to give approximately half screen amplitudes, Carefully note the value.
3) Change over to the other tone and make sure that amplitude is exactly the same.
4) Display the combined tones and measure as accurately as possible peak amplitudes P1 and P2 indicated in the figure.
5) Ratio P1/P2 or P2/P1 whichever is appropriate give a value equal to or less than unity. Ratio greater than 0.906 indicates satisfactory phasing.

MONITORING SYSTEM OPERATION :

This test is conducted to ensure that the total time period specified for out of tolerance limits., transmissions should never be existed to protect aircraft in the final stage of approach. It should be ensured that no guidance outside the monitor limits be radiated after the time period given and no attempts be made to restore service until a period of the order of 20 seconds has elapsed.

The situation can be simulated by taking Alarm limit beyond their limit positions.



ILS waveforms illustrating relative audio phasing of the 90 Hz and 150 Hz tones

FIG. 53

Alarm Limit Adjustment

The alignments of alarm limits should be carried out at the time of flight check.

GLIDE PATH

ANGLE STABILITY:

Glide path angle stability may be measured either at normal monitoring location or at a distance of at least 1000 feet from transmitting antenna. It is always beneficial to record the observed parameter on the monitoring point at the time of commissioning flight check for reference purposes.

For facilities with performance requirements of cat II and cat III, the field measurements are also carried out at threshold to measure the height of glide path above runway threshold. For subsequent practical measurements a suitable position out side the runway is established (at about same distance as threshold from antenna) and the reading& are correlated. For these measurements means should be provided for determining the height of the test antenna above ground level with an accuracy of 15 cm.

DISPLACEMENT SENSITIVITY AND CLEARANCE BELOW GLIDE PATH:

Measurement of these parameter can be made in the same way as the angle but measurements must be made at fixed distances above and below the glide path. Points at which DDM of 0.0875 is observed should be marked. For below glide path clearance ,far field monitoring is required to be done and a DDM value, are recorded *right down to* 0.3θ.Other checks are performed as per the methods explained for Localizer.

MARKER BEACON:

The purpose of the ground testing is to ensure an a continuous basis that the marker beacon radiates a signal meeting the requirements of Annexure 10 Volume 1. Since a large variety of beacon & are being used, an outline of the test procedure will be given.

The test equipments recommended for maintenance are as follows:

- A frequency meter covering 75 M Hz band with an accuracy of at least 0.001 percent.
- A modulation meter or oscilloscopes for modulation percentage measurements.
- A power meter probably a bi-directional type.
- A wave analyzer and a spectrum analyzer for checking the spectral purity are also recommended.

GROUND TESTING PROCEDURES:

The carrier frequency of the transmitter should be chocked using an accurate frequency counter either from the sampled R.F signal or any other method suggested by the supplier,

RF Output Power:

Since the coverage of markers beacons are directly related to the power being radiated, it is essential that radiated power must be kept as close to the power left at the time of commissioning as is possible. Mostly a motor is provided on every equipment to indicate the power, this should be correlated with actual power and also reflection should be measured to confirm that radiated power is same.

Modulation Depth:

The modulation depths can be measured by a modulation meter or an oscilloscope. In oscilloscope the familiar method of noting down maxima (Amax) and minima (Amin) is employed.

$$\text{The modulation percentage} = \frac{A_{max} - A_{min}}{A_{max} + A_{min}} * 100$$

Modulation Tone Frequency:

The modulation Tone frequency can be measured on a frequency counter as in the case of localizer, and glide path.

Harmonic Contents:

The harmonic levels of the modulating tone are measured with a wave analyzer.

Keying:

An audible indication of Keying normally is provided in the monitor. The code should be confirmed to be accurate, Ground Check Analysis.

LOCALIZER:

Localizer Course Alignments:

Intention is to establish that the relationship between the course time produced by Localizer and the physical centerline of runway holds. For the purpose, measurements are carried out on some pre-surveyed points on centerline with the help of a portable test monitor. These measurements are made in the far field only and the course structure at *these points* should be known to be stable, With the help of these measurements the position of course time relative to centerline is determined. Practical measurement must confirm the continuity of this relationship.

Displacement Sensitivity and Off Course Clearance:

Both these measurements can be made simultaneously with of a portable test monitor on pre-surveyed, points on a line perpendicular to the centerline & is in the far field. Through the measurements linearity of DDM increases, on either side of course line is confirmed. DDM of 15.5% at course width points are established. Measurements further along the path gives the complete signal structure in the space. In the facilities where two frequency clearance or quadrature clearance signals have been provided, particular attention should be paid to the DDM at the point where predominance changes from course to clearance signals.

GLIDE PATH

Glide Angle Alignment:

It is intended that the relationship between the actual glide path produced by the Glide path equipment at any time and the path with reference to the declared glide angle for that runway always holds . For this purpose$_s$ measurements are carried out at some pro surveyed points of the Centerline of the runway with the help of a test monitor and the readings observed should be same as the readings taken at these points at the time of commissioning flight check.

For Cat II and Cat III facilities the height of glide path over the threshold should be periodical ascertained with the help of portable monitor and relating the measurements taken at this pre surveyed point at the time of commissioning of the glide path.

Displacement Sensitivity and Below The Glide Path Clearance:

Both these measurements are made simultaneously at the portable monitor observation point. The DDM at various heights are noted and recorded. The DDMs at various heights are compared with those observed immediately after the commissioning flight check. The points at which a DDM reading of 8.75 percent is observed is recorded, The heights of these readings should hold.

Also the DDM structure both above the observed glide path position should compare with that left at the time of commissioning.

Inspection could not be carried out within the maximum allowable intervals. The facility may continue to remain in service provided the ground checks indicate normal performance.

PRE-FLIGHT AND POST-FLIGHT PROCEDURES

7.4.1 Pre Flight Inspection Preparation

Following are the points to be observed during Preflight Inspection Preparation:

1) Ensure that the result of all possible ground calibration and checking of equipment are satisfactory.
2) Maintenance personnel to be available to make corrections and adjustments.
3) Theodolite platform and its power supply should be available.
4) Availability of transport for movement of equipment and personnel.
5) Ensure all special tools and instruments are available at the site.
6) Availability of last Flight Inspection Report.
7) Any requirement of special investigation during flight inspection must be promptly intimated to FIU in advance.
8) In case the facility is not expected to be ready as per the regular schedule of inspection, FIU must be advised accordingly.
9) NOTAM action for withdrawal of facility during Flight Inspection.

7.4.2 In-Flight Inspection Action by the Ground Personnel:

During the inspection Flight Inspector will advise maintenance personnel of observed conditions which require adjustment of ground equipment. Request for adjustment will be specific and readily understandable by ground personnel. Normally the Flight Inspector is not expected to diagnose the fault, but will furnish sufficient information to enable the maintenance team to make the corrective adjustment, when the aircraft is airborne.

Record the adjustments done, for later analysis.

7.4.3 Post-Flight Inspection Action by the Ground Personnel

Ground maintenance personnel will complete the following actions:

1. Take action as per the advise of Flight Inspector.
2. Implement the suggestions contained in the remarks column of the Flight Inspection report.
3. Intimate FIU and all concerned regarding any major change in the facility performance (NOTAM action).

7.4.4 Airborne FIS Equipment

FIS console fitted on board the flight inspection aircraft may be of one of the following:

a. Manual System

Features manual data analysis and computation of results besides supported by a manual Theodolite (AVRO).

b. Semi-Automatic System

Features automatic data analysis and computation of results but supported by an operator dependent, position reference system/ Theodolite (DORNIER).

c. Automatic System

Features automatic data analysis and computation of results based on self contained automatic position reference systems, like GPS and INS. This system is presently not available in India and is expected to be available in the near future.

7.4.5. FLIGHT INSPECTION PROCEDURE

Important procedures are described in this section. Procedures discussed pertain to Manual/Semi Auto FIS equipment.

7.4.5.1 Localizer Flight Inspection

Following are the various Flight_ Inspection Checks carried on the Localizer equipment:

a. Identification Coding Checks
b. Mod-Balance and Mod-Depth Checks
c. Course width and Clearance Check
d. Course Structure, Course Alignment and Flyability Check
e. High Angle Clearance
f. Alignment Monitor Alarm Check
g. Width Monitor Alarm Check
h. Coverage and Power Monitor Alarm Check
i. Polarization Check

Course Width Symmetry Check.

n case of Routine/ Periodic inspections, normally adjustments are carried out on one of the transmitters and then:

i. All the monitors are adjusted to "zero".
ii. Transmitter is changed over.
iii. Controls of this transmitter are adjusted to obtain similar readings on the monitor.
iv. A confirmatory air check is made for this transmitter. It saves time and ensures that both the transmitters are balanced on monitors.

This procedure is also employed in glide path calibration.

7.4.5.1.1 Identification Coding Check

Ident should have no effect on Cross Pointer Ident level is adjusted to 10% Modulation.

7.4.5.1.2 Mod Balance and Mod-Depth Check

Purpose:

To confirm that mod balance and mod depth are set properly. On centerline of LLZ the DDM should be zero and Mod sum should be 40%.

Flight Procedure:

Park the A/C at Runway Threshold on Centerline (C/L). Ground staff asked to Adj. Mod Bal. & Mod Depth controls

Mod. Bal adjusted for 0 ± 5 p amps (cross pointer current in the FIS console)

Mod. Depth adjusted for 40% ± 2% (CAT I & II) 40% ± 1% (CAT III)

7.4.5.1.3 Course Width and Clearance Check

Purpose:

i. To ensure Course Width is satisfactory

In Commissioning / Annual flight checks the Course width is adjusted for nominal value

In Routine - flight checks it is ensured that the course width is with in tolerance

ii. To check off course clearance (in the sector 10°-35° either side of C/L)

FLT Procedure

Calibration aircraft flies an arc about Runway centerline at approx 5 NM from LLZ & 1000' AGL (Above Ground Level) as shown in figure 54

Theodolite/ Tracker

Calibration Aircraft is tracked by Theodolite/ Tracker
Event marks given –
at 1° interval in the ± 5° Zone
at 5° interval in the ± 5° to ± 35°.

In case of Tracker continuous azimuth readings are transmitted to the airborne console and recorded.

Ground Facility Adjustment

Ground staff is required to adjust Course Width control as advised by the Flight Inspector.

An increase in width DDM monitored on INT Width Mon socket will result in a decrease in Course Width values.

In case of Normarc ILS, SBO Power control is adjusted. A clockwise rotation increases the attenuation and thereby increases the course width.

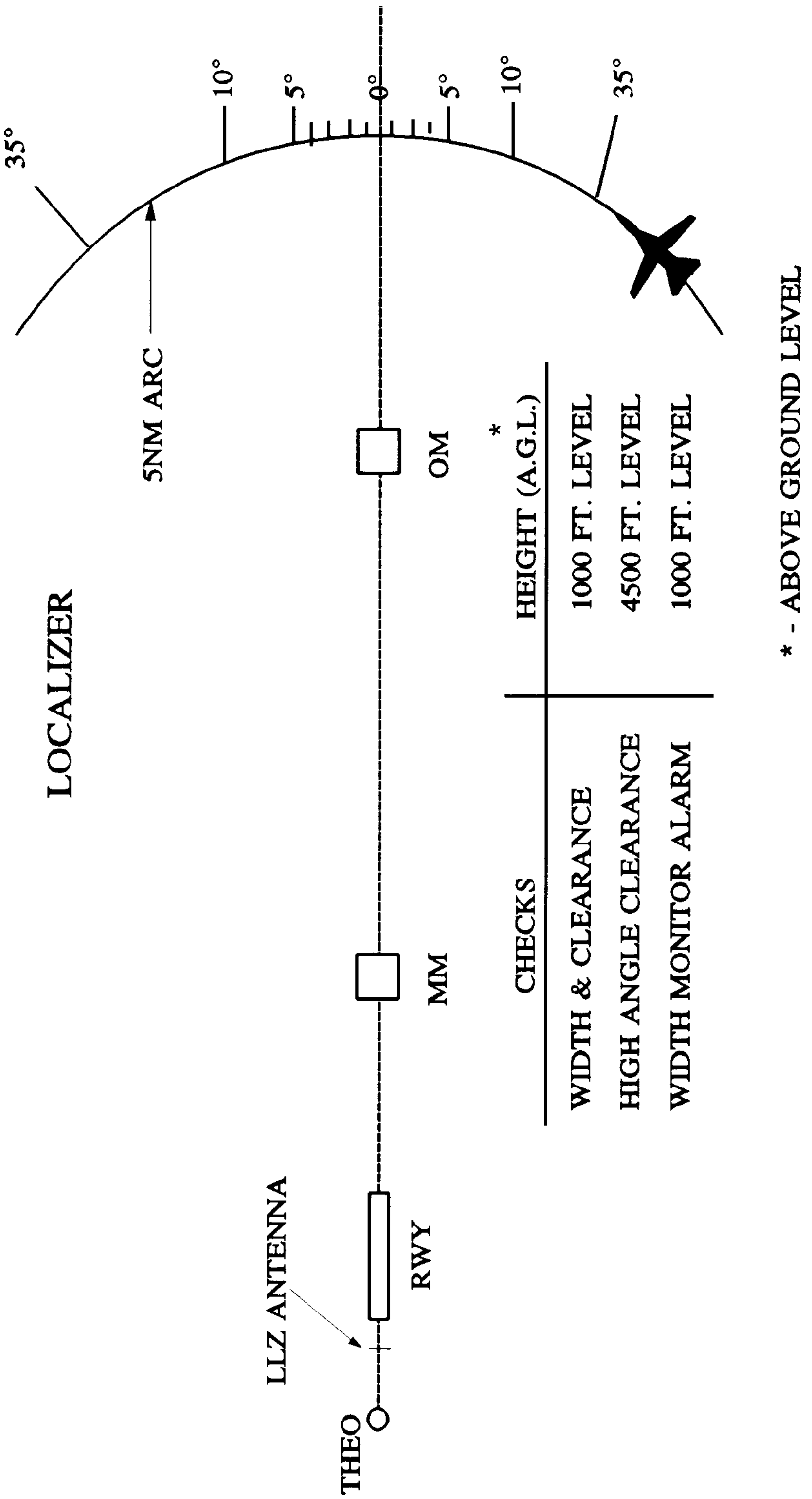


Fig. 54 Localizer Course Width and Clearance Check

In-sufficient clearance may be caused due to

i. Imperfect phasing
ii. High antenna VSWR in the RF

feeders/dipole(s) It should be rechecked and corrected.

Desired Result/Tolerances

COURSE WIDTH (W) = W ± 17% CAT I & II
(W) = W ± 10% CAT III

i. Clearance current should increase linearly to 175 1A Amps (18% DDM) from centerline and must not fall below this value up to 10° azimuth either side of C/L.
ii. Minimum Clearance current should be 150 p Amps (15% DDM) in ± 10° to ± 35° Sector

Important:

After the final adjustment panel should be closed.

Course Structure, Alignment and Flyability Check Purpose:

i. To check that electronic center line is aligned with the physical center line.
ii. To check that the quality of course signal is satisfactory. (Its course bends, roughness, scalloping all combined is within tolerance limits of the applicable category.)
iii. Flyability is checked to ensure it is satisfactory that an aircraft following the ILS can fly smoothly "manually" as well as on its "auto pilot".

Flight Procedure

i. Calibration A/C carries out ILS approaches inbound from 8 NM to R/W Threshold along the center line and on Glide Slope as shown in figure 55.
ii. When approaches are made aircraft is tracked by Theodolite.
iii. Event marks are recorded and Course Structure is calculated
iv. In the case of Tracker, continuous azimuth deviation data of the A/C gets automatically transmitted to the console and course structure is calculated by the computer immediately after the completion of the run.

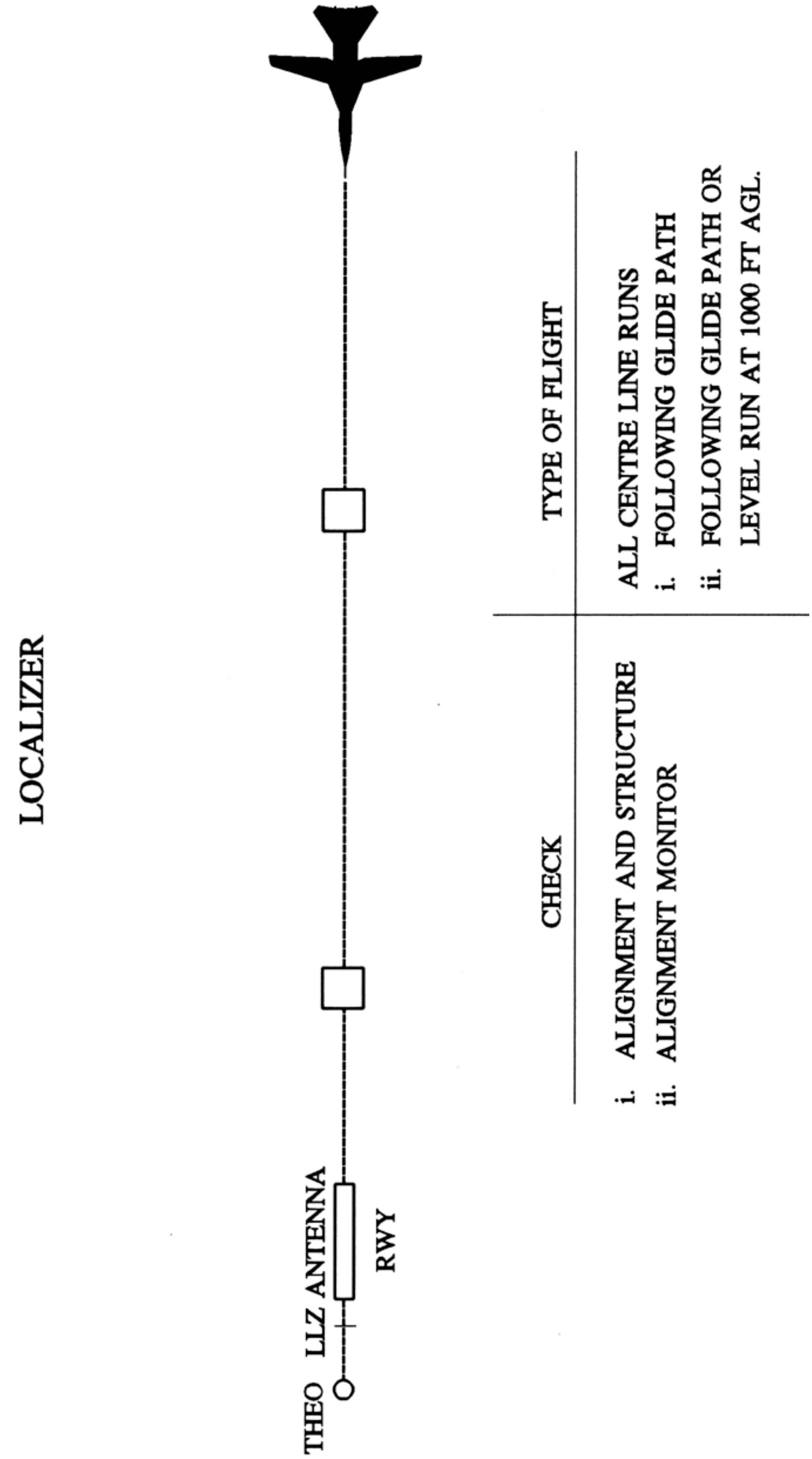


Figure 55 Course Structure Alignment and Flyability Check

Ground Adjustment

Normally no adjustment is carried out for above exercise. However light adjustment of MOD BAL & MOD DEPTH may be required to optimize the far field performance.

Desired Results and Tolerances

i. Alignment

a. Commissioning Inspection - No Tolerance permitted normally.

b. Periodic Inspection Within Tolerance Limits

CAT I	± 14.6μA
CAT II	±10.5μA
CAT III	±4.2μA

ii. Structure

a. Usable distance to ILS point `A' = 30μ Amps

b. ILS Point `A' to `B' - CAT I Linear decrease from 30μA to 15pA

CAT II & III Linear decrease from 30VA to 5μA

c. CAT I - ILS Point B to C maintain 15 u Amp

CAT II - ILS Point B to Threshold 5 μ Amp

CAT III - ILS Point B to Point D 5 μ Amp

d. CAT III - ILS Point D to Point E Linear increase from 5 to 10 μAmp

This data is illustrated in figures 56 and 57.

Flyability - Must be Satisfactory

ILS Points

ILS Point A - On extended C/L, on G/P - 4 NM from (7.5 Km) from Threshold

ILS Point B - On extended C/L, on G/P - 3500' (1050M) from Threshold

ILS Point C - On extended C/L, Down-ward extended straight portion of G/P where it crosses 100' above horizontal plane containing threshold.

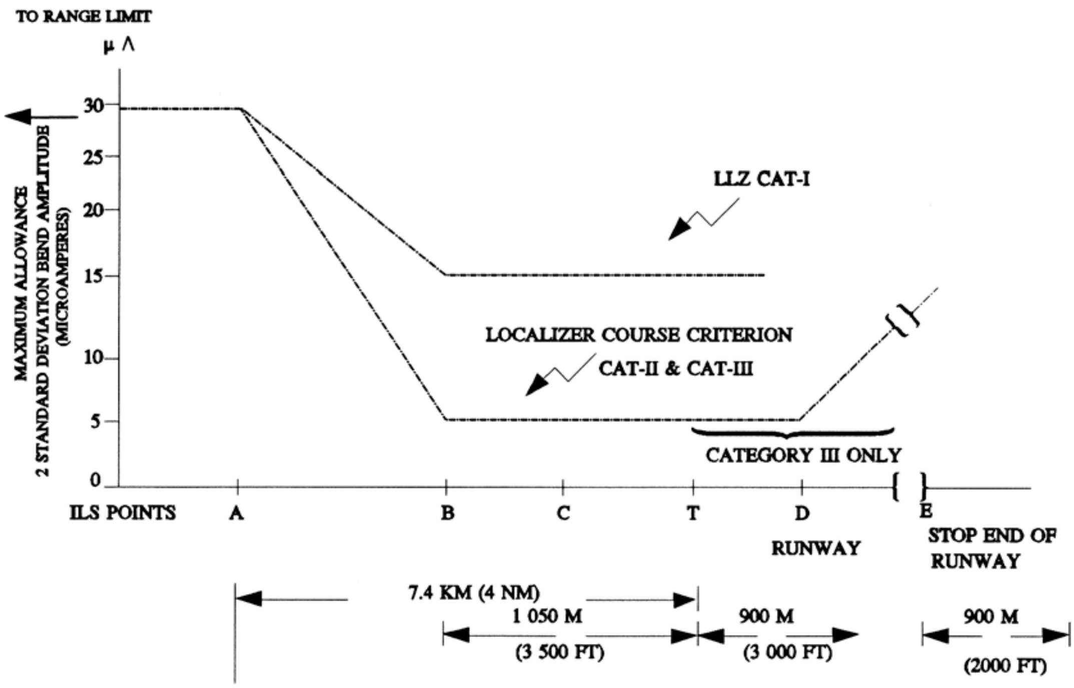


Figure 56 LLZ Course and maximum Bend amplitude criteria

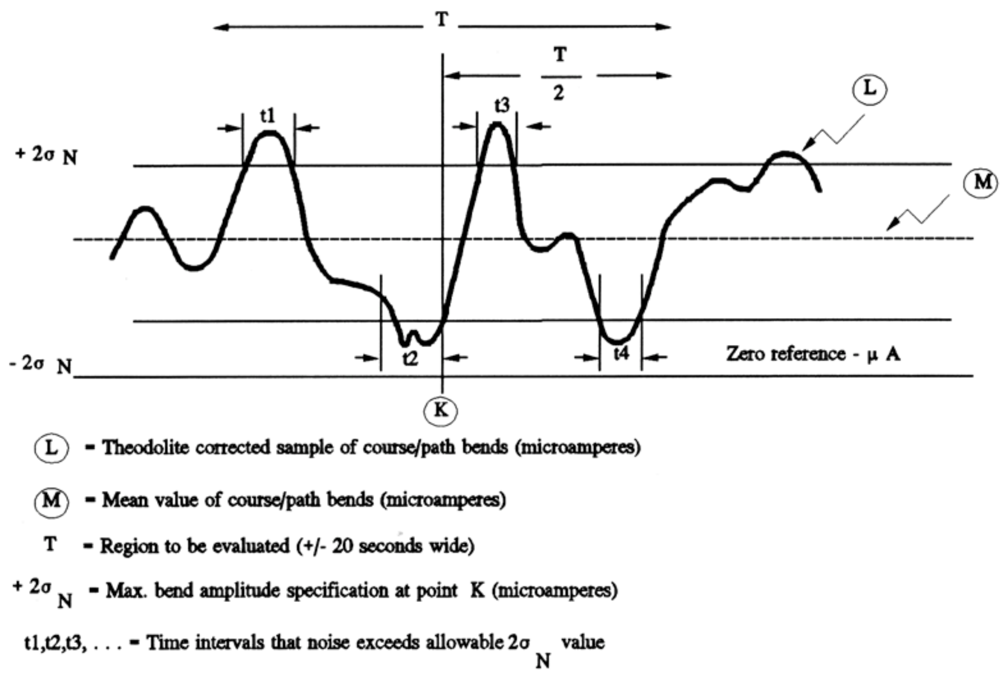


Figure 57 Evaluation of Course/Path bend amplitude

ILS Point D - A point 12' (4M) above Runway CL and 900 M (3000 ft) from threshold in the direction of LLZ.

ILS Point E - A point 12' (4M) above Runway C/L and 600M (2000' ft) from the stop end of runway in the direction of threshold.

7.4.5.1.5 High Angle Clearance

Purpose:

The Combination of ground environment and antenna height can cause nulls or false courses - These may not be apparent at all normal instrument approach altitudes.

High Angle Clearance should therefore be investigated upon in case of:

a. Initial Commissioning
b. Change in location of Antenna
c. Change in height of Antenna
d. Installation of a different type of Antenna

Procedure:

This check is similar to clearance check described earlier in para 7.5.1.3 except that a/c flies the arc at 4500' above the AGL or max' altitude of LLZ in use.
4500' AGL or Max service altitude.

7.4.5.1.6 Alignment monitor alarm check

Monitor alarm limits are cross checked. Ground maintenance personnel actuate alignment monitor alarm condition with Mod. Balance control. Calibration aircraft detects the deviation to confirm that the deviation is within the tolerance limits.

7.4.5.1.7 Width Monitor Alarm Check

Purpose :

To confirm that adjustment of Width Monitor Alarm is Satisfactory.

FLT Procedure :

This exercise is conducted similar to Course Width Check. Ground procedure in different.

Width wide Alarm Check

This check ensures that even during wide width condition, clearance current does not reduce below the minimum. In this check off Course Clearance must not fall below.
135 V Amps in the Zone ± 10° to ± 35°.

Ground Procedure

Inspection of width alarm are carried out on one Tx only. Increase SBO power to simulate narrow alarm condition ADOPT same procedure for WIDE ALARM. Return the control to earlier position to obtain original value of width DDM.

Permissible course width change for each category

CAT I }	-	± 17%
CAT II}		
CAT III	-	± 10%

7.4.5.1.8 Coverage & Power Monitor Alarm Check

Purpose:

To confirm that Localizer provide, coverage to the defined service volume even when operating at Half Power (Monitor Alarm).

Flight Procedure:

The FIU A/C carries out exercise as shown in the figure 58.

Ground Facility Adjustment

The field strength of the LLZ signal is measured on course at greatest distance at which it is expected to be used (But not less than 18 NM) while operating with 50% of normal power. If the field strength is less than 5 [t Volts the power will be increased to provide at least 5 ~t Volts and monitor limit adjusted to Alarm at that level. Normalise the power output to the original value.

Desired Result - Throughout the coverage volume:

Minimum AGC	5 μ Volts
Minimum SDM	24%

Figure 58 Localizer Usable Airspace Check

7.4.5.1.9 Polarization Check

Purpose:

To confirm that no adverse effect will be encountered while flying on LLZ course due to undesired vertical polarization component.
The desired polarization of LLZ is HORIZONTAL

FLT Procedure:

Calibration A/C files in bound Localizer at 1500' AGL between 6-10 NM. The A/C is made to BANK 20 ° Each side while remaining on center line as shown in figure 59.

Desired Result

No appreciable deflection of Cross Pointer on Banking. Tolerance in cross pointer current (DDM)

CAT I	±	15μ A
CAT II	±	8μA
CAT III	±	5μA

7.4.5.1.10 Course Width Symmetry

Check Purpose:

To confirm that course width on either side of center line is SYMMETRICAL within prescribed limit.

Flight Procedure

Figure 60 shows the flight procedure for the Course Width Symmetry Check. The calibration A/C flies inbound from Outer Marker to Runway threshold at half width (75 p Amps offset) point on either side of the LLZ Center line.
Pilot flies with the help of FIS CDI. The A/C is tracked at half course width angle.

Desired Result

Symmetry (1/2 width on 90 Hz side compared to width on 150 Hz side) must be
WITH IN 10% OF TOTAL SECTOR WIDTH.

This check is done only during commissioning. After the flight Inspection is completed the ground staff should ensure that both the Txs are BALANCED ON MONITORS.

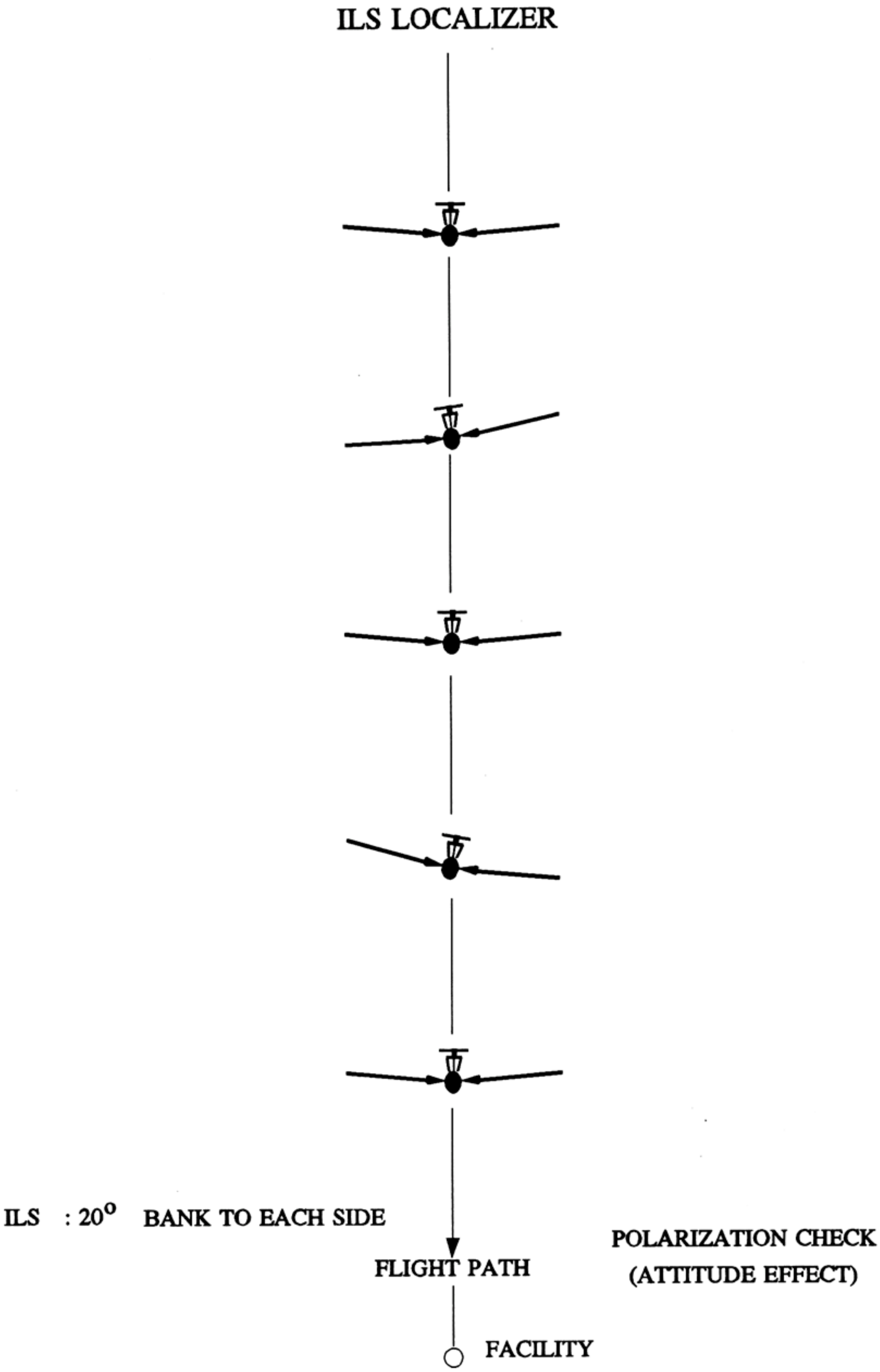


Figure 59 LLZ Polarization Check

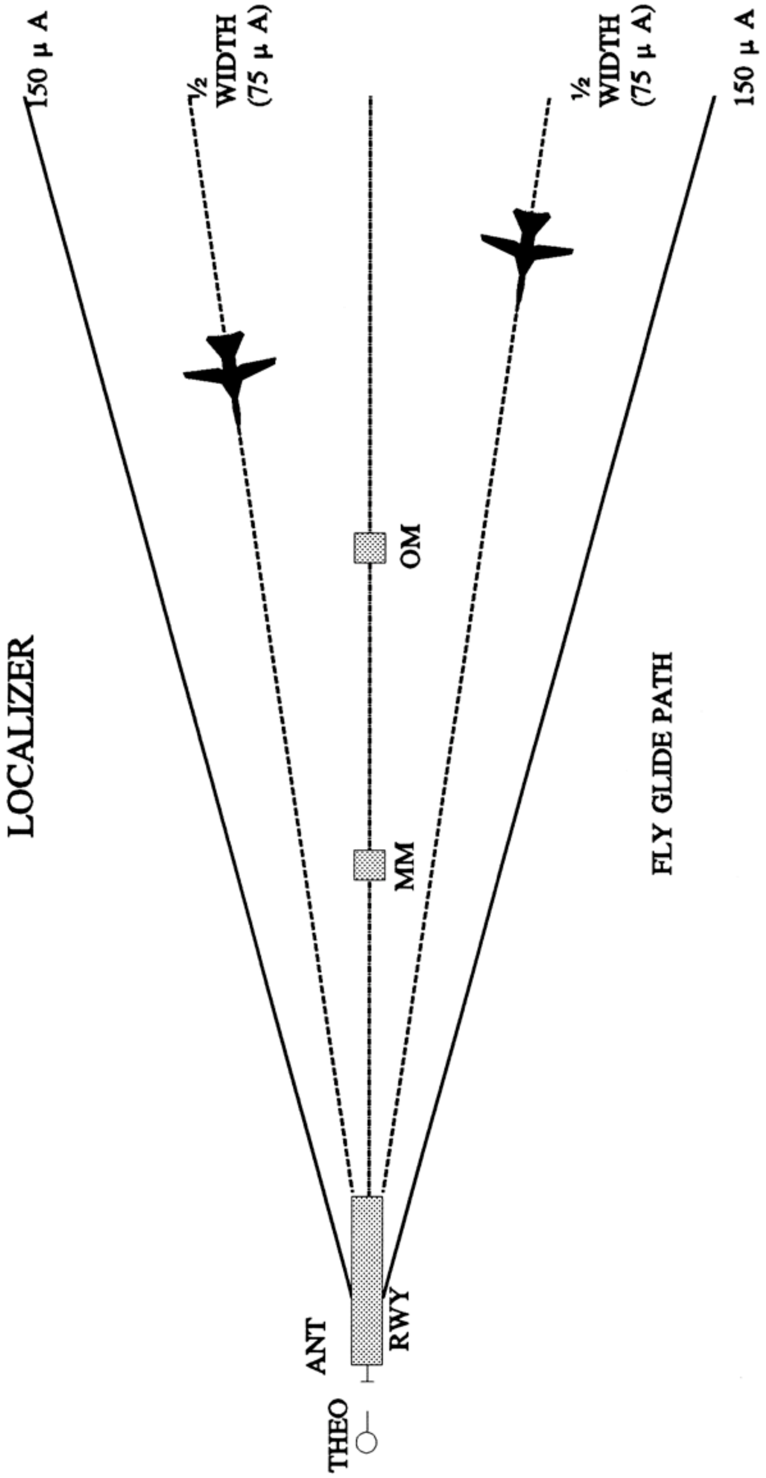


FIGURE 60 Course width symmetry check

7.4.6 GLIDE PATH FLIGHT INSPECTION

Following are the various Flight Inspection Checks.

a. Antenna Null Check
b. Phasing Check
c. Sector width and Glide Angle Check
d. Glide angle and Course Structure Check
e. Monitor Checks
   i. Position Alarm
   ii. Width Alarm
f. Azimuth Coverage

7.4.6.1 Antenna Null Checks

Purpose :

To confirm and correct (if required) the electrical height of G/P Antenna above ground. This check is performed during commissioning or after major maintenance of antenna.

Flight Procedure:

The calibration aircraft flies at 1000' AGL on LLZ from a distance of 8 NM to a point overhead G/P antenna. The a/c is tracked by Theodolite. The Theodolite gives event marks at 0.2° (elevation) interval starting from 1^0 to 4^0, and at 1^0 interval from 4^0 to 10^0. Figure 61 shows the procedure.

Ground Facility Adjustment

Dummy load the SBO signal in the Coaxial Distribution Unit/Antenna Changeover Unit. Feed CSB signal to antenna being checked (one antenna at a time). Adjust antenna height as advised by Flight Inspector. The height of antenna should be raised to decrease the NULL ANGLE & VICE VERSA.

Desired Results

For desired glide angle = θ, AGC nulls for various antenna should occur at

a. NULL REFERENCE SYSTEM

Upper Antenna - θ, 2θ

Lower Antenna - 2θ,

4θ

b. SIDE BAND REFERENCE SYSTEM

Upper Antenna - 4θ/3,

8θ/3 Lower Antenna - 4θ,

8θ

c. M-ARRAY

Upper Antenna - 2θ/3, 4θ/3

Middle Antenna - θ, 2θ

Lower Antenna - 2θ, 4θ

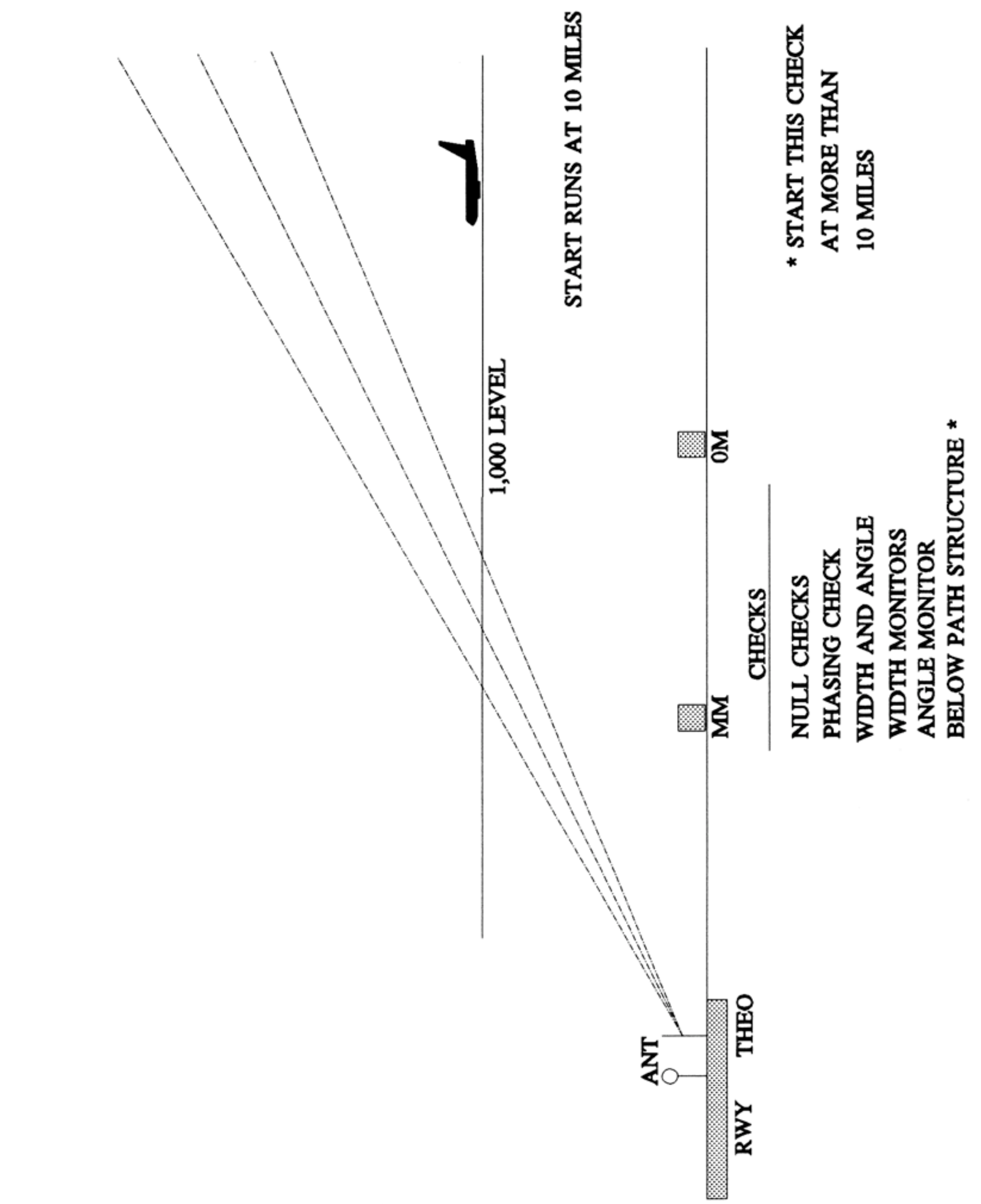

START RUNS AT 10 MILES
1,000 LEVEL
* START THIS CHECK
AT MORE THAN
10 MILES
OM
MM
CHECKS
NULL CHECKS
PHASING CHECK
WIDTH AND ANGLE
WIDTH MONITORS
ANGLE MONITOR
BELOW PATH STRUCTURE *
ANT
THEO
RWY

Figure 61 Glide Path Check

7.4.6.2 Phasing Check

Purpose:

To establish that correct quadrature phase relationship between CSB and SBO signals exists.

Flight Procedure:

Figure 62 shows the flight procedure for Phasing Check. The calibration A/C flies inbound on Center line at 1000' AGL The exercise is started at 10 NM from Runway threshold and is terminated at 1 NM before Outer Marker.

Ground Facility Adjustment:

In case of Normarc Glide Path equipment air phasing is seldom required. Necessary phasing adjustments are made in the Antenna Distribution Unit on ground itself. The details given below pertain to STAN/GCEL ILS, however it is interesting to know the RF adjustments which constitute the phasing procedure.

I. Put SBO O/P on Dummy load at Antenna Changeover Unit. Adjust MOD BAL Control as advised by flight inspector to attain zero cross pointer current in the a/c Console.

2. Insert quarter wave length (λ/4) line in SBO feeder and radiate both CSB and SBO signals.

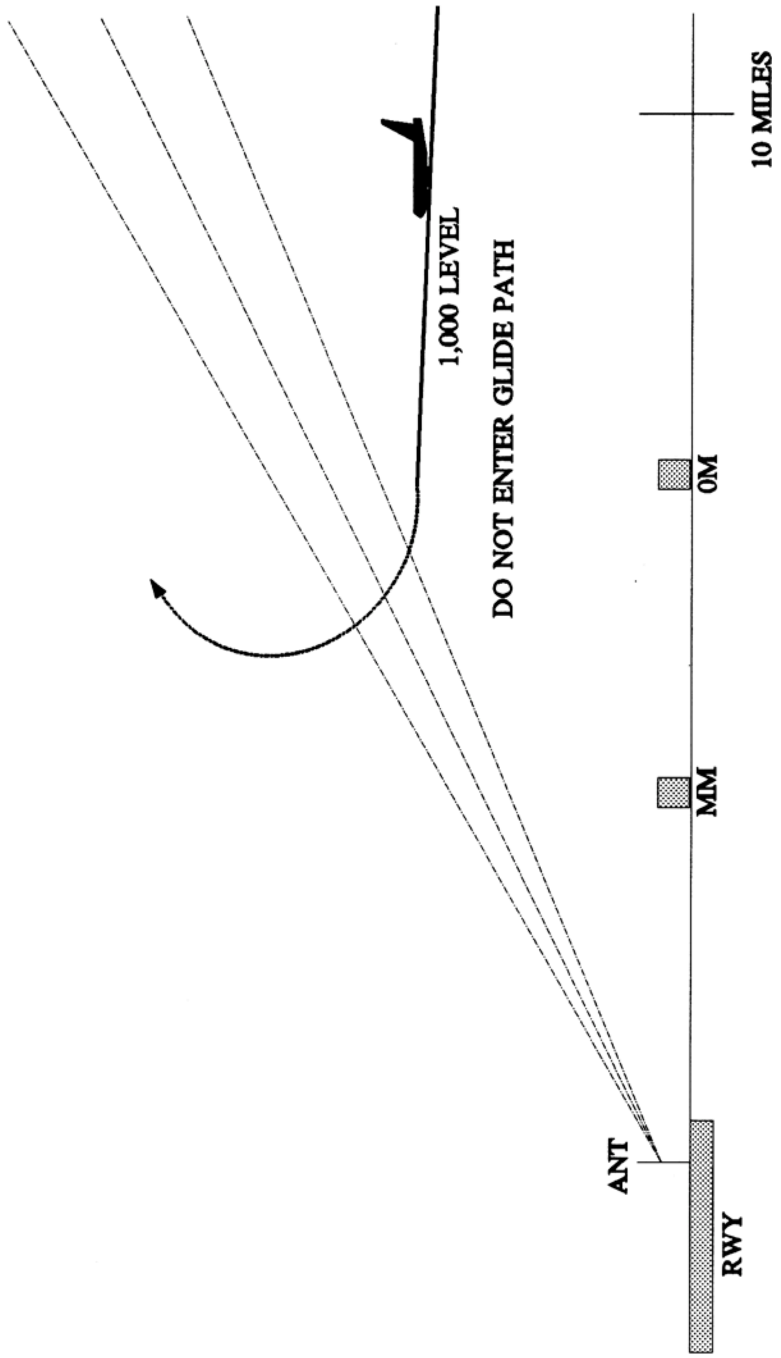


Figure 62 Phasing Check

a. Null Reference

For proper phasing the ground staff should always be quick and alert to monitor and act on instruction received on VHF R/T Set. After radiating CSB and SBO if the C.P. current is not zero flight inspector will intimate the C.P. current and accordingly the ground staff will adjust the Side Band Phaser. After phasing, remove λ/4 cable and give normal radiation.

b. Side Band Reference

Put upper antenna on Dummy Load before flying is started Adjust power ratio Control on ADU to achieve equal SBO power to both Antennas.

Put the SBO feed on Dummy Load, Check with a/c if CP current is zero. Feed SBO with λ/4 cable. Adjust `Side Band Phase' control to attain CP current = 0.

Remove Dummy Load from Antenna feeder and adjust upper ant phase control on ADU as advised by FIU to get CP current as zero. Remove λ/4 cable and normalize the feeds.

c. M-Array

Adjust various power ratio controls on ADU as prescribed. Put the Middle and Upper Ant on D/Load. Insert 1/4 cable in SBO feed and put it on D/Load. Radiate only CSB and check for Zero CP current. Radiate SBO also with λ/4 cable. Adjust phase Side Band Control to attain CP current zero. Remove D/Load from Middle Ant and adjust Middle antenna phaser to attain CP current zero. Remove D/Load from Upper Ant and adjust upper antenna phaser to achieve CP current = zero. Finally remove λ/4 cable and NORMALISE the equipment.

While doing phasing by SBO phaser if zero CP current cannot be attained, then insert about 3" (3 inch) of extra length in SBO Cable. If phasing comes proper then CSB cable may be cut equal to extra length (3" in this case). Extra length of cable can be put in CSB cable also if required to get zero CP current. In this case SBO cable may be cut.

Sector Width & Glide Path Angle Check

Purpose:

To determine the Glide angle and sector width and apply corrections if necessary Flight Procedure:

The calibration a/c flies inbound on extended centerline at 1000' AGL from 10 NM to MM. The A/C is tracked by Theodolite from 1°elevation and event marks are transmitted from Theodolite at 0.2° interval up to 4° and at 1° interval thereafter till the run is over. In case of semi-automatic FIS the event marks are automatically recorded in the console.

Ground Facility Adjustment

a. Angle.

If the angle is out of tolerance and MOD BAL setting is correct, antenna height will have to be adjusted, Minor adjustment of Mod Bal can be made as advised by of Flt Inspector. During the adjustment put the FTS on CSB course socket. In case the DDM is on 90 side the G/P is low and if DDM is on 150 side the angle is High. To increase the glide angle obtain a higher DDM predominant on 150Hz and vice versa.

b. Width:

Adjust SBO power attenuator. To increase the sector width reduce the SBO power or increase the attenuation and vice versa.

Carry out adjustment of SBO Power control as per advice of FIU team.
Desired Results

a. Glide Angle	-	θ (Selected)
b. $^1/a$ Sector Width	-	± 0.12 θ Lower and Upper
Tolerances		
i. Commissioning	-	No tolerances allowed
ii. Routine		
Glide Angle	-	± 7.5% of θ for CAT I & II
		± 4% of θ for CAT III

Half Sector Width

CAT I -	Lower Half Sector Width 0.07 θ to 0.14 θ
CAT II -	20% of nominal value
CAT III -	15% of nominal value

7.4.6.4 Glide Angle & Path Structure Check

Purpose :

i. To determine the computed (actual) Glide angle.
ii. To confirm that the G.P. aberrations, bends, roughness and scalloping are within tolerance.

Flight Procedure

The calibration A/C flies on G/P inbound on LLZ centerline from 10 NM up to threshold. The pilot follows glide path. The a/c is continuously tracked by Theodolite and event marks are passed on at regular intervals to give elevation information for recording in console. The Path Structure is Computed manually in case of manual FIS. In case of semi-automatic FIS the Azimuth information is automatically transmitted and recorded in console the result of path structure is computed by the computer and instant results are displayed on screen.

Ground Facility Adjustment

No adjustment is required in ground equipment. If structure results are not up to the mark the facility may be Down - Categorized. Site improvements may solve an out of-tolerance structure situation.

Desired Result

The Computed Glide Angle (Mean of all Glide Angles in Sector A-B) should be within Tolerance.

Tolerances

Structure:

Should not exceed

CAT I up to `A'	-	± 30 μ Amps
A-B	-	± 30 μ Amps
B-C	-	± 30 μ Amps
CAT II & III up to `A'	-	± 30 μ Amps
A-B	-	From ± 30 μ A at A to Linear decrease to ± 20μ A at Point B
B-T	-	± 20 μ A

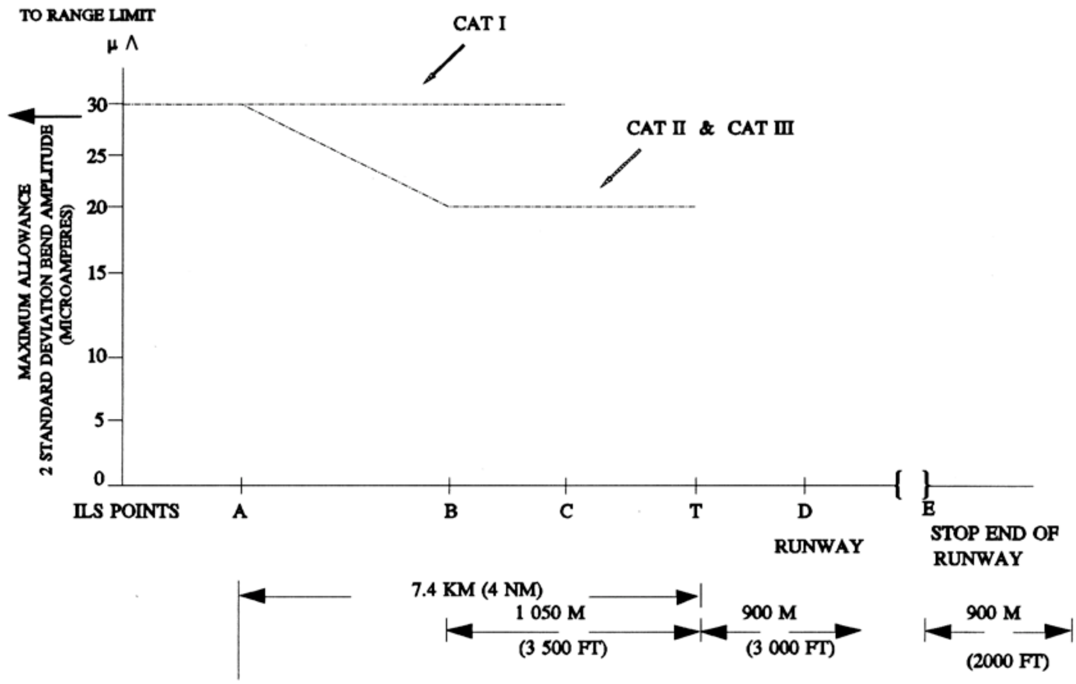


Figure 63 Glide Path and maximum Bend amplitude criteria

7.4.6.5 MONITOR CHECKS

a. ANGLE

ALARM Purpose:

To confirm that the Angle Alarm is adequately sensitive to detect a change of Glide Angle.

This check is carried out using one Tx only.

Flight check procedure

A/C flies ILS from 8 NM to Middle Marker.

Ground Facility Adjustment

Connect the FTS to course CSB socket in the changeover unit and note the DDM. On request from FIU A/C move MOD BAL in one direction till both Monitor 1 and Monitor 2 just exceed the threshold of alarm condition. Keep an eye on the C/L DDM display on the monitor. On advice of the flight inspector move the MOD Balance control in the other direction to achieve alarm condition as above. Afterwards, restore the control to obtain original value of DDM on FTS.

Desired Results

The change in the Glide Angle obtained by calibration A/C must be within ±7.5% of θ.

b. WIDTH ALARM

Purpose

To confirm that width alarm is adequately sensitive to detect an out-of tolerance change in sector width parameter.

Flight Procedure

A/C flies 1000 ft AGL along the extended C/L from 10 NM to middle marker.

Ground Adjustment

Set Monitor display for DS DDM and note the value.
Actuate width (DS) alarm condition on both monitor 1 and monitor 2 with the help of SBO power attenuation.
On advice of flight inspector move the control on the other side to obtain alarm condition.
Finally, as advised, restore the control and reconfirm by obtaining the original value of DS DDM.

Desired Results

For CAT I Change in the lower half sector width, in air, must be within ±0.037 θ.

For CAT II & III
Change in LHSW must be within 25% of the nominal value.

7.4.6.6 AZIMUTH COVERAGE

Purpose

To confirm that usable signal is available in the ± 8° azimuth zone (with the center line as the reference). This check is carried out only during commissioning or after major maintenance of the antenna.

Flight Procedure

A/C flies glide path with an azimuth offset of 8° (Pilot's estimate and aided by Theodolite guidance) w.r.t. The extended centerline.
This run is started at 5 NM and continued up to 2 NM.

Ground facility adjustment

None.

Desired Results

Glide path signal should have AGC equivalence of more than 15 µV and SDM/Mod sum more than 48%.

CHAPTER 08

NORMARC ILS SYSTEM DESCRIPTION

8.1. INTRODUCTION

This module introduces to the Localizer equipment NM 3513B and Glide Path equipment NM 3533B. Both of these are dual frequency/dual transmitter/dual monitoring systems.

8.2. NORMARC LOCALIZER/GLIDE PATH SYSTEM

Figure 64 shows the simplified block diagram of the Normarc Localizer/Glide Path system.

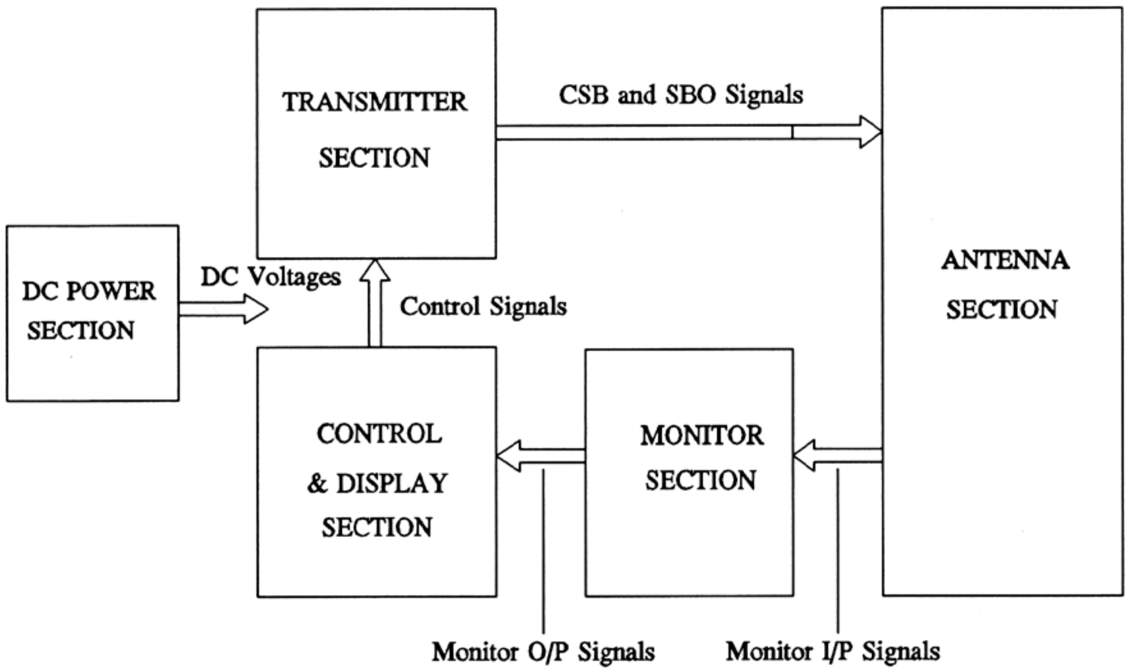


Figure 64 Normarc ILS Simplified Block Diagram

The Normarc Localizer/Glide Path system consists of the following five sections:

a. Transmitter Section
b. Control and Display Section
c. Monitor Section
d. Antenna Section
e. DC Power Section

8.2.1 Transmitter Section

This section generates the ILS signals, namely the CSB and SBO, in the required amplitude and phase relationship for radiation by the antenna system.

The Localizer transmitter section operates in the frequency band 108-112 MHz and produces four output signals namely:

a. CSB Course
b. SBO Course
c. CSB Clearance
d. SBO Clearance

The Glide Path transmitter section operates in the frequency band 328.6 - 335.4 MHz and produces three output signals namely:

a. CSB Course
b. SBO Course
c. CSB Clearance

8.2.2 Control and Display Section

This section has four different functions which are completely independent. These are:

a. Display, for displaying all parameters.
b. System status, for providing information about the system status and system switches.
c. Voting, for deciding which transmitter to be on.
d. Remote control, for receiving and sending messages from the remote control.

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8.2.3 Monitor Section

This section receives input from the Antenna section and depending on the preset internal alarm-limits sends control signals to the Control section. The Control section then will direct the correct transmitter for radiation. The other transmitter is directed into the dummy load. This transmitter is also RF sampled. The sample is also fed to the Monitor input.

8.2.4 Antenna Section

The antenna section contains the Log-Periodic Dipole (LPD) array, the antenna distribution network, the near field antenna and the monitor integral network.

The antenna array of the ILS localizer transmitter, consisting of twelve LPDs, is located on an extension of the centerline of the instrument runway of an airfield, but is located far enough from the stop end of the runway to prevent it being a collision hazard. The localizer antenna radiates a field pattern directed along the centerline of the runway towards the middle and outer markers. It also furnishes information outside the front course area in the form of full fly-left or full fly-right indications (CLEARANCE).

The antenna array of the ILS Glide Path transmitter, consisting of three LPDs in the form of M-array, is located at an offset distance of 450 feet from the runway centerline. The longitudinal distance from the runway threshold is a function of several factors which include:

a. The glide path angle
b. Threshold crossing height requirements
c. Obstruction clearance requirements
d. The slope of the terrain in front of the antenna system
e. The extent of smooth terrain in the site area and beyond the threshold.

8.2.5 DC Power Section

The equipment is powered by an SNIPS, external to the equipment, which produces a dc voltage of 27 V at 9 amps. This DC input voltage is converted into three DC voltages: +5 V, +12 V and -12 V required for equipment operation internally with the help of DC/DC converters.

8.3. NORMARC LOCALIZER/GLIDE PATH EQUIPMENT CABINET

The Normarc Localizer/Glide Path equipment is housed in a standard 19" rack as shown in figure 65.

The cabinet has 12 shelves which contain the equipment hardware. The contents of each of these shelves are as follows:

Shelf 0

This shelf does not contain any equipment hardware. It is covered with a blank panel.

Shelf 1

This Shelf contains the 24 V to +12/+5/-12 V DC/DC converter for the transmitter and the two fuses for the +27 V rail. The cards for monitoring the antenna distribution network (DC-loop) is also mounted in this Shelf. 24 V supply to the rack is switched ON/OFF through the switches mounted on this shelf. This is named as Power Distribution Unit.

Shelves 2/3/4 and 5

These shelves form the Transmitter Section. There are four transmitters, 2 Course and 2 clearance.

Shelf 6/7 and 8

These shelves form the Monitor Section. Shelf 6 contains the Hardware Based Monitor whereas shelves 7 and 8 contain the two Software Based Monitors.

Shelf 9/10 and 11

These Shelves form the Control and Display section of the equipment.

Shelf 9 contains the Local Control Unit. A Monitor Panel is mounted on the front of the rack.

Shelf 10 is the shelf where the coax-relay, phase adjusters and the attenuators are located.

Shelf 11 contains the Analog Meter Panel. The two instruments on the sides are analogue representations of the parameter currently displayed at the display in the Local Control Unit. The instrument in the middle indicates the output power for the transmitters.

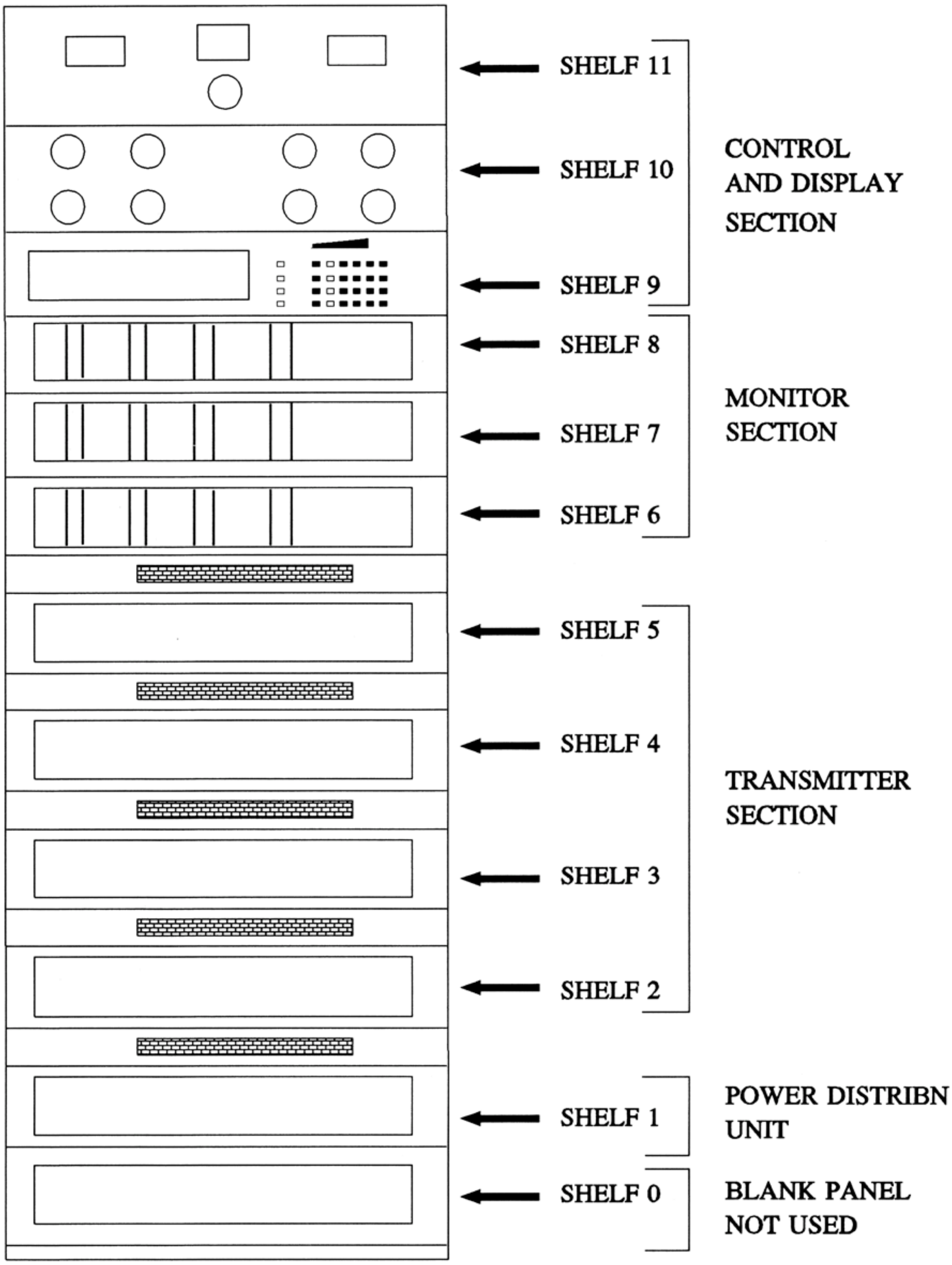

Fig. 65 Normarc ILS Equipment Cabinet

8.4. NORMARC LOCALIZER/ GLIDE PATH FUNCTIONAL BLOCK DIAGRAM

Figure 66 shows the functional block diagram of the Normarc Localizer/Glide Path equipment.

Depending on the input from the Monitor Integral Network, Field Antenna etc. and the preset internal alarm-limits, the monitors send control signals to the voting block. This block will, depending on the type of voting and the position of the Main Select Switch etc. turn the correct transmitter on. The change-over unit is also controlled by a signal from voting block.

The Display unit communicates with the monitors via a Serial Interface(SIP)-bus. All relevant parameters are transferred to the Display via this SIP-bus.

From the display an RS232 output is available. All parameter available on the Display are transferred to an external computer if this RS232 option is used.

The Remote Control makes it possible to operate and monitor LLZ/GP from the tower.

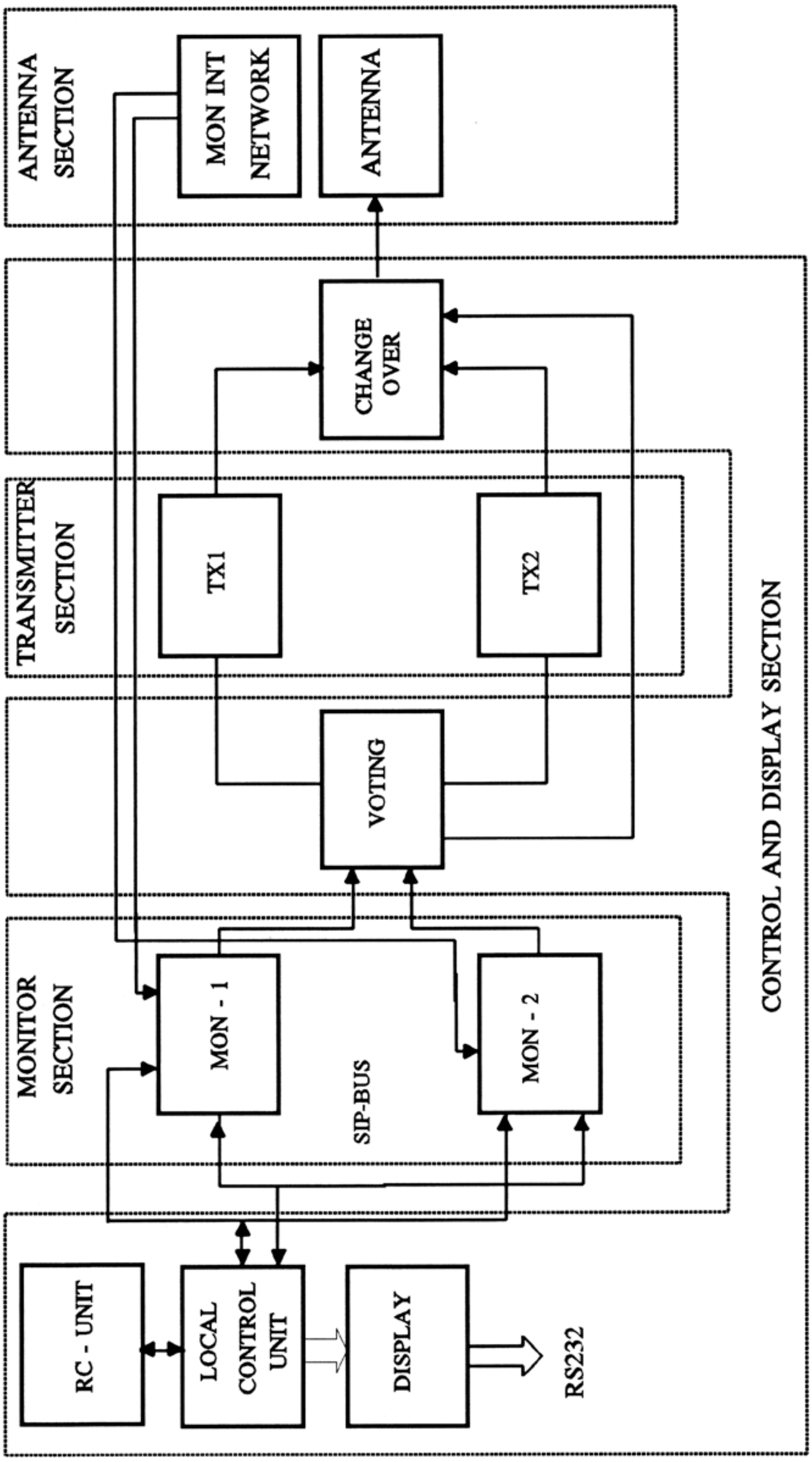

Fig. 66 Normarc ILS Functional Block Diagram

8.5 NORMARC ILS POWER SUPPLY

8.5.1. INTRODUCTION

In the earlier handout the Normarc ILS equipment was introduced. In this handout a detailed description of the power supply units of this equipment will be discussed.

The equipment operates on a DC voltage of 27 Volts supplied by a wall mounted Switch Mode Power Supply Unit (SMPS 600). The equipment is also capable of no break operation using a standby battery of 24 V. The 27 volts supplied by the SMPS is then converted into regulated +5 V, +12 V and -12 V DC voltages within the equipment with the help of various power supply modules.

8.5.2. SMPS

The SMPS supplied by WS ELTECK is wall mounted, operates on the commercial AC supply of single phase 220 V and produces 27 V DC. This DC voltage is supplied to the Power Distribution Unit in the ILS rack and then distributed to the different units of the equipment through a cable labelled 11. The SMPS output is also used to keep a 24 volt battery bank on float charge for system back-up power while supplying power to the ILS rack.

POWER SUPPLY MODULES

The Power Supply Module PS 635 is built around switched mode DC/DC converter module. The module PS 635 A employs PKA 2231, module PS 635 B employs PKA 2212 and module PS 635 C employs PKA 2314 switched mode DC/DC converter modules.
The module features shut down up on too low input voltage, and current limit on outputs. Inputs are protected with fuses.

The following table explains the specifications of these power supply modules.

Specifications	PS 635 A	PS 635 B	PS 635 C
Input Voltage:	19 to 35 V DC	19 to 35 V DC	19 to 35 V DC
Output Voltages:	+5.15V ± 2% DC +12V ± 2%DC -12V ± 2%DC	+5 V ± 2% DC	+5.15 V ± 2% DC +12V ±2%DC -12V±2%DC
Output Currents: -	4 A at 5 V 1 A at +12V 1A at -12V	4 A	4 A at 5 V 2.5 A at +12V 1 A at -12V
Ripple/noise:	60 mV p-p at 5 V 140mVp-p at ±12V	80 mV p-p	60 mV p-p at 5 V 140mVp-p at ±l2V
Efficiency:	80%	80%	80%
Input/Output Isolation:	Common Ground	Common Ground	Common Ground
Environment operating:	-45 to +85 C	-45 to +85 C	-45 to +85 C
Storage:	-55 to +125 C	-55 to +125 C	-55 to +125 C

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8.6. NORMARC ILS TRANSMITTER SECTION

8.6.1. INTRODUCTION

The modulator/transmitter is a complete section built into a 19" rack. The output signals are labelled CSB and SBO and are available at two SMA ports . The SBO power level is the same as the sideband power level of the CSB port. The SBO phase is in quadrature phase with the CSB sidebands.

The transmitter section of the Localizer and Glide Path equipments are identical except for a minor change which will be described as the module progresses.

8.6.2. TRANSMITTER SECTION BLOCK DIAGRAM

Figure at the annexure shows the simplified block diagram of the Transmitter Section of the Normarc Localizer equipment.

The Transmitter Section is divided into two units namely:

a. Course Transmitter Unit
b. Clearance Transmitter Unit.

Each of these units will have two transmitters namely Transmitter 1 (TX1) and Transmitter 2 (TX2). Each course transmitter produces two signals namely the CSB CL and SBO CL. Each clearance transmitter produces two signals namely CSB CLR and SB0 CLR. All the CSB signals are routed to the Coaxial Change Over unit directly while the SBO signals are routed through Phaser and Attenuator units to the Coaxial Change Over unit.

The Coaxial Change Over unit is activated by two control signals namely COAX Control CL and COAX Control CLR from the Relay Driver Cards housed in the Local Control Unit. Depending on the logic level of these signals, the coaxial relay allows one of the two transmitter signals to be passed on to the Antenna Section while the other transmitter signal is routed to the Dummy Load. If the logic level is "1", Transmitter 1 signals are selected and if the logic level is "0", the transmitter 2 signals are selected.

In the Transmitter section of Glide Path equipment, there is no generation of SBO CLR signal. Hence the corresponding transmitter circuits will be absent.

8.6.3 TRANSMITTER UNIT BLOCK DIAGRAM

8.6.3.1 Localizer Course Transmitter Unit

The Localizer Course Transmitter Unit consists of the following 9 modules of which 7 are different:

a.	90/150 Hz Generator	PV20396
b.	Identity Keyer	PV21204
c.	Feedback Control	FC550A
d.	RF Oscillator	OS551A
e.	Power Amplifier	PA552A (2 pcs)
f.	AM Detector	DT555A (2 pcs)
g.	Combiner	CB556A

Figure at the annexure shows the block diagram of the Localizer Course Transmitter unit.

In order to produce the required modulated rf-outputs two crystal oscillators and three feedback loops are implemented. In addition a 1020 Hz morse-coded signal is generated from a free running RC oscillator.

The Tx ON/OFF function is accomplished by supplying the RF crystal oscillator circuit with 12V supply (Vcc) which is switched off for Tx power off. (In this case the power amplifiers are not consuming power from the 27.6V supply because the operate in class C.

The first crystal oscillator is operating on 460.8 KHz and located on the 90/150 Hz Generator module. The frequency is divided down to 90 and 150 Hz phase locked and filtered to sine-wave voltages, which are fed to the Feedback Control module and used as driving signals for the modulator circuits.

The second crystal oscillator is operating on the Localizer channel frequency (108.1 - 111.95 MHz) and is located on the RF Oscillator unit. The signal is split into two paths and amplified to a power level suited for driving the two Power Amplifier modules.

Two of the feedback loops are identical, one is in the 90 Hz modulation path and the other is in the 150 Hz path. The purpose is three-fold:

a. Maintain a constant output power level.
b. Maintain a constant modulation depth for each tone.
. Cancel modulation distortion generated in the class c type Power Amplifier.

The third feedback loop is a differential control loop for the rf phase of the carrier signal. The purpose is to maintain a constant static rf phase in quadrature at the inputs of the combiner hybrid located in the Combiner module.

The 90 Hz and 150 Hz sine wave signal originating from the 90/150 Hz Generator module is level-stabilized through AGC circuits in the Feedback control module. The tone levels can be controlled differentially from the MOD BAL potentiometer and single-ended from the MOD SUM potentiometer.

The modulation levels for 90 and 150 Hz are now fixed and ready for adding to a dc voltage which determines the rf carrier power level. This dc voltage is stabilized and controlled from the RF POWER potentiometer, split into two branches and added to the 90 and 150 Hz voltages in op-amps, then current-amplified to drive the modulation stage in each Power Amplifier module.

The feedback signals from the AM Detector module are compared with the modulation voltages in the op-amps 180 degrees out of phase such that negative corrective feedback takes place. A potentiometer labelled RF BAL is used to balance the feedback signals differentially such that a carrier cancellation occurs at the SBO output port.

The RF carrier signal is generated from the RF Oscillator Modulator. An rf phase regulator incorporated in one signal path is controlled from the phase-detector in the combiner module such that the phase referenced to the other path is maintained, constant when the feedback loop is closed. (The phase compensation loop is not removing the dynamic phase modulation because the loop operates differentially and not single-ended).

The phase controlled RF signals are now driving the two Power Amplifier Modules which amplify the power in three class C stages. The AM modulation is implemented in the first stage simply by varying the collector voltage originating from the emitter follower driver in the Feedback Control Module. One Power Amplifier Module is carrying 90 Hz modulation while the other is carrying 150 Hz modulation each at 20% modulation depth.

The two main power signal paths are sampled by the AM detector module, the sampled signals are rectified and filtered (for each modulation) and fed back to the Feedback Control module for corrective actions described above.

The modulated carriers are now in phase-quadrature due to a 90 degrees delay line in one signal path, and are ready for entering the combiner hybrid located in the combiner module. Prior to this quadrature combination another dual signal-sampler/detector is looking at the two power signals, and in co-operation with the phase-detector is generating in the phase-correction signal back to the phase detector in the RF Oscillator module. The combiner hybrid now combines the 90 and 150 Hz modulated power signals in such a way that both carriers will add together at the SUM port and the modulation sidebands will be distributed equally in two parts between the SUM port and DIFF port. Hence, carrier sideband (CSB) and sideband only (SBO) is generated.

Finally, the CSB and SBO powers are sampled by the last AM Detector module in order to provide test signals to panel meters.

The Identity Keyer module provides morse-keyed 1020 Hz sine-wave signal to the Feedback Control module. This modulation is distributed equally to both Power Amp modules. The rf phase due to modulation is 0 degree, therefore Ident modulations are routed to the SUM port (CSB) only and cancelled at the SBO port.

8.6.3.2. Localizer Clearance Transmitter Unit:

The Localizer Clearance Transmitter Unit will be identical to that of the Course Transmitter unit except the absence of the 90/150 Hz Generator Module. The 90/150 Hz signals for this unit are fed from the Course Transmitter unit.

8.6.3.3 Glide Path Course Transmitter Unit

The Glide Path Course Transmitter Unit consists of the following 9 modules of which 7 are different:

a.	90/150 Hz Generator	PV20396
b.	Feedback Control	FC549A
c.	RF Oscillator	OS551A
d.	Power Amplifier	PA552a (2 nos.)
e.	Tripler	FT553A
f.	AM Detector	DT554A (2 pcs)
g.	Combiner	CB557A

It can be easily seen that 8 of the above 9 modules are the same as that of Localizer transmitter unit. Figure 67 shows the block diagram of the Glide Path Course Transmitter unit.

The block diagram explanation of this transmitter is exactly the same as that of the Localizer transmitter except for the following differences:

i. The second crystal oscillator is operating on one third of the Glide Path channel frequency (329.15. 335 MHz).
ii. The two Power Amplifier Modules carry 90 Hz modulation and 150 Hz modulation, each at 40% depth of modulation.
iii. The modulated power signals from the power amplifier modules are processed in the Tripler Module before going to the AM detector module.

8.6.3.4 Glide Path Clearance Transmitter

The Glide Path Clearance Transmitter Unit contains only 5 modules namely:

a. Feedback Control FC549B

b. RF Oscillator OS551B

c. Power Amplifier PA552B

d. Tripler FT553B

e. AM Detector DT555B

Figure at the Annexure shows the block diagram of the Glide Path Clearance Transmitter unit. Since there is no requirement of SBO CLR signal, the corresponding circuits will be absent. The 90/150 Hz signals for this unit are fed from the Course Transmitter unit. These 90/150 Hz tones are added together in the FC 549 B Module to form a composite modulation signal. The tone ratio is 20/60 for 90 Hz and 150 Hz depth respectively.

8.7 BLOCK DIAGRAM OF MONITOR SECTION

The LLZ/GP is equipped with dual monitoring system consisting of two monitor units called MONITOR 1 and MONITOR 2. Each Monitoring Unit consist of two different types of monitoring systems. These are:

a. Software Based Monitor (SBM); and
b. Hardware Based Monitor (HBM).

Figure at the Annexure shows the block diagram of the Monitor Section. The HBM acts like a "fuse". In case the SBMs are not able to detect an ALARM due to any software problem, the HBM will shut down the equipment without subsequent shift. The overall monitor integrity figure is based on the HBM. Hence, no software failure can reduce the over-all monitor integrity.

8.7.1 FUNCTIONS OF MONITOR SECTION

The functions of the SBM and HBM will be discussed in this section.

8.7.1.1 Functions of Software Based Monitor (SBM)

Following are the functions of the SBM:

i. Monitors Radiating Channel
Inputs Course Line, Near Field, Displacement Sensitivity and Clearance Signals from Monitor Combining Unit and computes DDM, SDM and RF and then compares these computed values with preset limits.
ii. Gives data to Control Section
In addition to above, it also passes on the computed values to Control Section as also other data required by the Control Section.
iii. Difference Frequency Monitor

The Normarc ILS being a two frequency system, uses two frequencies for the carriers of Course and Clearance radiations. We know their frequency tolerances and the limits of difference in frequency between the two carriers. The difference frequency is monitored in SBM.

iv. Monitors Power Supplies of other channels

SBM also monitors the power supplies of the other SBM to ensure that the power supplies do not stay outside limits. This is necessary as it is always advisable to monitor the power supply of microprocessor based units independently because in microprocessor atmosphere the load requirements are not uniform and many problems can arise if power supply develops glitches and/or outside specification voltage.

8.7.1.2 Functions of Hardware Based Monitor (HBM)

Enabling transmitter signal is in fact, as we shall see a little later, is a set of four signals in the form of pulses. They are generated in SBM if all is well with the monitored channel, and are passed on to the transmitter section via the Control Section to keep the channel radiating. But even before going to the Control Section it has to pass through the HBM and if in HBM it finds that any of the monitor inputs of CL, NF, DS and CLR are outside the set limits, as per the specification of ILS monitoring, then it inhibits further progress of the Enabling Transmitter signal.

However, there is marked difference between the monitoring of the four signals CL, NF, DS and CLR by the SBM and HBM. Where as SBM limits are set inside the tolerances, the limits for HBM are actually are the tolerances themselves. This ensures that for a channel operating on the edge of tolerance, the SBM diagonises a particular parameter as having fault even before HBM actually takes corrective action.

The entire Monitor system described above is duplicated to form two Monitors 1 and 2.

8.8 CONTROL AND DISPLAY SECTION

8.8.1. INTRODUCTION

In this module, the Control and Display section will be discussed.

7.8.2. BLOCK DIAGRAM OF CONTROL AND DISPLAY SECTION

The Control and Display Section comprises the following units:

a. Local Control Unit
b. Change-over Unit
c. Meter Panel Unit
d. Remote Control Unit

Figure at the Annexure shows the block diagram of the Control and Display Section.

8.8.3. FUNCTION OF CONTROL AND DISPLAY SECTION

The control and Display Section has the following different functions which are completely independent:

- Voting: To decide which transmitter to be on.
- Change-over: To decide which transmitter to be connected to antenna and which to the dummy.
- System status: To provide information about the system status and system switches in the form of visual indications.
- Display: For displaying all parameter values in LCD display as well as to provide their analogue representation in analogue meters.
- Remote control: For receiving and sending messages from the remote control unit and thus making it possible to operate and monitor the LLz/GP equipment from the remote.

8.8.3.1 Functional description of Control and Display Section

Control and Display Section can be functionally described by the following four different operations namely:

- Local switching
- Remote switching
- Key board & display
- Control action

Each of these operations are briefly described in the following paragraphs.

a. Local switching

LLZ / GP equipment rack can be operated locally from the membrane switches mounted on the front panel of the local control unit. When a switch is pressed logic goes to the monitor I/II through cable 8/9 where it causes each monitor (SBM) to generate pulse train (from KI649). This pulse train is routed to HBM, before it finally reaches to the voting gate. Voting card decides which Tx(s) is to be ON. Accordingly voting card extends the Tx ON/OFF control signal (+ 12V supply) through cable 11 to the respective Tx(s) for switching ON. Simultaneously, voting card also sends a "Coax control" signal through cable 2/3 to the coaxial relays in the changeover unit, which connects the operating Tx(s) output signals to the antenna.

b. Remote switching

LLZ / GP equipment rack can also be operated from a remote place through remote control unit (RCU). The remote control system uses digital multiplexing of channels. It uses two pairs of 600 ohm line, designed for full duplex operation, between ILS cabinet and the remote control unit.

One pair of lines (L1) carry the following status information from the ILS site to the RCU:

i. NORMAL ii. STANDBY iii. ALARM iv. WARNING

The other pair of lines (L2) is used to communicate the following commands from the RCU to the ILS site:

i. ON/OFF ii. Change Over iii. Interlock

The 'Interlock' switch is installed in the ATC tower. When two ILS systems are installed and used for reciprocal directions of the same runway, the interlock switch enables only one ILS system to be switched on.

Frequency Shift Keying (FSK) modulation is used for the transmission of data between the RCU and ILS cabinet. The frequency deviations are + 100Hz for Space and -100 Hz for Mark. The transmitting frequency from ILS cabinet to RCU is 1750 Hz while that from RCU to ILS cabinet is 1080 Hz. The modulation rate is 150 bits per second and the system will work satisfactorily up to -14 dBm on the lines.

The control signal may be originated from FSK Rx/Tx module installed in the equipment room or from the slave panel kept in tower room. This control signal is FSK modulated and sent serially to the equipment site on two-wire line. FSK Rx at site demodulates it before the UART converts it into a parallel format, which goes to monitor I/II through cable 8/9, where it causes each monitor (SBM) to generate a pulse train (from KI649). This pulse train is routed to HBM, before it finally reaches to the voting gate. Voting card then acts in the same way as explained above to provide the operating Tx(s) output signals to the antenna.

c. Keyboard and display

The only purpose of key board and display is to present the relevant information to the user. If this unit fails, the ILS is still fully operative.

CPU of the local control unit continuously communicates with the CPU of the monitors via serial inter phase (SIP) bus. Each monitor is sending a complete message approximately 6 times per sec. these messages contain all information about the various parameters. In other words, the CPU in local control unit continuously updates all the parameters values. From the key board, the user selects which parameter to be displayed. The keyboard/display interface card scans which push button (row & column) has been activated and sends the information regarding the scanned key to the CPU on data bus. CPU now finds out the relevant information from the information it has updated from monitor I/II and displays on the LCD display through the keyboard/display interface card. It is also this CPU that handles the RS232 communication. By connecting a Heyes compatible modem to the CPU, all parameter values and status information can be transferred to a distant computer.

The keyboard/ display interface card also converts the digital parameter value currently being displayed on LCD into its analogue value for analogue representation in the meter panel.

d. Control Action

As mentioned earlier, the CPU of local control unit continuously communicates with the CPU of each of the monitors and updates the monitored parameter values approximately 6 times/sec. CPU of monitor reads the measured values for 90 Hz, 150 Hz modulation depth, RF levels, alarm limits etc. and calculates DDM, SDM and communicates to CPU of control unit. CPU of control unit then determines, if there is an alarm and which transmitter is to be ON etc.

When CPU finds out that a transmitter is to be ON due to alarms in the operating transmitter or otherwise, it generates a pulse train in each of the monitors from KI649. This pulse train is routed to HBM before it finally reaches to the voting card. Voting card then acts in the same way as explained earlier to provide the standby Tx(s) output signals to the antennas.

CHAPTER 09

NM 7000 SERIES ILS

PART I - INTRODUCTION

9.0 General Information

This paragraph gives a description of a typical ILS installation and the Normarc Glide path system .Conventions and abbreviations used in this manual are also given.

9.1 Introduction

This is an overview of Normarc's NM703X ILS glide path systems.

9.1.1 ILS Overview

A complete Instrument Landing System comprises:

- A LOCALIZER SYSTEM, producing a radio course to furnish lateral guidance to the airport runway.
- A GLIDE PATH SYSTEM, producing a radio course to furnish vertical guidance down the correct descent angle to the runway.
- MARKER BEACONS, to provide accurate radio fixes along the approach course.

The layout of a typical ILS airport installation is shown below.

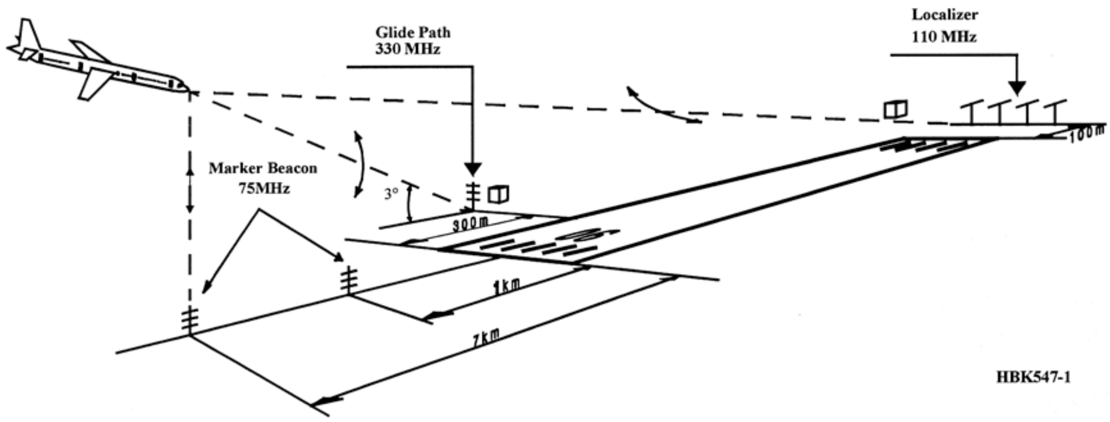

Figure 64 Typical ILS installation

9.1.2 Glidepath Overview

The complete ILS Glide path system comprises:

- A GP transmitter/monitor cabinet
- An antenna distribution network
- A monitor network
- A GP antenna array
- Near-field monitor antenna

A block diagram is shown below:

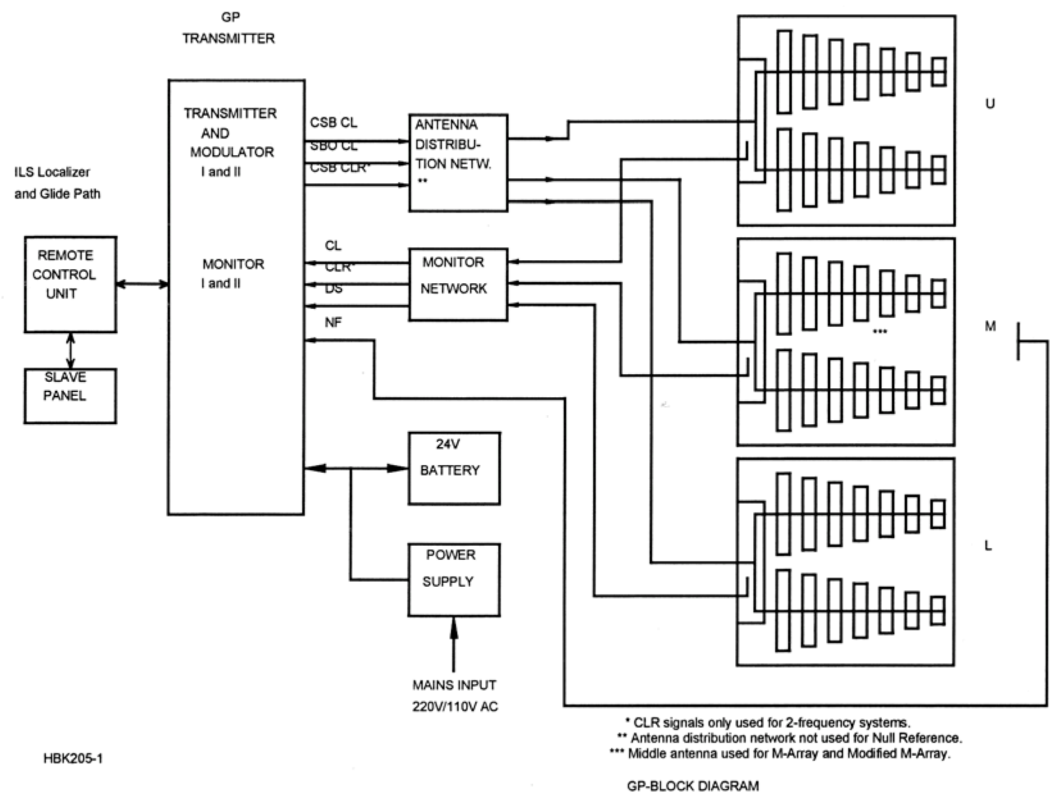

FIG.65

9.1.3 Glidepath Description

To shape the glide path signal, ground plane reflection from an area in front of the antenna array is necessary. The specific requirements to the area are given in the antenna handbook.

The glide path site may be located on either side of the runway, but the most reliable operation will be obtained if the site is selected on terrain least obstructed by taxiways, aircraft holding aprons, parking ramps, buildings, power lines etc. The site should offer the widest area of smooth ground with possibilities of leveling without excessive physical or economical effort, if indeed leveling is deemed necessary.

The glide path antenna system should be located at a distance of 75-200 m from the runway center line. The distance from the runway threshold is a function of several factors upon which establishment of the optimum operational conditions depend. These factors are:

1. The glide path angle.
2 Threshold crossing height requirements.
3. Obstruction clearance requirements
4 The slope of the terrain in front of the antenna system.
5. The extent of smooth terrain in the site area and beyond the threshold.

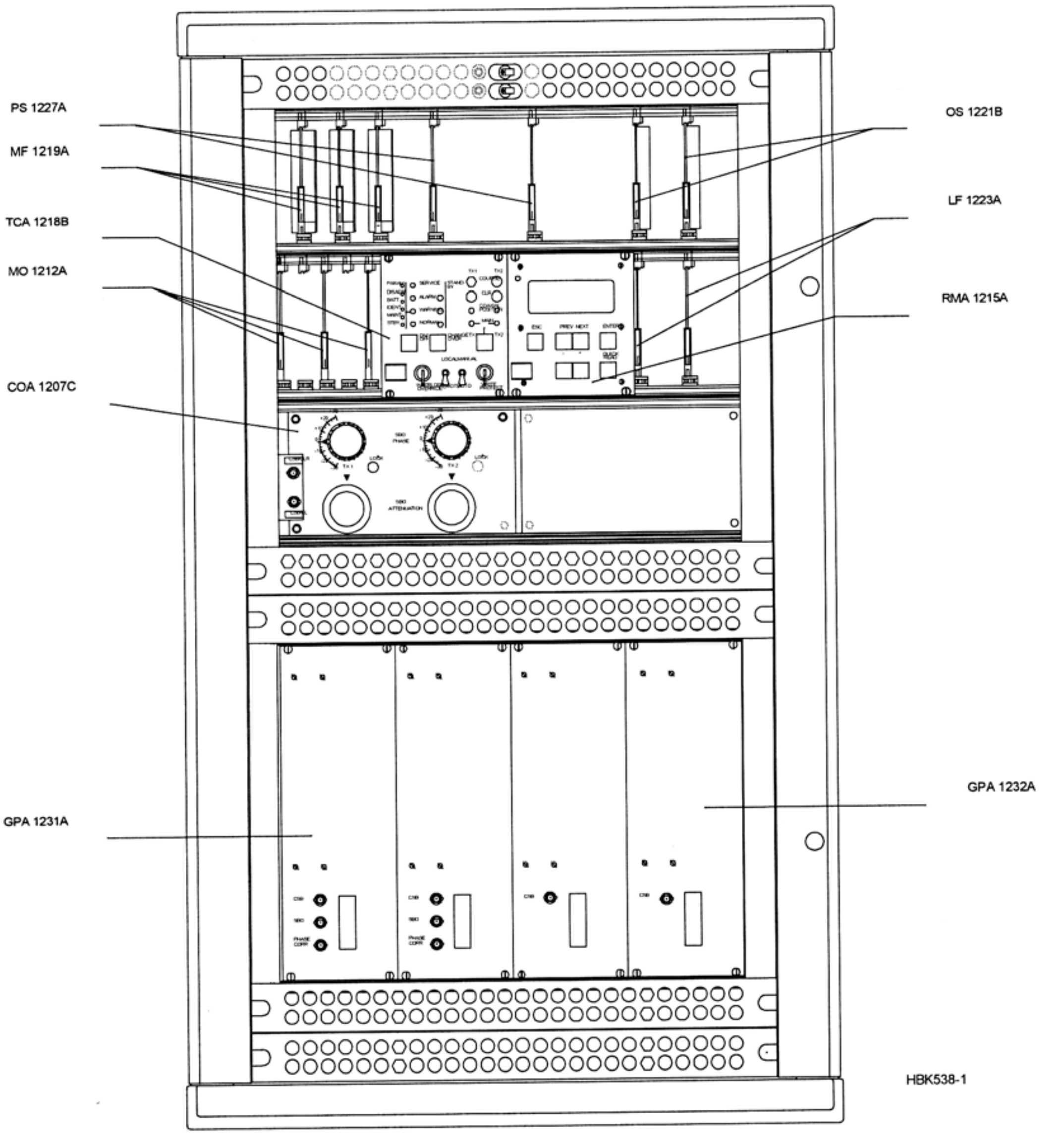

Figure 66. NM 7034 Module Location – Front view.

9.2 System description

This chapter gives a functional overview of the NM70xx ILS systems.

9.2.1 Overview

The complete ILS electronic system is housed in a compact, wall mounted cabinet. The cabinet and the electronics, except for RF units, are common to the LLZ and GP systems.

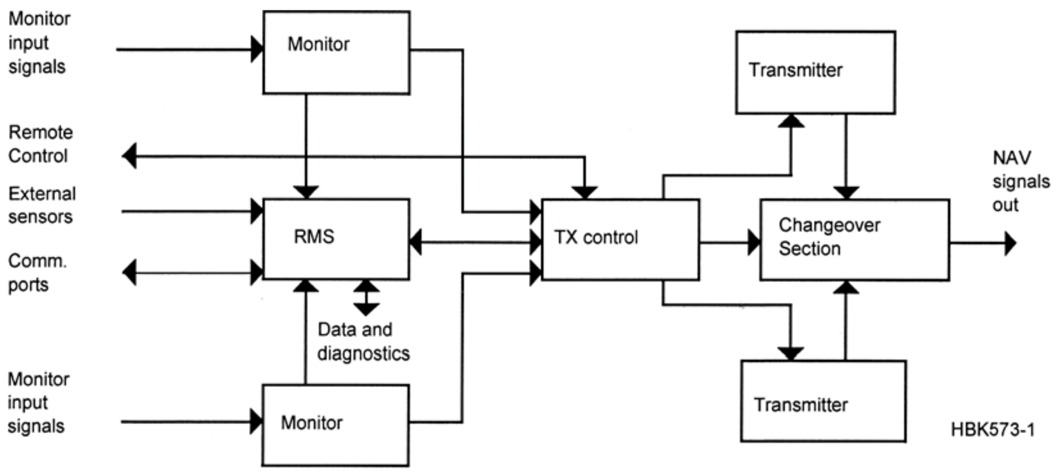

Fig.67

The ILS cabinets can be configured for Cat I, Cat II, or Cat III requirements with no basic changes.

Eight models are available:

NM 7011	Single frequency LLZ
NM 7012	Single frequency LLZ with hot standby monitoring (Cat III)
NM 7013	Two frequency LLZ
NM 7014	Two frequency LLZ with hot standby monitoring (Cat III)
NM 7031	Single frequency GP
NM 7032	Single frequency GP with hot standby monitoring (Cat
III) NM 7033	Two frequency GP
NM 7034	Two frequency GP with hot standby monitoring (Cat III)

The system is based on modern technology with extensive Remote Monitoring and Maintenance capabilities, and very high reliability and integrity. To meet this objective, the monitor comparator and station control are based on digital hardware, while the RMS interface is microprocessor based.

9.2.2 Physical Description

The cabinet contains three sections:

- The electronics card cage
- The change-over section
- The transmitter / PA section

The electronics card cage contains the RF oscillators, the LF signal generators, the monitors, the station control, the RMS processor, and the voltage regulators.

The change-over section contains coaxial relays, attenuators and phasers for the RF outputs.

The transmitter / PA section contains the PA blocks including couplers etc. for each output.

The cabinet is divided in two parts, with the rear part fixed to a wall, and the front part hinged to give access to interior of the cabinet.

All external connections are made to the rear part of the cabinet.

9.2.3 Monitors

The ILS has duplicated monitors with inputs for Course Line (CL), Displacement Sensitivity (DS), Near Field (NF), and Clearance (CLR) (Dual Freq. only). The signals are detected by the input stage, and then digitized. In the next block they are filtered by a Fast Fourier Transform performed by a signal processor. The results for each parameter is then compared with stored limits in a digital hardware comparator. Each of the two monitors consists of two modules. For Cat III use, Hot Standby monitoring can be added by using one additional monitor and associated RF couplers and combiners. The design of the monitors ensures a very high integrity due to the use of digital hardware for the alarm comparators and a very simple Fast Fourier filtering with a signal processor. In addition, the monitor is checked by automatic self-tests. The alarm limits are stored locally in EEPROM, and can be updated from the RMS processor, with a separate hardware write protection to ensure that the integrity is not affected by the RMS system.

9.2.4 Transmitters / Modulators

The transmitters are duplicated, either single frequency or dual frequency. Each transmitter consists of a RF oscillator, a LF generator, and one or two PA blocks (single or dual frequency). The RF oscillator uses a synthesizer for easy frequency changes and simple logistics. The oscillator has two outputs for use in dual frequency systems. The LF generator contains the generators for 90Hz, 150Hz and 1020Hz signals, the ident keyer / sequencer and interface for DME master or slave keying. All signals are generated by division from a common clock oscillator, ensuring very stable phase relations between the modulation signals. The modulation balance, modulation sum, RF level and Ident morse code are set in this module by means of multiplying digital to analog converters. The values are stored locally in EEPROM and can be updated from the RMS processor with hardware write protection. The same LF generator is used for single and dual frequency systems.

9.2.5 TX Control

The TX control unit controls the system dependent on alarms from the monitors and inputs from the local control, the remote control and, optionally, the RMS. It also generates status information to the same units. The local control and status indicators are a part of the TX control unit. All functions in the TX Control are based on digital hardware to ensure the highest integrity.

9.2.6 Remote Monitoring (RMS) Unit

The RMS unit contains the system microprocessor. It handles storage and read-out of monitor parameters, measurements for maintenance and fault finding, and performs fault analysis to isolate faults to line replaceable modules. It is also used to set monitor limits and transmitter adjustments. The RMM handles communication to local and remote RMS computers, and in addition it handles a small display and keyboard for parameter setting and readout.

9.2.7 Remote Control Unit

The remote control unit is used in the tower or in the technical control room. It has indicators for operating status as well as detailed warnings and an aural alarm device with reset. It can control equipment on/off and change-over, and has an Access Grant-switch to allow remote control from the RMS.

The Remote Control Unit is connected to the ILS by one telephone pair cable.

9.2.8 Remote Slave Panel

The slave panel is connected to the remote control by a multi-pair wire. It is intended for use in the control tower. It has indicators for normal / warning / alarm and has an aural alarm device, in addition it can turn the equipment on and off, and has an aural alarm reset. Optionally a slave panel with remote control functionality can be delivered.

9.2.9 Remote Maintenance Monitoring (RMM)

The NM7000 series has a built-in Remote Maintenance Monitoring system. This system consists of the RMS, remote PC terminals with the RMM program installed, and the local keyboard/ display.

PART II – TECHNICAL SPECIFICATIONS

9.3 Technical Specifications

NM 7034 Dual-Frequency Glidepath Cabinet with hot standby monitoring.

9.3.1 Signal Minimum Performance

GP Transmitter

Frequency range	328.6-335.4 MHz
Frequency tolerance	± 0.002%
Output power (CSB + SBO) Course	3-7 W adjustable
Output power (CSB) Clearance adjustable	0.3-1 W
Harmonic radiation	2.5 μW maximum
RF difference frequency (2-freq. only)	15 kHz + 5 kHz
Spurious	25 μW maximum
Output power stability	± 0.2 dB
CSB/SBO stability	± 0.3 dB

Modulator - Course line

Modulation depth 90/150 Hz	40%
adjustable range	10 - 44%
SDM stability	± 0.8% SDM
DDM stability	± 0.2% DDM
Frequency tolerance	± 0.05 Hz
Total harmonic dist. (90/150 Hz)	1% maximum
Phase locking (90 Hz to 150 Hz)	5° maximum ref 150
Hz SBO phaser adjustment range	± 30°

Modulator - Clearance

Modulation depth	80%
90 Hz component	20%
150 Hz component	60%
Adjustable range DDM	20 - 100% 150 Hz dominance
Adjustable range SDM	20 - 90%
Stability	± 0.2 dB
Frequency tolerance	± 0.05 Hz
Total harmonic dist. (90/150 Hz)	1% maximum
Phase locking (90 Hz to 150 Hz)	5° maximum ref 150 Hz

Monitoring

Alarm Functions	Adjustable Range (*)
RF power reduction	1 - 5 dB
Change of nominal CL	± 10 - 60
μA Change of nominal DS from nominal μA value	± 10 - 60
Change of nominal CLR (2-freq only)	± 10 - 60 μA
Change of nominal NF	± 10 - 60 μA
Change of nominal SDM	± 2 - 8%

SDM Difference frequency (2-freq. only)	2 - 5 kHz

Total period of radiation out of tolerance	1 - 6 sec.
Additional NF time delay	0 - 20 sec.

Line break, ILS - Remote Control (disable optional)
(*) asymmetrical limits are possible.

Monitor input levels:

Adjustment range, nominal level	- 5 to –34 dBm
AGC range for less than 1% dB change in SDM	5

Monitor stability at nominal levels:

RF power values	± 0.3 dB
DDM values	± 1 µA
SDM values	± 1% SDM

Warning Functions:

RF power reduction	40 - 75% of Alarm limit
Change of nominal CL	40 - 75% of Alarm limit
Change of nominal DS	40 - 75% of Alarm limit
Change of nominal CLR	40 - 75% of Alarm limit
Change of nominal NF	40 - 75% of Alarm limit
Change of SDM	40 - 75% of Alarm limit
Difference frequency	40 - 75% of Alarm

limit Mains failure
Standby TX failure

Remote Control

Data Transmission Medium	2-wire line, 600 ohm
Data modulation	serial, FSK
Transmitter level	-10dBm ± 2 dB
Receiver dynamic range	-10dBm to -34dBm

9.3.2 Environmental Characteristic

Operating temperature	- 10 to + 55 °C
Storage temperature	- 30 to + 60 °C

9.3.3 Mechanical Characteristics

Dimensions: (H x W x D)

ILS Rack:	1020x600x500 mm
Remote control:	129x71x170 mm
Slave panels:	129x41x170 mm

The ILS rack is wall mounted. The remote control and slave panels fit a standard 3U (132mm) high 19" subrack.

9.3.4 Power Supply

External supply:	
Input voltage:	230V +15%/ -20%, 45-65 Hz or 120V +15%/ -20%, 45-65 Hz
Output voltage:	27.6V
Output current:	20A max
ILS cabinet	
Input voltage	22 - 28V DC
Current consumption:	8A – 14A depending on configuration
Stand-by Battery	24V DC nominal, 85 Ah-110Ah valve regulated lead-acid battery recommended

PART III DESCRIPTION

9.4 Functional Description

9.4.1 Introduction

The NM 7000-series Instrument Landing System is a fourth generation system featuring extensive remote maintenance and monitoring features and systematic use of modern electronic components and processors.

Careful analysis has guided the partitioning of the system into analog hardware, digital hardware and software to meet the reliability and integrity objectives as well as easy maintenance and low cost of ownership.

In the monitor, comparison between monitor measurements and stored monitor limits is performed by digital hardware. Thus safety critical software is avoided in those functions. The filtering functions are performed by a dedicated signal processor running a FFT algorithm, with the signals sampled after base-band detection.

The transmitter/modulator uses a synthesizer as a RF source. In two-frequency systems a common reference crystal is used, avoiding drift in difference frequency. The LF and ident frequencies and ident keying are generated by digital hardware, while the level setting and modulation control are performed by digitally controlled analog feedback loops.

Local and remote control, and change-over and shut-down functions are performed by digital hardware.

Software is used for the remote maintenance and monitoring functions, including alarm and parameter storage, diagnostic functions, transmitter adjustments and change of monitor limits.

Appropriate hardware protection is used to avoid that the software becomes safety critical.

Technology:

Most of the modules in the NM 7000-series ILS are based on surface mount components on multi-layer boards. This reduces the number of modules, and gives very good EMC/EMI performance. Most of the digital hardware is contained in field programmable gate arrays (FPGA), giving very high reliability. The processors used are well proven Texas and Intel types. In the RF stages, modern RF power FET transistors are used.

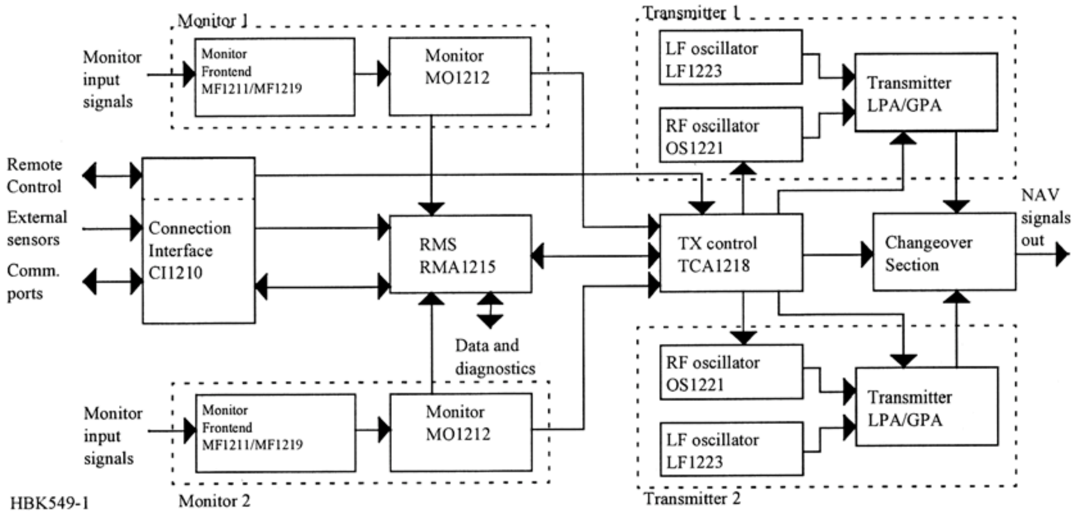

Figure 68 ILS Block Diagram

9.4.2 Transmitter

The transmitter section generates the ILS signal with the required RF power levels and modulations levels. The section comprises two identical transmitters, TX 1 and TX 2, where one is connected to the antenna, while the other is connected to dummy loads, acting as a back-up.

The reference signals in the transmitter section are RF signals from the oscillator OS1221B and LF modulation signals (90Hz and 150Hz) from the low frequency generator LF1223A.System DC voltages comes from the Power Supply board PS1227.

In each transmitter, the RF oscillator has separate outputs for Course and Clearance. These two channels are offset by 10 kHz. The LF Generator also has independent outputs for Course and Clearance.

The GPA 1231A Glidepath Course Power Amplifier Assembly contains modules to modulate, amplify and combine signals into the required CSB and SBO signals. Amplitude- and RF phase feedback ensures correct RF power level and modulation.

The Clearance transmitters GPA1232A generate only CSB signals, and only amplitude feedback is therefore incorporated.

The COA 1207A/C Change Over section has relays to connect the CSB and SBO outputs from one transmitter to the antenna while the other is connected to dummy loads. The relays are controlled by a Coax-control signal. SBO phase shifters and attenuators are incorporated for obtaining the correct CSB/SBO relationship.

The block diagram is shown on the next page.

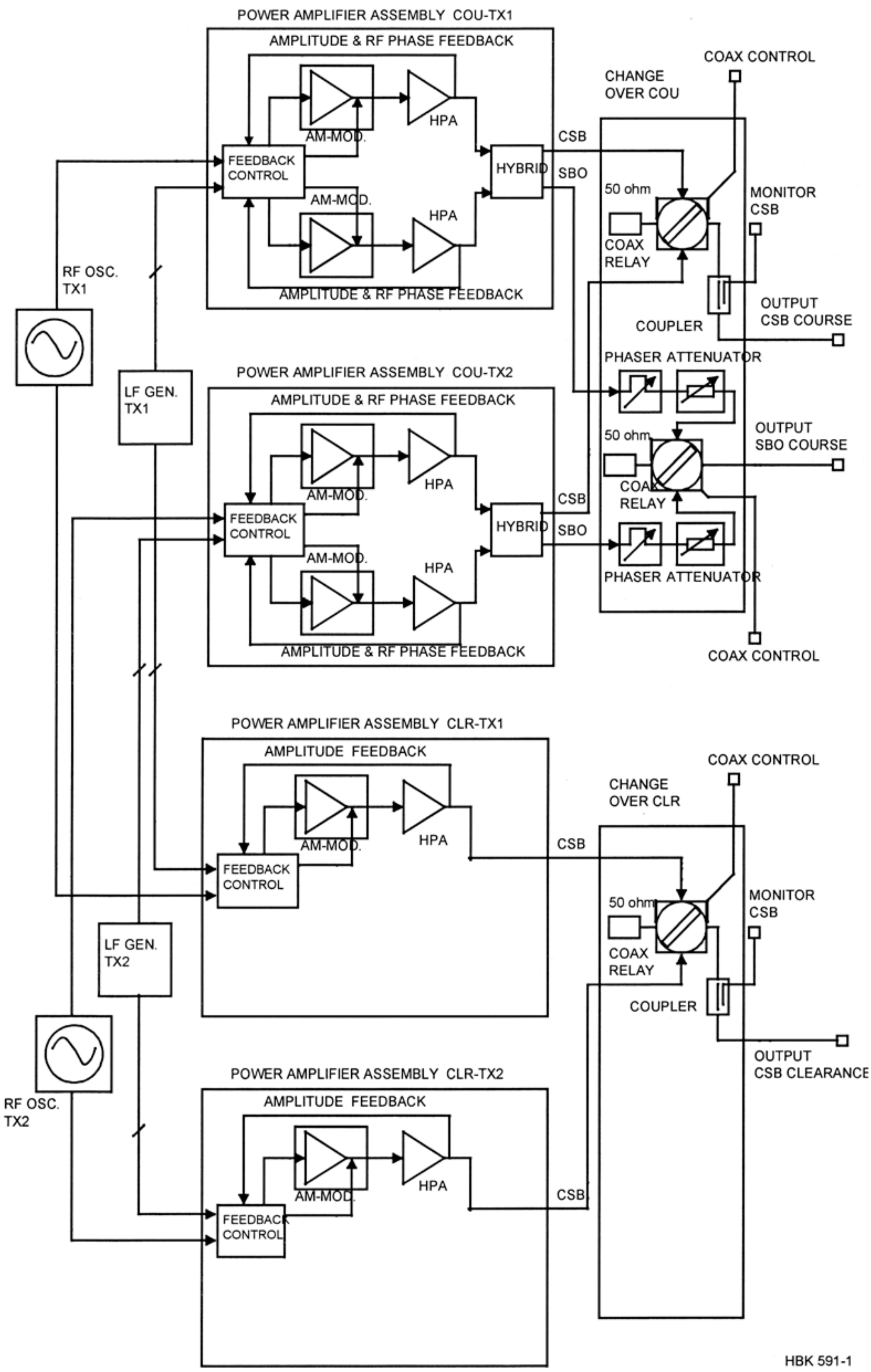

Figure 69. System block diagram of a 2 – Frequency GP transmitter