NORMARC 7000 ILS

NORMARC 3545 M-ARRAY GLIDE PATH ANNTENA SYSTEM

INSTRUCTION MANUAL

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Rev. 3.0	—	Full revision of content and layout to match January 2002 revision of doc. no. 21465-40, “NORMARC 7000 ILS Installation and Commissioning Handbook”.
Rev. 4.0	1.6.1/3, 2.3, 2.4, 5.2.4 & 5.2.5.1	Substitute DIA 346A with DIA 346B, new mechanical design of MOA 338D
Rev. 4.1	2.4, 3.4 & 5.25	Description of Monitor Combining Unit changed to incorporate 150μA monitoring on DS (displacement)
Rev. 4.2	5.2.5	Correction of Table 5.2 and new text
Rev 4.3	2.3.3.2	Adjustable powers dividers: correction of port signal from “4” to “1”

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Reservation: **Park Air Systems AS** reserves the right to make design changes, additions to improvements in its products without obligation to install such in products previously manufactured.

Limitations of use: The use of this manual is limited to the operation and maintenance of the system stated in the Title Page. It shall not be used for purposes of product manufacture.

FIRST AID IN CASE OF ELECTRIC SHOCK

The Expire Air method of artificial respiration is recommended for use in any case of electrical shock. It is comparatively simple and produces the best and quickest results when correctly applied.

Start without delay but **do not touch the victim until the circuit is broken.**

1 Break the electrical circuit by switching OFF or, if not possible, PROTECT YOURSELF with dry insulating material and pull the victim clear of the conductor

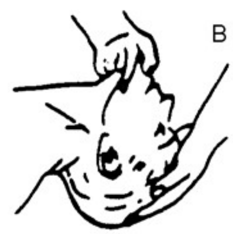
2 **Lay the patient on his back** and, if on slope, have the stomach slightly lower than the chest

A

3 **Make a brief inspection of the mouth and throat** and ensure that they are clear of obvious obstruction

4 **Give the patient's head the maximum backwards tilt,** so that the chin is prominent, the mouth closed and the neck stretched to give clear airway - fig. A

B



5 **Inhale, open your mouth wide, make an airtight seal over the nose of the patient and blow.** The operator's cheek or the hand supporting the chin can be used to seal the patient's lips - Fig. B, or **if the nose is blocked**, open the patient's mouth using the hand supporting the chin; open your mouth wide and make an airtight seal over his mouth and blow - Fig. C. This may also be used as an alternative to the mouth to nose technique provided that the nose is held closed

C

6 **After blowing, turn your head to watch for chest movement,** whilst inhaling deeply in readiness for blowing again - Fig. D

7 **If the chest does not rise**, check that the patient's mouth and throat are free of obstruction and the head is tilted backward as far as possible. Ensure that the tongue is not blocking the throat. Blow again

D

Send for medical assistance if possible.

PROTECTION OF ELECTRONIC EQUIPMENT AGAINST ELECTRO STATIC DISCHARGE

Electro Static Discharge - ESD

This electronic equipment and its spare parts are built from semiconductor components, which are sensitive to ESD. The equipment may be damaged or suffer from reduced performance and lifetime if improperly handled during servicing and transportation.

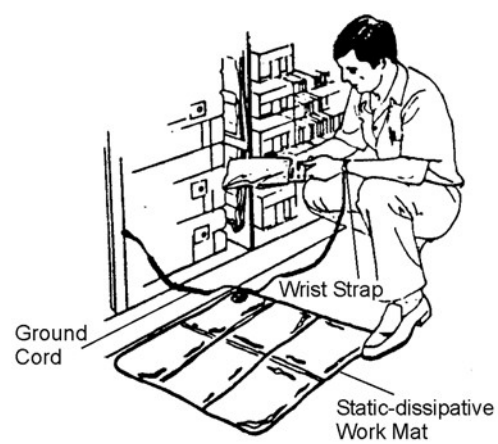
WARRANTY
To obtain the **Park Air Systems AS** warranty the following precautions must be taken:

- All semiconductor components and modules containing semiconductors shall be handled and transported as ESD-sensitive

HANDLING PROCEDURE:

To achieved ESD-protection, the operator shall use a portable static-dissipative field kit containing dissipative mat, wrist strap and ground cord or equivalent protection connected to same potential as the equipment, see picture.

- Connect the dissipative mat to the equipment via the ground cord and connect the wrist-strap cord to the mat
- The operator must wear the wrist strap before modules are removed or components touched
- Anytime a module must be laid down, it should be placed only on the grounded dissipative mat
- All electronic equipment must be properly reinserted in the rack or protected by ESD-shielding bags or boxes before the ground cord, wrist strap cord or wrist strap are removed



Nonconductive objects such as synthetic clothing, Styrofoam™ coffee cups, cigarette packs, vinyl work order envelopes or common plastics shall be removed from the work area as they may cause damage to semiconductor components.

TRANSPORTATION PROCEDURE:

Electronic equipment, spare part modules or any faulty modules removed from the equipment, to be returned for repair shall be stored and transported in ESD-shielding bags or equivalents.

The electro static shielding package shall not be opened without operator and work area being properly protected as stated above.

SHIPPING PRECAUTIONS

Do not ship the rack or subrack assemblies (i.e. transmitter sections) with heavy modules inserted. All encapsulated modules must be pulled out and packed separately before shipping.

All modules must be packed in electrostatic conductive (ESD) bags or boxes before shipping.

REVISION NUMBERS

Modules used in the system, which have the same type of designation, may in particular cases have different revision numbers.

This is due to the production of modules in different batches where certain changes have taken place from one batch to the next.

New revisions of all modules, always replace the old revisions.

Documentation of the latest revision is enclosed in the manual.

Please contact us if you should need information on older revisions of modules for servicing purposes.

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LIST OF ABBREVIATIONS

ADU	Antenna Distribution Unit
BFA	Beam Forming Area
BNC	Bayonet Neil Concelman (Bayonet locking connector used with coaxial cable)
CL	Course Line
CLR	Clearance
COU	Course
CS	Course Sector
CSB	Carrier and Side Bands
DDM	Difference in Depth of Modulation
DS	Displacement Sensitivity
FSL	Forward Slope
GPA	Glide Path Angle
GP	Glide Path
LLZ	Localizer
MCU	Monitor Combining Unit
MOD	Modulation
NF	Near Field
PIR	Portable ILS Receiver
RF	Radio Frequency
SBO	Side Bands Only
SDM	Sum of Depth of Modulation
SSL	Side Slope
TX	Transmitter

1 General information

1.1 Antenna system

The antenna system comprises:

- 3 dipole-array antenna elements installed on the antenna mast
- Antenna mast, standard or frangible type
- Antenna Distribution Unit (ADU)
- Monitor Combining Unit (MCU)
- CSB feed cable, SBO feed cable and CLR feed cable from the NORMARC 7000 cabinet to the ADU
- 3 antenna feed cables of equal electrical length from ADU to the antenna elements
- 3 monitor cables of equal electrical length from antenna probes to the MCU
- 3 monitor cables from the MCU to the NORMARC 7000 cabinet
- 1 monitor cable from the near field monitor antenna to the NORMARC 7000 cabinet

Drawing no. 16642A3 shows the standard mast assembly for the three antennas.
A frangible aluminium mast can be provided as an option. Refer to handbook no. 22805, ”Glide Path Antenna Frangible Mast – Assembly and Erection Procedure”.

All drawings mentioned in this document are attached in Chapter 0.

1.2 Antenna element

The radiating element is a stacked dipole antenna with reflector, housed in a fibreglass radome for weather protection. See Figure 1-1.

A signal coupler network linked to all dipole elements is used to monitor the signal fed to the antenna elements. The signal from the coupler is about 35dB below the level of the feed signal.

The antenna element is fastened to the mast assembly with brackets at the back of the reflector.

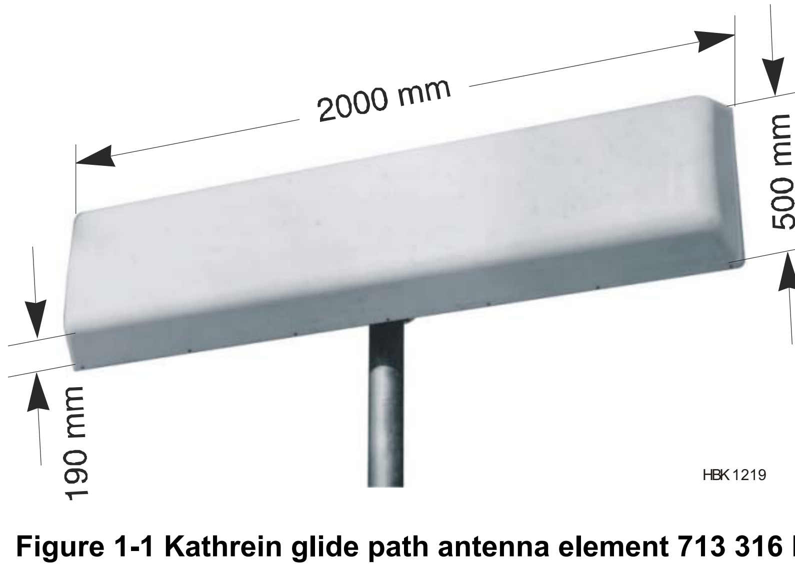
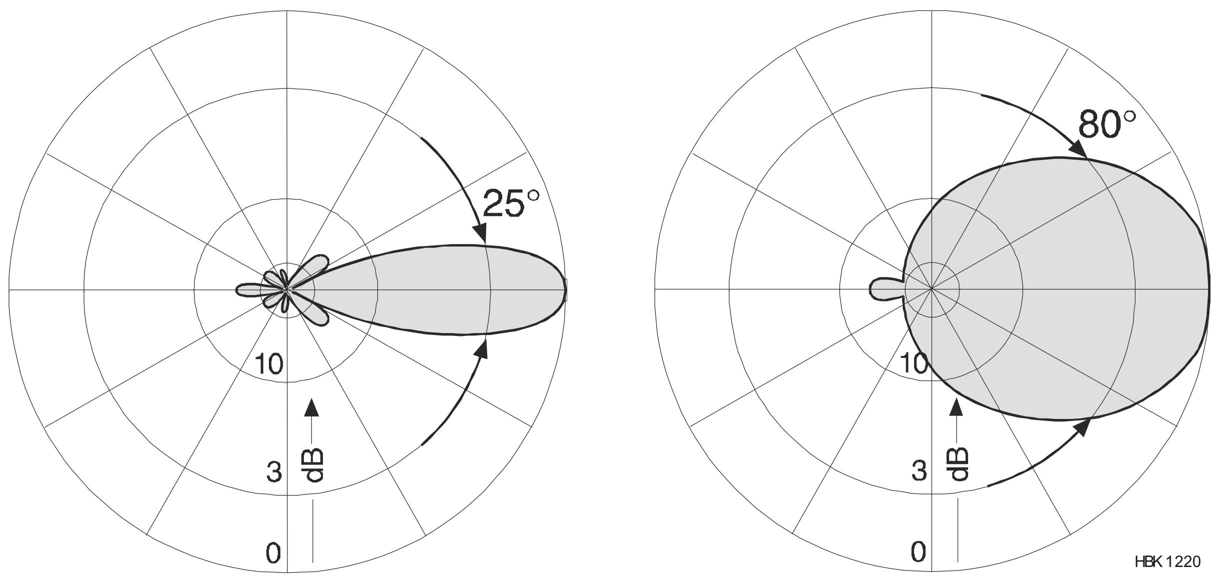


Figure 1-1 Kathrein glide path antenna element 713 316 B

The free space radiation patterns at mid band are shown in Figure 1-2.



Horizontal Pattern

Vertical Pattern

Figure 1-2 Kathrein glide path antenna element radiation patterns at mid-band

1.3 Antenna mast

Two main types of antenna masts are available; Standard mast and Frangible mast

1.3.1 Standard mast

The mast is a 15 m high, triangular, self-supporting, galvanized steel framework construction consisting of three 5-metre sections bolted together.

The mast is equipped with three steel antenna element mounting frames, whose position can be adjusted by moving them along vertical rail assemblies on the mast. The horizontal position of the antenna elements is adjustable by moving them along horizontal rails on steel frames.

The mast is painted red and white to ensure that it is clearly visible in the daytime, and is equipped with red obstruction light for use at night.

The distribution and monitor cables are protected from the environment by cable conduits running along the mast.

A ladder arrangement in the mast provides access to the antenna elements and the obstruction light.

The mast assembly and adjustment frame are illustrated in drawing no. 16642A3.

1.3.2 Frangible mast

The triangular, self-supporting aluminium mast is 15 m high and has 3 legs. Each leg consists of 5 sections of 3 m each. The leg sections are bolted together. A red obstruction light is mounted on top of the mast.

The mast is equipped with three aluminium frames for mounting of the antenna elements. Their position can be adjusted by moving them along vertical rail assemblies on the mast. The horizontal position of the antenna elements is adjustable by moving them along horizontal rails.

A ladder arrangement in the frangible mast provides access to the antenna elements and the obstruction light.

1.4 Performance and radiation patterns

The performance of the antenna system can be expressed as far field signal patterns and modulation distribution diagrams.

- Figure 1-3 shows CSB, SBO and Clearance radiation patterns
- Figure 1-4 shows the resulting modulation distribution
- Table 1-1 shows the signal distribution data from the Antenna Distribution Unit

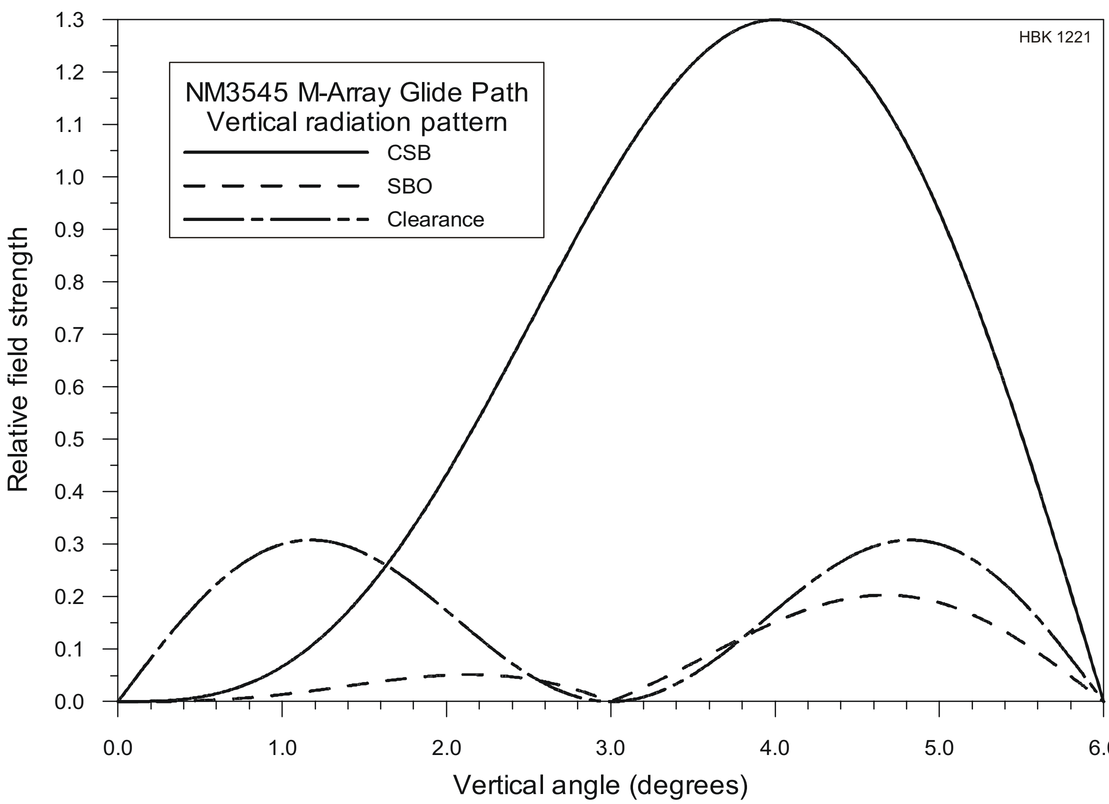


Figure 1-3 CSB, SBO and Clearance field distribution

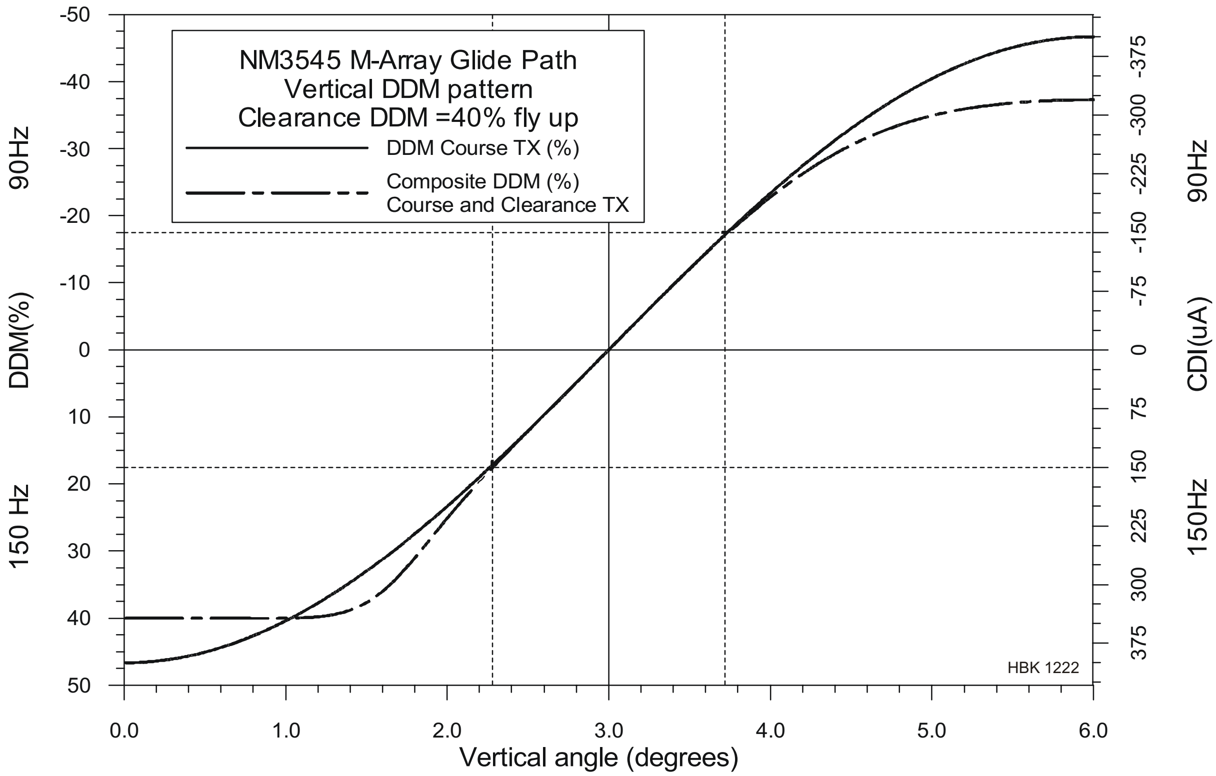


Figure 1-4 DDM distribution for a 3° glide path

1.5 Antenna system signal distribution

Table 1-1 below shows relative amplitude and phase for standard CSB, SBO and Clearance feeding of the three antennas. SBO amplitude is not related to CSB amplitude in the table. For horizontal reflection area SBO signal level is 11.67% of CSB signal level.

	CSB		***SBO***		***CLR***	
	Amplitude (dB)	Phase (°)	Amplitude (dB)	Phase (°)	Amplitude (dB)	Phase (°)
Upper Antenna (A3)	-	-	-6.0	180	0.0	0
Middle Antenna (A2)	-6.0	180	0.0 (Ref)	0	-	-
Lower Antenna (A1)	0.0 (Ref)	0	-6.0	180	0.0	0

Table 1-1 NORMARC 3545 Antenna System Signal Distribution

1.6 Technical specifications

1.6.1 General

Frequency range	329.15-335 MHz
Temperature range Outdoor equipment	-40°C to +70°C
Temperature range Indoor equipment	-10°C to +55°C
Glide path angle	2.0° - 4.0° adjustable
Coverage	According to Annex 10, paragraph 3.1.5.3
Clearance	According to Annex 10, paragraph 3.1.5.6
Number of antenna elements	3

1.6.1.1 Standard Antenna Mast

Number of mast sections	3
Length of mast sections	5m
Wind velocity (operational)	140 km/h
Wind velocity (survival)	200 km/h
Weight, approximately	2000 kg

1.6.1.2 Frangible Antenna Mast

Number of mast sections	4 or 5
Length of mast sections	3m
Wind velocity (operational)	140 km/h
Wind velocity (survival)	200 km/h
Frangibility	According to Attachment C to state letter AN4/1.1.37/64 "Interim guidance on frangibility" *The mast should break, distort and yield readily when subjected to sudden collision forces of a 3000 kg aircraft travelling at 140 km/h or moving at the ground at 50 km/H.*
Weight, approximately	1000 kg

1.6.2 Antenna element

Type	Kathrein 713.316 B Stacked dipoles with reflector (See attached document no. HBK 1160)
Gain	14.3 dBi
Front-to-back ratio	17 dB
Beam width, (-3 dB level)	E-plane: 25° (± 12.5°) H-plane: ±80° (±40°)
Weight, approximately	19 kg

1.6.3 Antenna Distribution Unit DIA 346B

Input return loss (50Ω)	≥20 dB
Adjustable Amplitude resolution	≤±0.1 dB
Adjustable Phase resolution	≤±1°
Panel connectors	N (female)
Dimensions	600mmX600mmX210mm plus brackets
Weight, approximately	35 kg

1.6.4 Monitoring Combining Unit MOA 338D

Input and output return loss (50Ω)	≥20 dB
Panel connectors	N (female)
Dimensions	600mmX600mmX210mm plus brackets
Weight, approximately	25 kg

2 Technical description

2.1 Mechanical antenna assembly

2.1.1 Standard mast

The mast is a 15-metre high, triangular, self-supporting, galvanized steel framework construction consisting of three 5-metre sections bolted together.

The glide path antenna is assembled horizontally on the ground. The surface of the assembling area should be as level as possible. The three mast legs are assembled first, then the supports for the antenna elements, the cable brackets, ladders and obstruction light.

The mast is equipped with three steel antenna element mounting frames the positions of which can be adjusted by moving them along vertical rail assemblies on the mast. See drawing no. 16643A3. The horizontal position of the antenna elements is adjustable by moving them along horizontal rails on steel frames.

The mast assembly and horizontal adjustment frame are illustrated in drawing no. 16642A3.

One of three section assemblies is shown in drawing no. 16612A3. Supplier’s drawings are delivered with the mast.

Lengths other than 15m are available upon request.

2.1.2 Frangible mast

The triangular, self-supporting aluminium mast is 15 m high and has 3 legs. Each leg consists of 5 sections of 3 m each. The leg sections are bolted together.

The glide path antenna is assembled horizontally on the ground. The surface of the assembling area should be as level as possible. The three mast legs are assembled first, then the supports for the antenna elements, the cable brackets, ladders and obstruction light.

The foundation for the finished mast is cast in concrete according to drawings delivered with the mast. The bolts for the mast legs are embedded in the concrete, or alternatively set in resin in holes drilled in the concrete. The foundation must be ready and prepared before the mast is hoisted into place.

The procedures for mast assembly and installation are described in handbook no. 22805, ”Glide Path Antenna Frangible Mast – Assembly and Erection Procedure”.

Lengths other than 15m are available upon request.

2.2 Antenna element

The Kathrein antenna element is described in attached document no. HBK 1160.
The fixture for the Kathrein antenna element is shown in drawing no. 16792A3.

2.3 Antenna Distribution Unit - DIA 346B (ADU)

2.3.1 Mechanical description

See drawing no. 18757A4 Cabinet Outline Drawing.

The antenna distribution unit DIA 346B consists of a network of coaxial cables, mechanical Phase Shifters and coaxial type hybrids mounted in a hinged frame. See drawing no. 18724A4 “Interconnection Diagram”.

2.3.2 Electrical description

The signal distribution is shown in Figure 2-1. CSB, SBO and CLR inputs are split and combined in various power dividers and combiners to form the required signal distribution scheme given in Table 1-1, paragraph 1.5 above.
See drawing no. 18725A4, “Circuit Diagram”.

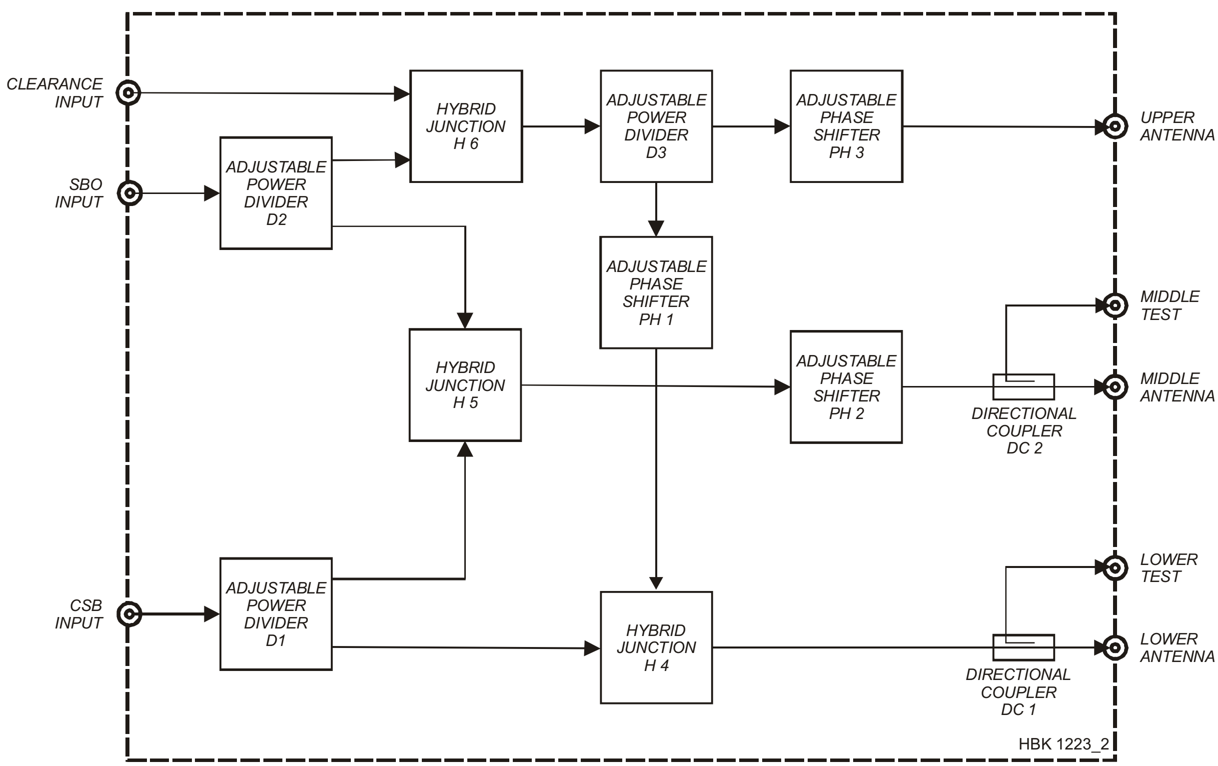


Figure 2-1 Block diagram of DIA 346B Antenna Distribution Unit

2.3.3 Power distribution components

2.3.3.1 Hybrids

The 3 dB hybrids are constructed as shown in Figure 2-2. They are made from 50-ohm semi rigid coaxial cables and N-type connectors. Using 50 ohm means that in order to obtain perfect impedance matching, the lengths of the cables must be 0.152λ and 0.652λ.

An input signal at port 2 is divided equally to ports 1 and 3 but not to port 4. Similar, a signal input at port 3 is divided equally to ports 4 and 2 but not to port 1.

Typical performance:
Power unbalance: Less than 0.1 dB.
Isolation: Better than 30 dB.
Input return loss: Better than 25 dB.

2.3.3.2 Adjustable power dividers

A power divider consists of a hybrid and a differential phase shifter (see Figure 2-3). The phase shifter splits the input signal into two signals of equal amplitude. The phases of the signals can be adjustable to lead or lag by changing the location of the T-junction. A short-circuited coaxial cable stub is used to provide an impedance match of the input signal. When the phases of the signal to port 3 varies by + θ and the signal to port 1 varies by - θ the signals at the output ports 2 and 4 are:

$$A2 = A\cos(\theta)$$
$$A4 = jA\sin(\theta)$$

These two signals are therefore in quadratic relationship and of constant phase regardless of θ.

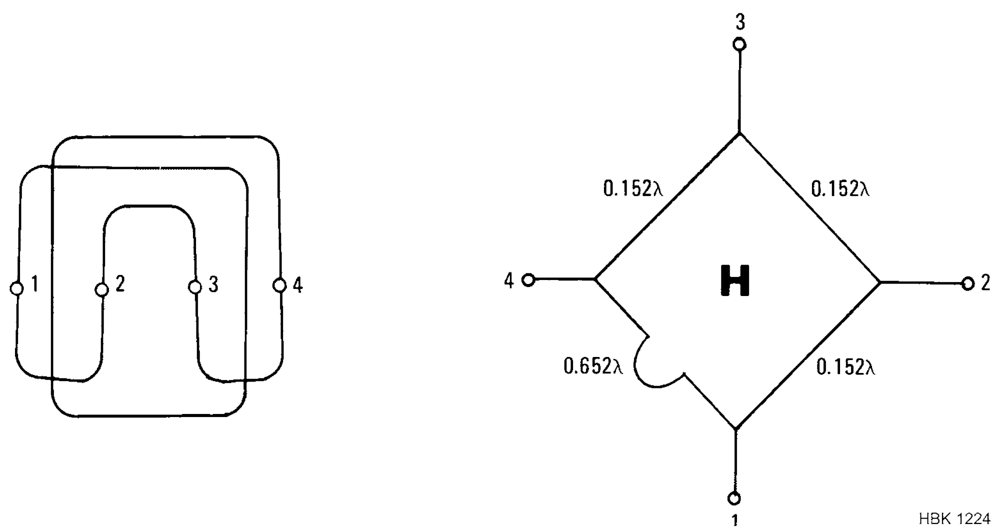


Figure 2-2 3dB Hybrid (180°-type)

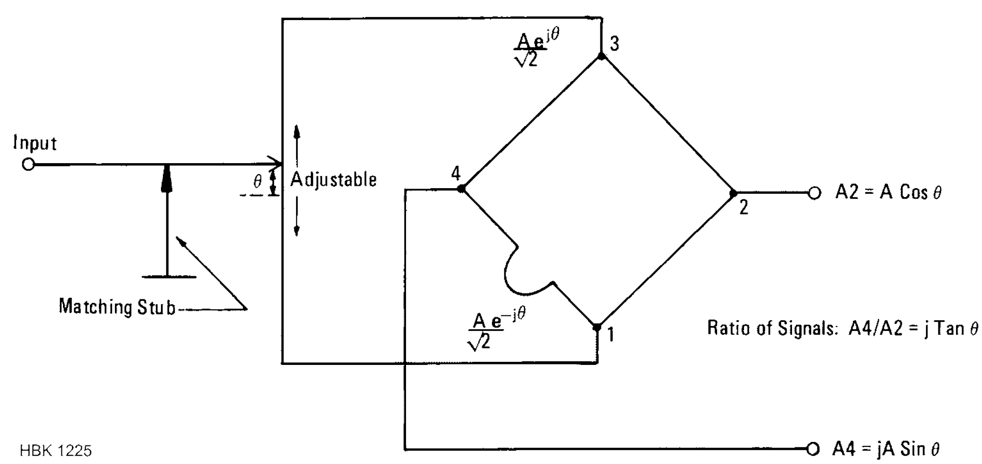


Figure 2-3 Adjustable power divider

2.3.3.3 Adjustable phase shifter

This component is a coaxial line stretcher with a length adjustment of ±5cm corresponding to ±18° phase shift of the output signal. The return loss is better than 25 dB.

2.4 Monitoring Combining Unit - MOA 338D (MCU)

The Monitoring Combining Unit performs integral monitoring of these parameters:

- Glide path angle (θ)
- Displacement sensitivity (Sector width)
- Clearance

NOTE: Park Air Systems recommends monitoring the lower section width (75μA fly-up), but some systems are designed for monitoring at 150μA. The values for these systems are given in brackets.

2.4.1 Mechanical description

The monitor network is housed in a steel cabinet designed for wall mounting; the three outputs of the network should be connected to the proper monitor circuits in the main cabinet. See drawing no. 18757A4 Cabinet Outline Drawing.

2.4.2 Electrical description

The signals from the pick-up couplers - which are proportional to the radiated signal from the antenna elements - are fed through the equal length monitor cables to the Monitor Network MOA 338.

The far field glide path angle, the lower sector width, and the clearance are simulated in the network by combinations of the three signals.

The glide path angle is simulated by addition from the upper and lower antenna elements in reversed phase. The lower sector width at $0.88\theta_0$ ($0.755\theta_0$), or DDM = 0.0875 (0.175) fly-up and the clearance at 0.3θ are simulated by adding the signals from the three elements in a prescribed amplitude and phase relationship. The amplitude relationship is given by the radiation patterns of each element for the elevation angle corresponding to the detected DDM.

The monitor network MOA338D circuit diagram is shown in drawing no. 15581A3. It consists of a microstrip circuit board, step attenuators, phase shifters, and interconnecting cables. All components except the adjustable controls are mounted on the circuit board (MM1304). Here, PD11 - PD16 are power dividers/combiners of the Wilkinson type. AT3 - AT7 are plug-in attenuators (AT1305). AT3 and AT4 determine sector width monitoring, AT5, AT6, and AT7 determine clearance monitoring. Sector width and clearance monitoring are dependent upon glide path angle θ_0 and forward slope (FSL). Plug-in attenuators are available for Forward Slopes given in Table 5-2. AT1, AT2, PH1, PH2 and PH3 are step attenuators and phase shifters located on the control panel. AT1 and AT2 allow compensating for tolerances in the pick up probe coupling and possible adjustments in the distribution network due to non-perfect ground plane. AT2 is also used to adjust sector width to correspond with the glide path angle, but as this will have a small influence on clearance a slightly compromised setting of AT2 (within ±0.2dB) may become desirable. Clearance is not separately adjustable. PH1, PH2 and PH3 are used to obtain correct phasing for the working frequency, and to compensate for phase errors in cables and probes.

2.5 Near field monitoring

The Near field monitor comprises a receiving antenna mounted on a mast about 80 metres in front of the M-array antenna system, and a coaxial cable sending the received signal to the near-field monitor channel.
The monitor antenna is a half-wave dipole fitted with a reflector, it is protected against the weather by the fact that all the conductors are embedded in fibreglass reinforced polyester.
The monitor mast, which is 5.5 metres high, is embedded into a concrete block foundation.

The phase relationship of the signals from the three M-array antenna elements and their images are not the same near to the antenna system (near field) as at the position of an aircraft (far field), due to non-parallel rays from the antenna elements in the near field. This near field phenomenon will vary with distance from the antenna system. At distance $D = (4h^2/\lambda) - \lambda$ (h is the vertical distance between two antenna elements) the glide path angle sensitivity corresponds to the far field relationship.

For a 3° glide path angle the distance is approximately 81 metres and the height of the NF antenna should be approximately 4.3 metres.
The exact position of the monitor antenna can be determined only when the complete M-array system has been adjusted.

3 Operation

3.1 Mechanical - antenna system

The first commissioning flight check will confirm (by primary parameters within tolerances) whether the antenna mast is correctly mechanically aligned or not, and if the antennas are installed at optimal height above ground. When possible deviations have been corrected, there are no further mechanical adjustments.

3.2 Electrical - antenna system

The first commissioning flight check will confirm whether the antenna system is correctly electrically adjusted or not, i.e. that the signals from the antenna distribution unit are within given tolerances, and if the phasing of the antennas is correct. Possible deviations will be adjusted to correct values.

3.3 Antenna Distribution Unit

Under normal conditions there are no adjustments to be carried out within the antenna distribution unit at the commissioning flight calibration or any other time.

3.4 Monitoring Combining Unit

During the first flight calibration procedure it may be necessary to re-adjust the DS DDM value in the case of a changed setting of the SBO power from the transmitters. For example, if the SBO power has been increased in order to achieve correct sector width, a decreasing setting of adjustable attenuator AT2 is required in order to retain standard DS DDM output [8.75% (17.5%) DDM 150 Hz predominance]

There are no adjustments at other times (routine flight checks).

4 Maintenance

4.1 Preventive maintenance

4.1.1 Antenna system

It is sufficient to check periodically, depending on the local conditions, the condition of all connectors and antenna mast structure, and remove any corrosion if necessary.

Under some climate conditions, a layer of salt/pollution could grow on the antenna radomes. Hence, the surface of the antenna radomes should be checked and cleaned at regular intervals depending on local climate and environmental conditions. A typical interval would be yearly.

4.1.2 The glide path Beam Forming Area (BFA)

The glide path BFA is a levelled area in front of the glide path antenna mast necessary to generate the correct vertical and horizontal radiation patterns. The BFA should be regarded as a part of the antenna system. The size of the BFA is dependent of each specific site. A typical BFA is shown in Figure 4-1.

4.1.2.1 Control of vegetation in BFA

Vegetation within the BFA must be controlled. Maximum allowable height of grass, bushes and other vegetation is 20 cm. To avoid unnecessary shut down of the facility, the grass within the BFA should be cut, and bushes and other vegetation should be removed before it reaches this level.

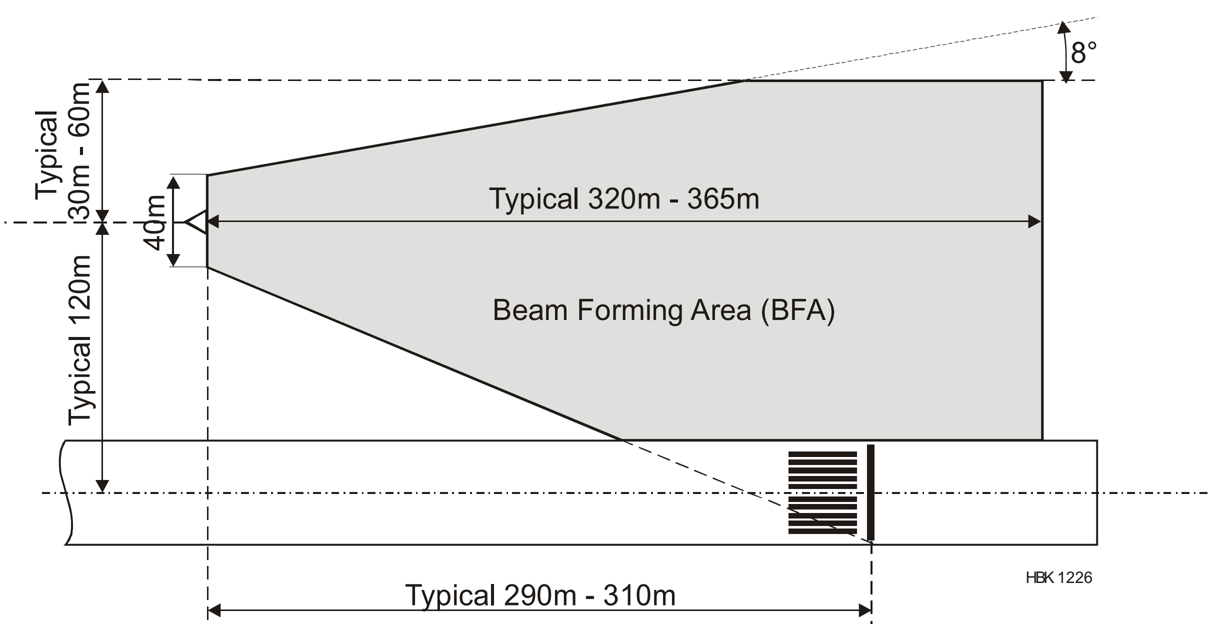


Figure 4-1 M-array glide path BFA

4.1.2.2 Snow removal from BFA

In regions with snow, the accumulation of snow in the BFA must be controlled. The maximum allowable snow height within the BFA is 20 cm. To avoid unnecessary shut down of the facility, the snow within the BFA should be removed before it reaches this level. No steep banks at the area borders are allowed.

Note! *The ILS glide path must be shut off during maintenance work in the BFA!*

4.2 Corrective maintenance

Any faults occurring in the antenna system probably result from a defective coaxial connection. The standing wave ratio of each part of the distribution and monitor networks can be measured relatively easily using a vector voltmeter or a through-line wattmeter.

If parts of the antenna system have been replaced or repaired, relevant parts of the adjustment procedure must be repeated.

5 Adjustments procedure

5.1 General

5.1.1 Objective

This procedure provides a method to align the antenna system mechanically as well as electrically after mechanical installation. When the procedure has been completed the antenna system is ready for commissioning flight calibration. In addition this procedure may be used in parts in order to restore signal quality after replacing vital components such as antenna elements, cables or signal networks. In such cases a new flight calibration may be required.

5.1.2 Discussion

It is essential to mechanically position the antenna elements on the mast accurately in order to achieve required glide path angle and clearance requirements. The positioning data can be calculated from the following parameters:

- Average forward slope angle (FSL)
- Average sideways slope angle (SSL)
- GP zero (GP reference point near or at the base of the GP mast)
- Sideway distance from the runway centre line to GP mast
- Glide path angle (GPA)
- GP RF channel frequency

A ground level plot using a theodolite is essential in order to determine accurately FSL, SSL and GP zero.
In some cases when the reflection area is non-linear it may be necessary to carry out computer simulated GP approach in order to predict FSL and GP zero.

Electrically, a CSB balance of less or equal to 1 µA DDM should be maintained during electrical adjustments using modulation as a tool for pre-adjustments.

5.1.3 Required test equipment

The following test equipment is required:

- Theodolite for setting up antennas in three dimensions referenced to GP zero
- Vector-voltmeter including four-port directional coupler
- Network Analyzer (optional for antenna return loss measurement)
- PIR (NORMARC 3710B/7710) with portable antenna and a 20-30 dB attenuator
- 90° phasing stub
- Test accessories such as dummy loads, test cables and coaxial adaptors

5.1.4 Conditions

The glide path cabinet shall be aligned (calibrated) and producing CSB, SBO course and CSB clearance signals into dummy loads. RF signals from the cabinet may be used for the antenna system alignments.

5.2 Alignments procedure

5.2.1 Mechanical alignments.

The procedures for carrying out mechanical adjustments/alignments are described in detail in document no. 21465, “Installation and Commissioning Handbook”.

The procedures for calculating antenna heights, antenna element forward shift and antenna element offset, are described in document no. 22563-1, “ILS Glide Path Systems – Calculation of Antenna Parameters”.

5.2.1.1 Antenna element forward shift

The antenna elements should be aligned along a straight line, which shall be perpendicular to the average forward slope. For example if the forward slope is rising, the lower antenna shall be forward compared to middle, and upper antenna. The tolerance for any one antenna deviating from a straight-line alignment is ±5 mm.

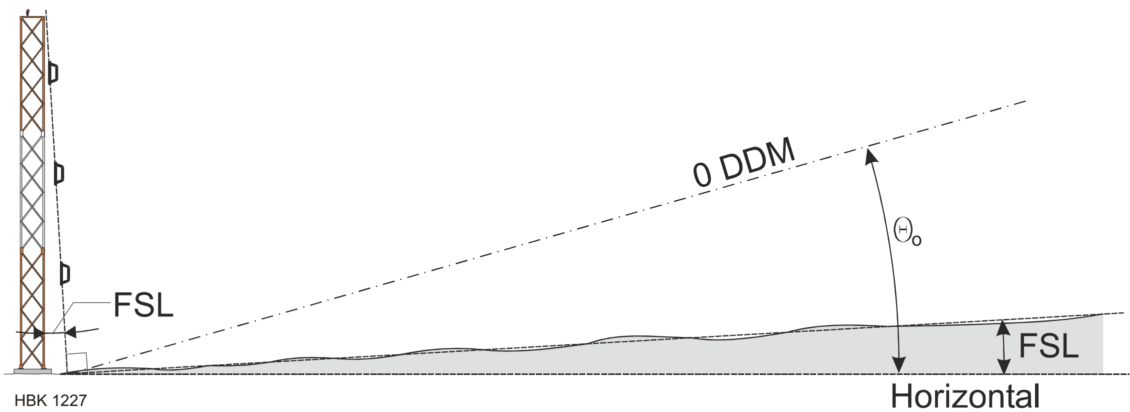


Figure 5-1 Forward slope (FSL) and antenna forward shift

5.2.1.2 Antenna height

The spacing between antenna elements shall be equal. The spacing shall be referenced to GP zero which is the intercept between average forward slope and GP mast. The middle antenna height is critical to glide path angle. A 5 cm shift of the middle antenna, for example, changes the angle by 0.02° (4 µA). Lowering the antenna increases the angle. Antenna spacing tolerance: ±3 cm.

5.2.1.3 Antenna element offset

The sideways offset of the antenna elements shall be accurately adjusted. Orientation is such that the upper antenna is closer to the runway than the middle antenna. The middle antenna shall be closer to the runway than the lower antenna.
Typical offsets are upper (A3) –35 cm, middle (A2) reference, lower (A1) +23 cm for 120 metres distance to centre line. Tolerance: ±3 cm in 3D space.

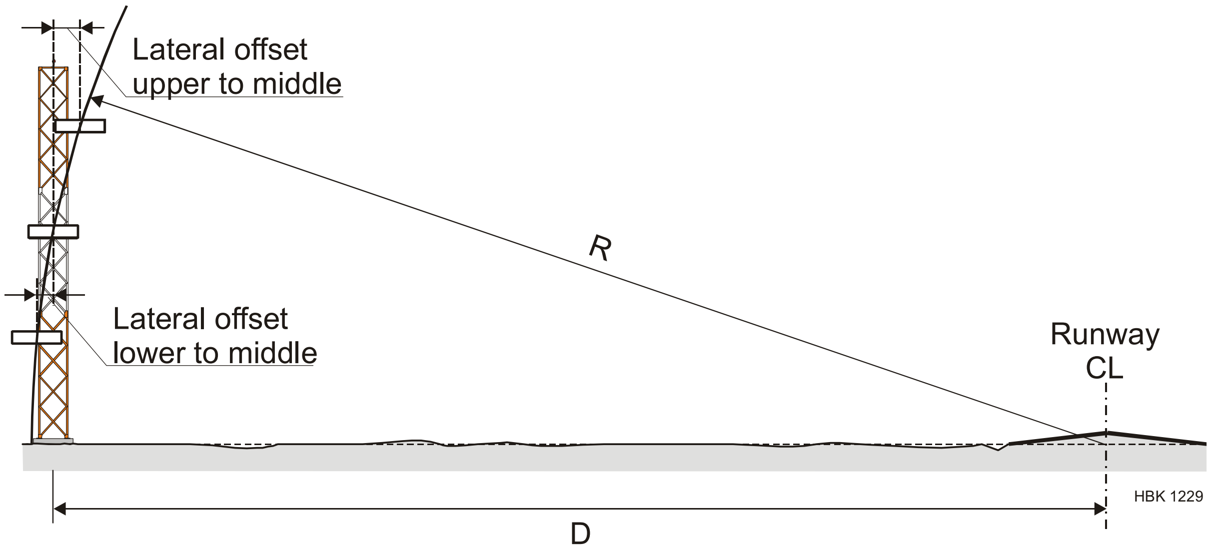


Figure 5-2 Lateral antenna offset (NORMARC 3545)

5.2.2 Electrical alignments - cable phasing

5.2.2.1 CSB and SBO cables

The CSB and SBO cables between the cabinet and ADU shall be of equal electrical length. Apply a vector voltmeter or network analyser in a test set-up as in Figure 5-3.
Measure open cable return phase for each cable.

On the CSB cable, normalize to zero phase and measure the return phase for the SBO cable. The cable pair shall be matched within ±4.0° return phase which is equal to ±2.0° true phase.

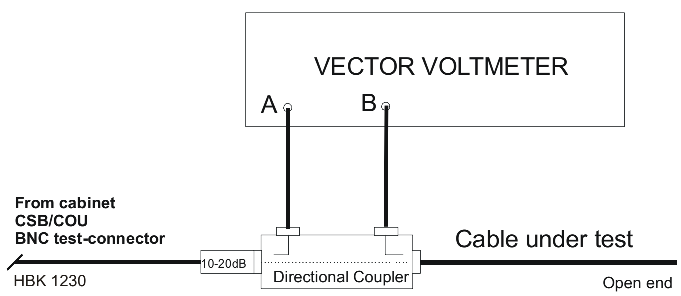


Figure 5-3 Cable phasing measurement set-up

5.2.2.2 CSB/SBO phasing

Note! *Make sure that the TX/modulator used is optimally calibrated.*

1. Switch off the clearance transmitter
2. Insert the 90° phasing stub in the SBO signal path
3. Connect the portable ILS receiver (PIR) to the monitor return cable lower antenna (M1)
4. Adjust Course SBO phase shifter in the Cabinet (associated with TX to air) to obtain 0.0% DDM reading
5. Repeat the phasing procedure for the other transmitter

5.2.2.3 Preliminary SBO power adjustment

Conditions as in Section 5.2.2.1 except that the 90° phasing stub shall be removed. Adjust the TX SBO attenuator (associated with TX to air) until a value of 11.7% DDM (90) is displayed with the PIR.

Note! *This value DDM is associated with horizontal reflection plane only. For example if the forward slope is 0.2° falling the corresponding DDM should be 12.4% (90) and vice versa. This change corresponds to about 0.5 dB more SBO power.*

A formula for resulting DDM observed from the lower antenna output (A1) of the Antenna Distribution Unit is given below. Θ_0 is the glide path angle; FSL is forward slope, negative for falling terrain referred from the GP.

$$DDM = \frac{-11.67\%(\theta_0 - FSL)}{\theta_0}$$

Restore the facility to normal.

5.2.2.4 Antenna cable lengths

The three antenna cables shall be of mechanically and electrically equal length. This may be checked using the following procedure.

1. Apply a vector voltmeter or network analyser. Normalize lower antenna cable (A1) return phase as 0° reference phase
2. Measure return phase for middle antenna (A2) and upper antenna (A3)
   Tolerance: ±2.0° true electrical cable length.
   See measurement set-up diagram in Figure 5-3

5.2.2.5 Phase and amplitude transfer measurement

1. Connect each antenna cable and monitor cable to antenna element load and source respectively
2. Apply a vector voltmeter or network analyser in the test set-up as shown in Figure 5-4

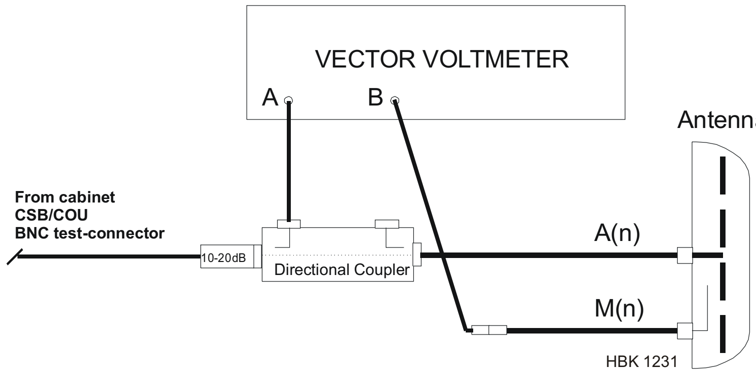


Figure 5-4 Phase and amplitude transfer measurement set-up

3 Measure relative transfer phase and amplitude for each Antenna-to-Monitor cable signal path in reference to A1-to-M1. Tolerance: ±3°

If a particular signal path measures more than –3°, the associated monitor cable should be trimmed. (On the other hand, if a signal path measures more than +3° as the highest positive value, the other two monitor cables should be trimmed.)

Amplitude tolerance: ±0.2 dB. If this amplitude tolerance is exceeded, this indicates a possible error in the monitor loop

5.2.3 Antenna return loss

Follow this procedure to measure return loss:

1. Apply a vector voltmeter in a test set-up as shown in Figure 5-3
2. Measure return loss for each antenna element
   Tolerance: 20 dB minimum

Alternatively use a network analyser in swept frequency mode (325 – 340 MHz), which is a better choice for antenna return loss measurement.

5.2.4 Phase and amplitude check of Antenna Distribution Unit DIA 346B

Note! *No adjustments shall be carried out during this check.*

The purpose of this check is to make sure that the antenna signal distributions are within tolerances at the time of commissioning flight calibration. Table 5-1 shows the ideal values.

	CSB		***SBO***		***CLR***	
	Amplitude (dB)	Phase (°)	Amplitude (dB)	Phase (°)	Amplitude (dB)	Phase (°)
Upper Antenna (A3)	-	-	-6.0	180	0.0	0
Middle Antenna (A2)	-6.0	180	0.0 (Ref)	0	-	-
Lower Antenna (A1)	0.0 (Ref)	0	-6.0	180	0.0	0

Tolerances: Amplitude ±0.2 dB, phase: ±2°.

Table 5-1 Standard antenna distribution values

5.2.4.1 Preparation

Use a vector voltmeter in a test set-up as shown in Figure 5-5.

1. Switch off the course and clearance transmitters
2. Connect CSB and SBO outputs from Cabinet to dummy loads
3. Disconnected all cables from the Antenna Distribution Unit. Terminate unused ports to 50 Ω dummy loads
4. Switch on the course transmitter, but leave the clearance transmitter switched off
5. Switch off the modulation to the transmitter used for the test
6. Insert a 10 or 20 dB attenuator at the input port of the directional coupler
7. Connect a test cable from the CSB/COU BNC connector on the cabinet to the 10-dB or 20-dB attenuator
8. Connect the A-probe of the vector voltmeter to the directional coupler's forward output

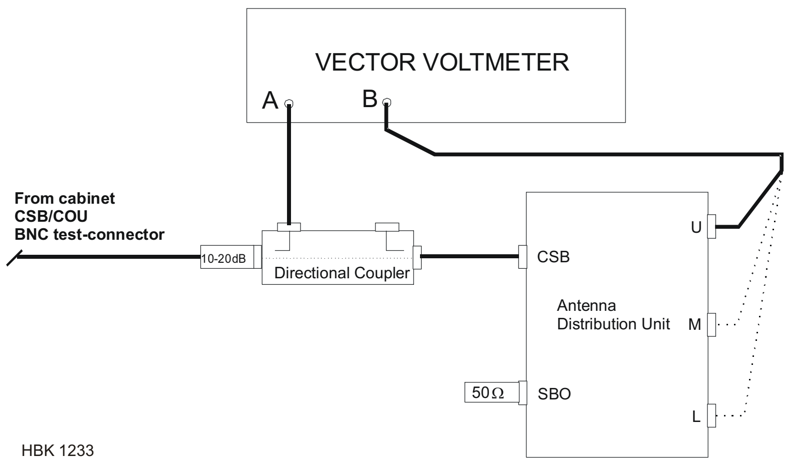


Figure 5-5 Test set-up for Antenna Distribution Unit Phase and Amplitude check

5.2.4.2 Procedure (measurement and verification only)

1. Connect the cable from the directional coupler to the CSB input on the ADU. Connect the B-probe to output L. Normalize the vector voltmeter B-probe RF level and phase. Move the B-probe to M output. Make a note of the level and phase

2. Connect the cable TEST SIG to the SBO input. Connect the B-probe to M output. Normalize the vector voltmeter B-probe RF level and phase. Move the B-probe to the L output. Make a note of the level and phase

3. Move the B-probe to U output. Make a note of the level and phase

4. Compare the noted values with those in Table 5-1 and check with tolerances

5.2.4.3 Procedure (in case parameter is out of tolerance given in Table 5-1)

1 Connect the cable from the directional coupler to the CSB input on the ADU. Connect the B-probe to output L. Normalize the vector voltmeter B-probe RF level. Move the B-probe to M output. If necessary adjust phase shifter D1 to obtain -6.0 dB difference referenced to L output

Note!
If D1 has been adjusted re-normalize the reference level at L output and measure again the M output level. Repeat until a -6.0 dB difference is achieved.

2 Connect the cable TEST SIG to the SBO input. Connect the B-probe to U output. Normalize the vector voltmeter B-probe RF level. Move the B-probe to the L output. If necessary adjust phase shifter D3 to obtain 0.0 dB difference referenced to U output

Note!
If D3 has been adjusted re-normalize the reference level at U output and measure again the L output level. Repeat until a 0.0 dB difference is achieved.

3 Connect the B-probe to M output. Normalize the vector voltmeter B-probe RF level. Move the B-probe to L output. If necessary adjust phase shifter D2 to obtain -6.0 dB difference referenced to M output

Note!
If D2 has been adjusted re-normalize the reference level at L output and measure again the M output level. Repeat until a -6.0 dB difference is achieved.

1 Connect the cable TEST SIG to the CSB input. Connect the B-probe to L output. Normalize the vector voltmeter B-probe to 0° reference phase

2 Connect the B-probe to M output. If necessary adjust MIDDLE ANT phase shifter (PH1) to obtain 180° (±1°)

3 Connect the cable TEST SIG to the SBO input. Connect the B-probe to M output. Normalize the vector voltmeter B-probe to 0° reference phase

4 Connect the B-probe to L output. If necessary adjust SBO U/L phase shifter (PH2) to obtain 180° (±1°)

5 Connect the B-probe to U output. If necessary adjust UPPER ANT phase shifter (PH3) to obtain 180° (±1°). (same phase as in (7))

5.2.5 Monitoring Combining Unit adjustments

Monitor Combining Unit MOA338D is equipped with plug-in attenuators dependent upon forward slope, according to the following table:

FSL relative to Θ_0	Equiv. FSL in degrees for Θ_0= 3°	AT3 Type*75uA (Stock)	AT3 Type* 150uA	AT4 Type*75uA (stock)	AT4Type* 150uA	AT5 Type	AT6 Type	AT7 Type
$-0.4\Theta_0 \pm 0.05\Theta_0$	-1.2° ± 0.15°	AT 1305Z	AT 1305AA	AT 1305i	AT 1305AC	AT1305V	AT1305R	AT1305X
$-0.2\Theta_0 \pm 0.05\Theta_0$	-0.6° ± 0.15°	AT 1305B	AT 1305W	AT 1305G	AT 1305AD	AT1305M	AT1305A	AT1305S
$-0.1\Theta_0 \pm 0.05\Theta_0$	-0.3° ± 0.15°	AT 1305C	AT 1305Y	AT 1305H	AT 1305AE	AT1305N	AT1305A	AT1305T
$0.0\Theta_0 \pm 0.05\Theta_0$	0.0° ± 0.15°	AT 1305D	AT 1305U	AT 1305J	AT 1305AF	AT1305P	AT1305A	AT1305U
$+0.1\Theta_0 \pm 0.05\Theta_0$	+0.3° ± 0.15°	AT 1305E	AT 1305AB	AT 1305K	AT 1305B	AT1305Q	AT1305A	AT1305V
$+0.2\Theta_0 \pm 0.05\Theta_0$	+0.6° ± 0.15°	AT 1305F	AT 1305G	AT 1305L	AT 1305AG	AT1305B	AT1305A	AT1305W

Table 5-2 Plug-in attenuator type versus forward slope angle

Make sure that correct attenuators are installed for the actual site.

Example on how to select attenuators:

Glideslope $\Theta_\circ$ = 3.2 degrees:
FSL = -0.55 degrees.
In this case the FSL relative to $\Theta_\circ$ is -0.55° / 3.2° = -0.172$\Theta_\circ$. This means that the second set of attenuators (line 2 in Table 5-2) should be selected, since these attenuators are designed for FSL in the range -0.15 to -0.25$\Theta_\circ$.

*Please note that there are two columns for both AT3 and AT4. Select the attenuator sets corresponding to the desired DS monitoring (75uA or 150uA).

Conclusion:
In this example AT 1305B, AT 1305G, AT 1305M, AT 1305S and AT 1305A should be used for AT3, AT4, AT5, AT7 and AT6 respectively.
(*If 150uA DS monitoring is desired, AT1305W should be used for AT3 and AT1305AD AT4.)

5.2.5.1 Adjustments procedure

The Clearance transmitter shall be switched off during steps (1) through (5) below.

1 Connect the PIR to the CL output of the Monitoring Combining Unit. Insert the 90° phasing-stub in the SBO output of the Transmitter Cabinet. In the Antenna Distribution Unit disconnect SBO to lower antenna by removing the cable connector to hybrid H4 port 1. (See Interconnection Diagram DIA 346B). Terminate open ends to 50 ohm. Adjust upper antenna phase shifter PH1 in the Monitoring Combining Unit to give 0.0% DDM, or nearest to zero value

2 Reconnect the cable connector to H4 port 1 to lower antenna. Remove the 90° phasing-stub. Adjust CL attenuator AT1 to give 0.0 % DDM

3 Connect the PIR to the DS output of the Monitoring Combining Unit. Insert the 90° phasing-stub in the SBO output of the Transmitter Cabinet. Adjust middle antenna phase shifter PH2 in the Monitoring Combining Unit to give 0.0% DDM

4 Remove the 90° phasing-stub. Adjust DS attenuator AT2 to give 8.75% (17,5%) DDM or 75μA (150), 150 Hz dominance, or nearest to this value

5 Connect the PIR to the CLR output of the MCU. Adjust phase shifter PH3 in the Monitoring Combining Unit to achieved maximum DDM (150 Hz dominance). (The clearance transmitter signal shall still be switched off.)

6 Switch on CLR transmitter. Check that the CLR DDM is not less than 38%

5.2.6 Near field monitor antenna position

5.2.6.1 General

The near field monitor antenna is positioned at a height where there is a RF null (or minimum) in the vertical radiation pattern for the middle antenna, and at a distance in front of the glide path antenna where there is an RF phase difference for the signals from upper and lower antenna of 360° compared to the corresponding RF phase shift in the far field. For a 3° GP angle and horizontal reflection area this occurs at a distance of approximately 81 metres forward from the GP antenna mast. At this location near field conditions are close to far field conditions regarding deviations in phase and amplitude of the ILS signal. (Fly-up and fly-down modulation sense are reversed).

The procedure for calculating initial position of the near field monitor antenna, is described in document no. 22563-1, “ILS Glide Path Systems – Calculation of Antenna Parameters”.

5.2.6.2 Near field monitor antenna position tolerance

The nominal measured RF phase shift between the received signal from the upper and lower antenna at the correct Near Field Monitor antenna position is 180°.

The tolerance is ±10° from the nominal value of 180°.

5.2.6.3 Check of correct near field monitor antenna position

The location of the near field monitor antenna changes if the glide path system/antenna phasing is changed. Therefore, it is essential that the glide path system/antenna phasing is correct before the near field monitor antenna is positioned. Therefore, before locating the monitor antenna, the glide path should have passed a flight check.

Two alternative test methods are described below.

Vector Voltmeter/Network analyser method

Test procedure.

1 Install the NF antenna at the calculated position
2 Switch off the clearance transmitter
3 Adjust the height to 0 DDM reading on the PIR connected to the NF monitor cable. (Note that the DDM reading is quite sensitive to persons and objects within the sensitive area.)

4 Construct a test set-up as described in Figure 5-6. Connect the CSB cable from the cabinet to the SBO input of the ADU. Dummy-load the SBO from the cabinet. Dummy-load CSB input of the ADU. Dummy-load M and U outputs from the ADU. Connect a 10 dB attenuator at the A-probe of the vector voltmeter. Connect a test cable from cabinet CSB/COU BNC test-connector to the 10 dB attenuator input of the vector voltmeter. Connect the B-probe to the NF antenna cable. Switch off the clearance transmitter and the modulation of the course transmitter. Connect the lower antenna cable to the L output of the ADU
5 Switch on the course transmitter. Normalize the B-probe level and phase. Switch off the course transmitter
6 Disconnect the lower antenna cable from the ADU and connect the upper antenna cable to the ADU L output. Switch on the course transmitter. Make a note of the B-probe level and phase. Switch off the course transmitter
7 Determine if the NF antenna is within tolerance. (Ref. 5.2.6.2)

If the measured phase difference is within the tolerance, proceed with step 9.

If the measured phase difference is outside the tolerance, proceed with the following step 8 to 10.

8 The Near Field Monitor antenna should be re-positioned to meet the tolerance. The phase sensitivity is approximately 4° per metre in the direction toward the GP antenna mast. The phase value is increasing versus shorter distance. For example if the measured phase difference is 172°, the NF antenna should be moved about 2 metres closer to the GP mast. Repeat the procedure from step 3 to verify the new position
9 Switch on the clearance transmitter. The DDM reading should not change more than 0.4% DDM (4µA). A typical value is 0.2% DDM (2µA) for a well adjusted system
10 Restore the facility to normal

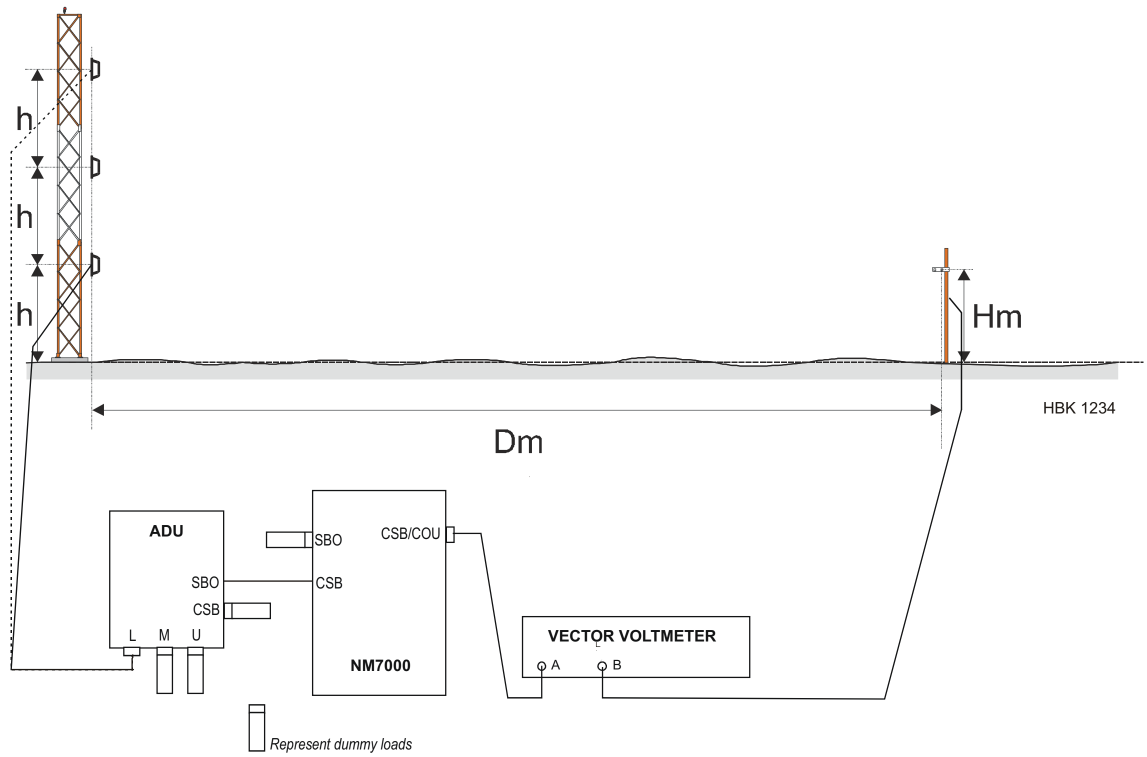


Figure 5-6 Near field monitor carrier phase test set-up

PIR method

Initial position of near field monitor antenna:

1. Install the NF antenna at the calculated position
2. Switch off the clearance transmitter
3. Adjust the height of the near field monitor antenna to 0 DDM reading on the PIR connected to the NF monitor cable. (The DDM reading is quite sensitive to persons and objects within the Sensitive Area.)

Test procedure:
The system shall be configured for normal operation.

1. Switch off the transmitter
2. Insert the quadrature (90°) line in the SBO input to the ADU
3. Dummy load the clearance transmitter output and its input port to the ADU
4. Insert a dummy load on the ADU middle antenna ouput
5. Connect the PIR to the near field monitor antenna cable
6. Insert a 27° stub (double male/female N adaptor) in the upper antenna feed line.
7. Switch on the transmitter
8. Make a note of the DDM reading on the PIR as DDM_{UPPER}
9. Switch off the transmitter
10. Move the 27° stub from the upper antenna feed line to the lower antenna feed line
11. Switch on the transmitter
12. Make a note of the DDM reading on the PIR as DDM_{LOWER}
13. Calculate the phase error and check if it is within tolerance (see Section 5.2.6.2) using the following formula:

$$\text{Phase error} = 27° \cdot \left(1 - 2 \cdot \frac{\text{DDM}_{\text{MIN}}}{|DDM_{UPPER}| + |DDM_{LOWER}|}\right)$$

where DDM_{MIN} is the smaller of $|\text{DDM}_{\text{UPPER}}|$ and $|\text{DDM}_{\text{LOWER}}|$

Example:
$\text{DDM}_{\text{UPPER}}$ = -8.46% DDM
$\text{DDM}_{\text{LOWER}}$ = 5.75% DDM

$$\text{Phase error} = 27° \cdot \left(1 - 2 \cdot \frac{5.75}{8.46 + 5.75}\right) = 5.1°$$

If the result is within the tolerance, proceed with step 24.

If the result is outside the tolerance, proceed with the following steps 14 to 24.

14 Remove the stub from the lower antenna feed line
15 The clearance transmitter remains dummy loaded as in step 3
16 Insert the quadrature (90°) line in the SBO input to the ADU
17 Move the Near Field Monitor antenna in and out until the PIR reads 0 DDM
18 Remove the quadrature (90°) line and restore the SBO to normal
19 Move the near field monitor antenna up and down until the PIR reads minimum 90Hz dominance
20 Repeat steps 16 to 19 until the near field monitor reads 0 DDM as found in steps 17 and 19 without moving the near field monitor antenna
21 Remove the dummy load from the ADU middle antenna output. Reconnect the middle antenna to the ADU
22 Remove the quadrature (90°) line and restore the SBO to normal
23 Move the near field monitor antenna up or down until the PIR reads 0 DDM. This adjustment should be very small. This adjustment locates the Near Field antenna in the RF null of the middle antenna
24 Connect the clearance transmitter to the ADU and switch on the clearance transmitter. The DDM reading should not change more then 0.4% DDM (4µA). A typical value is 0.2% DDM (2µA) for a well adjusted system
25 Restore the facility to normal

Appendix 1: Calculation of antenna parameters

This appendix contains a document that provides guidelines for the following calculations:

- Initial antenna heights
- Antenna lateral offsets
- Antenna forward shift

Position of near field monitor for image glide path systems

NORMARC 7000 ILS

ILS GLIDE PATHS SYSTEMS

CALCULATION OF ANTENNA PARAMETERS

Park Air Systems AS	Name	Signature	Date
Author	Alf W. Bakken	AWB (Sign.)	25-jan-02
Approved by	Thor Breien	TBR (Sign.)	25-jan-02

STATUS

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Issue	ECO	Review	Date/Year	Author	Based on document
Rev. 1.0	—		25-jan-02	AWB/PKF	“Calculation of mechanical setting-up of parameters and initial antenna feeds for ILS Glide Path systems” provided by Alf W. Bakken 04.01.02.

Changes Incorporated

Issue	Paragraph	Paragraph Heading/Description of Change
Rev. 1.0	—	The document is new.

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1 General

The purpose of this document is to give some guidelines for calculation of initial antenna heights, antenna lateral offsets, antenna forward shifts, and the position of the Near Field Monitor for image Glide Path systems.

1.1 Definitions

Antenna Forward Shift

A displacement in the forward direction (parallel to the runway centreline) from a vertical line to align the antennas along a line perpendicular to the forward slope (FSL). The purpose of the antenna forward shift is to eliminate phase errors between the antennas caused by a FSL deviating from the horizontal.

Antenna Lateral Offset

A displacement in the lateral direction (perpendicular to the runway centreline) from a vertical line to align the antennas along an arc, with radius like the perpendicular distance between the ILS Glide Path antenna mast and the runway centreline. The purpose of the antenna lateral offset is to eliminate phase errors between the antennas along the runway centreline, caused by near field defocusing.

Beam Forming Area (BFA)

The levelled area in front of the ILS Glide Path antenna needed to achieve satisfactory vertical and horizontal radiation patterns within the coverage volume for the ILS Glide Path.

Forward Slope (FSL)

The average forward slope of the part of the BFA used to generate the ILS Glide Path signal between ILS point A and ILS Point B on the Glide Path angle. The FSL is positive for an upslope and negative for a downslope in front of the ILS Glide Path antenna. The FSL is used to calculate correct initial antenna heights and antenna forward shift. See Figure 4.

ILS Glide Path angle (θ_o)

As defined in ICAO Annex 10.

Sideways Slope (SSL)

The average sideways slope of the part of the BFA used to generate the ILS Glide Path signal between ILS point A and ILS Point C or T, on the Glide Path angle. The SSL is used to calculate correct initial antenna lateral offsets. The SSL is positive for an upslope and negative for a downslope from the ILS Glide Path antenna mast towards the runway centreline. See Figure 5.

2 Calculation of terrain slopes

The methods described in this chapter for calculating the FSL and SSL are only valid if the levelling of the BFA complies with the specifications given in the chapter "Site requirements for ILS" in the Installation and Commissioning handbook. If the BFA is smaller than specified, or if there are discontinuities in the terrain within the BFA that substantially exceeds the specifications, it will be necessary to use an advanced ILS Glide Path simulation program. This program must have capabilities to make a full 3D terrain model to determine the correct FSL and SSL for that specific site.

2.1 Coordinate system

An appropriate coordinate system to use in the slope calculations is defined as follows: Origin positioned at the intersection between the runway centreline and the runway threshold. The X-axis is oriented perpendicular to the runway centreline in the horizontal plane containing the threshold. The Y-axis is oriented along the runway centreline in the horizontal plane containing the threshold. The Z-axis is perpendicular to both the X-axis and the Y-axis. The coordinate system is shown in Figure 1.

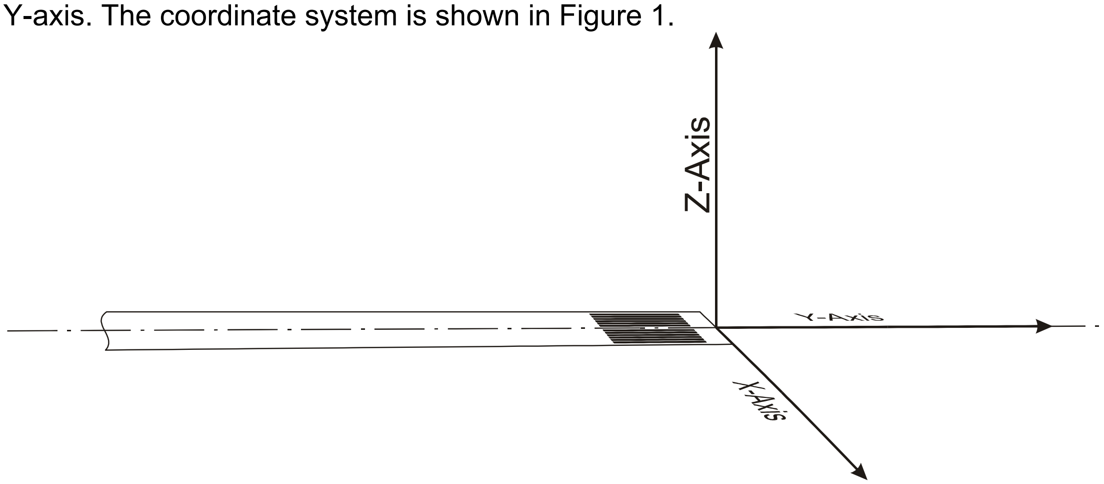


Figure 1 Coordinate system

2.2 Calculation of FSL

The preferred method to calculate the FSL is to use a least square fit to a planar surface with surveyed terrain heights (x, y, z triplets) within the relevant part of the BFA. The density of the surveyed points must be high enough to define all irregularities within the area in question, and should be evenly distributed. The area in question is shown in Figure 2. The equation of the approximated planar surface will be of the form:

$$Z(X,Y) = a_0 + a_1 X + a_2 Y$$

where

$$a_0 = \text{aproximated surface height at threshold}$$

$$a_1 = \text{tangent of SSL}$$

$$a_2 = \text{tangent of FSL}$$

The coefficients a_0, a_1 and a_2 can be calculated from the surveyed data using Microsoft Excel and the Analysis ToolPack add in, or other adequate software. If no such tools are available, a simple straight line fit (linear regression) can be used with points sampled along a line in front of the ILS Glide Path antenna mast.

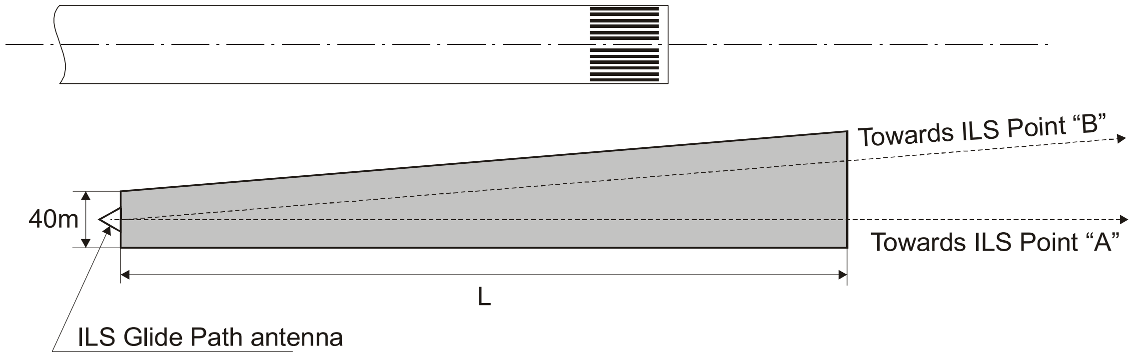


Figure 2 Area for FSL calculation

The distance L is dependent of type of Glide Path antenna system and of the specific site.

Typical values are:
For NORMARC 3543 (Null-Reference) antenna system: 400m – 500m
For NORMARC 3544 (Sideband Reference) antenna system: 360m – 400m
For NORMARC 3545 (M-Array) antenna system: 320m – 365m

2.3 Calculation of SSL

The preferred method to calculate the SSL is to use a least square fit to a planar surface with surveyed terrain heights (x, y, z triplets) within the relevant part of the BFA. The density of the surveyed points must be high enough to define all irregularities within the area in question, and should be evenly distributed. The area in question is shown in Figure 3. The equation of the approximated planar surface will be of the form:

$$Z(X,Y) = a_0 + a_1 X + a_2 Y$$

where

$$a_0 = \text{aproximated surface height at threshold}$$
$$a_1 = \text{tangent of SSL}$$
$$a_2 = \text{tangent of FSL}$$

Depending on which side of the runway the antenna mast is positioned, the sign of the SSL may have to be changed to coincide with the definition.

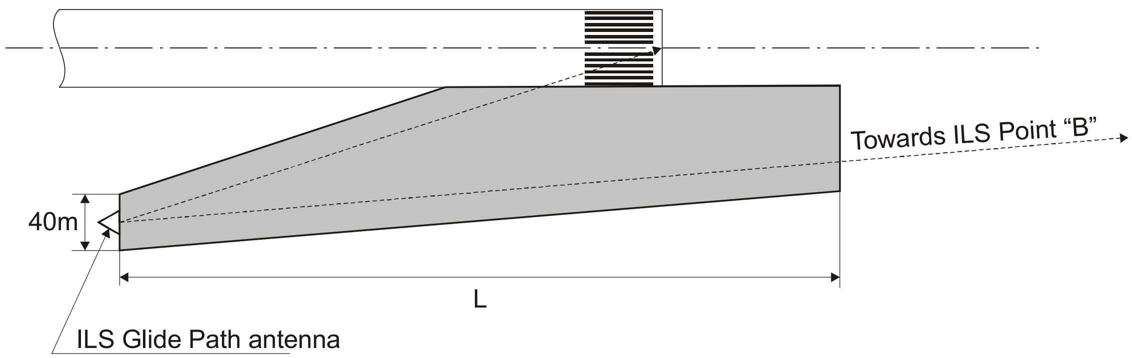


Figure 3 Area for SSL calculation

The coefficients a_0, a_1 and a_2 can be calculated from the surveyed data using Microsoft Excel and the Analysis ToolPack add in, or other adequate software. If no such tools are available, a simple straight line fit (linear regression) can be used with points sampled along lines perpendicular to the runway centreline within the area shown in Figure 3. The average value of the calculated slopes can then be used as SSL.

The distance L is dependent of type of Glide Path antenna system and of the specific site.

Typical values are:

For NORMARC 3543 (Null-Reference) antenna system:	300m – 450m
For NORMARC 3544 (Sideband Reference) antenna system:	300m – 400m
For NORMARC 3545 (M-Array) antenna system:	300m – 350m

3 Calculation of ILS Glide Path antenna positions and feeds

This chapter describes calculations for the antenna systems NORMARC 3543 (Null-Reference), NORMARC 3544 (Sideband Reference), and NORMARC 3545 (M-Array).

3.1 Common parameters

This figure refers to paragraphs 3.1.1, 3.1.2, 3.1.3 and 3.1.4.

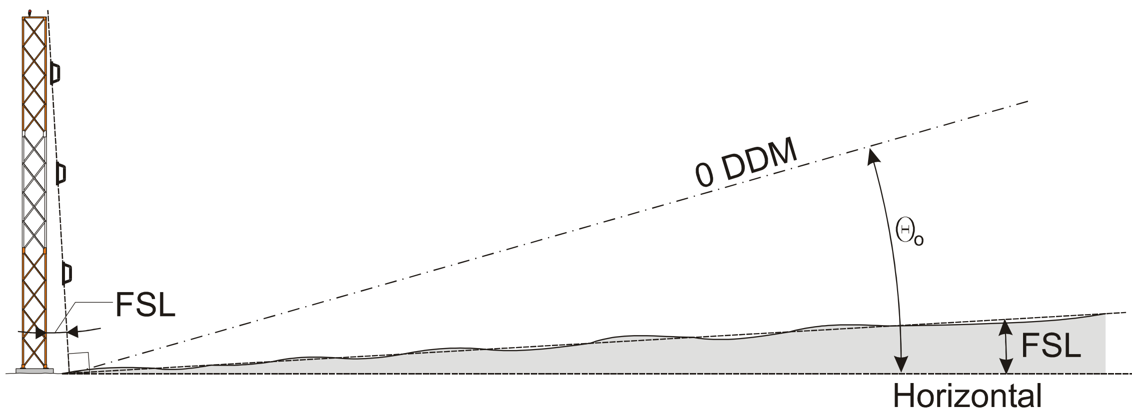


Figure 4 Forward slope (FSL) and antenna forward shift

This figure refers to paragraphs 3.2.2, 3.3.2 and 34.2.

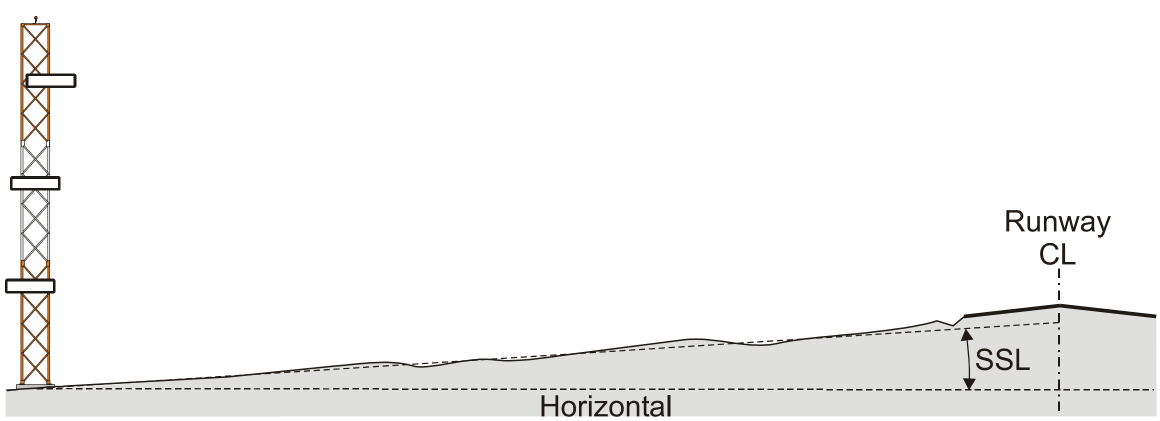


Figure 5 Side slope (SSL) and antenna lateral offset

3.1.1 Vertical antenna element spacing

$$h = \frac{\lambda}{4 \cdot \sin(\theta_0 - FSL)}$$

where

$h = \text{vertical spacing between antenna elements in metres}$

$\lambda = \text{vavelength in metres} = \frac{c}{f}$

$c = \text{velocity of light in free space} = 299.792458 \cdot 10^6 \, {}^{m}\!/\!_{s}$

$f = \text{frequency in MHz} \cdot 10^6$

3.1.2 Antenna forward shift

To align the antenna elements along a line perpendicular to the BFA in the forward direction, the antenna elements must be shifted in the forward direction from a vertical line, if the FSL is different from zero.
The antenna that will be positioned closest to the antenna mast is chosen as reference. If the FSL is positive (upslope) the upper antenna is reference (see Figure 4), if the FSL is negative (downslope) the lower antenna is chosen as reference.
The relative antenna forward shift (Δy) is calculated as follows:

$$\Delta y = h \cdot \sin(|FSL|)$$

For the NORMARC 3545 (M-Array) antenna system, a forward shift of Δy shall be applied for the antenna closest to the reference antenna and 2Δy to the next.

3.1.3 Vertical DDM distribution on course line (far field)

NOTE: *for the* NORMARC *3545 (M-Array) ILS Glide Path system, this is with the clearance transmitter switched off.*

$$DDM(\theta) = \frac{4 \cdot A_{SBO}}{A_{CSB}} \cdot \cos\left(90^o \cdot \frac{\theta - FSL}{\theta_0 - FSL}\right)$$

where

$\theta = \text{vertical angle with respect to the horizontal}$

$A_{SBO} = \text{largest SBO feed amplitude}$

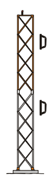
$A_{CSB} = \text{largest CSB feed amplitude}$

3.1.4 Ratio between largest CSB and SBO feed amplitudes

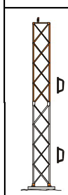
$$\frac{A_{SBO}}{A_{CSB}} = \frac{7}{320\cdot\sin\left[10.8^{o}\cdot\left(\frac{\theta_0}{\theta_0-FSL}\right)\right]} \approx 0.1167\cdot\left(1-\frac{FSL}{\theta_0}\right)$$

3.1.5 Antenna feeds

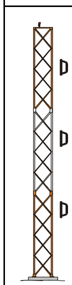
NORMARC 3543 (Null Reference) ILS Glide Path system

		CSB		SBO	
		Amplitude	Phase	Amplitude	Phase
	Upper antenna	—	—	A_{SBO}	0º
	Lower antenna	A_{CSB}	0º	—	—

NORMARC 3544 (Sideband Reference) ILS Glide Path system

		CSB		SBO	
		Amplitude	Phase	amplitude	Phase
	Upper antenna	—	—	A_{SBO}	0º
	Lower antenna	A_{CSB}	0º	A_{SBO}	180º

NORMARC 3545 (M-Array) ILS Glide Path system

		CSB		SBO		CLR	
		Amplitude	Phase	Amplitude	Phase	Amplitude	Phase
	Upper antenna	—	—	0.5 A_{SBO}	180º	A_{CLR}^{*}	0º
	Middle antenna	$0.5\cdot A_{CSB}$	180º	A_{SBO}	0º	—	—
	Lower antenna	A_{CSB}	0º	$0.5\cdot A_{SBO}$	180º	A_{CLR}^{*}	0º

*) $A_{CLR} = 0.2\cdot A_{CSB}$

3.2 NORMARC 3543 (Null Reference) ILS Glide Path system

3.2.1 Near Field Monitor position

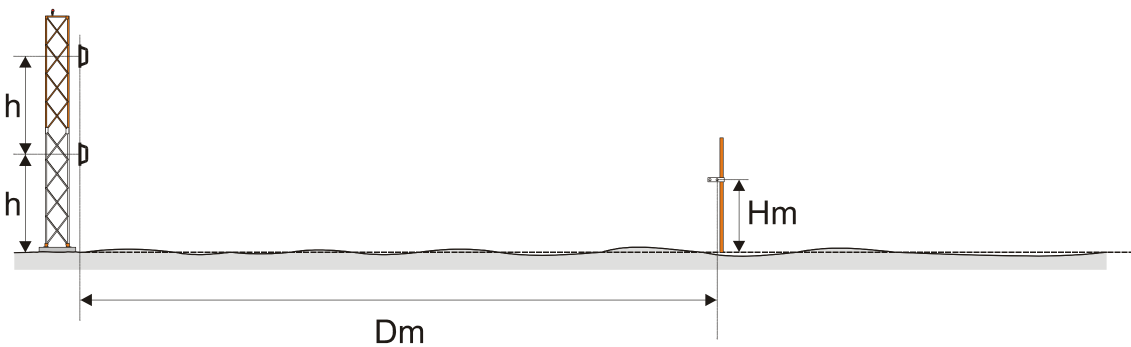


Figure 6 Distance and height of NF Monitor (NM3543)

The Near Field Monitor antenna is placed at a height Hm where there is a zero (or minimum) in the vertical radiation pattern for the upper antenna, and at a distance Dm where there is an RF phase difference for the signals from upper and lower antenna of 180º compared to the corresponding RF phase shift in the Far Field.

$$Dm = \frac{3 \cdot h^2}{\lambda} - \frac{21 \cdot \lambda}{64} \qquad Hm = \frac{3 \cdot h}{4} - \frac{7 \cdot \lambda^2}{64 \cdot h}$$

3.2.2 Lateral antenna offset between upper and lower antenna

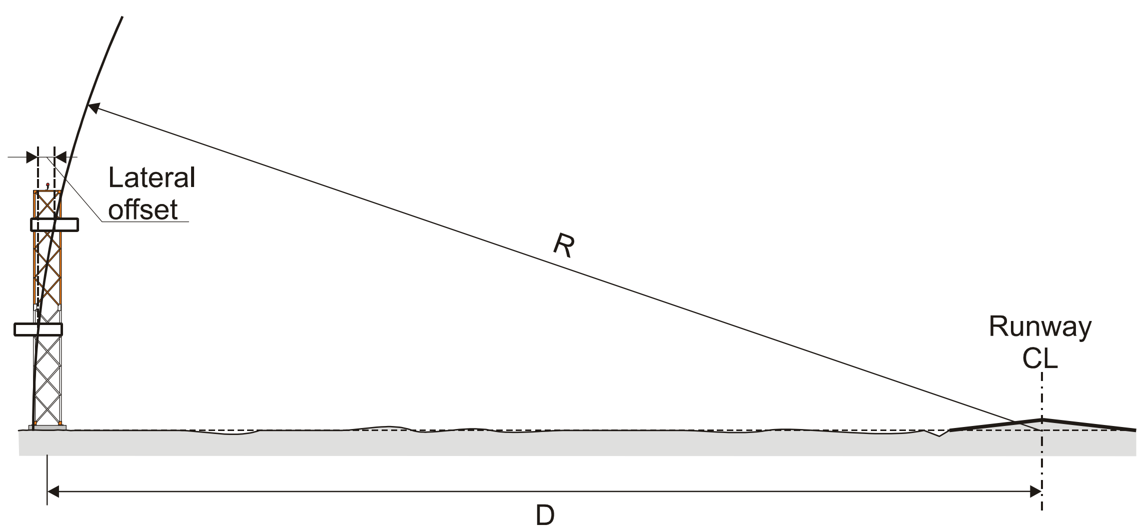


Figure 7 Lateral antenna offset (NM3543)

$$\text{Lateral offset} = \frac{3 \cdot h^2}{2 \cdot D} - h \cdot \sin(SSL)$$

Sideslope (SSL) is shown in Figure 5.

3.3 NORMARC 3544 (Sideband Reference) ILS Glide Path system

3.3.1 Antenna heights and Near Field Monitor

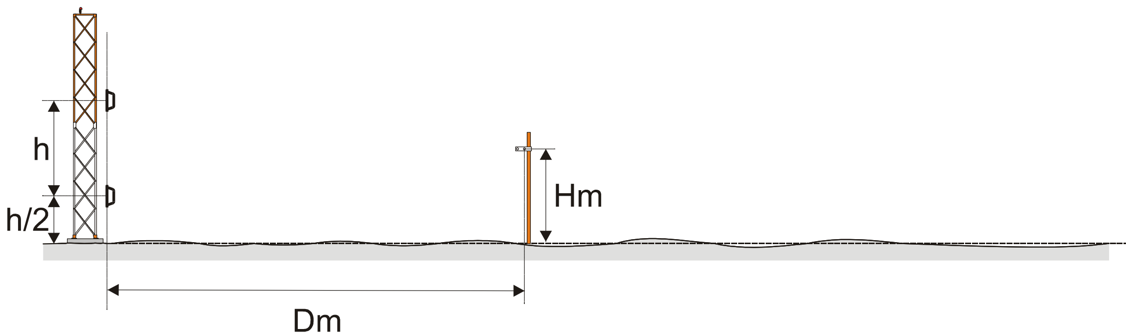


Figure 8 Distance and height of NF Monitor (NM3544)

The Near Field Monitor antenna is placed at a height Hm where maximum in the vertical radiation pattern for the upper and lower antenna coincide (approx. $2\theta_o$), and at a distance Dm where there is an RF phase difference for the signals from upper and lower antenna of 180º compared to the corresponding RF phase shift in the far field.

$$Dm = \frac{2 \cdot h^2}{\lambda} - \lambda \qquad Hm = h - \frac{11 \cdot \lambda^2}{32 \cdot h}$$

3.3.2 Lateral antenna offset between upper and lower antenna

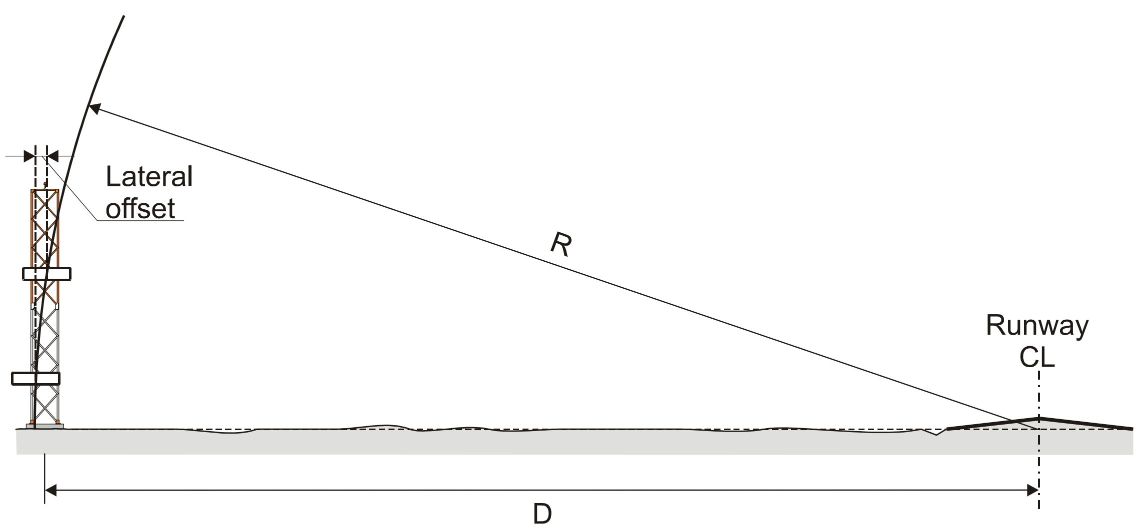


Figure 9 Lateral antenna offset (NM3544)

$$\text{Lateral offset} = \frac{h^2}{D} - h \cdot \sin(SSL)$$

Sideslope (SSL) is shown in Figure 5.

3.4 NORMARC 3545 (M-Array) ILS Glide Path system

3.4.1 Antenna heights and Near Field Monitor

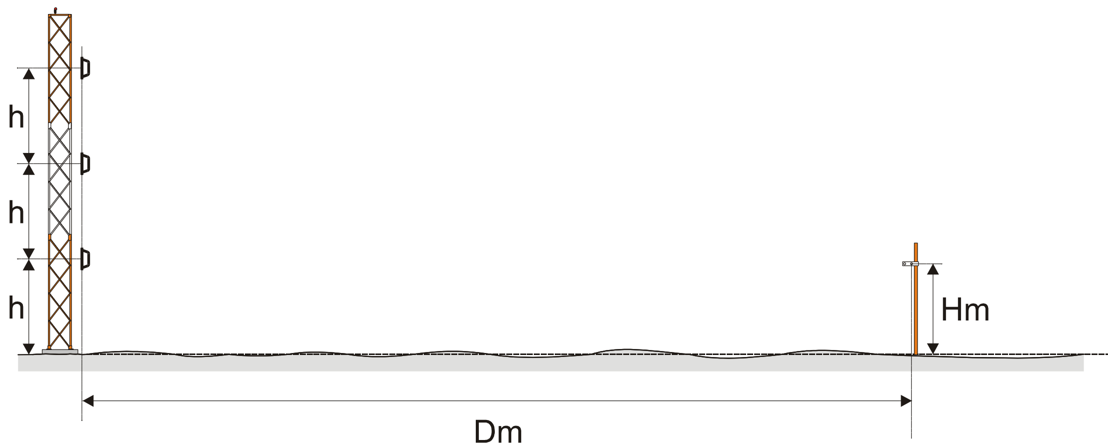


Figure 10 Distance and height of NF Monitor (NM3545)

The Near Field Monitor antenna is placed at a height Hm where there is a zero (or minimum) in the vertical radiation pattern for the middle antenna, and at a distance Dm where there is an RF phase difference for the signals from upper and lower antenna of 360º compared to the corresponding RF phase shift in the far field.

$$Dm = \frac{4 \cdot h^2}{\lambda} - \lambda \qquad Hm = h - \frac{3 \cdot \lambda^2}{32 \cdot h}$$

3.4.2 Lateral antenna offset between antennas

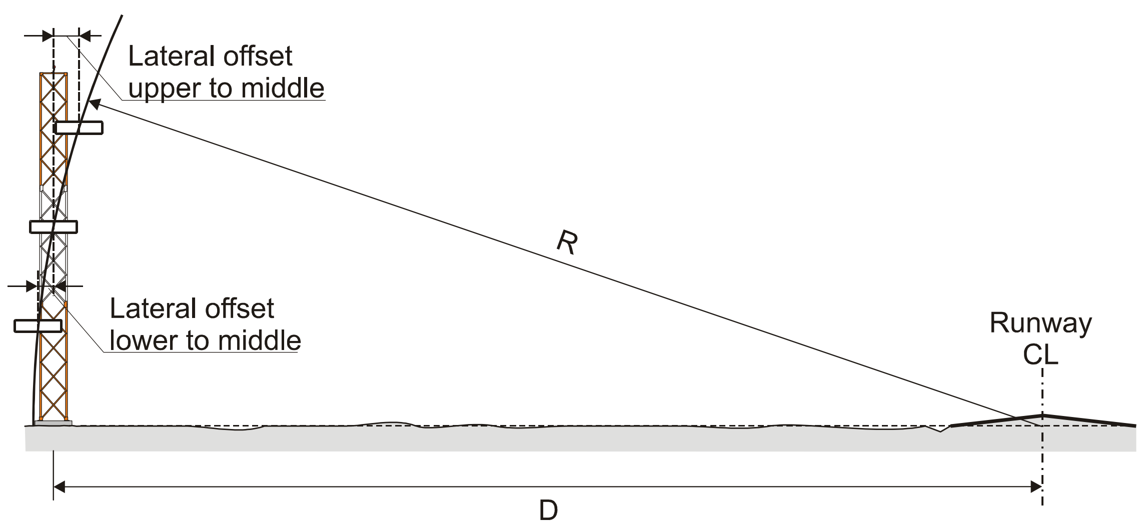


Figure 11 Lateral antenna offset (NM3545)

$$\text{Lateral offset upper to middle} = \frac{5 \cdot h^2}{2 \cdot D} - h \cdot \sin(SSL)$$

$$\text{Lateral offset lower to middle} = \frac{3 \cdot h^2}{2 \cdot D} - h \cdot \sin(SSL)$$

Sideslope (SSL) is shown in Figure 5.

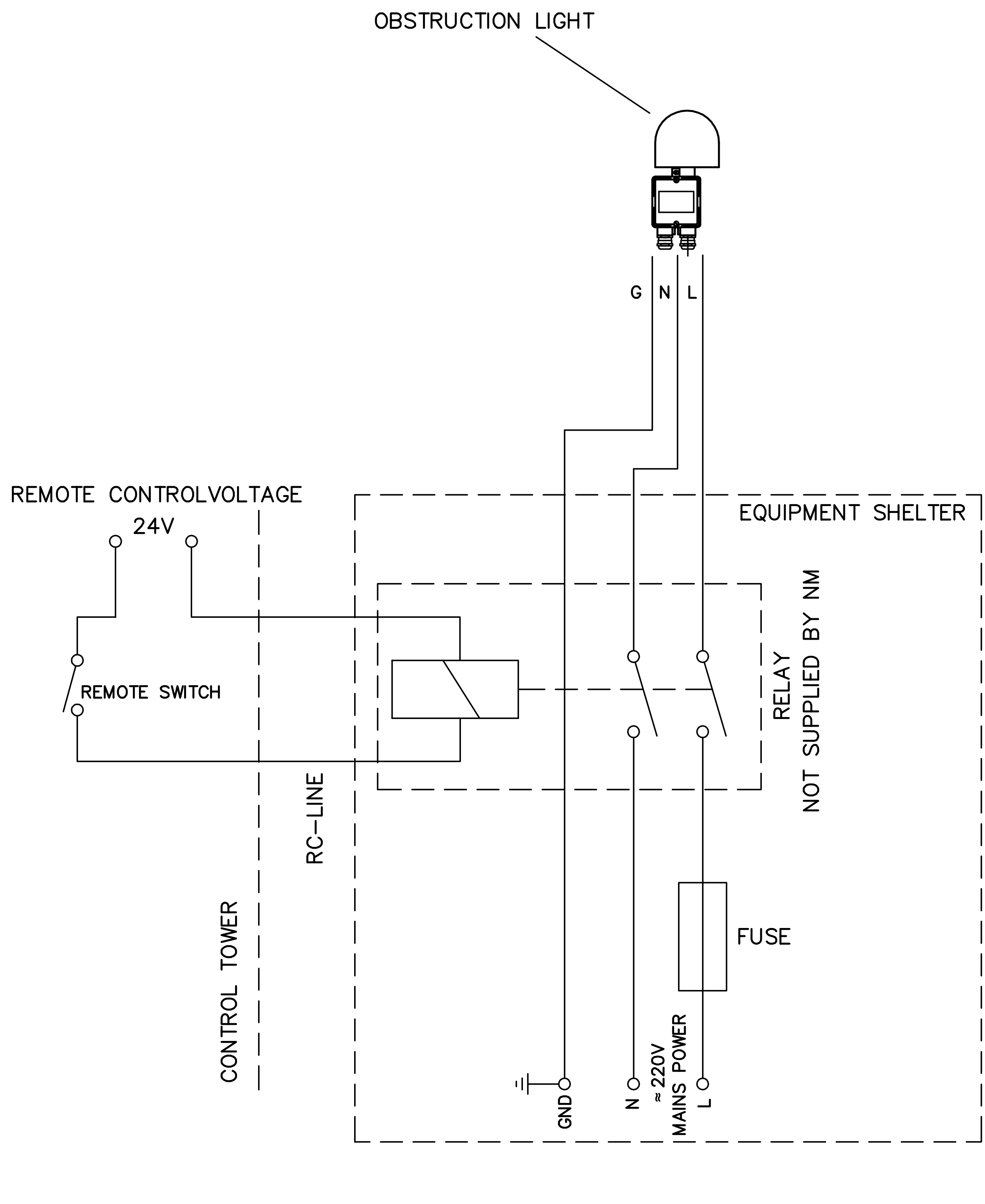
Appendix 2: Attached drawings

Format A4:

Drawing no.	***Title***
6344A4	GP Obstruction Light Wiring
18725A4	Distribution Network, DIA 346B Circuit Diagram
18724A4	Distribution Network, DIA 346A Interconnection Diagram
18757A4	Cabinet Outline Drawing DIA 346B/MOA 338D
HBK 1160	Kathrein antenna element

Format A3:

15581A3	Monitor Network, MOA 338D Circuit Diagram
16375A3	GP Installation Diagram M-array
16612A3	GP Antenna Mast Section Assembly
16642A3	Antenna Mast 15 m
16643A3	Vertical Adjustment Frame
16792A3	Adapter for Kathrein Antenna



ECO	Rev.	Date	Sign.
3834_9	5	130301	ARJ
2593	4	150296	ARJ

Title: GLIDE PATH
OBSTR.LIGHT WIRING

Subject: NM 3543-46

NORMARC

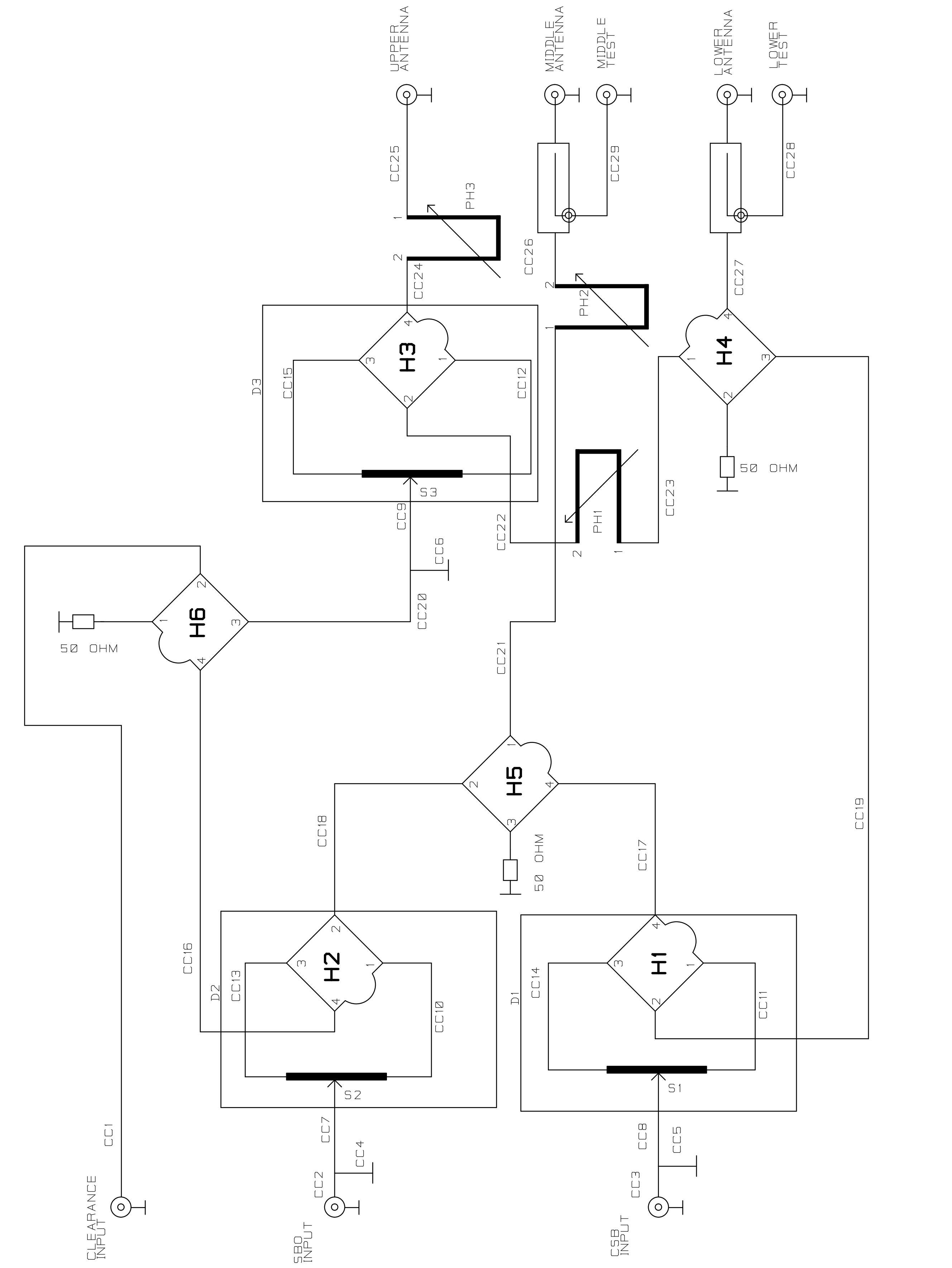
Scale: 1:10

Drawn	200281	FrH
Checked	170301	HSA
Appr.	061294	JSA

Sup.for: 6344A4-3 Sup.by:

Dwg.no.: F 6344A4 Rev. 5

Projection method:



TITLE:

CIRCUIT DIAGRAM

SHEET NO. 1 OF 1

SUBJECT:

DIA 346B

NORMARC

SCALE			
	DRAWN	22.10.03	TMA
	CHECKED	13.01.04	HSA
	APPR.	13.01.04	JSA

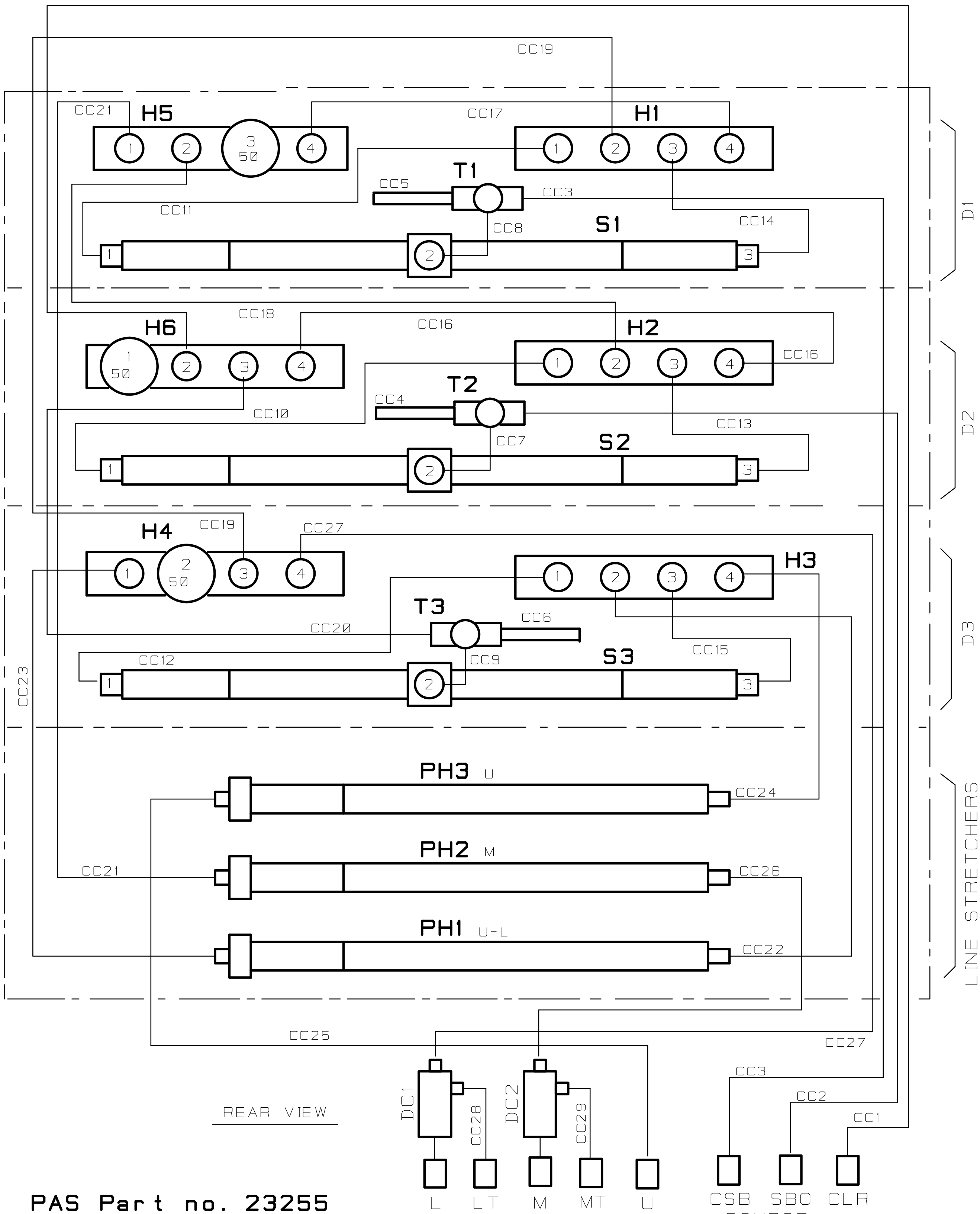
SUP FOR: SUP BY:

DWG.NO.: 18725A4

ISSUE 1

FILENAME :

REF.NO.	ISSUE	DATE	SIGN



PAS Part no. 23255

fig 2.9

				TITLE: INTERCONNECTION DIGRAM	SCALE	DRAWN	22.10.03 TMA
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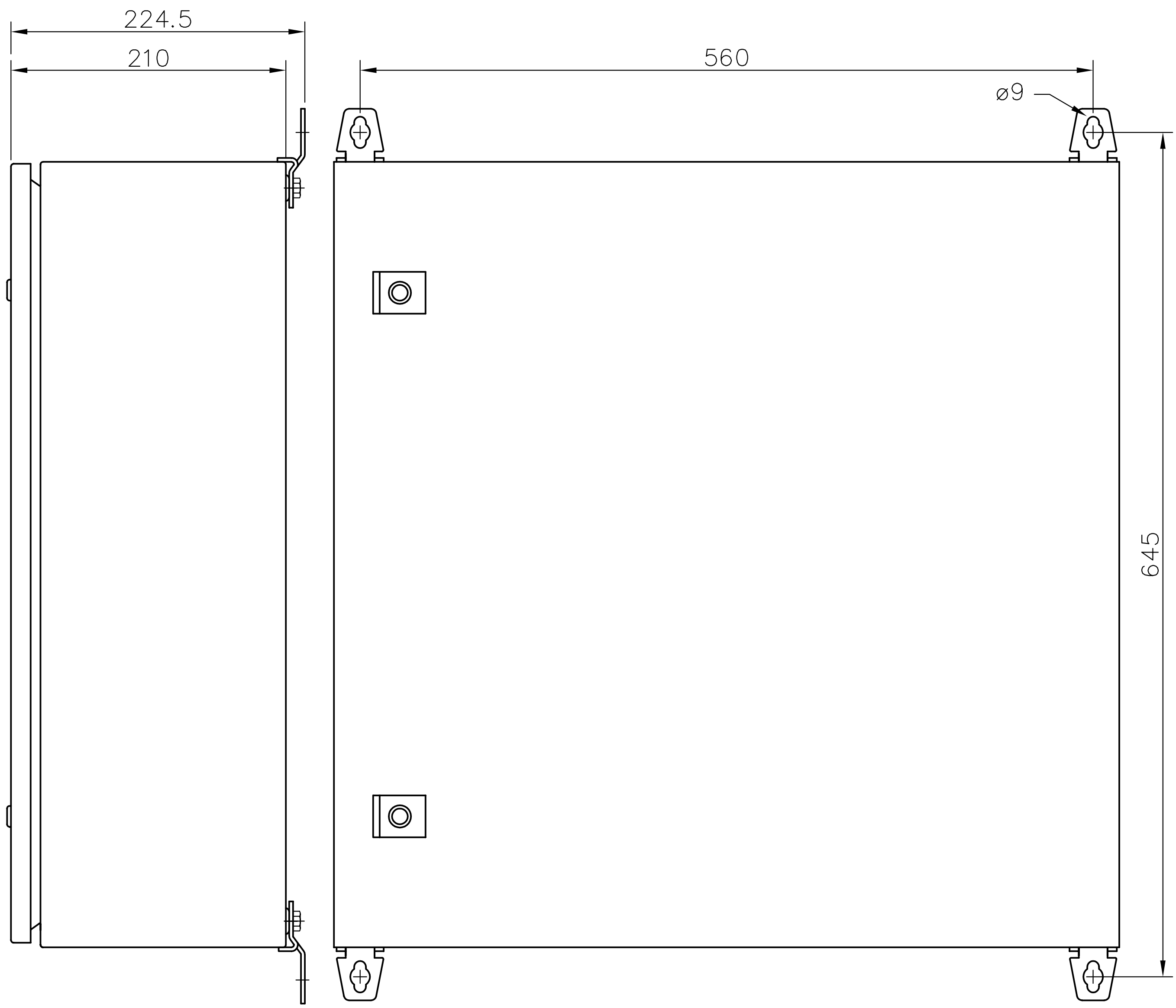
						APPR.	13.01.04 JSA
				SUBJECT: DIA 346B	SUP FOR:	SUP BY:	
					DWG.NO.: 18724A4	ISSUE 1	
				NORMARC	FILENAME :		
REF.NO.	ISSUE	DATE	SIGN				



				Title:	CABINET OUTLINE DRAWING	Scale:	Drawn	161203	RAJ
						1:5	Checked	130104	JSA
				Subject:	DIA 346/MOA 338		Appr.	130104	HSA
						Sup.for:		Sup.by:	
				NORMARC		Dwg.no.:	18757A4	Rev.	1
ECO	Rev.	Date	Sign.	Copyright and all modification rights reserved Park Air Systems AS, NORWAY		Projection method:			

Glide Path Antenna
328 – 335.5 MHz
713 316 B

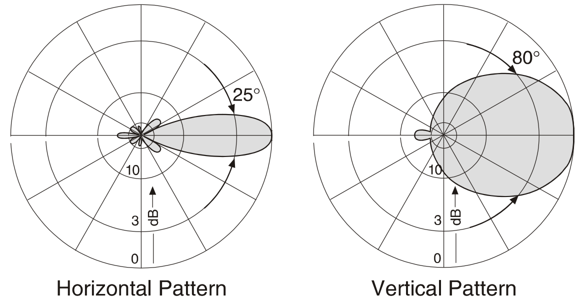
KATHREIN
Antennen · Electronic

RF monitor system integrated

Type No.	713 316 B
Input	Type N female connector
Frequency range	328 – 335.5 MHz
VSWR	< 1.1
Gain	12 dBd
Impedance	50 Ω
Polarization	Horizontal
Half-power beam width	H-plane: 80°/ E-plane: 25°
Max. power input (CW)	60 Watt (at 50 °C ambient temperature)
Max. current (DC)	1 A (between inner and outer conductor)
Weight	19 kg
Max. exp. area	1.0 m^2
Lateral thrust	1450 N at 160 km/h
Max. wind velocity	200 km/h (incl. $^1/_2$″ radial ice)
Width/height/depth	2000 / 500 / 190 mm
Packing size	2100 x 510 x 260 mm

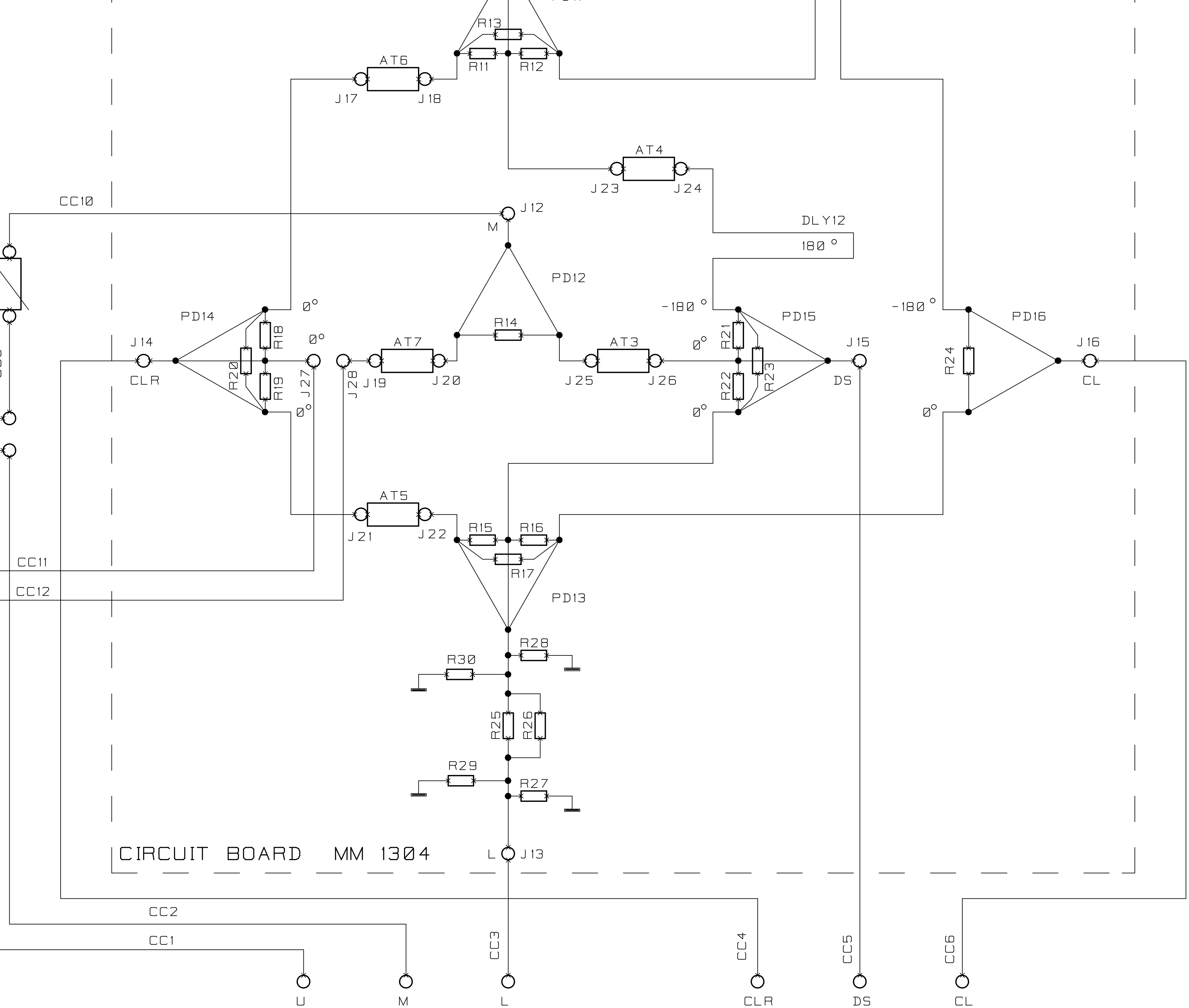
Material:	Dipole system: Cast aluminum. Reflector: Weatherproof aluminum. Radome: Fiberglass (white). All screws and nuts: Stainless steel.	
Scope of supply:	Antenna with two weather protective rubber caps for the connectors, but without mounting hardware.	
Mounting hardware:	Type No.	Mast diameter
	K 61 32 4	60 – 115 mm
	K 61 32 41	115 – 200 mm
Lightning protection:	The antenna is DC grounded including the inner conductors.	

Radiation Pattern (at mid-band)



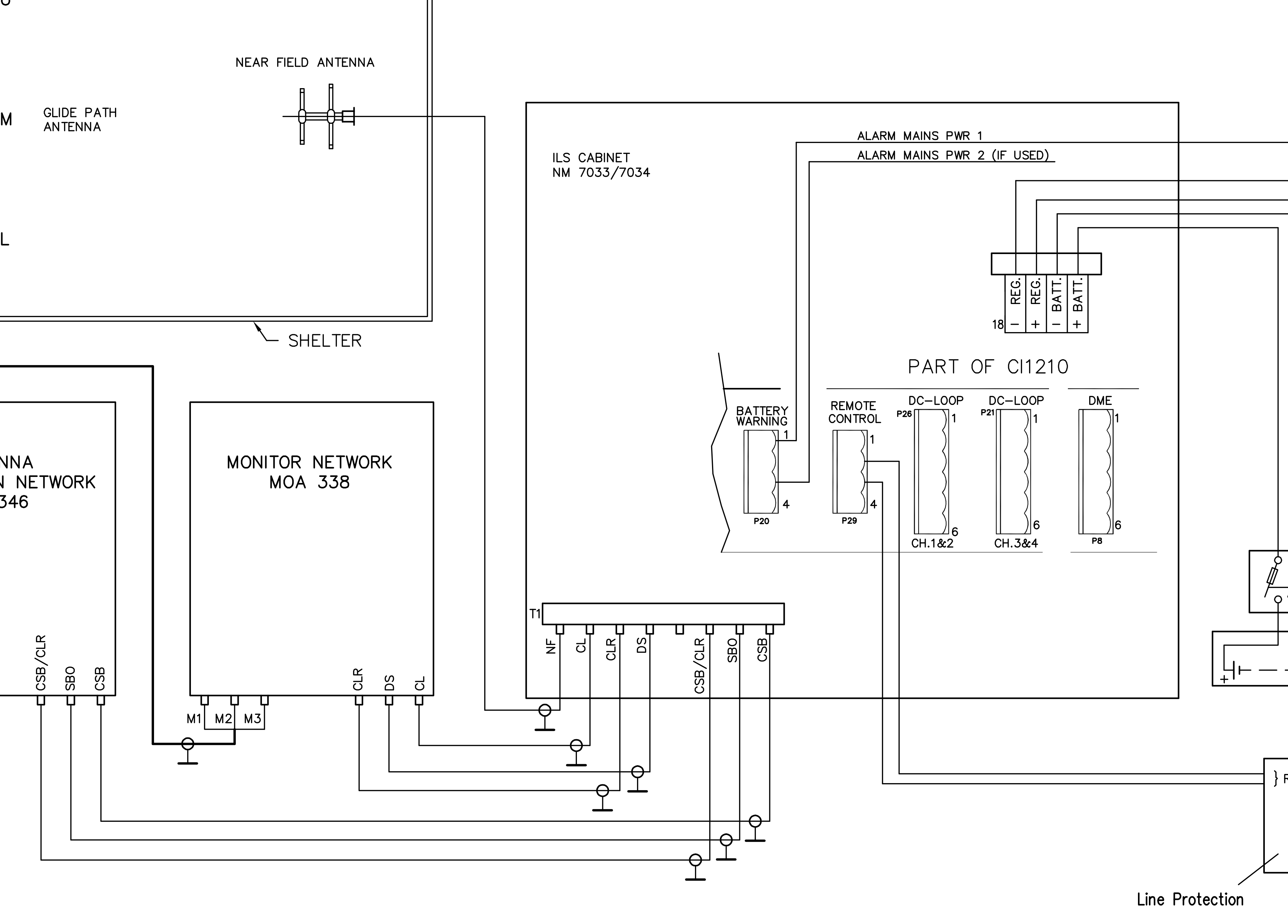
RF monitor system	
Input	Type N female connector
Frequency range	328 – 335.5 MHz
VSWR	< 1.3
Coupling attenuation	31 ± 1 dB

Park Air Systems doc. no. HBK 1160



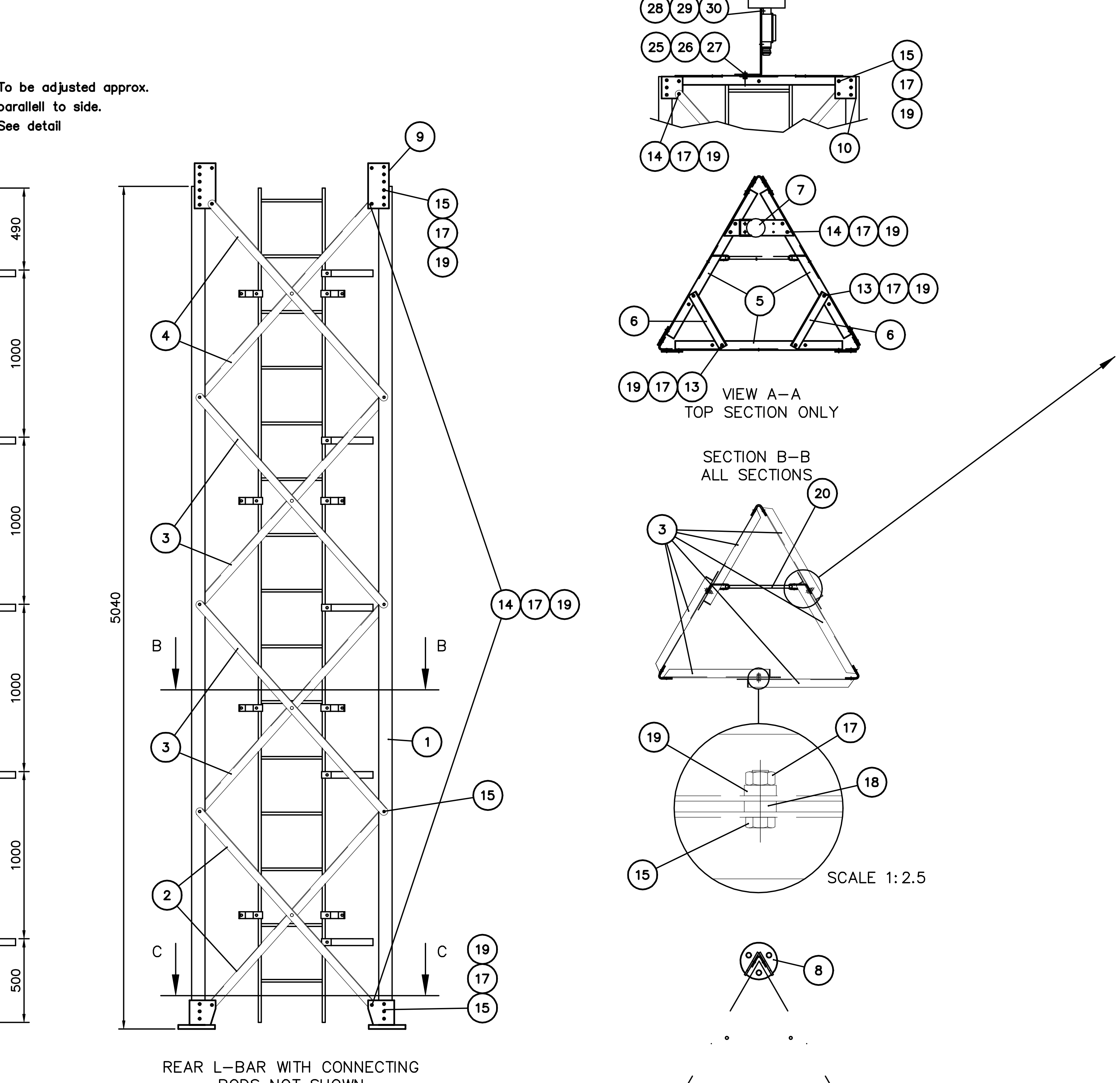
TITLE:

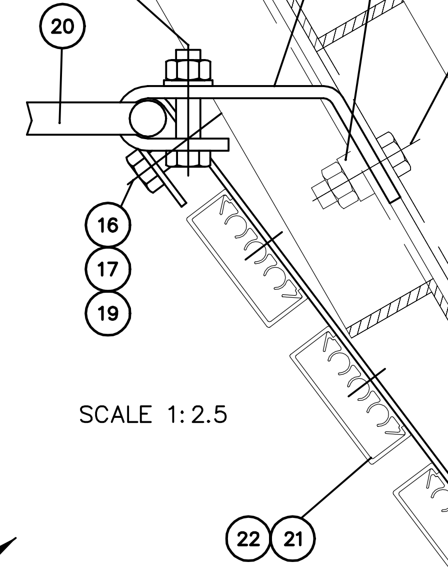
CIRCUIT DIAGRAM



TE 1: Normally not supplied by Normarc.
TE 2: Normally supplied by Normarc.

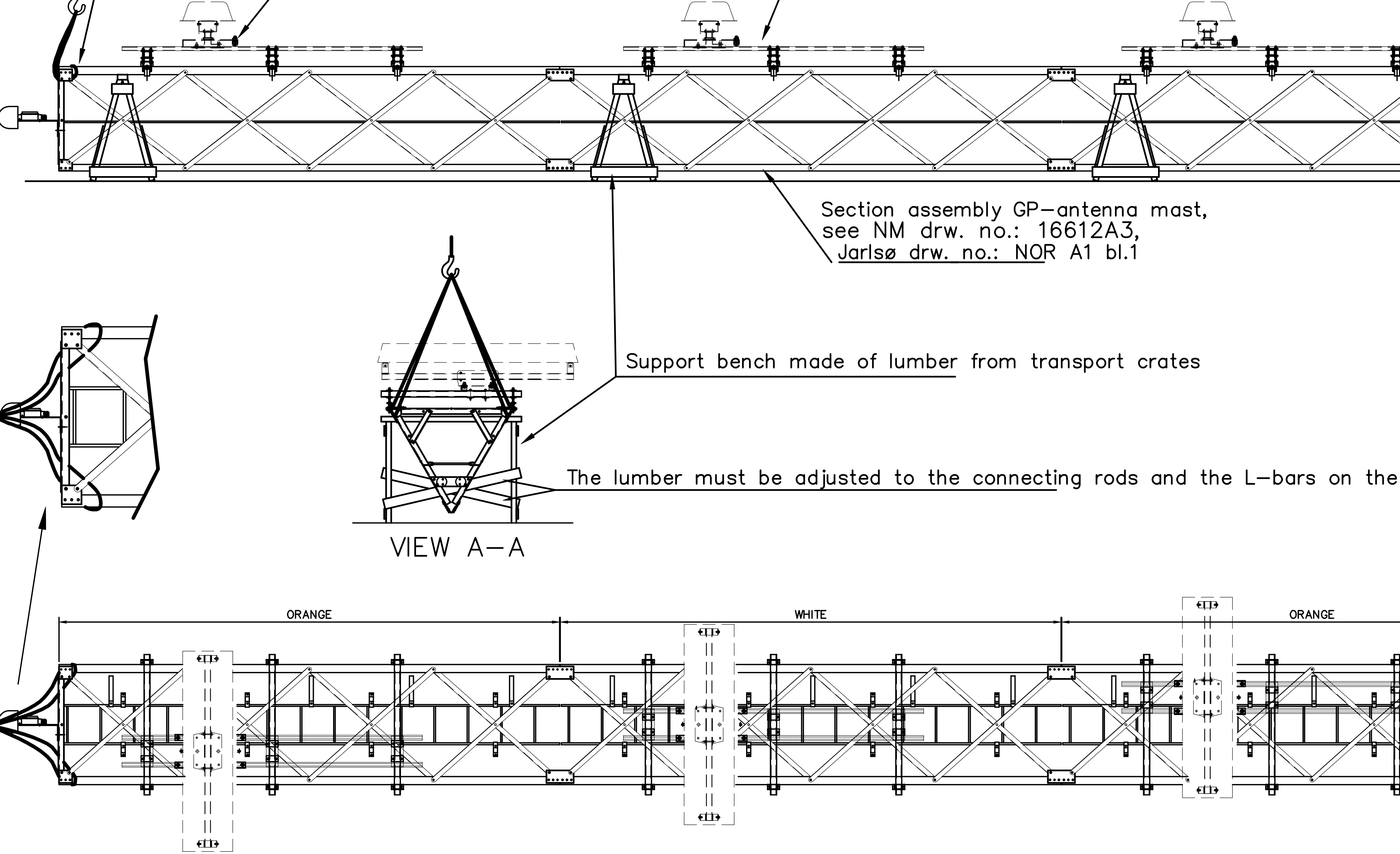
				Title: GP Installation Diagram M–Array



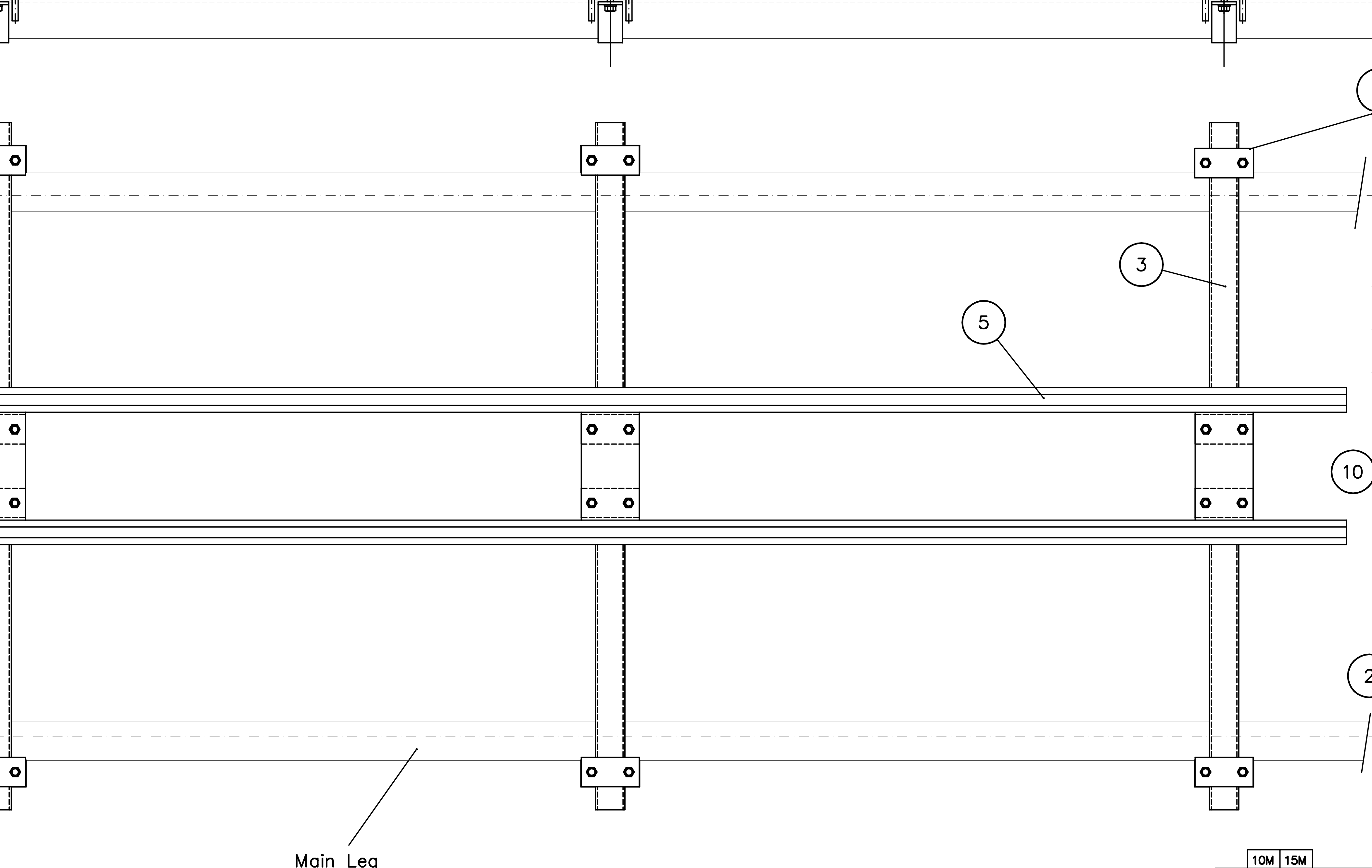


NB!: UPPER MASTSE

30	2	Hex.Nut M5 DIN93
29	2	Lockwasher M5 DIN
28	2	Screw M5x20 DIN8
27	2	Hex.Nut M6 DIN93
26	2	Lockwasher M6 DIN
25	2	Screw M6x25 DIN9
24	1	Obstuction Light
23	15	Rivet, TAP/D-48-B
22	3	Cabelduct, cover
21	3	Cabelduct
20	1	Ladder
19	117	Washer, 24/14x6 11
18	4	Washer, 24/14x8 DI
17	105	Hex.Nut, M12 NS182
16	13	Bolt, M12 x 50 DIN
15	57	Bolt, M12 x 40 DIN
14	16	Bolt, M12 x 35 DIN
13	4	Bolt, M12 x 30 DIN
12	5	Cable–bracket
11	8	Ladder–bracket
10	6	Top–plate / leg
9	6	Conection–plate /
8	3	Foot–slab
7	1	Obstr.light bracket
6	2	Cross–diagonal / t
5	3	Horisontal top
4	6	Diagonal
3	12	Diagonal
2	6	Diagonal
1	3	Main Leg
Item	Qty.	Description

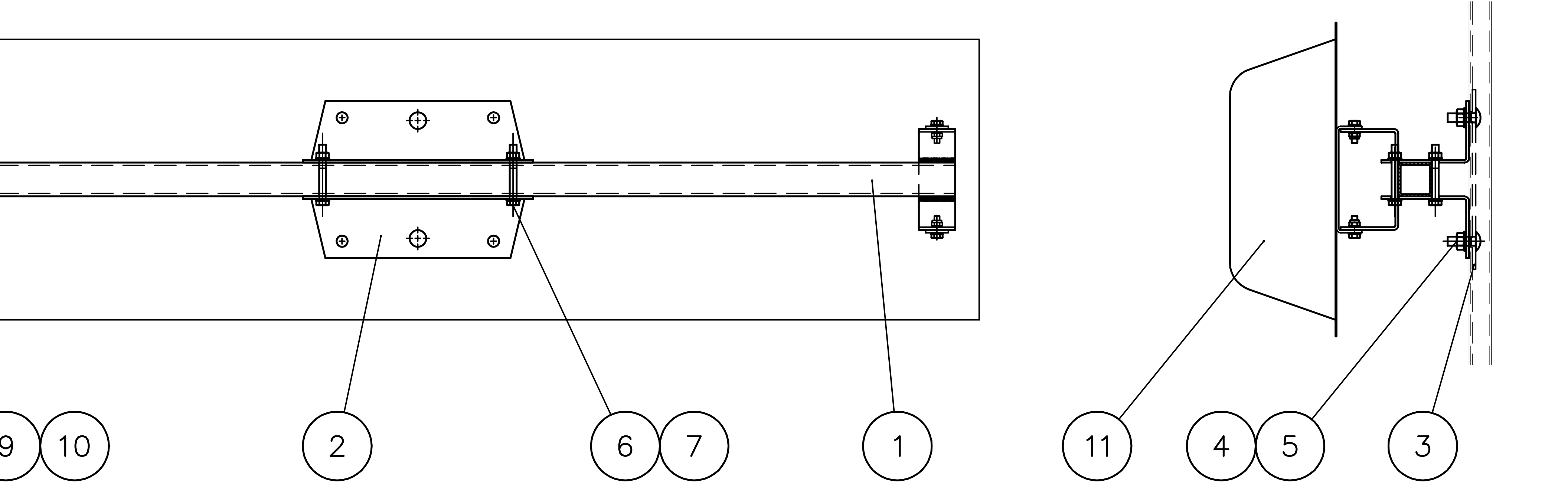


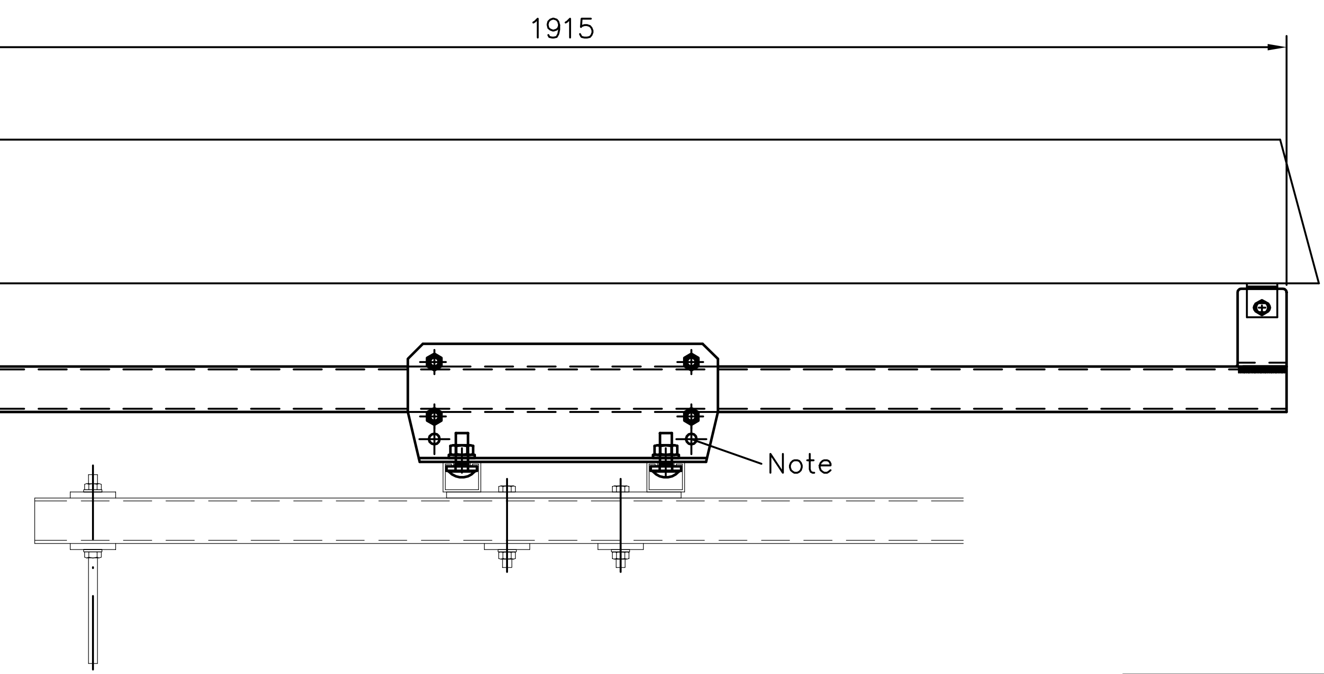
Title:
ANTENNA MAST 15m



	10M	15M	
10	144	168	Hex. Nut,
9	144	168	Washer, 2
8	24	36	Bolt M12
7	24	36	Bolt M12
6	24	36	Threaded
5	2	3	Vertical A
4	36	54	Holdingpla
3	6	9	Horizontal
2	12	18	Holding B
1	12	18	Leg Brack

Ref. Jarlsø Drwg.: NOR–A2 Sh.60





Item	Qty.	Description	
11	1	GP–Antenna Kathrein 713 316B	
10	4	Lockwasher M10 DIN127	ga
9	4	Washer M10 DIN125A	g
8	4	Bolt w/n M10x30 DIN601/555	g
7	11	Washer M12 DIN125A	g
6	4	Bolt w/n M12x100 DIN601/555	ga
5	4	Washer 30/18x6 DIN126	ga
4	4	Bolt w/n M16x50 DIN603/555	ga
3	2	Locking bar	ga
2	2	Bracket (Clamp)	ga
1	1	Antennasupport	ga

Title:
Assembly
Adapter f. Kathrein Antenna