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RADIO NAVIGATIONAL AIDS

300 DME

MARU 310/320 DME

TECHNICAL MANUAL

RADIO NAVIGATIONAL AIDS

300 DISTANCE MEASURING EQUIPMENT

MOPIENS 310 / 320 DME

Rev. A/2017-05-03

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TERMS AND ABBREVIATIONS

AC	*Alternating Current*
A/C	*Aircraft*
AC/DC	*AC-to-DC Converter*
ADC	*Analog-to-Digital Converter*
ADN	*Antenna Distribution Network*
AGC	*Automatic Gain Control*
AM	*Amplitude Modulation*
BITE	*Built-In Test Equipment*
CAN	*Controller Area Network*
CFB	*Cartesian Feedback*
CPLD	*Complex Programmable Logic Device*
CSP	*Control Status Panel*
DAC	*Digital-to-Analog Converter*
DC	*Direct Current*
DC/DC	*DC-to-DC Converter*
DDS	*Direct Digital Synthesis*
DME	*Distance Measuring Equipment*
DPX	*Duplexer*
DPX-MSC	*Duplexer Mute Switch, Combiner*
DSP	*Digital Signal Processing*
EMC	*Electro Magnetic Compatibility*
EMI	*Electro Magnetic Interference*
EMU	*Environmental Monitor Unit*
ESD	*Electro Static Discharge*
EUROCAE	*European Organisation for Civil Aviation Equipment*
FAA	*Federal Aviation Administration*
GP	*Glide Path*
GUI	*Graphic User Interface*
HPA	*High Power Amplifier*
I/Q	*In-phase / Quadrature*
ICAO	*International Civil Aviation Organization*
IDENT	*Identification*
IFB	*Interface Board*
ILS	*Instrument Landing System*
IMC	*International Morse Code*
LAN	*Local Area Network*
LCD	*Liquid Crystal Display*

LDES	*Long Distance Echo Suppression*
LED	*Light Emitting Diode*
LMI	*Local Maintenance Interface*
LOC	*Localizer*
LRU	*Line Replaceable Unit*
MCN	*Monitor Combiner Network*
MCU	*Micro Controller Unit*
MKR	*Marker*
MON	*Monitor*
MSC	*Mute Switch, Combiner*
NM	*Nautical Mile*
PLL	*Phase Locked Loop*
PMDT	*Portable Maintenance Data Terminal*
PMU	*Power Management Unit*
RCS	*Remote Control System*
RCU	*Remote Control Unit*
RF	*Radio Frequency*
RFG	*Radio Frequency Generator*
RSU	*Remote Status Unit*
RXU	*Receiver Unit*
SCU	*System Controller Unit*
SDES	*Short Distance Echo Suppression*
SMPS	*Switched Mode Power Supply*
SRU	*Shop Replaceable Unit*
STDBY	*Standby*
SYN	*Synthesizer*
TCP/IP	*Transmission Control Protocol/Internet Protocol*
TCU	*Transponder Control Unit*
TCXO	*Temperature-Controlled Crystal Oscillator*
TFT	*Thin Film Transistor*
THD	*Total Harmonic Distortion*
TMA	*Terminal Maneuvering Area*
T/R	*Transmit/Receive*
TX	*Transmitter*
TXU	*Transmitter Unit*
UART	*Universal Asynchronous Receiver/Transmitter*
USB	*Universal Serial Bus*
UTP	*Unshielded Twisted Pair*
VGA	*Variable Gain Amplifier*

VOR	*Very High Frequency Omnidirectional Radio Range*
VSWR	*Voltage Standing Wave Ratio*
WPM	*Word Per Minute*

1. GENERAL INFORMATION

1.1. INTRODUCTION

This technical manual describes the 310 (100W) and the 320 (1kW) DME manufactured by MOPIENS, Inc. The purpose of this document is to provide information required to install, operate and maintain the MOPIENS 310 DME and 320 DME equipment when used together with the relevant Antenna System technical manual.

Included are a general description and specifications, block diagram theory, detailed theory of operation, operating procedures, standards and tolerances, periodic and corrective maintenance procedures, parts list, installation procedures, schematics, and other diagrams.

1.2. EQUIPMENT DESCRIPTION

MOPIENS 310/320 DME is type “N” distance measuring equipment, primarily serving operational needs of en-route or TMA navigation, where the “N” stands for narrow spectrum characteristics.

The DME system provides for continuous and accurate indication in the cockpit of the slant range distance of an equipped aircraft from an equipped ground reference point.

MOPIENS 310/320 DME is fully compliant with ICAO Annex 10 and EUROCAE ED-57 minimum performance specification.

MOPIENS 310/320 DME is designed to be fully solid state design with state-of-the-art surface mount technology. All materials, workmanship and tests are in accordance with the highest standards for this class of equipment.

Also MOPIENS 310/320 DME is designed for protection from:

- High values of VSWR caused by loss of tuning or disconnection of antennas, problems in coaxial cables or disconnection of them.
- Surge protection (transient voltage suppression) and physical interfaces to various units such as LMI, EMU, remote voice, RCU and PMDT via RS-232, USB, modem (telephone line) and Ethernet.
- Lightning protection.

Figure 1-1 shows the system cabinet of MOPIENS 310/320 DME

Figure 1-1. MOPIENS 310/320 DME System Cabinet

1.2.1. DME OVERVIEW

The DME system provides for continuous and accurate indication in the cockpit of the slant range distance of an equipped aircraft from an equipped ground reference point.

The system comprises two basic components, one fitted in the aircraft, and the other installed on the ground. The aircraft component is referred to as the interrogator and the ground component as the transponder.

In operation, interrogators interrogate transponders which, in turn, transmit to the interrogator replies synchronized with the interrogations, thus providing means for accurate measurement of distance. The airborne interrogator uses a random timing algorithm in transmitting interrogation pulse pairs in series to recognize the transponder's replies synchronized to its own interrogations.

1.2.2. PRINCIPLES OF OPERATION

DME operates on principle of secondary radar system, and is used to determine the slant range distance of an aircraft (interrogator) to a ground station (transponder).

The airborne interrogator transmits a series of pulse pairs to the ground based transponder. The transponder evaluates the interrogation signals by measuring the time spacing of each pulse pair and, if the signals are determined to be valid; i.e. 12 μs for X channel and 36 μs for Y channel, transmits a series of reply pulse pairs on a different frequency. The reply frequency will be either above or below the interrogation frequency by 63 MHz depending on the channel number. The interrogator measures the total elapsed time for interrogation and reply, and it is converted into a distance in nautical miles for cockpit indication.

A measure of the time for a radio signal to travel a distance of one nautical mile and return is called “Radar Mile”. A nautical mile is defined as 1852 meters, and therefore, a radar mile is derived as follows:

$$\text{1 Radar Mile} = \frac{1852\ m \times 2}{c} = \frac{3704\ m}{299{,}792{,}458\ m/s} \fallingdotseq 12.36\ \mu s$$

Where, c is the speed of light (299,792,458 m/sec).

Note:

A radar mile may also be derived from the substitution of feet for meter in the above calculation. With the knowledge that a radio signal travels at approximately 984 feet per microsecond and a nautical mile is approximately 6,080 feet, we can figure the approximate time required for the radio signal to travel back-and forth a nautical mile:

$$\text{1 Radar Mile} = \frac{6080\ \text{ft} \times 2}{984\ \text{ft}/\mu\text{s}} \fallingdotseq 12.36\ \mu s$$

DME transponder imposes a 50 μs delay (for X channel; 56 μs for Y channel) from the receipt of an interrogation to the transmission of a reply. Therefore, the total elapsed time measured in the airborne interrogator is the sum of the two-way travel time to and from the ground station and the delay time. Accordingly the distance will be determined by subtracting 50 μs (delay time) from T (total elapsed time), and dividing the remaining two-way propagation time (T-50 μs) by the radar mile as given below:

$$\text{D} = \frac{(\text{T} - 50)\mu s}{12.36\mu s}\text{NM}$$

Where, D is the distance in nautical miles, and T is the total elapsed time in microseconds.

The time delay, also referred to as reply delay or system delay, must be the same for all ground stations in order to have an accurate measurement of distance. The channel code, pulse pair spacing and time delay established by ICAO Annex 10 are given on the following table.

Table 1-1. Pulse Spacing and Time Delay for X and Y Channel

Channel	Pulse pair spacing (μs)		Time delay (μs)	
	Interrogation	Reply	1st pulse timing	2nd pulse timing
X	12	12	50	50*
Y	36	30	56	50*

The DME signal is encoded by transmitting two pulses. Because of such simple coding, the DME receiver cannot completely eliminate false triggering due to noise but encoding does provide some improvement.

A DME interrogation consists of two Gaussian pulses separated by 12 µs for X channel and 36 µs for Y channel. The reply pulse pair is separated by 12 µs for an X channel and 30 µs Y channel. The master reference point for making all timing measurements is the 50% amplitude point of the transmitter envelope as shown in Figure 1-2

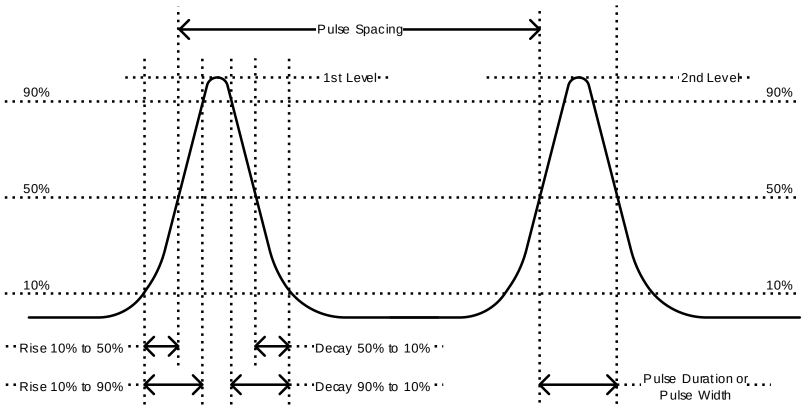


Figure 1-2. Pulse Spacing and Timing Definition

The interrogation is made on an interrogation frequency and received by the DME transponder at the ground station. After a specified time period of delay (50 µs X channel and 56 µs Y channel for first pulse timing), the ground transponder transmits a reply with a pulse pair with exactly the same pulse width and pulse separation. (Refer to Figure 1-3 and Figure 1-4). The time delay shall be the interval from the half voltage point on the leading edge of the first pulse of the interrogation pulse pair and the half voltage point on the leading edge of the first pulse of the reply pulse pair.

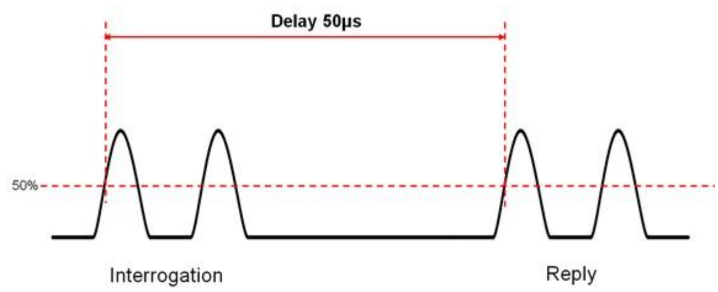


Figure 1-3. X channel Time Delay

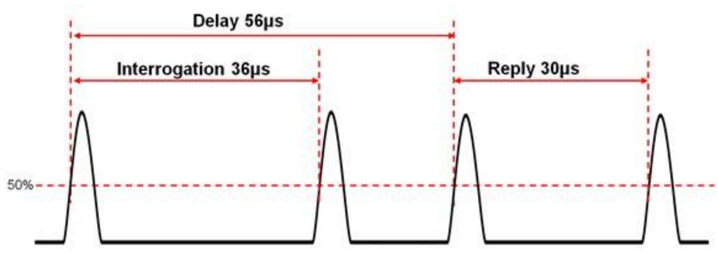
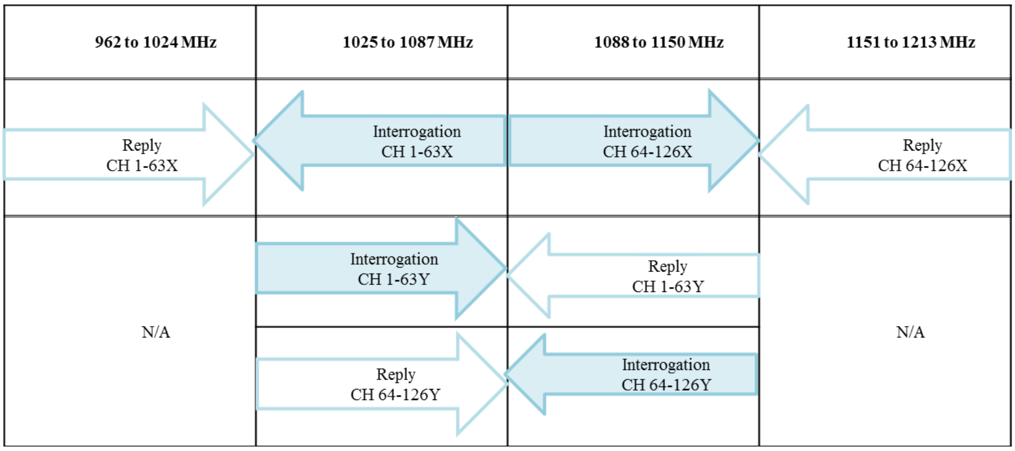


Figure 1-4. Y channel Time Delay

Both X-channel and Y-channel share the same interrogation frequencies but operate on different reply frequencies. . (Refer to Table 1-2).

Table 1-1. Interrogation and Reply Frequency Assignment for X and Y channel



The DME channels may be paired with its collocated VHF localizer and UHF glide path so that the pilot can dial one control and simultaneously tune a runway's ILS equipment. It is also channel paired for VOR/DME combination. (Refer to Table 1-2).

Table 1-2. Channel Pairing with VOR and ILS

DME Channel Number	Interrogation Frequency MHz	Reply Frequency MHz	VHF Frequency MHz	Glide Path Frequency MHz
1X	1 025	962	-	-
1Y	1 025	1 088	-	-
2X	1 026	963	-	-
2Y	1 026	1 089	-	-
3X	1 027	964	-	-
3Y	1 027	1 090	-	-
4X	1 028	965	-	-
4Y	1 028	1 091	-	-
5X	1 029	966	-	-
5Y	1 029	1 092	-	-
6X	1 030	967	-	-
6Y	1 030	1 093	-	-
7X	1 031	968	-	-
7Y	1 031	1 094	-	-
8X	1 032	969	-	-
8Y	1 032	1 095	-	-
9X	1 033	970	-	-
9Y	1 033	1 096	-	-
10X	1 034	971	-	-
10Y	1 034	1 097	-	-
11X	1 035	972	-	-
11Y	1 035	1 098	-	-
12X	1 036	973	-	-
12Y	1 036	1 099	-	-
13X	1 037	974	-	-
13Y	1 037	1 100	-	-
14X	1 038	975	-	-
14Y	1 038	1 101	-	-
15X	1 039	976	-	-
15Y	1 039	1 102	-	-

16X	1 040	977	-	-
16Y	1 040	1 103	-	-
17X	1 041	978	108.00	-
17Y	1 041	1 104	108.05	-
18X	1 042	979	108.10	334.7
18Y	1 042	1 105	108.15	334.55
19X	1 043	980	108.20	-
19Y	1 043	1 106	108.25	-
20X	1 044	981	108.30	334.1
20Y	1 044	1 107	108.35	333.95
21X	1 045	982	108.40	-
21Y	1 045	1 108	108.45	-
22X	1 046	983	108.50	329.9
22Y	1 046	1 109	108.55	329.75
23X	1 047	984	108.60	-
23Y	1 047	1 110	108.65	-
24X	1 048	985	108.70	330.5
24Y	1 048	1 111	108.75	330.35
25X	1 049	986	108.80	-
25Y	1 049	1 112	108.85	-
26X	1 050	987	108.90	329.3
26Y	1 050	1 113	108.95	329.15
27X	1 051	988	109.00	-
27Y	1 051	1 114	109.05	-
28X	1 052	989	109.10	331.4
28Y	1 052	1 115	109.15	331.25
29X	1 053	990	109.20	-
29Y	1 053	1 116	109.25	-
30X	1 054	991	109.30	332.0
30Y	1 054	1 117	109.35	331.85
31X	1 055	992	109.40	-
31Y	1 055	1 118	109.45	-
32X	1 056	993	109.50	332.6
32Y	1 056	1 119	109.55	332.45
33X	1 057	994	109.60	-
33Y	1 057	1 120	109.65	-
34X	1 058	995	109.70	333.2
34Y	1 058	1 121	109.75	333.05
35X	1 059	996	109.80	-
35Y	1 059	1 122	109.85	-
36X	1 060	997	109.90	333.8
36Y	1 060	1 123	109.95	333.65
37X	1 061	998	110.00	-
37Y	1 061	1 124	110.05	-
38X	1 062	999	110.10	334.4
38Y	1 062	1 125	110.15	334.25
39X	1 063	1 000	110.20	-
39Y	1 063	1 126	110.25	-
40X	1 064	1 001	110.30	335.0
40Y	1 064	1 127	110.35	334.85
41X	1 065	1 002	110.40	-
41Y	1 065	1 128	110.45	-
42X	1 066	1 003	110.50	329.6
42Y	1 066	1 129	110.55	329.45
43X	1 067	1 004	110.60	-
43Y	1 067	1 130	110.65	-
44X	1 068	1 005	110.70	330.2

44Y	1 068	1 131	110.75	330.05
45X	1 069	1 006	110.80	-
45Y	1 069	1 132	110.85	-
46X	1 070	1 007	110.90	330.8
46Y	1 070	1 133	110.95	330.65
47X	1 071	1 008	111.00	-
47Y	1 071	1 134	111.05	-
48X	1 072	1 009	111.10	331.7
48Y	1 072	1 135	111.15	331.55
49X	1 073	1 010	111.20	-
49Y	1 073	1 136	111.25	-
50X	1 074	1 011	111.30	332.3
50Y	1 074	1 137	111.35	332.15
51X	1 075	1 012	111.40	-
51Y	1 075	1 138	111.45	-
52X	1 076	1 013	111.50	332.9
52Y	1 076	1 139	111.55	332.75
53X	1 077	1 014	111.60	-
53Y	1 077	1 140	111.65	-
54X	1 078	1 015	111.70	333.5
54Y	1 078	1 141	111.75	333.35
55X	1 079	1 016	111.80	-
55Y	1 079	1 142	111.85	-
56X	1 080	1 017	111.90	331.1
56Y	1 080	1 143	111.95	330.95
57X	1 081	1 018	112.00	
57Y	1 081	1 144	112.05	
58X	1 082	1 019	112.10	
58Y	1 082	1 145	112.15	
59X	1 083	1 020	112.20	
59Y	1 083	1 146	112.25	
60X	1 084	1 021	-	
60Y	1 084	1 147	-	
61X	1 085	1 022	-	
61Y	1 085	1 148	-	
62X	1 086	1 023	-	
62Y	1 086	1 149	-	
63X	1 087	1 024	-	
63Y	1 087	1 150	-	
64X	1 088	1 151	-	
64Y	1 088	1 025	-	
65X	1 089	1 152	-	
65Y	1 089	1 026	-	
66X	1 090	1 153	-	
66Y	1 090	1 027	-	
67X	1 091	1 154	-	
67Y	1 091	1 028	-	
68X	1 092	1 155	-	
68Y	1 092	1 029	-	
69X	1 093	1 156	-	
69Y	1 093	1 030	-	
70X	1 094	1 157	112.30	
70Y	1 094	1 031	112.35	
71X	1 095	1 158	112.40	
71Y	1 095	1 032	112.45	
72X	1 096	1 159	112.50	
72Y	1 096	1 033	112.55	

73X	1 097	1 160	112.60	
73Y	1 097	1 034	112.65	
74X	1 098	1 161	112.70	
74Y	1 098	1 035	112.75	
75X	1 099	1 162	112.80	
75Y	1 099	1 036	112.85	
76X	1 100	1 163	112.90	
76Y	1 100	1 037	112.95	
77X	1 101	1 164	113.00	
77Y	1 101	1 038	113.05	
78X	1 102	1 165	113.10	
78Y	1 102	1 039	113.15	
79X	1 103	1 166	113.20	
79Y	1 103	1 040	113.25	
80X	1 104	1 167	113.30	
80Y	1 104	1 041	113.35	
81X	1 105	1 168	113.40	
81Y	1 105	1 042	113.45	
82X	1 106	1 169	113.50	
82Y	1 106	1 043	113.55	
83X	1 107	1 170	113.60	
83Y	1 107	1 044	113.65	
84X	1 108	1 171	113.70	
84Y	1 108	1 045	113.75	
85X	1 109	1 172	113.80	
85Y	1 109	1 046	113.85	
86X	1 110	1 173	113.90	
86Y	1 110	1 047	113.95	
87X	1 111	1 174	114.00	
87Y	1 111	1 048	114.05	
88X	1 112	1 175	114.10	
88Y	1 112	1 049	114.15	
89X	1 113	1 176	114.20	
89Y	1 113	1 050	114.25	
90X	1 114	1 177	114.30	
90Y	1 114	1 051	114.35	
91X	1 115	1 178	114.40	
91Y	1 115	1 052	114.45	
92X	1 116	1 179	114.50	
92Y	1 116	1 053	114.55	
93X	1 117	1 180	114.60	
93Y	1 117	1 054	114.65	
94X	1 118	1 181	114.70	
94Y	1 118	1 055	114.75	
95X	1 119	1 182	114.80	
95Y	1 119	1 056	114.85	
96X	1 120	1 183	114.90	
96Y	1 120	1 057	114.95	
97X	1 121	1 184	115.00	
97Y	1 121	1 058	115.05	
98X	1 122	1 185	115.10	
98Y	1 122	1 059	115.15	
99X	1 123	1 186	115.20	
99Y	1 123	1 060	115.25	
100X	1 124	1 187	115.30	
100Y	1 124	1 061	115.35	
101X	1 125	1 188	115.40	

101Y	1 125	1 062	115.45	
102X	1 126	1 189	115.50	
102Y	1 126	1 063	115.55	
103X	1 127	1 190	115.60	
103Y	1 127	1 064	115.65	
104X	1 128	1 191	115.70	
104Y	1 128	1 065	115.75	
105X	1 129	1 192	115.80	
105Y	1 129	1 066	115.85	
106X	1 130	1 193	115.90	
106Y	1 130	1 067	115.95	
107X	1 131	1 194	116.00	
107Y	1 131	1 068	116.05	
108X	1 132	1 195	116.10	
108Y	1 132	1 069	116.15	
109X	1 133	1 196	116.20	
109Y	1 133	1 070	116.25	
110X	1 134	1 197	116.30	
110Y	1 134	1 071	116.35	
111X	1 135	1 198	116.40	
111Y	1 135	1 072	116.45	
112X	1 136	1 199	116.50	
112Y	1 136	1 073	116.55	
113X	1 137	1 200	116.60	
113Y	1 137	1 074	116.65	
114X	1 138	1 201	116.70	
114Y	1 138	1 075	116.75	
115X	1 139	1 202	116.80	
115Y	1 139	1 076	116.85	
116X	1 140	1 203	116.90	
116Y	1 140	1 077	116.95	
117X	1 141	1 204	117.00	
117Y	1 141	1 078	117.05	
118X	1 142	1 205	117.10	
118Y	1 142	1 079	117.15	
119X	1 143	1 206	117.20	
119Y	1 143	1 080	117.25	
120X	1 144	1 207	117.30	
120Y	1 144	1 081	117.35	
121X	1 145	1 208	117.40	
121Y	1 145	1 082	117.45	
122X	1 146	1 209	117.50	
122Y	1 146	1 083	117.55	
123X	1 147	1 210	117.60	
123Y	1 147	1 084	117.65	
124X	1 148	1 211	117.70	
124Y	1 148	1 085	117.75	
125X	1 149	1 212	117.80	
125Y	1 149	1 086	117.85	
126X	1 150	1 213	117.90	
126Y	1 150	1 087	117.95	

DME transponder transmits IMC coded identification signal which consists of a series of paired pulses transmitted for an appropriate period of time at a repetition rate of 1 350 Hz, which means a 740 μs separation between consecutive ident pulse pairs. The transmission of identification repeats approximately every 30 seconds so that the pilots can identify the selected ground DME station.

Since the identification of ground-based DME station is very important, the highest priority in the emission of DME signals is given to identification. The second priority is given to the reply signals, and the third priority to squitter pulses. Consequently the transmission of identification signal temporarily replaces all reply pulses that would normally occur during that key-down time. These identification pulses have similar characteristics to the other pulses of the reply signals.

1.2.3. MOPIENS 310/320 DME OVERVIEW

Key features of MOPIENS 310/320 DME are as follows:

Compact Design

Full dual high-power transponder, dual monitor and dual backup batteries are included in an industry standard 19” rack cabinet for easy accessibility and maintenance. The equipment is fully solid-state design with no mechanically moving parts.

Modular Construction

Construction with plug-in or easily replaceable sub-assemblies (i.e., no special tools required) is used throughout the equipment in order to provide the specified level of maintainability. Modularization is based on logical functional block concepts. Design is such as to minimize the cost and number of different types of modules required for equipment support. Modules are printed circuit boards whenever practical from the standpoint of component size weight and consistent with circuit performance requirements.

Hot-swappable Plug-in Units

Most of the system hardware components are line replaceable units, which are designed to be hot-swappable plug-in modules. Therefore operators can replace a live unit without powering off, and this makes it easier to carry out routine preventive maintenance service.

Modernized microprocessor-based digital control

All the system functions are monitored and controlled by high performance 16/32-bit microcontrollers. Most of the pulse waveforms are electronically synthesized using state-of-the-art direct digital synthesis technology.

Non-volatile memory is used for storing all the system configuration, adjustments, and calibration data that any system data will not be damaged or lost after any accidental power outage or scheduled maintenance.

Long design life & durability

- Minimum 15 years of design life through normal and regular maintenance
- Designed to operate on 24hours a day and 365 days per year basis
- Protection from EMI radiation, high voltage, etc.

Built-in Test Equipment

The Built-In Test Equipment (BITE) is included to check the integrity of system operation. The Built-In Self-Test function is independent from the monitoring operation

Full Local and Remote Control/Monitor

By using high performance microprocessor based control/monitor circuitry, full local and remote monitoring and maintenance as well as fault finding from remote are possible with detailed system status including each LRU status. Also up to two slave indicators (RSU) can be connected for providing status indicator.

Collocation with any VOR or ILS

By using software programmable PLL frequency synthesizer and flexible IDENT keying interface, a collocation with any VOR or ILS equipment on any operational frequency/channel pair can be easily achieved. Both coaxial collocation and offset allocation can be implemented by means of programmable delay offset adjustment.

Wideband Operation

The equipment is completely wideband that it can operate on any DME channel without any module change or modification. The channel or the identification assigned to the station can be easily changed on site by software operation and no tuning or adjustment is required.

1.2.4. MOPIENS 310/320 DME DESCRIPTION

The dual equipment, MOPIENS 310/320 DME system comprises two DME/N transponders, two independent monitors and two AC/DC power supplies with backup batteries.

The transponders can be configured as dual system capable of working as main and standby. Any of the system can be designated as main. The other automatically works as standby. The changeover between the main and standby can be either initiated by an operator command or automatically by the monitor system when an executive alarm condition is detected.

The monitors can be configured such that both monitors are monitoring the main transponder simultaneously or such that one monitor is monitoring the main transponder and the other is monitoring the standby transponder. When two monitors are monitoring the main transponder, they can be configured either in ‘AND’ mode or in ‘OR’ mode for a changeover or a complete shutdown in the event of failure.

The two power supplies work in parallel sharing load currents in normal condition. When one of the power supplies fails, the other power supply continues to provide enough power for the dual system with “no break’ operation.

The power supplies also charge the backup batteries. When the mains power is interrupted, the backup batteries supply the power for the system with “no-break” operation.

1.3. EQUIPMENT IDENTIFICATION

The 310/320 DME is part of a family of comprehensive and latest-generation radio navigation equipment. The versions share many features, modules and principles of operation, and differ only slightly in frequency and purpose. All of the versions are available in a single or dual equipment configuration and can be used with a set of antenna configurations also. A single equipment version is denoted with a suffix –S, preceded by the type number, i.e. 310S DME refers to a low power, single equipment version DME.

- 310S DME: a low-power, single equipment DME
- 320S DME: a high-power, single equipment DME

- 310 DME: a low-power, dual equipment DME
- 320 DME: a high-power, dual equipment DME

1.4. COMPOSITION AND IDENTIFICATION

The Table 1-1 shows the various units and the related reference labels of the 310/320 DME for single and dual equipment configurations. The features and function of the units are common to all configurations with only difference in the quantity of some specific units.

Table 1-3. Reference Labels, 310/320 DME

Unit	Label	Low Power		High Power	
		310S	310	320S	320
AC to DC Converter Unit p/n: 3151-0016	AC/DC	1	2	1	2
Control and Status Panel p/n: 0330-7560	CSP	1	1	1	1
DC to DC Converter Unit p/n: 0330-7710	DC/DC	1	2	1	2
DC to DC Converter Unit-A p/n: 0130-7720	DC/DC-A	1	2	1	2
Duplexer Mute Switch, Combiner p/n: 0330-7120	DPX-MSC	1	2	1	2
Environment Monitoring Unit p/n: 0130-7540	EMU	0(1)	0(1)	0(1)	0(1)
Interface Board p/n: 0130-3410	IFB	1	1	1	1
Local Maintenance Interface p/n: 0130-7530	LMI	0(1)	0(1)	0(1)	0(1)
Receiver Unit p/n: 0330-7180	RXU	1	2	1	2
Transponder Control Unit p/n: 0330-7570	TCU	1	2	1	2
Transmitter Unit p/n: 0330-7140	TXU	1	2	1	2
High Power Amplifier p/n: 0332-7150c	HPA	0	0	1	2
Modem p/n: 0130-7420	Modem	(1)	(2)	(1)	(2)
Monitor Unit p/n: 0330-7550	MON	1	2	1	2(3)
Radio Frequency Generator p/n: 0330-7190	RFG	1	2	1	2
Power Management Unit p/n: 0130-7730	PMU	1	2	1	2
System Controller Unit p/n: 0130-7520	SCU	1	2	1	2

*The number in ( ) is optional.

1.5. PHYSICAL DESCRIPTION

The 310/320 DME subsystems are housed in an enclosed, floor-mounted type cabinets.

The cabinet material is durable and non-corrodible. Major assemblies or LRUs are designed to be completely removable from their enclosures without disassembly. The cabinet has two doors. The front door provides access to the front panel, LRUs and all the other assemblies of the subsystem. The rear door provides access to the back of the backplane, cables and connectors of the assemblies. With the front door open, all the maintenance operations can be performed from the front of the equipment. The locking, hinged door protects the front of the cabinet.

The front control panel is on the front door of the cabinet. On the front-door, the LMI is mounted to provide a quick access to the system maintenance as well as the basic system control and status information.

Figure 1-5 shows the equipment cabinet front and rear view.

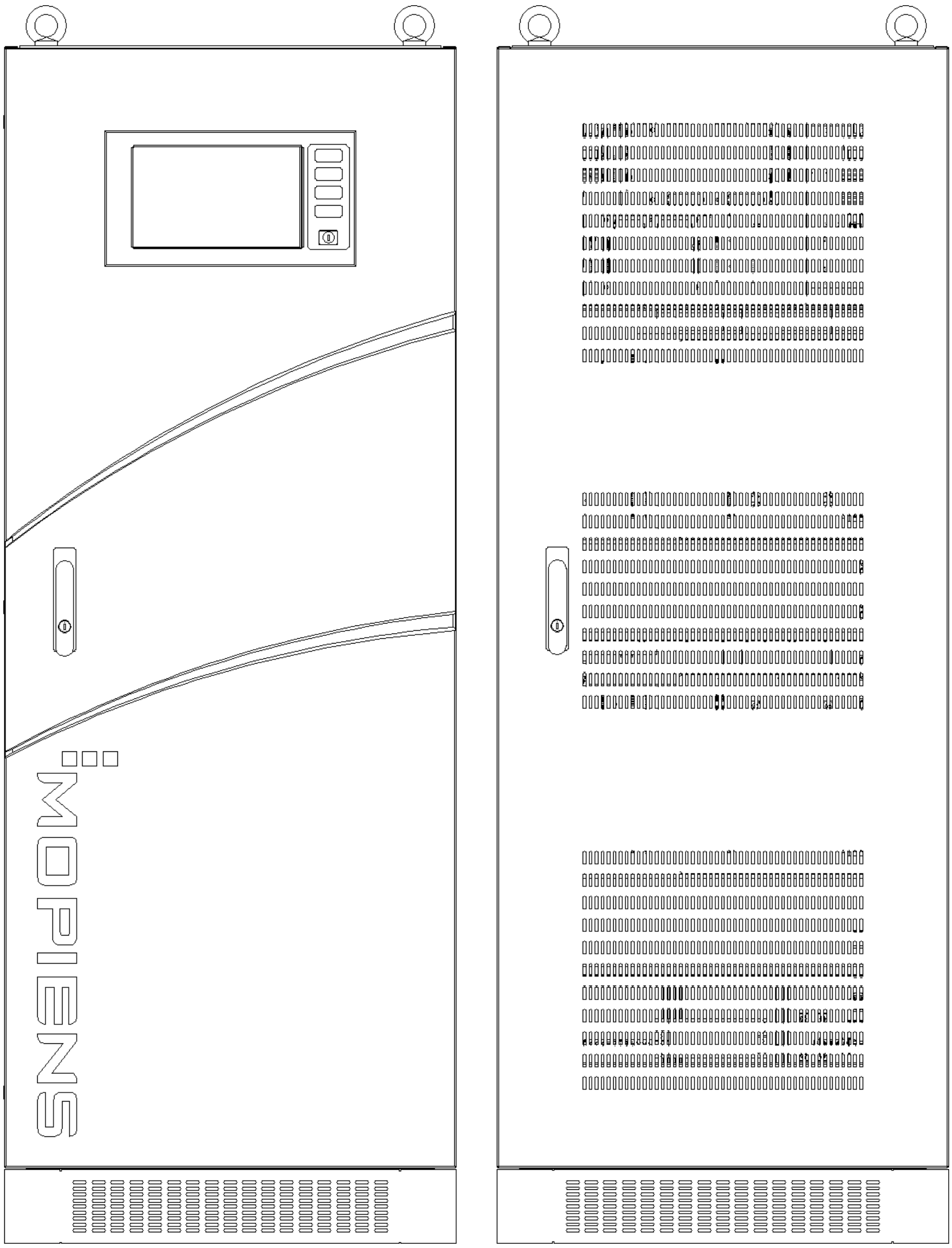


Figure 1-5. Equipment Cabinet Front and Rear View

The cabinet is self-ventilated. It has got perforated metal plate on top and bottom so no forced ventilation is required. The top of the cabinet has four threaded holes for screwing in the eyebolts that are used to lift the equipment.

The standard configuration of the 310/320 DME is composed of two transmitters, a dual monitor, a dual power supply and control and monitoring unit. The equipment assemblies are housed in a single 19-inch standard cabinet. The steel cabinet can accommodate three assembled sub-racks and plug-in 6-U or 3-U Eurocard printed circuit boards with depth of 200 mm or 6-U size modules with metal shield case of 300 mm depth.

Each module or unit is designed to be plugged-in to each designated slot. If it is inserted into a wrong place, it does not fit as a special keying-mechanism prevents it for protection. The modules and units with printed circuit boards has hot swap and hot plug-in circuits and mechanism so that it can be plugged and unplugged even when the equipment is powered on.

The RF output connector to the antenna distribution network and the monitor combining network are located on top of the cabinet. The RF components of the modules are enclosed in metal housings.

The RF components of the modules are enclosed in metal housings for prevention of electronic crosstalk and electro-magnetic interferences (EMI) as well as for protection of human body. Thanks to such design, it does not cause interference to the equipment and systems nearby airport and has no harmful effect on human body and equipment.

Figure 1-6 and Figure 1-7 show the interior layout of 310/320 DME equipment cabinets respectively, showing the location of the major LRUs and modules.

Each sub-rack can be unscrewed and pulled out. All the LRUs are plug-in types with either ejectors or captive screws. Each LRU slides and can be easily pulled out by its handles or ejectors.

1.6. MECHANICAL DESCRIPTION

The 310/320 DME equipment comprises of a 19” standard rack cabinet. The Figure 1-6 and Figure 1-7 show the location of the LRUs and modules in 310/320 DME. The figures refer to dual equipment configuration which equips two transponders for redundancy.

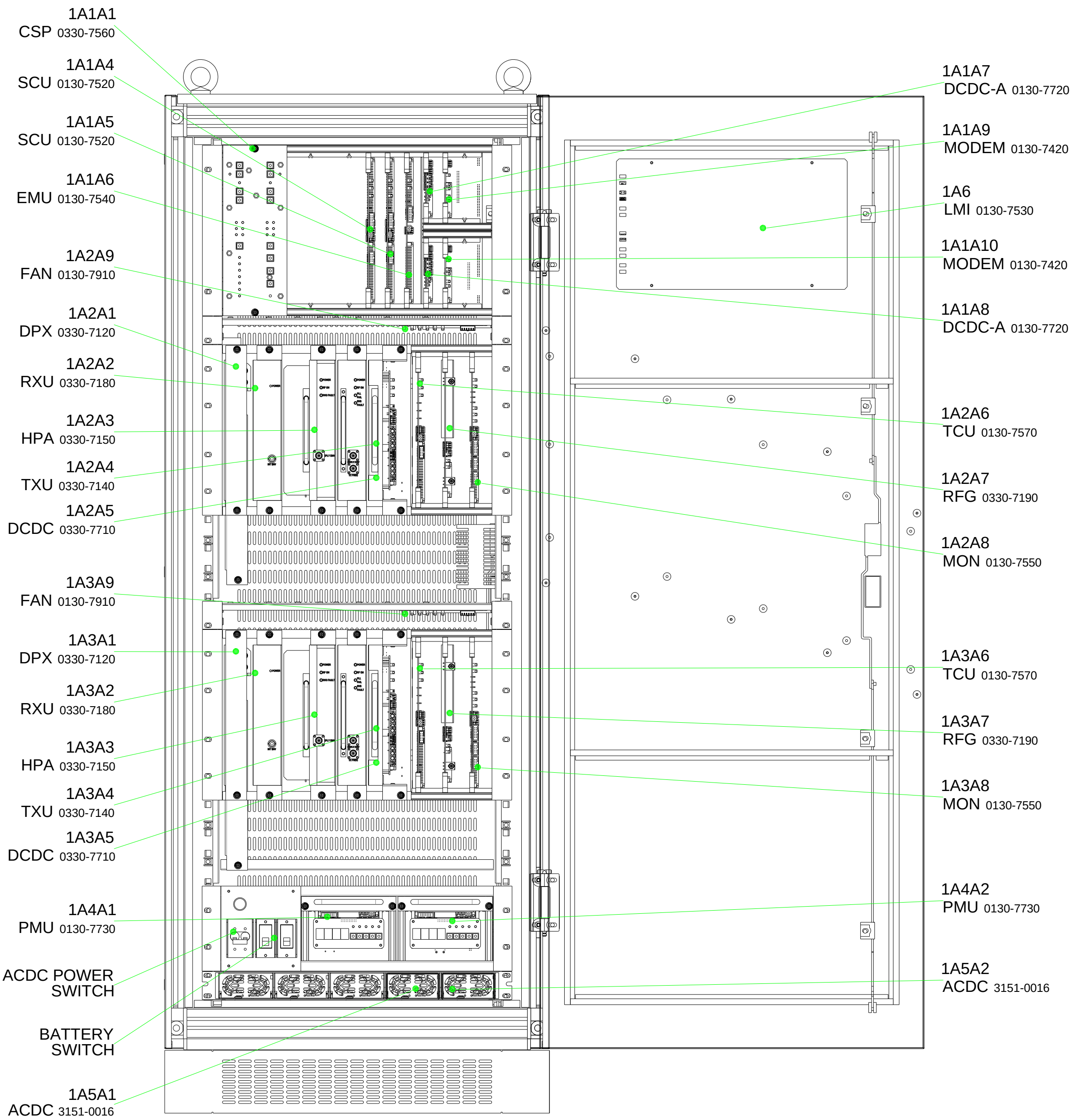


Figure 1-6. Equipment Cabinet, front view; door open

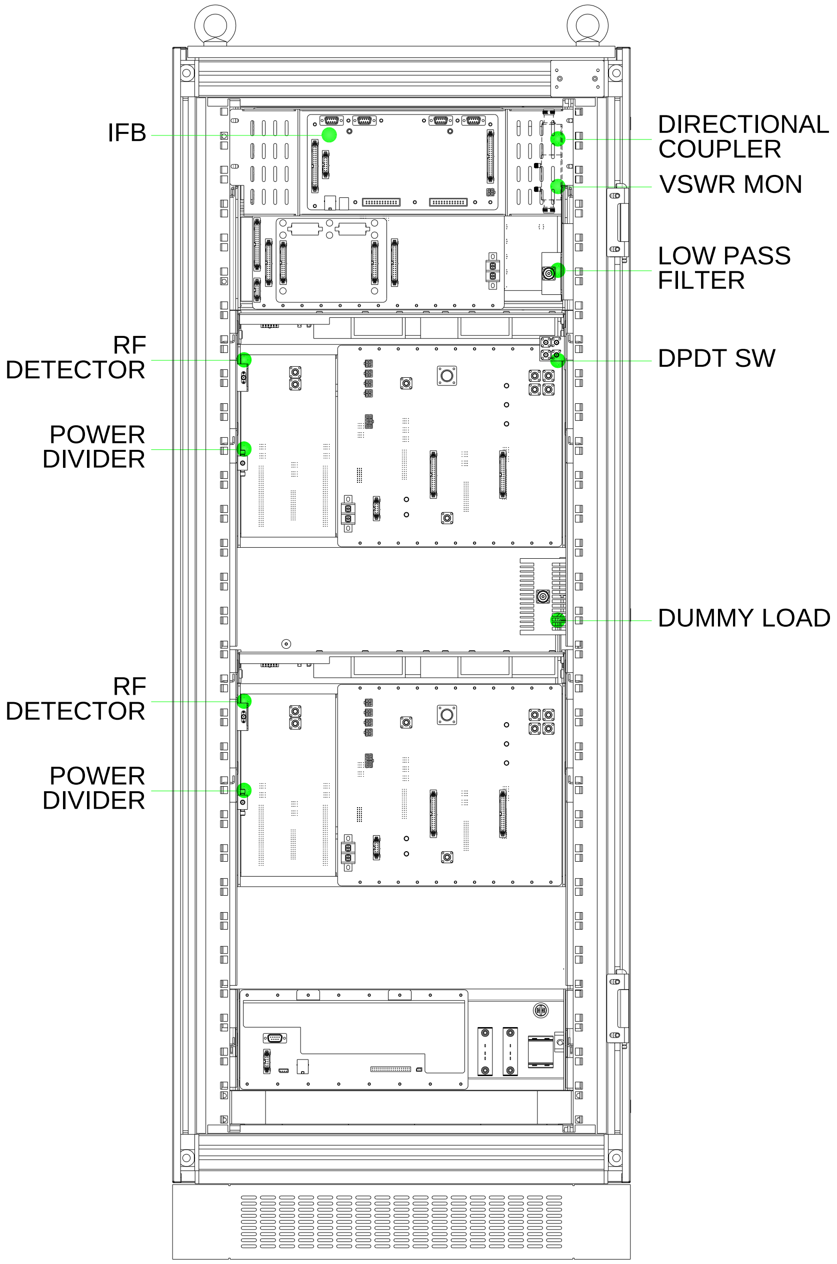


Figure 1-7. Equipment Cabinet, rear view; door detached

1.7. FUNCTIONAL DESCRIPTION

1.7.1. OVERVIEW

The 310/320 DME equipment consists of dual transponders and monitors whereby each monitor performs monitoring for both transponders. The hardware is based on RF and digital assemblies and the software that controls them.

1.7.2. TRANSPONDER

The transponder receives and validates the interrogation signals and transmits reply pulse pair if the integration signal is valid. The random squitter pulses are transmitted in order to maintain the minimum pulse rate. Identity pulse pairs are transmitted for identification of ground DME stations.

The transponder can be either single or dual redundant equipment. In case of dual redundant equipment, one transponder is designated as the main transponder and the other transponder designated as the standby transponder. While main transponder is radiating through the antenna, the standby transponder is either off or on the dummy load. If the monitor senses a monitor action condition, the control circuit causes the main transponder turned off and the standby transmitter takes over.

The transponder consists of RXU, TCU, TXU, HPA (for 320 DME only), DC/DC, FAN, T/R DPX-MSC, Changeover relays and etc.

1.7.3. MONITOR

The Monitor can be either a single or dual redundant system. Two monitors watch for the active main transponder and the standby transponder simultaneously.

It generates alarms in case of transmitter or antenna system failure. The monitor analyzes the DME parameters such as time delay, pulse spacing, reply efficiency and voltage, current, temperature of subrack and compares with operator programmed threshold values. If any parameter is beyond the tolerance values, an alarm is generated.

This system provides fault detection by injecting test interrogation signals and monitoring the replies from the transponder. It also initiates changeover to standby transponder or shutdown of transponder in the event of an out-of-tolerance condition.

If dual monitor system is used, the voting logic determines the action to take. The ‘AND’ configuration requires both monitors sense an alarm condition in order to take the monitor action. In the ‘OR’ configuration, only one of the either monitor requires to report an alarm condition to cause the monitor action.

The monitor consists of the MON unit, envelope detector, and RFG unit. The baseband pulse processing is handled by the MON unit and the RF signal processing is done in the envelope detector and the RFG. The test interrogation carrier signal is generated and pulse-modulated by the RFG.

1.7.4. POWER SUPPLY

The Power Supply system consists of:

- *AC/DC converter*, which takes 110V/220V AC mains power input and converts it into 28V DC. The 28V power source is fed to the multi-voltage DC/DC converters and also used to charge external backup batteries.
- *DC/DC converter*, which receives +28V DC input from either AC/DC or Battery backup source and converts to the output voltages of +5V, +8V, +15V, -15V, +28V and +50V which is used for VOR/DME only.
- *DC/DC-A converter* to provide power to the auxiliary electronics subrack by converting +28 V DC to +5V, +15V and -15V output voltages.
- *Power Management_Unit (PMU)*, which monitors the output voltages, current, temperature and battery status.
- *Backup batteries*, which provide DC 24V and are connected in parallel with the AC/DC converter outputs to provide uninterrupted power supply.

The AC/DC power supply units are placed at the bottom of the cabinet. The primary power source of the equipment is the commercial AC line power (mains). For uninterrupted continuous operation, a secondary power source by backup batteries is supported. The primary power and secondary power run in parallel without switching so that “no-break” operation is possible.

1.7.5. CONTROL AND MONITORING

The Control and Monitoring subsystem of the 310/320 DME provides system status information and allows monitoring functions to be performed locally and remotely. The major building blocks of Control and Monitoring subsystem are the SCU, CSP, LMI, IFB and EMU.

The System Controller Unit (SCU) provides control and monitoring of all system units. The SCU monitors the alarm/fault signal lines from all internal units. Also it exchanges data with some units such as TCU, MON, PMU, EMU and external components such as RCU and PMDT. The Control Area Network (CAN) bus is used for communication with internal units. The RCU and PMDT exchange data with SCU via RS 232C, modem or Ethernet interface.

When the SCU senses alarm signals from MON units, it initiates a transfer of the equipment or shutdown. In case of a dual equipment system, the voting logic in the SCU determines the monitor action to take based on the preconfigured option ‘AND’ or ‘OR’. In case of ‘AND’ configuration, the transfer or shutdown action takes place only when both monitors signal alarm status at the same time, while either one of the MON units triggers the action in case of ‘OR’ configuration. For increased reliability, emergency terminator logic is included in the SCU, which shuts down the system if the voting logic is malfunctioning.

The LMI provides the system status and control using a combination of LCD and touchscreen panel. Touchscreen-based, graphic user interface software running on the LMI provides simple, easy-to-use and intuitive access to the system status and equipment control. The LMI also provides a message routing service for remote control and maintenance devices via a USB port and an Ethernet LAN port which supports TCP/IP protocol. With these interfaces, the operator can connect a PC running the PMDT software to view equipment status and alarm history, set up system parameters, and perform troubleshooting either at local or at remote.

The CSP consists of push buttons and light emitting diode (LED) indicators using which the system status and configuration can be displayed and modified.

The IFB provides surge protection (transient voltage suppression) and physical interfaces to various units such as LMI, EMU, remote voice, RCU and PMDT via RS-232, USB, modem (telephone line) and Ethernet.

The equipment is protected from any unexpected incoming high voltages by means of IFB. Digital input and output signals are photo coupled for galvanic insulation from outside. Also in case both TX1 and TX2 shutdown, the SCU is directed to block the +28V DC power being supplied to DUCU.

The EMU provides interface to various sensors such as smoke, temperature and intrusion sensor using which it monitors the environmental conditions that may affect continuous operation of the equipment. Also user-definable, analog and digital expansion input/output is provided. The EMU sends the information on the environmental conditions and the expansion I/O data to SCU via CAN bus.

1.8. PMDT

1.8.1. GENERAL

The Portable Maintenance Data Terminal (PMDT) is an input/output device, which enables the user to communicate with the transponder and monitor of DME equipment.

The PMDT consists of the PMDT software with a laptop computer (or a desktop PC with a monitor display as a substitute for laptop computer), a printer (optional), and etc. For convenient handling of laptop computer, an external mouse may be used as an option. With the PMDT, the maintenance personnel are able to not only easily monitor and control the equipment but also diagnose, troubleshoot and calibrate the equipment. Each PMDT is designed to individually connect to the equipment to work on.

1.8.2. PMDT SOFTWARE

Computer software is provided for the Portable Maintenance Data Terminal (PMDT). The PMDT software is based on IBM PC compatible computers and Microsoft Windows operating system. It provides an intuitive and easy-to-use graphic user interface (GUI) for the maintenance of the navigation aids equipment.

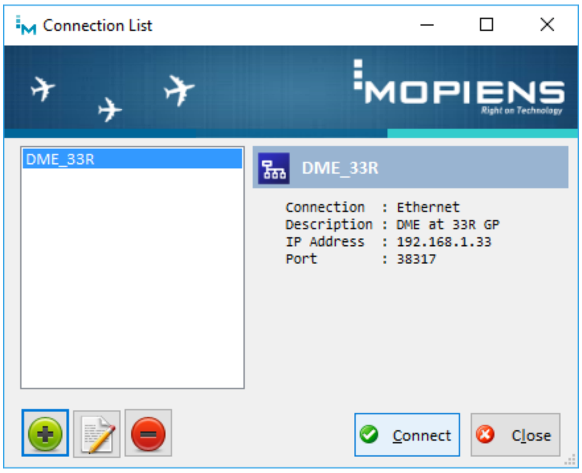


Figure 1-8. PMDT screenshot showing connection setup

The PMDT can be connected to the equipment either locally or remotely over a suitable data link including UTP copper cable, fiber-optic and radio-link via TCP/IP Ethernet LAN port. The functions listed in 1.8.3 below are equally available to both locally connected PMDT and remotely connected PMDT.

The PMDT provides a log-on security to protect the system from an unauthorized access. By the access control, it is ensured that only the authorized personnel can get access to the equipment.

1.8.3. FUNCTIONS

Functions that the PMDT provides include, but not limited to, the following:

- Selection of Main/Standby transmitter
- Transmitter On/Off
- Changeover between Main/Standby transmitters

- Bypass of Monitors for maintenance
- Control and adjustments of transmitter and power supply
- Control and adjustment of monitors
- Setup and configuration of system parameters
- Access to the Built-In Test Equipment (BITE) and identifying faulty units or antennas
- Readout and printout of system parameters at present
- Printout of transmitter and monitor status
- Data logging of alarms, warnings, system parameter values, etc.
- Flight check/inspection and calibration support

With the PMDT, it is possible to control or adjust the standby transmitter, monitor or power supply while the main transmitter is in normal operation. The results of the maintenance works are recorded and saved into a file on the computer storage. The data logging is performed on real time basis. The size of the data logging is only limited by the capacity of the computer storage.

1.8.4. SECURITY

Access to the system is controlled by security levels assigned to the users: i.e. level 1 for read-only, level 2 for read-only plus limited control of non-critical parameters, and level 3 for complete access. Only level-3 user is allowed to create and delete the user ID account.

The built-in security system enforces the following policies by default:

- The user ID consists of up to 16 alpha-numeric characters. The user ID is case insensitive.
- The password consists of up to 16 alpha-numeric or special characters. The password is case-sensitive.
- The access control list (ACL) which contains the IDs and passwords are kept in a protected storage area and updated on real-time basis when the administrator makes changes on it.
- Failed log-on attempts are recorded with its timestamp and relevant information and can be notified to the administrator.

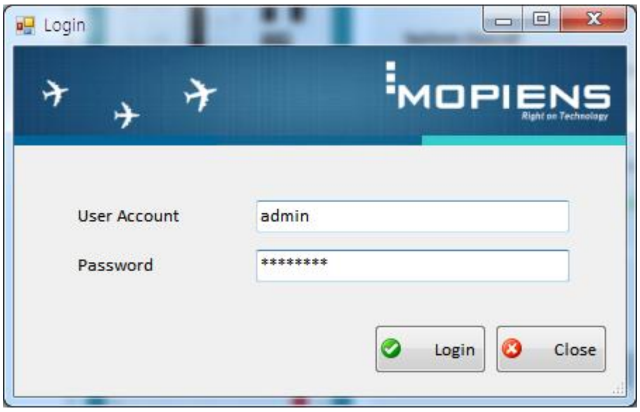


Figure 1-9. PMDT screenshot showing login

1.9. ANTENNA SYSTEM

1.9.1. GENERAL

The interrogation signals from airborne interrogators are received and the reply pulse pairs from the transponder are transmitted by the DME antenna. The radiation from DME antenna is vertically polarized.

Typically the DME antenna has one or two monitor pick-up probes to sample the radiated signal which is to be used for monitoring the transmitted signal.

Typically omnidirectional antenna is used when the DME is used in stand-alone or collocated with a VOR. Optionally directional sector antenna can be used when the DME is used in association with an ILS system. For the stand-alone DME, a tower is provided for installation next to the equipment shelter. If the DME is to be collocated with VOR system, appropriate mounting adapter kits may be furnished for a coaxial installation above the VOR antenna.

MOPIENS-supplied DME antenna system is housed in a weatherproofing fiberglass radome to withstand adverse environmental conditions like extreme temperatures, fog, rain, snow, ice, salinity and etc. An obstruction light assembly with two incandescent lamps is furnished for installation above the DME antenna radome.

1.10. REMOTE CONTROL AND STATUS MONITORING

1.10.1. GENERAL

The 310/320 DME system can provide indications at designated remote control points of the operational status of ground system components. For this purpose, the 600 Remote Control System is installed at the designated remote control points.

The 600 RCS provides visual indications, when systems are operating normally, provides audible and visual alerts when alarm conditions exist, and when communication faults exist. The aural alert can be stopped by pressing the SILENCE button. The visual indicators and aural alert can be fully activated by pressing LAMP TEST button to verify its integrity.

The RCS is capable of displays and remote control of an ILS, VOR, DME, FFM, or a combination of all.

The 600 RCS can contain one or a combination of the following optional kits; the DME (single or dual) interface kit, Localizer / Glides Path (single or dual) interface kit, Marker Beacon (single or dual) interface kit, VOR (single or dual) interface kit, and FFM interface kit for facility performance category III localizer.

The 600 RCS consists of two distinct units: 610 Remote Control Unit (RCU) and 620 Remote Status Unit (RSU).

1.10.2. REMOTE CONTROL UNIT

The remote control unit provides the following capabilities:

- to transfer to standby equipment, if system is a dual equipment system;
- to turn the system ON and OFF;

- to designate one transponder as main and the other as standby;
- to manually transfer the equipment from the main transponder to standby transponder;
- to indicate the status of environmental sensors such as fire, intrusion or temperature;
- to indicate whether AC power or backup battery is in operation;
- to reset alarm status and put the transmitter into initial state

The 610 RCU contains an equipment cabinet assembly, a backplane, and a power supply.

The RCU is generally located in the remote maintenance equipment room for monitoring and control of the navigational aids equipment.

The RCU has a built-in dedicated line modem and a generic RS-232C serial interface. Also it supports various types of remote access including UTP copper cable, fiber-optic and radio-link via TCP/IP Ethernet LAN port.

Figure 1-10. MOPIENS 610 Remote Control Unit, standard version

Figure 1-11. MOPIENS 610 Recmote Control Unit, mini version

1.10.3. REMOTE STATUS UNIT

The 620 RSU processes information which is transformed into a visual and audible indication of the operating status of the systems being monitored. The equipment status is indicated as normal, warning, or alarm.

The 620 RSU contains an equipment cabinet assembly, a backplane, and a power supply.

The RSU is generally located in the control tower for monitoring of the ILS/VOR/DME and connected to the RCU via RS-485 link. Also it supports various types of remote access including fiber-optic and radio-link via TCP/IP Ethernet LAN port.

Figure 1-12. MOPIENS 620 Remote Status Unit, standard version

Figure 1-13. MOPIENS 620 Remote Status Unit, mini version

1.10.4. RCU / RSU WITH MULTI-FUNCTION DISPLAY (OPTIONAL)

The 610 RCU and 620 RSU provide Multi-Function Display with Touch Screen Color LCD.

It indicates current ILS status whether the system is either CAT I, CAT II, or CAT III

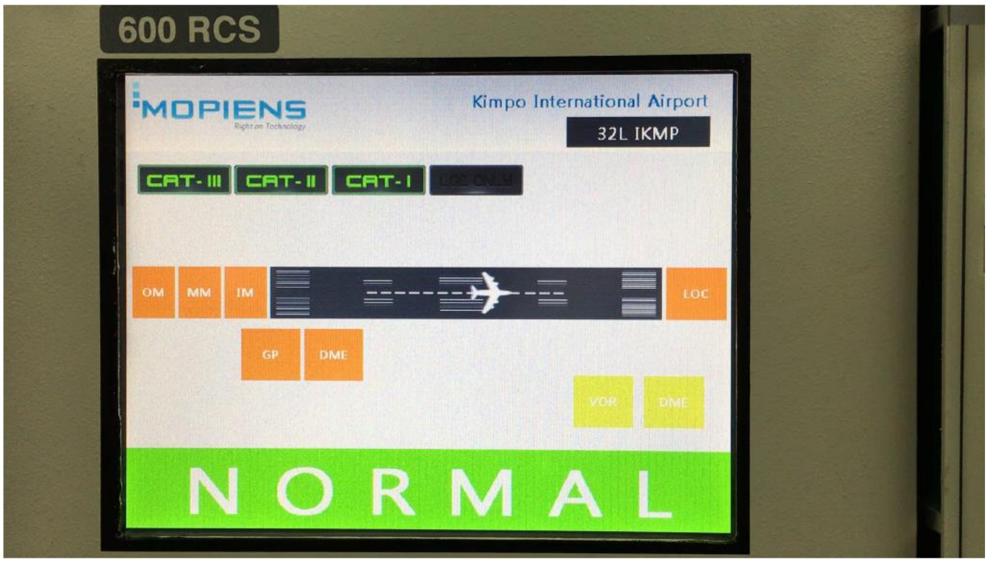


Figure 1-14. MOPIENS 610 RCU and 620 RSU Multi-Function Display

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2. TECHNICAL SPECIFICATIONS

2.1. APPLICABLE REFERENCE DOCUMENTS

Applicable reference documents for the technical specifications of MOPIENS 310/320 DME are listed below.

- International Civil Aviation Organization (ICAO), International Standards and Recommended Practices, Aeronautical Telecommunications, Annex 10 to the Convention on International Civil Aviation, Radio Navigational Aids, Volume I, Sixth edition, July 2006

- International Civil Aviation Organization (ICAO), *Manual on Testing of Radio Navigation Aids, Testing of Ground-Based Radio Navigation Systems*, Doc. 8071, Volume 1, Fourth Edition, Amendment No.1, October 31, 2002

- The European Organisation for Civil Aviation Equipment (EUROCAE), Minimum Operational Performance Specification for Distance Measurement Equipment (DME/N and DME/P) (GROUND EQUIPMENT), ED-57, Edition 2, October 26, 1992.

- United States Department of Transportation, Federal Aviation Administration (FAA), *Performance Specification Distance Measuring Equipment (DME)*, FAA-E-2996, April 1, 2008

2.2. ENVIRONMENTAL SERVICE CONDITIONS

The 310/320 DME environmental service conditions are listed below.

<u>For Indoor Equipment</u>

- Temperature — -10°C to +55°C
- Relative Humidity — up to 95% for temperature range -10°C to +35°C

  up to 60% for temperature range +35°C to +55°C
- Atmospheric Pressure — 840 hectopascal

<u>For Outdoor Equipment</u>

- Temperature — -40°C to +70°C
- Relative Humidity — up to 95% for temperature range up to +35°C

  up to 60% for temperature range up to +70°C
- Wind Velocity — up to 45 m/sec, average,

  up to 62 m/sec, instantaneous maximum
- Icing — encased in 1.27 cm thick clear ice

2.3. PHYSICAL CHARACTERISTICS

• Housing	19” Standard rack cabinet
• Dimension	600 mm (w) × 600 mm (d) ×1600 mm (h)
• Weight	< 120 kg
• Transponder Output Impedance	50 Ω nominal
• Monitor Input Impedance	50 Ω nominal

2.4. SYSTEM FEATURES

2.4.1. GENERAL

The DME system provides for continuous and accurate indication in the cockpit of the slant range distance of an equipped aircraft from an equipped ground reference point.

The system comprises two basic components, one fitted in the aircraft, the other installed on the ground. The aircraft component is referred to as the interrogator and the ground component as the transponder.

In operation, interrogators interrogate transponders which, in turn, transmit to the interrogator replies synchronized with the interrogations, thus providing means for accurate measurement of distance.

The MOPIENS 310/320 DME is a DME transponder system, which is the ground component.

2.4.2. COVERAGE

With a combination of suitable antenna system properly installed at normal site, the coverage limit is up to 200NM. The actual coverage is dependent upon site location, terrain, and aircraft altitude. The peak power density within the service range and level is at least -83 dBW/m^2.

Also it is fully comply with ICAO Annex 10 3.5.3.1.2 when the MOPIENS 310/320 associate with ILS and DVOR system.

2.4.3. ACCURACY

The total system error does not exceed ±370m (0.2 NM) at distances of from 0 to 370 km (200NM). The accuracy specified here is met on a 95% probability basis, which is the accuracy that is within the error limit for 95% of the time in any 40-second evaluation window. Note that the total system limits include errors from all causes such as those from airborne equipment, ground equipment, propagation, and random pulse interference effects and this system accuracy is predicated upon the achievement of an airborne interrogator error contribution of not more than ±315m (0.17 NM).

Also it is fully comply with ICAO Annex 10 3.5.3.1.3 when the MOPIENS 310/320 associate with ILS and DVOR system.

2.4.4. RADIO FREQUENCIES AND POLARIZATION

The system operates with vertical polarization in the frequency band 960 MHz to 1,215 MHz.

The interrogation and reply frequencies are assigned with 1 MHz spacing between channels.

126 channels are available for each X and Y channel.

2.4.5. CHANNELING

DME operating channels are formed by pairing interrogation and reply frequencies and by pulse coding on the paired frequencies.

2.4.6. AIRCRAFT HANDLING CAPACITY

The aircraft handling capacity (also referred to as traffic handling capacity or simply traffic capacity) of the 310/320 DME transponder is adequate for peak traffic of 200 interrogators with an average interrogation rate of 30 pulse pairs per second and transponder reply efficiency of 70%. The 310/320 DME provides slant range adequate for peak traffic load of 5,400 transmissions per second including the identification and squitter pulses.

2.4.7. TRANSPONDER IDENTIFICATION

MOPIENS 310/320 DME transponder transmits identification signal coded (dotted and dashed) with International Morse Codes (IMC) approximately every 30 seconds so that the pilots can identify the selected ground DME station. For each dot and dash period, a series of paired pulses are transmitted at a repetition rate of 1,350 Hz.

The identification of ground-based DME station is so important that the highest priority is given to identification in the emission of DME signals. The second priority is given to the reply signals, and the third priority to squitter pulses.

Consequently the transmission of identification signal temporarily replaces all reply pulses that would normally occur during that key-down time. This is accomplished in the way that the identification code inhibits the replies and the squitter pulses as long as the dots and dashes continue**.** And the decoded pulses inhibit the squitter pulses at the encoder input until the reply is transmitted.

Reply pulses are transmitted between code letters, and also between dots and/or dashes, i.e. between key down times.

The DME can transmit an identification signal in one of the following forms:

- An “independent” identification consisting of coded International Morse Code identity pulses which can be used with all transponders.
- An “associated” signal which can be used for transponders specifically associated with a VHF navigation or an MLS angle guidance facility which itself transmits an identification signal.

Optionally, an equalizing pair of pulses, having the same characteristics as the identification pulse pairs, can be transmitted 100 ± 10 μs after each identity pair, if it is desired to preserve a constant duty cycle.

The characteristics of the “independent” identification signal are as follows:

- The identity signal consists of the transmission of the beacon code in the form of dots and dashes (International Morse Code) of identity pulses at least once every 40 seconds, at a rate of at least 6 words per minutes; and

- The identification code characteristic and letter rate for the DME transponder conforms to the following to ensure that the maximum total key down time does not exceed 5 seconds per identification group.

  - The time duration of a dot is 0.1 second to 0.160 second.
  - The time duration of a dash is three times the dot.
  - The time duration between dots and/or dashes is equal to that of one dot plus or minus 10 per cent.
  - The time duration between letters or numerals is not less than three dots.
  - The total period of transmission of an identification code group does not exceed 10 seconds.

The characteristics of the “associated” signal are as follows:

- When associated with a VHF or an MLS angle facility, the identification is transmitted in the form of dots and dashes (International Morse Code) and synchronized with the VHF facility identification code;

- Each 40-second interval is divided into four or more equal periods, with the transponder identification transmitted during one period only and the associated VHF and MLS angle facility identification, where these are provided, transmitted during the remaining periods;

Normally, the “independent” identification code is employed wherever a transponder is not specifically associated with a VHF navigational facility or an MLS facility. Wherever a transponder is specifically associated with a VHF navigational facility or an MLS facility, identification is provided by the “associated” code. When voice communications are being radiated on an associated VHF navigational facility, an “associated” signal from the transponder is not suppressed.

2.5. TRANSMITTER

2.5.1. FREQUENCY

The transponder transmits on the reply frequency appropriate to the assigned DME channel. The radio frequency of operation does not vary more than ±0.001% from the assigned frequency.

The transmitter frequency band is between 960 MHz and 1215 MHz. Total 126 channels are available for each X and Y channel.

The frequency is controlled by a PLL frequency synthesizer driven by a precision temperature-controlled crystal oscillator (TCXO) clock source.

2.5.2. PULSE SHAPE

Pulse rise time does not exceed 3 μs.

Pulse duration is 3.5 μs ± 0.5 μs.

Pulse decay time is normally 2.5 μs but does not exceed 3.5 μs.

The instantaneous amplitude of the pulse does not, at any instant between the point of the leading edge which is 95% of maximum amplitude and the point of the trailing edge which is 95% of the maximum amplitude, fall below a value which is 95% of the maximum voltage amplitude of the pulse.

2.5.3. PULSE SPECTRUM

The spectrum of the pulse modulated signal is such that during the pulse the effective radiated power contained in a 0.5 MHz band centered on frequencies 0.8 MHz above and 0.8 MHz below the nominal channel frequency in each case does not exceed 200 mW, and the effective radiated power contained in a 0.5 MHz band centered on frequencies 2 MHz above and 2 MHz below the nominal channel frequency in each case does not exceed 2 mW. The effective radiated power contained within any 0.5 MHz band decreases monotonically as the band center frequency moves away from the nominal channel frequency.

The instantaneous magnitude of any pulse turn-on transients which occur in time prior to the virtual origin is less than 1% of the peak amplitude. This is to ensure proper operation of the thresholding techniques. Initiation of the turn-on process does not commence sooner than 1 µs prior to the virtual origin.

2.5.4. PULSE SPACING

The spacing of the constituent pulses of transmitted pulse pairs is as follows:

Channel suffix	Interrogation pulse spacing	Reply pulse spacing
X	12 µs	12 µs
Y	36 µs	30 µs

The tolerance on the pulse spacing is ±0.10 µs.

2.5.5. PEAK POWER OUTPUT

The nominal peak power output at the connector on the equipment cabinet is 100 W for the 310 DME and 1,000 W for the 320 DME. With a combination of suitable antenna system, this gives sufficient peak effective radiated power to ensure a peak pulse power density of approximately -83 dBW/m^2 at the maximum specified service range and level. The peak power of the constituent pulses of any pair of pulses does not differ by more than 1 dB.

The reply capability of the transmitter is such that the transponder is capable of continuous operation at a transmission rate of 5,400 ± 180 pulse pairs per second.

2.5.6. SQUITTER PULSES

The transmitter operates at a transmission rate, including randomly distributed pulse pairs and distance reply pulse pairs, of not less than 700 pulse pairs per second except during identity. The minimum transmission rate is 700 pulse pairs per second. Even in the absence of interrogation signals from aircraft, the squitter pulse pairs are generated and transmitted for the purpose of stabilizing AGC circuits of the aircraft interrogator.

The time spacing between squitter pulse pairs is random. The spacing is not less than 200 µs but not in the range of 730 to 750 µs which is typical spacing for identification code repetition.

2.5.7. SPURIOUS RADIATION

During the intervals between transmission of individual pulses, the spurious power received and measured in a receiver having the same characteristics as transponder receiver, but tuned to any DME interrogation or reply frequency, is more than 50 dB below the peak pulse power received and measured in the same receiver tuned to the reply frequency in use during the transmission of the required pulses. This specification refers to all spurious transmissions, including modulator and electrical interference.

The spurious power level specified herein is more than 80 dB below the peak pulse power level. (Ref: ICAO Annex 10 ‡3.5.4.1.6.1)

Out-of-band Spurious Radiation

At all frequencies from 10 to 1800 MHz, but excluding the band of frequencies from 960 to 1215 MHz, the spurious output of the DME transponder transmitter does not exceed -40 dBm in any one kHz of receiver bandwidth.

2.6. RECEIVER

2.6.1. FREQUENCY

The receiver center frequency is the interrogation frequency appropriate to the assigned DME operating channel.

The center frequency of the receiver does not vary more than ±0.001% from the assigned frequency.

The receiver frequency band is between 1025 MHz and 1150 MHz. Total 126 channels are available for each X and Y channel.

The frequency is controlled by a PLL frequency synthesizer driven by a precision temperature-controlled crystal oscillator (TCXO) clock source.

2.6.2. TRANSPONDER SENSITIVITY

In the absence of all interrogation pulse pairs, with the exception of those necessary to perform the sensitivity measurement, interrogation pulse pairs with the correct spacing and nominal frequency trigger the transponder if the peak power level of the interrogation signal at the RF connector on the equipment cabinet is at least -91 dBm and this cause the transponder to reply with an efficiency of at least 70%.

When a properly installed, suitable antenna system is used, this signal level is equivalent to the peak power density of approximately -103 dBW/m^2 at the transponder antenna.

2.6.3. DYNAMIC RANGE

The performance of the transponder properly installed in combination with suitable antenna system can be maintained when the power density of the interrogation signal at the transponder antenna has any value between -103 dBW/m^2 up to a maximum of -22 dBW/m^2 when installed with ILS or MLS and - 35 dBW/m^2 when installed for other applications.

The transponder sensitivity level does not vary by more than 1 dB for transponder loadings between 0% and 90% of its maximum transmission rate.

When the spacing of an interrogator pulse pair varies from the nominal value by up to ±1 μs, the receiver sensitivity is not reduced by more than 1 dB.

2.6.4. LOAD LIMITING

When transponder loading exceeds 90% of the maximum transmission rate, the receiver sensitivity is automatically reduced in order to limit the transponder replies, so as to ensure that the maximum permissible transmission rate is not exceeded.

The available range of sensitivity reduction is more than 50 dB.

2.6.5. NOISE-GENERATED PULSE PAIRS

When the receiver is interrogated at the power densities of -103 dBW/m^2 to produce a transmission rate equal to 90% of the maximum, the noise-generated pulse pairs does not exceed 5% of the maximum transmission rate.

2.6.6. BANDWIDTH

The bandwidth of the receiver is such that the transponder sensitivity level does not deteriorate by more than 3 dB when the total receiver drift is added to an incoming interrogation frequency drift of ±100 kHz.

The receiver bandwidth is sufficient to allow compliance with the accuracy specifications when the pulse shape and spectrum of the input signals are those specified in 2.5.2 and 2.5.3 above.

2.6.7. OFF-CHANNEL AND SPURIOUS RESPONSE

Signals greater than 900 kHz removed from the desired channel nominal frequency and having power densities up to the value -22 dBW/m^2 (when installed with ILS) or -35 dBW/m^2 (when installed for other applications) do not trigger the transponder.

Signals arriving at the intermediate frequency (IF) is suppressed at least 80 dB. All other spurious response or signals within the 960 MHz to 1215 MHz band and image frequencies are suppressed at least 75 dB.

2.6.8. RECOVERY TIME

Within 8 μs of the reception of a signal between 0 dB and 60 dB above minimum sensitivity level, the minimum sensitivity level of the transponder to a desired signal is within 3 dB of the value obtained in the absence of signals.

This specification is met with echo suppression circuits rendered inoperative. The 8 μs are to be measured between the half voltage points on the leading edges of the two signals, both of which conform in shape, with the specifications in 2.5.2 above.

2.6.9. CW AND ECHO SUPPRESSION

- Short Distance Echo Suppression (SDES):

  If enabled, echo pulses that occur between the pulses of a valid interrogation pair do not affect the reply timing by more than 0.15 μs. The presence of such synchronous pulse signals does not cause the reply efficiency to be reduced by more than 10% from the measured in the absence of the pulse signals.

- Long Distance Echo Suppression (LDES):

If enabled, echo pulses that fall after the dead time (60 μs) interval are suppressed. The duration for LDES can be set between 0 μs and 300 μs.

The presence of CW interference signal on the assigned channel frequency or elsewhere within the receiver pass-band does not reduce the on-channel threshold sensitivity by more than 2 dB when the level of CW is 10 dB and more below the on-channel sensitivity level in the absence of CW interference.

Additionally, within the range of the receiver desensitization provided by automatic gain reduction the reply efficiency to a single aircraft interrogation is not reduced by more than 10% when the level of the interrogation signal is 6 dB and more above the level of the interfering CW signal.

2.6.10. DECODING

The transponder includes a decoding circuit such that the transponder can be triggered only by pairs of received pulses having pulse duration and pulse spacings appropriate to interrogator signals.

The decoding circuit performance is not affected by signals arriving before, between, or after, the constituent pulses of a pair of the correct spacing.

An interrogation pulse pair with a spacing of ±2 μs, or more, from the nominal value and with any signal level up to the value of -22 dBW/m^2 is rejected such that the transmission rate does not exceed the value obtained when interrogations are absent.

2.6.11. TIME DELAY

The time delay is the interval from the half voltage point on the leading edge of the first constituent pulse of the interrogation pair and the half voltage point on the leading edge of the first constituent pulse of the reply transmission. This delay is consistent with the following table:

Channel suffix	Interrogation pulse spacing	Reply pulse spacing	Time delay
X	12 μs	12 μs	50 μs
Y	36 μs	30 μs	56 μs

The time delay is digitally controlled and adjustable from 35 μs to 75 μs by software.

The stability of time delay is within ±0.5 μs for the interrogation signal level -10 dBm to -81 dBm and within ±0.8 μs for the interrogation signal level -81 dBm to -91 dBm.

2.6.12. ACCURACY

The transponder does not contribute more than ± 0.5 μs (75 m) to the overall system error if associated with instrument landing system, and not more than ± 1 μs (150 m) for other application.

2.6.13. REPLY EFFICIENCY

The transponder reply efficiency is at least 70% at all values of the transponder loading up to 200 interrogators and at the minimum sensitivity level of -103 dBW/m^2.

2.6.14. TRANSPONDER DEAD TIME

The transponder is rendered inoperative for a period normally not to exceed 60 μs after a valid interrogation decode has occurred. In extreme cases when the geographical site of the transponder is such as to produce undesirable reflection problems, the dead time may be increased but only by the minimum amount necessary to allow the suppression of long distance echoes.

2.7. MONITORING AND CONTROL

2.7.1. ALARM CONDITIONS

The conditions that cause the system to initiate monitor action vary depending on the installation and configuration setup. The following basic conditions are specified in ICAO Annex 10:

- The transponder delay differs from the assigned value by 1 μs (150 m) or more;
- In the case where the DME is associated with a landing aid, the transponder delay differs from the assigned value by 0.5 μs (75 m) or more.
- The spacing between the first and second pulse of the transponder pulse pair differs from the nominal value by 1 μs or more.

These conditions are fully implemented with the 310/320 DME. The actual alarm conditions that trigger monitoring actions can be programmed by software in detail. Monitored parameters are categorized as primary or secondary depending on the severity of the effect that occurs if outside specification. Primary parameters are those parameters which, if outside specification, may be the cause of false guidance or a degradation of accuracy. Other monitored parameters are defined as secondary. The conditions listed above are primary parameters.

Alarms can be triggered in the 310/320 DME if the following conditions are detected:

- The time delay deviates outside the preset tolerance range. The tolerance range can be set 30 μs to 80 μs in 0.01 μs resolution. This is a primary parameter.
- Time (spacing) between the constituent pulses of a pulse pair deviates outside the preset tolerance range. The tolerance range can be set 5 μs to 40 μs in 0.01 μs resolution. This is a primary parameter.
- The reply efficiency falls below preset limit. The limit can be set from 0% to 100% in 1% resolution. This is a secondary parameter but can be escalated to primary by software.
- There is a reduction in the transmitter power output to below preset value. The limit can be set from 20 W to 150 W in 0.1 W resolution for 310 DME and 200 W to 1500 W in 1W resolution for 320 DME. This is a secondary parameter but can be escalated to primary by software.
- The pulse pair transmission rate falls below a preset lower limit value or exceeds a preset upper limit value. The limit can be set from 0 to 6000 pp/s. This is a secondary parameter but can be escalated to primary by software.
- Identification code group lasts more than a preset period of time or there is no identification in any period of a preset value. The time value can be set up to 30 seconds in 0.1 seconds resolution. This is a secondary parameter but can be escalated to primary by software.
- The effective radiated power (ERP) drops by more than a preset limit. The threshold can be programmed by software. The ERP alarm threshold is typically 3 dB.

2.7.2. MONITORING ACTIONS

According to the ICAO Annex 10, in the event that any of the conditions specified in 2.7.1 above, which is categorized as primary parameters, the monitor should cause the following action to take place:

- A suitable indication is given at a control point;
- The operating transponder is automatically switched off; and
- The standby transponder, if configured, is automatically placed in operation.

By default, the alarms by both primary and secondary parameters give both aural and visual alert locally on the CSP, LMI and PMDT if connected as well as RSU, RCU and PMDT if connected at remote site.

The primary parameter alarms cause the operating transponder automatically switched off and the standby transponder, if configured, is automatically placed in operation. The secondary parameters by default do not trigger the transfer or shutdown action. However the secondary parameters can be escalated to primary by software so that the transfer or shutdown action can be initiated.

2.7.3. ALERT CONDITIONS

According to ICAO Annex 10, the monitor should cause a suitable indication to be given at a control point if any of the following conditions arise:

- A fall of 3 dB or more in transponder transmitted power output;
- A fall of 6 dB or more in the minimum transponder receiver sensitivity (provided that this is not due to the action of the receiver automatic gain reduction circuits);
- The spacing between the first and second pulse of the transponder reply pulse pair differs from the normal value by 1 μs or more;
- Variation of the transponder receiver and transmitter frequencies beyond the control range of the reference circuits.

Except for the spacing, these conditions are secondary parameter by default but can be escalated to primary.

2.7.4. ALARM DELAY

A configurable delay timer is provided so that any of the condition and malfunctioning enumerated above which are monitored can persist for a certain period before the monitor takes action. This period is software adjustable.

2.7.5. MONITOR INTERROGATION

The transponder is not triggered more than 120 times per second or preset value for either monitoring or automatic frequency control purposes, or both.

Baseband monitor interrogation pulse pairs for testing the transponder are generated by the monitor unit and sent to the RF generator unit (RFG) which generates a suitable RF carrier signal, performs pulse modulation and signal conditioning.

The characteristics of the monitor interrogation pulse pairs are:

• Output Frequency	Adjustable 960 MHz to 1215 MHz in 100 kHz step
• Output Level	Adjustable -95 dBm to -10 dBm in 0.1 dB step
• Pulse Spacing	Adjustable 10 µs to 49 µs in 0.1 µs step
• Pulse Repetition Rate	Adjustable 0 pp/s to 5400 pp/s

2.7.6. MONITOR FAILSAFE

Failure of any part of the monitor itself automatically produces the same results as the malfunctioning of the element being monitored.

2.8. POWER SUPPLY

2.8.1. POWER INPUT

• AC Input Voltage	95 to 265 V; 47 Hz to 63 Hz
• DC Input Voltage	28 V nominal, 22 to 32V

2.8.2. POWER CONSUMPTION

• 310 DME	190 W (cold-standby mode)
	230 W (hot-standby mode) or less
• 320 DME	450 W (cold-standby mode)
	700 W (hot-standby mode) or less
	Excluding battery charging current.

2.8.3. BACKUP BATTERY

• Action on power interruption	“No-break” – continuous operation
• Backup capacity	4 hours of full hot-standby operation
	with the standard 65 Ah battery bank.
	Longer backup option is available.

2.9. INTEGRITY AND CONTINUITY OF SERVICE

2.9.1. CONTINUITY OF SERVICE

The continuity of service of the DME expressed as a probability of not losing the radiated guidance signals is equal to or greater than 0.999996/1, which is equivalent to -4 x 10^{-6}, with an exposure time of 120 seconds.

2.9.2. INTEGRITY OF SIGNAL

Integrity of signal expressed as a probability of not radiating false guidance signal is equal or greater than 0.9999999/1, which is equivalent to -1 x 10^{-7}.

2.9.3. RELIABILITY

The DME system in single equipment configuration has a mean time between failures (MTBF) of not less than 8760 as a serial reliability model, as per MIL-STD-217F.

The mean time between outage (MTBO) of the dual equipment DME system is longer than 20,000 hours.

2.9.4. MAINTAINABILITY

The mean time to isolate and replace a faulty Line Replaceable Unit (LRU) does not exceed 30 minutes. In no case the time required to isolate and replace a faulty LRU exceeds 120 minutes with the assumptions that a single maintenance technician performs the repair; the technician has had adequate equipment-specific training; and, the repair work is performed under normal conditions in the equipment shelter.

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3. TECHNICAL DESCRIPTION

3.1. SYSTEM DESCRIPTION

3.1.1. OVERVIEW

Figure 3-1 shows a simplified system block diagram of MOPIENS 310/320 DME with dual transponder and dual monitor configuration.

The system consists of four parts as follows:

- Transponder
- Monitor
- Control and Monitoring
- Power Supply

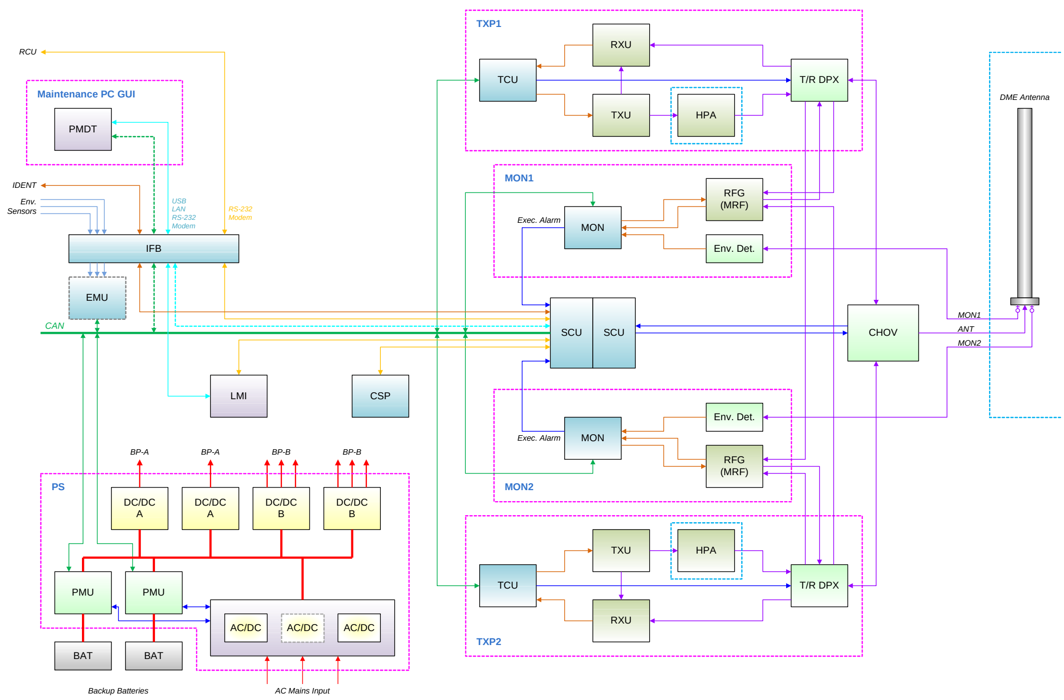

Figure 3-1. MOPIENS 310/320 System Block Diagram

3.2. TRANSPONDER

3.2.1. OVERVIEW

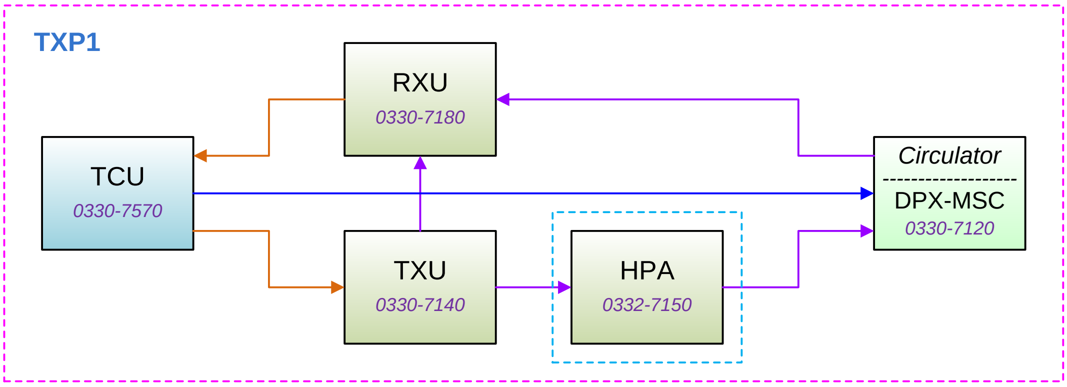

Figure 3-2. Transponder Simplified Block Diagram

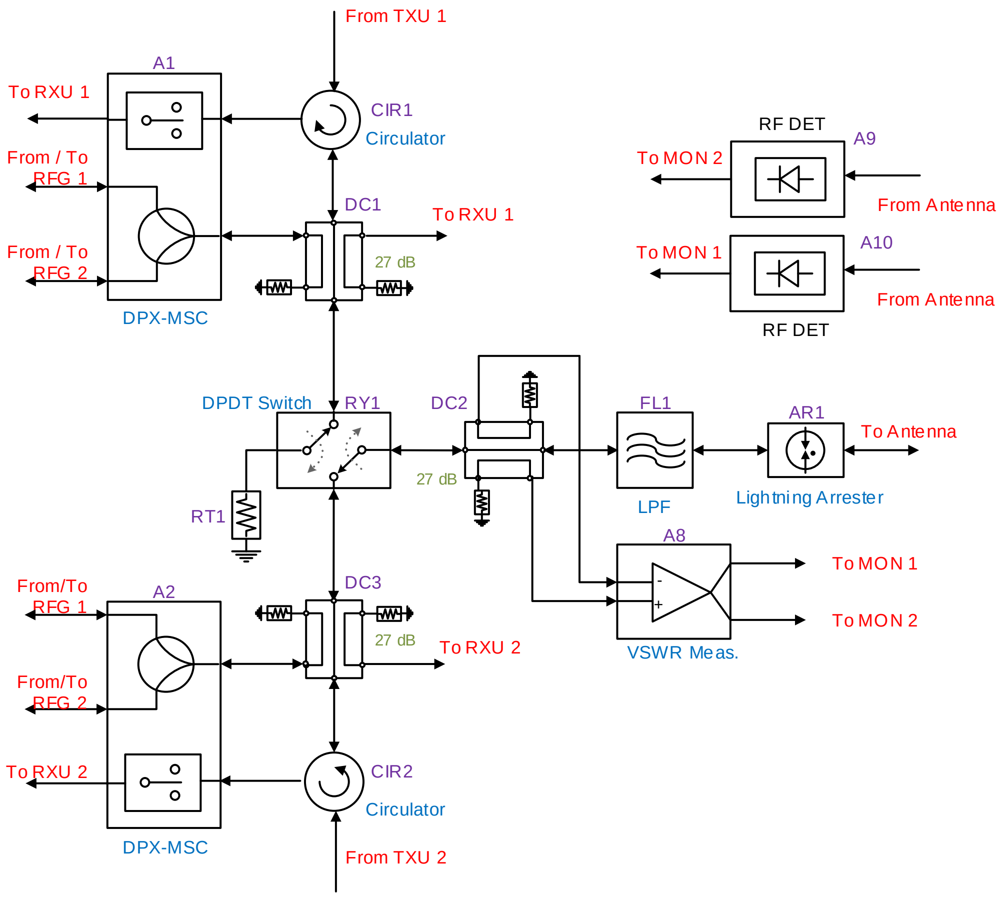

Figure 3-3. Changeover Relay, Coupler and Dummy Load

3.2.2. DPX-MSC

The Transmit/Receive Duplexer – Mute Switch, Combiner

Figure 3-4. T/R DPX Simplified Block Diagram

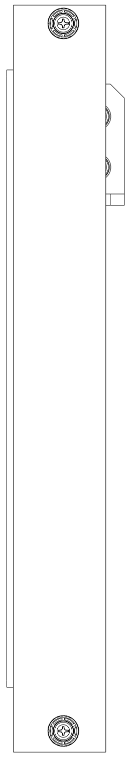

Figure 3-5. DPX-MSC Front View

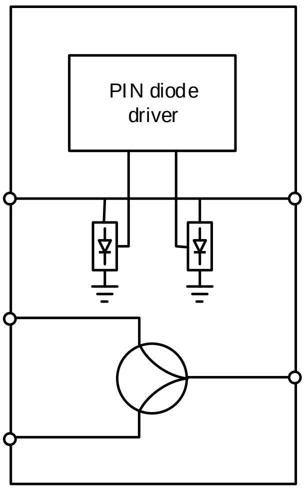

Figure 3-6. DPX-MSC Block Diagram

3.2.3. RXU

OVERVIEW

The RXU provides the following functions:

- Detection and recovery of incoming interrogation pulse pair
- Discrimination of ON channel and OFF channel
- Adjusting receiver sensitivity

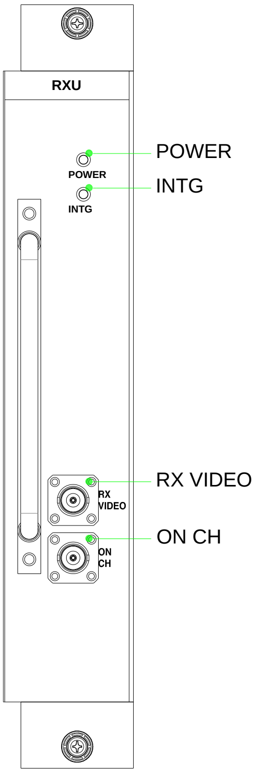

Figure 3-7. RXU Front View

DESCRIPTION

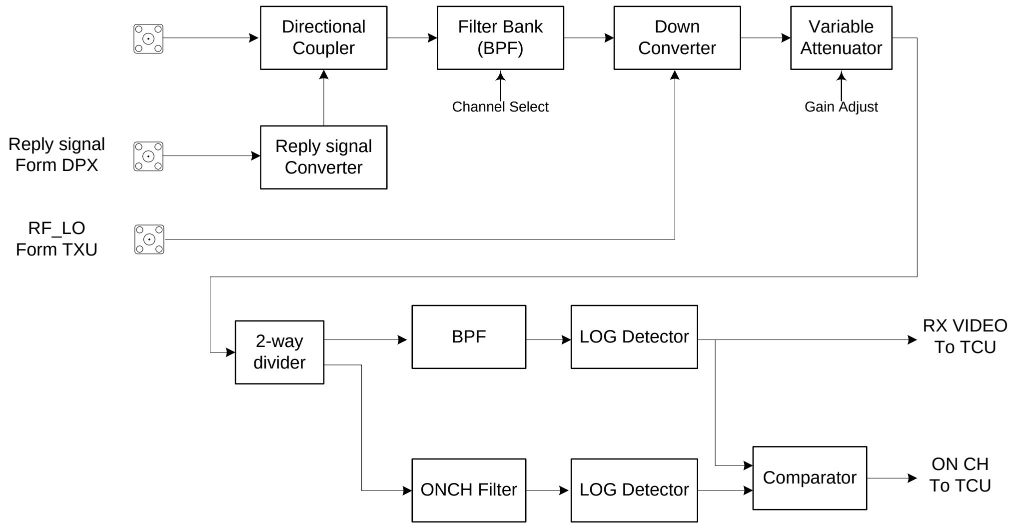

Figure 3-8. RXU Simplfied Block Diagram

The RF down converter converts received RF signal with frequency range between 1025 MHz and 1150 MHz into 63 MHz intermediate frequency signal. The received signal from DPU is fed to a high dynamic range double balanced mixer and filtered by LC band pass IF filter. The local oscillator signal is a CW signal with the frequency same as that of transmitter and supplied from the TXU.

The Variable RF attenuator attenuates the received signal to desensitize the receiver in case the load level is over a threshold point by a control of TCU. The attenuation range is from 0 dB to 80 dB.

The signal from the attenuator is fed to a channel filter and gets divided into by a two-way divider. One output of the two-way divider is fed to a logarithmic detector. The output of the log detector is fed to TCU.

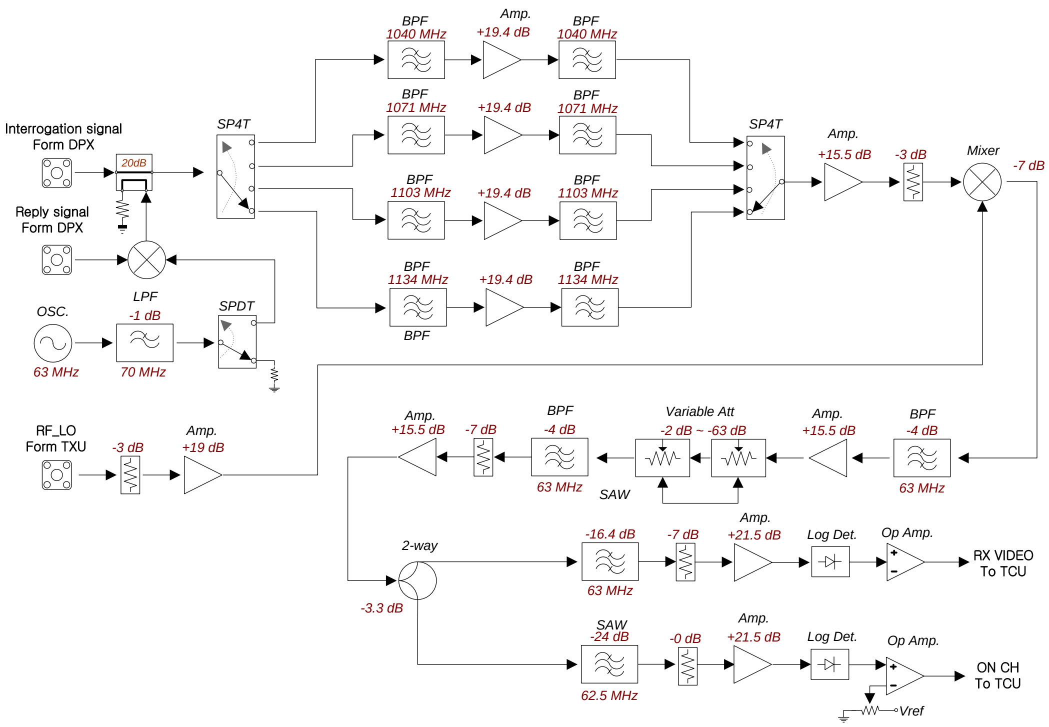

Figure 3-9. RXU Block Diagram

3.2.4. TXU

<u>OVERVIEW</u>

TXU provides the following functions:

- Generation of transmit carrier reference signal
- Pre-scaling the reference signal for use with frequency monitoring
- Binary modulation of transmit signal

- Providing the local oscillator signal for the RXU
- Providing automatic gain control to maintain constant output power level

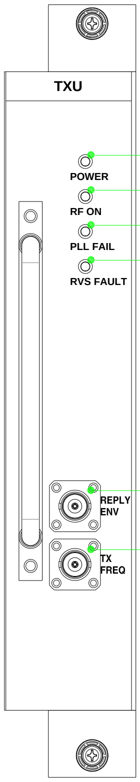

Figure 3-10. TXU Front View

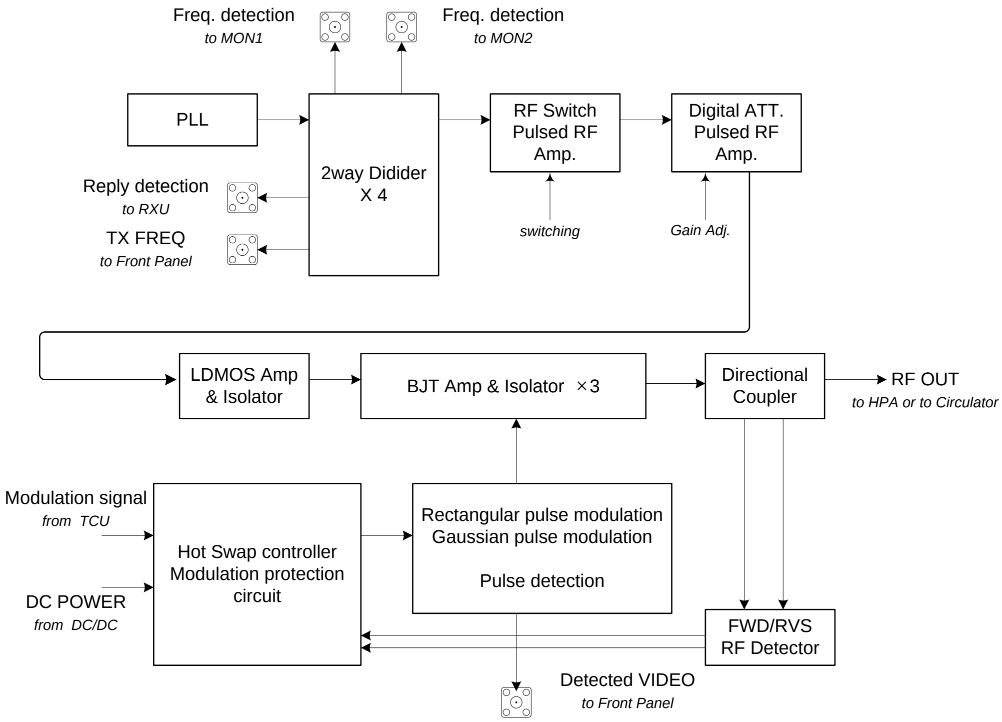

Figure 3-11. TXU Simplified Block Diagram

TCXO

generates a stable reference frequency for the PLL frequency synthesizer

PLL frequency synthesizer

synthesizes CW signal with a station frequency from the reference signal from the TCXO.

Driver amplifier

The output signal from the PLL frequency synthesizer is amplified to -20dBm, a level to drive the final amplifier

AGC attenuator

The transmit carrier signal should be regulated by an AGC circuit to maintain stable amplitude. The attenuator is used to control amplitude of the transmit signal. The AGC control signal is generated by converting detected sample of output signal into a dc signal. A two-way power splitter, RF Schottky diodes and OP amp circuitry are used for this purpose.

Frequency detector

To monitor integrity of the station frequency, a sample of generated transmit signal is pre-scaled by 1/80 and fed to a TCU, which measures the station frequency by counting the number of pulses per unit time.

RF Switch

RF switch is used to modulate the CW input signal with rectangular pulse shape. This is done by switching on/off the input signal in sync with the modulation signal.

Final amplifier

The final amplifier amplifies the input signal from the driver amplifier to a 100W of peak power.

Coupler & Detector

The signal from the final amplifier is supplied to either DPX or HPA through a directional coupler. The directional coupler samples a small amount of RF energy and RF Schottky diode detects the RF signal envelope.

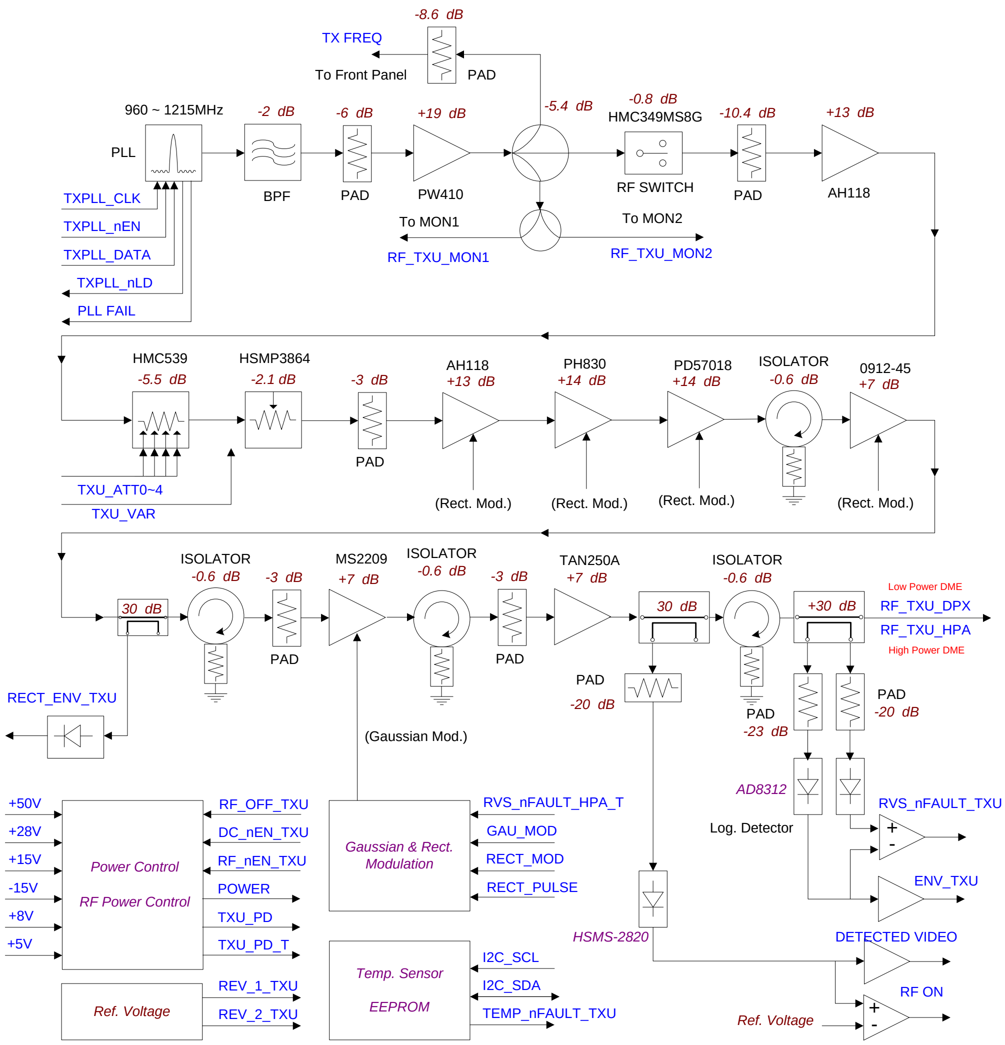

Figure 3-12. TXU Block Diagram

3.2.5. TCU

<u>OVERVIEW</u>

TCU provides the following functions:

- Sampling and quantization of received signal
- Decoding of received pulse pair
- Generation of system delay
- Echo suppression
- Generation of pulse modulation signal
- Measurement and adjustment of reply pulse pairs

- Generation of squitter pulse pairs and IDENT pulse pairs
- Load limiting by controlling receiver sensitivity
- Control of station frequency for both transmitter and receiver

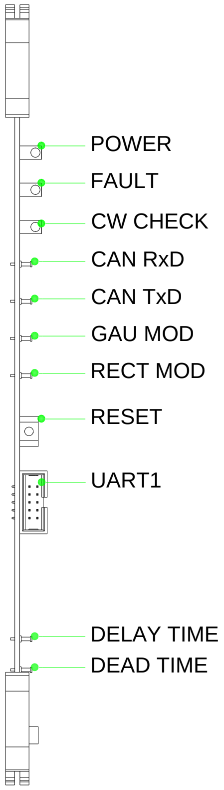

Figure 3-13. TCU Front View

DESCRIPTION

In the heart of the TCU, two large scale field programmable gate arrays (FPGAs) and a high-performance 16/32-bit microcontroller are comprised.

The log video signal of received pulse pair is fed via buffer to a high speed analog-to-digital converter, which digitize each video sample of input pulse pair. The stream of digitized video signals are queued onto a FIFO and numerically processed to evaluate the pulse pair coding. All the processing logic is built into a FPGA 1. When valid interrogation pulse pair is detected, a trigger pulse is generated at the point of 50% amplitude.

The trigger pulse is fed to the reply processing block of the FPGA and causes it to initiate a reply pulse generation after fixed time delay. The reply pulse is generated by using combination and sequential digital logic circuitry.

The pulse modulation signal is a Gaussian shape pulse signal. It is numerically synthesized and converted to an analog pulse through a digital-to-analog converter.

The echo suppression is provided under control of the second FPGA.

Measurements of reply pulse pair is done by sampling the transmit signal from the TXU or HPA.

The sampled pulse signal is digitized by an analog-to-digital converter. The stream of digitized data samples are processed in similar way as the MON does and measured parameters are used to complement output pulse shape.

The squitter signal is a pulse pair with random interval, transmitted even in no interrogation signal is present. The squitter signal is generated in the FPGA 1 and its pulse repetition is programmable via the microcontroller on the TCU.

The IDENT signal is also generated in the FPGA 1 and its Morse code keying is controlled by TCU software.

The TCU monitors the load level of received interrogation pulse pairs. If the load level is increased beyond a preset threshold level, the TCU lowers the control voltage supplied to the attenuator in the DPX, so as to desensitize the receiver responding range and eventually limits load level.

The TCU provides the serial setup data for the phase locked loop (PLL) frequency synthesizers of both transmitter and receiver with the station frequency.

3.2.6. HPA

OVERVIEW

HPA is equipped only in MOPIENS 320 DME, which is 1 kW output version. The HPA provides the following functions:

- High-power amplification of DME response signal
- Additional Gaussian shape pulse modulation
- Adjustment of power output
- Monitoring of inside temperature
- Detection of RF output power

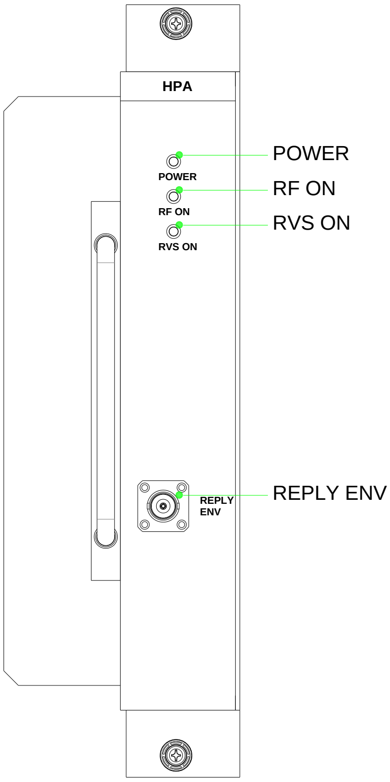

Figure 3-14. HPA Front View

DESCRIPTION

The HPA takes input of peak power 44.5 dBm from the output of TXU and amplifies it with maximum gain of up to 17.5 dB. To maintain stable constant amplitude, a sample of output power is detected and fed back to TCU for digital control of output amplitude.

The HPA comprises two stages of amplification. The first stage is driven by a bipolar transistor operating as class C. Besides the modulation in TXU, additional pulse modulation is applied to the first stage of HPA. The final stage is driven by four transistors combined in parallel operating as class C.

Like TXU, the final output signal is fed to an isolator for protection against possible mismatching and the resulting reflected power.

Supervisory circuits similar to that of TXU are provided including a digital temperature sensor for monitoring inside temperature, a directional coupler, an envelope detector circuits for detecting RF output power.

A hot-swap controller controls the power supply line for safe unit swapping.

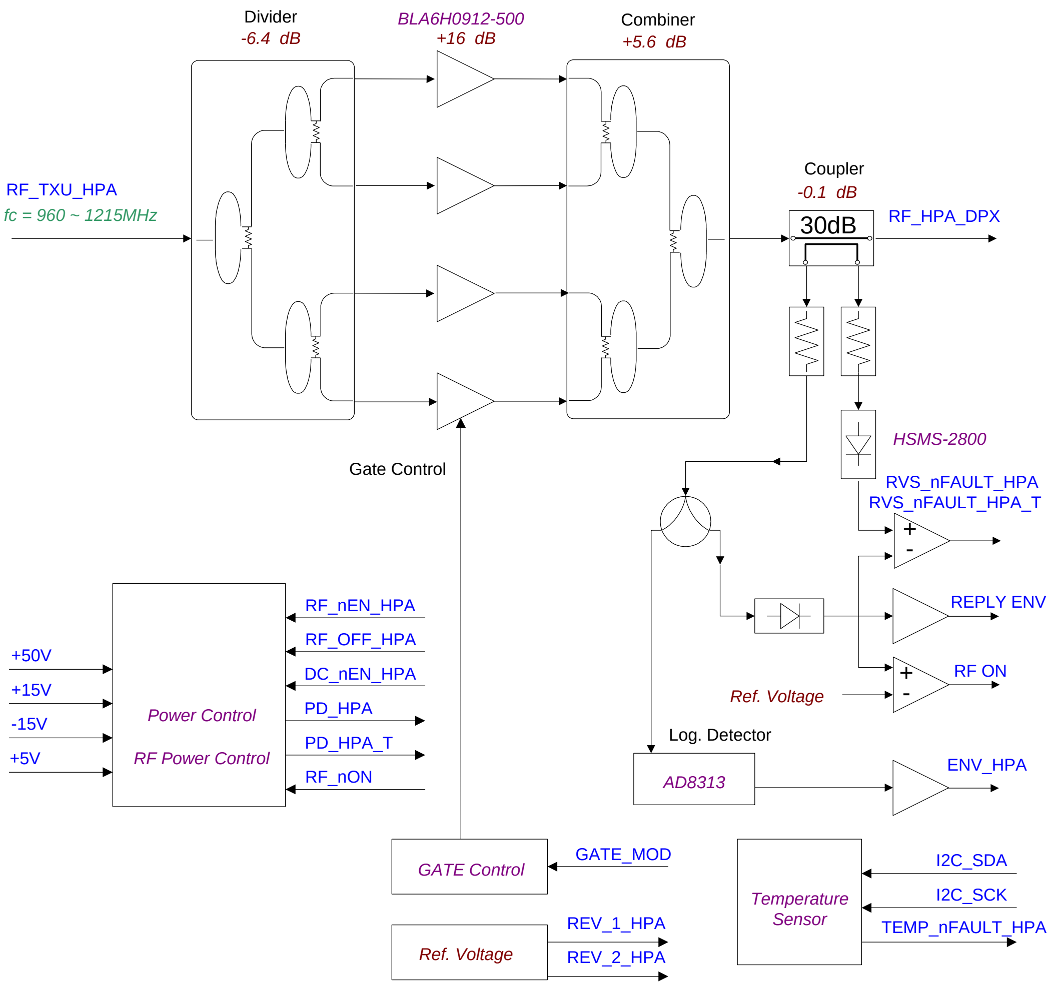

Figure 3-15. HPA Block Diagram

3.2.7. DC/DC

<u>OVERVIEW</u>

The DC/DC converter provides the multi-voltage dc power needed for the transmitter / monitor subrack. The DC/DC unit receives +28V DC input from either AC/DC converter or battery backup source via PMU subrack and converts it into +5V, +8V, +15V, -15V, +28V output voltages and +50V.

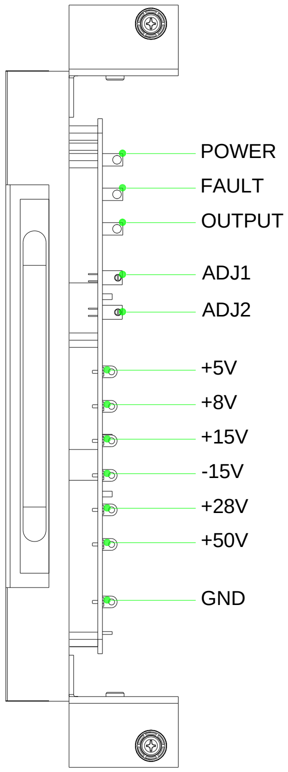

Figure 3-16. DC/DC Front View

DESCRIPTION

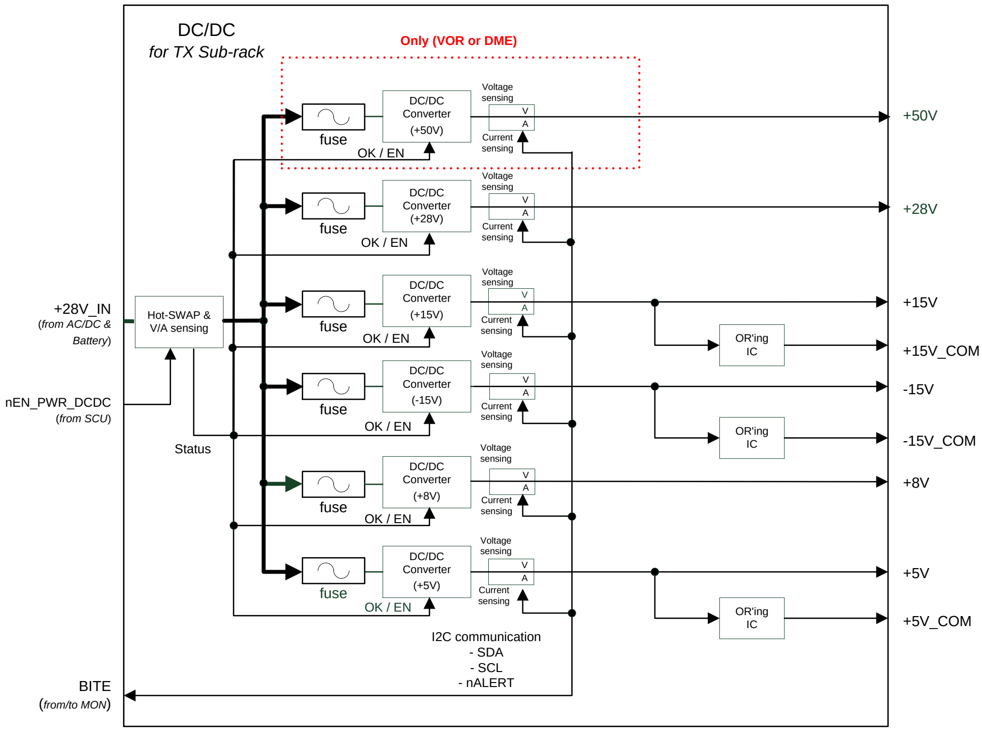

Figure 3-17. DC/DC Block Diagram

3.3. MONITOR

3.3.1. OVERVIEW

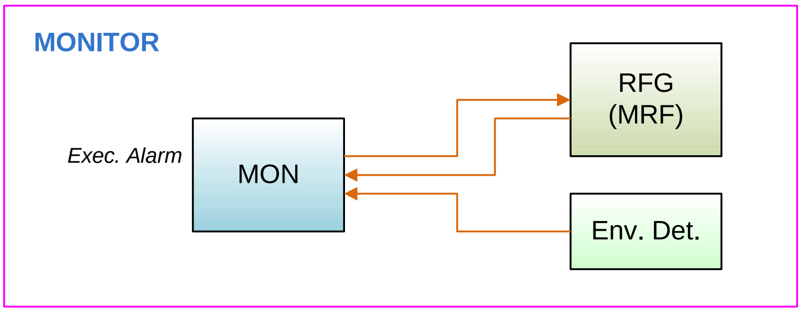

Figure 3-18. MONITOR Block Diagram

3.3.2. MON

OVERVIEW

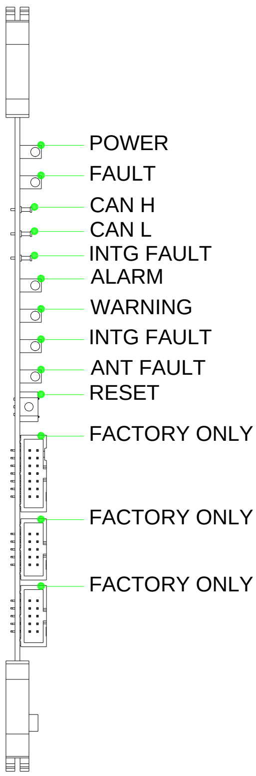

Figure 3-19. MON Unit Front View

DESCRIPTION

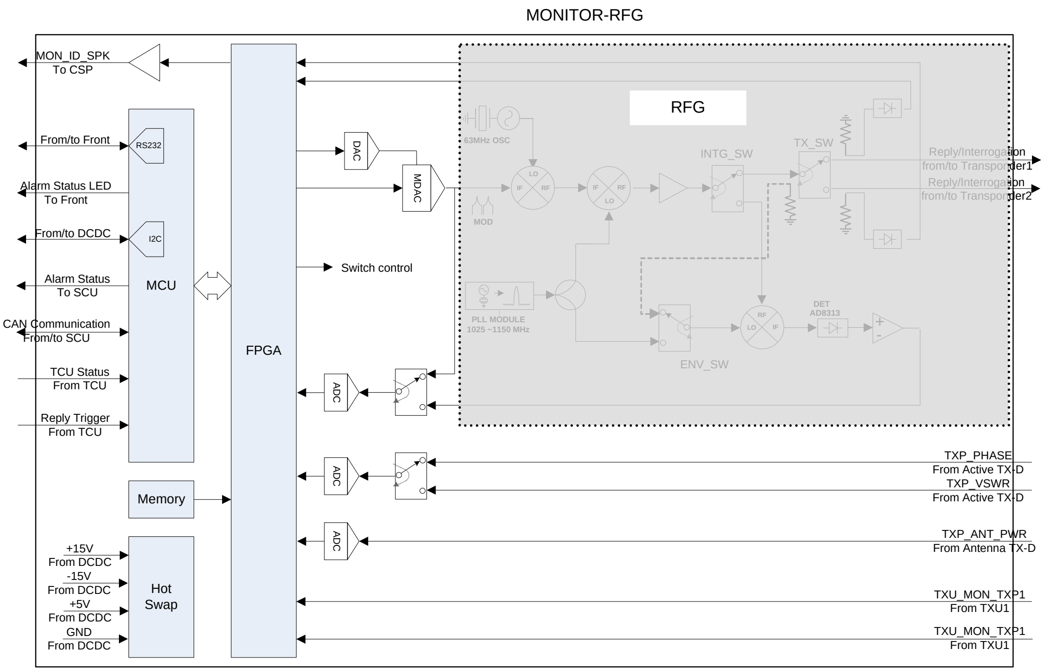

Figure 3-20. MON Unit Simplified Block Diagram

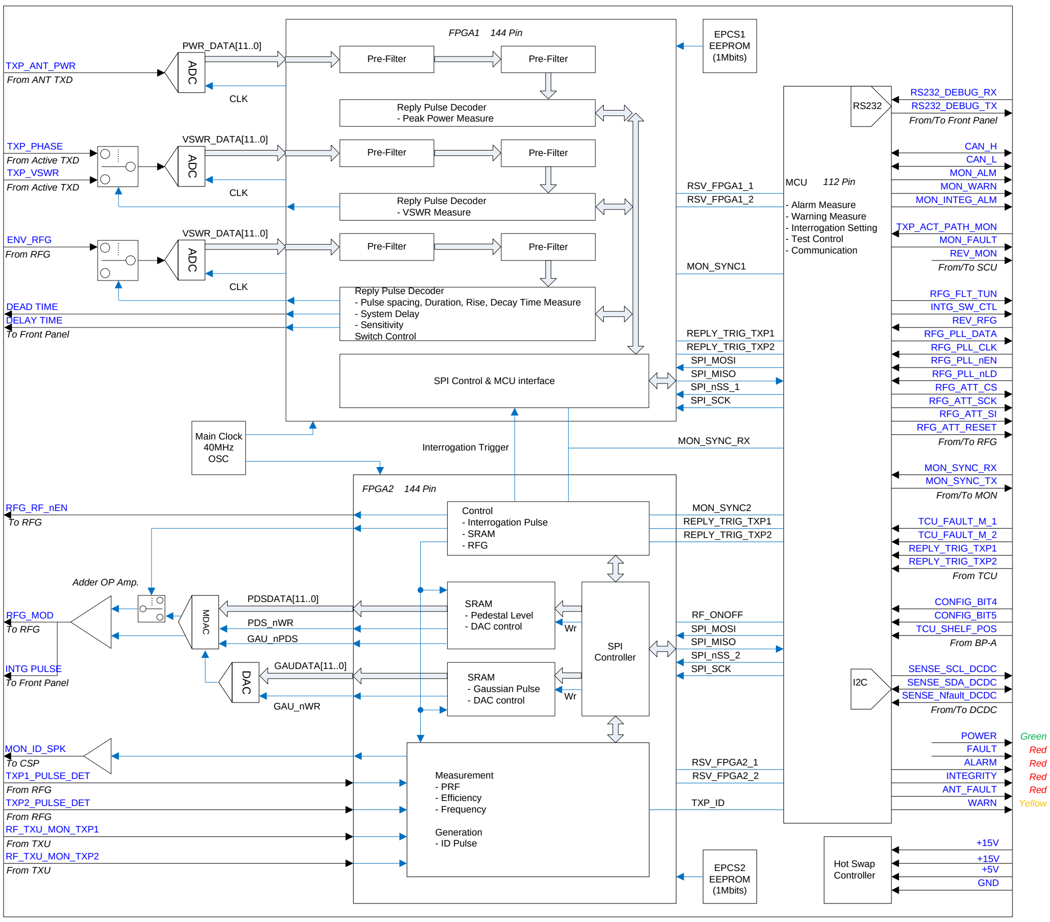

Figure 3-21. MON Unit Block Diagram

3.3.3. RFG

OVERVIEW

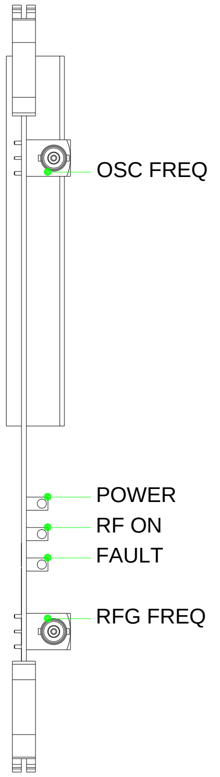

Figure 3-22. RFG Front View

DESCRIPTION

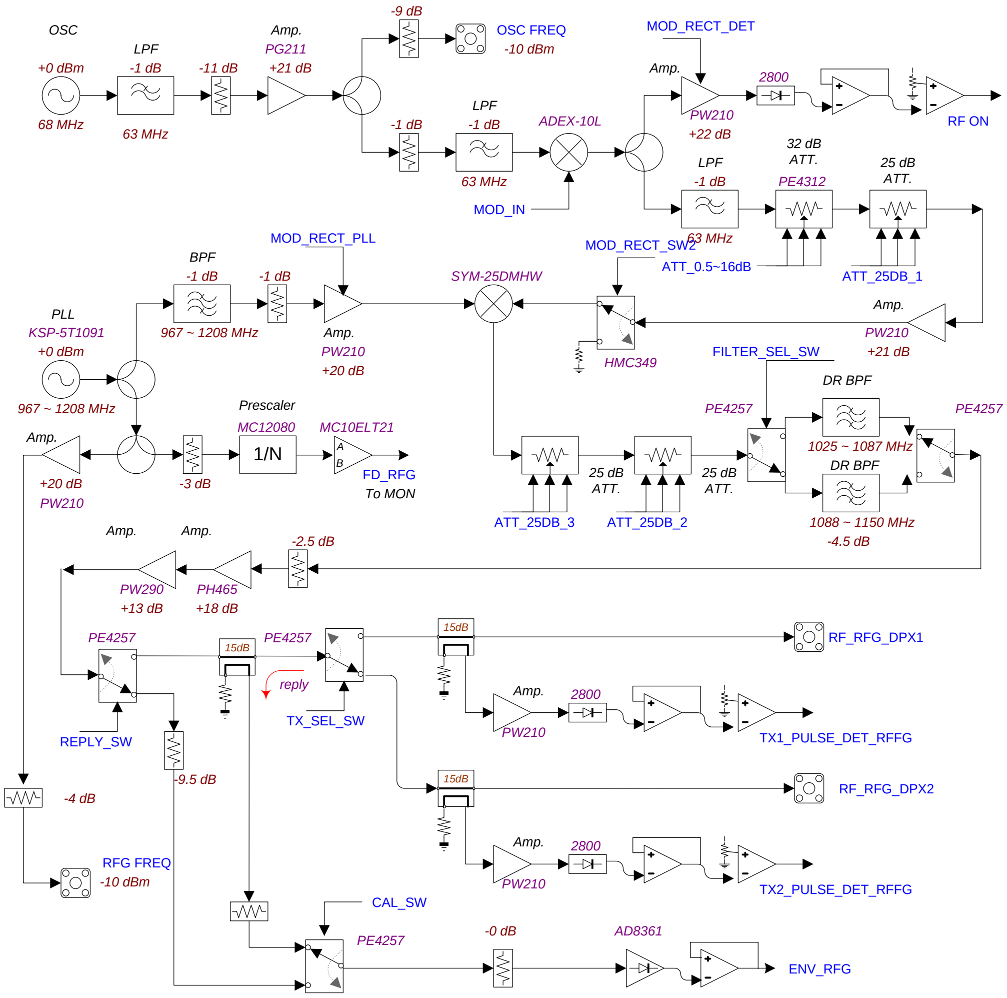

Figure 3-23. RFG Block Diagram

3.4. CONTROL AND MONITORING

3.4.1. OVERVIEW

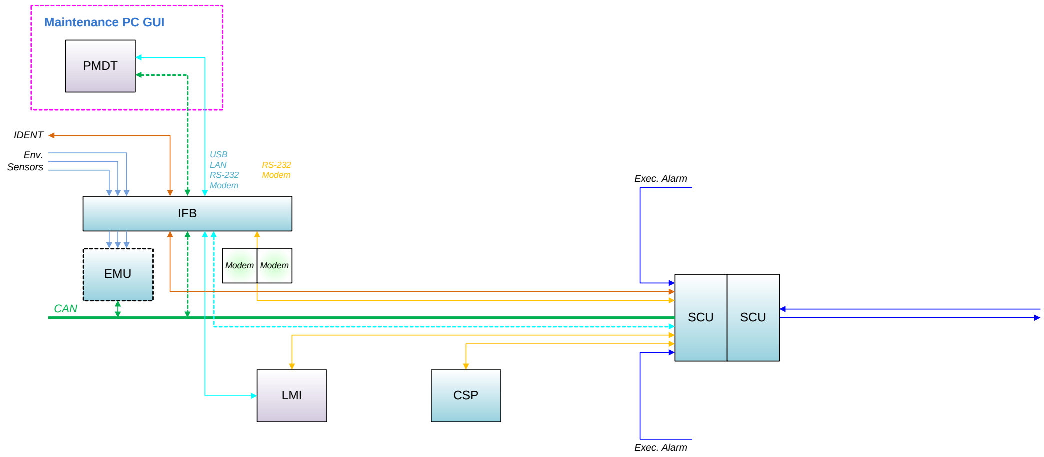

Figure 3-24. Control and Monitoring

3.4.2. SCU

<u>OVERVIEW</u>

The System Controller Unit, SCU is responsible to control the switching of the transmitters (changeover). It also serves as the communication interface between the control units (CSP, LMI) and remote control unit (RCU, PMDT) and provides the status of the equipment.

The block diagram of SCU is shown in Figure 3 10.

The main functional units of SCU are: Microcontroller and Peripheral Logic and SCU Software.

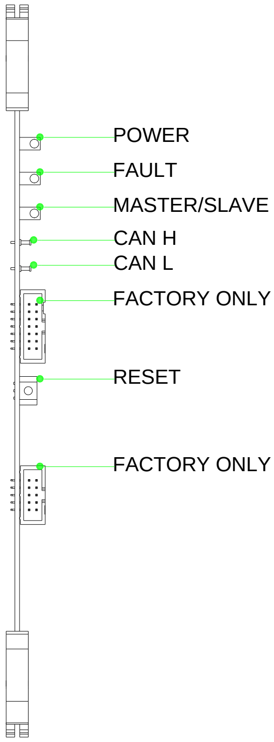

Figure 3-25. SCU Front View

DESCRIPTION

Microcontroller and Peripheral Logic

The microcontroller and peripheral logic are almost identical to those of the MSG and the MON.

The SCU communicates with the MSG and the MON via internal CAN bus, issuing and receiving control commands and responses. For communicating with user both locally and remotely, the SCU is equipped with two RS-232C ports on the rear panel of the system cabinet. Various other communication links including direct null-modem cable, dedicated-line modem, dial-up modem, twisted-pair balanced-line are also supported.

The SCU provides the following communication interfaces

- CAN : MON, MSG, PMM, EMU
- RS-485 : LMI
- Modem : PMDT
- RS-232C : PMDT, Debug

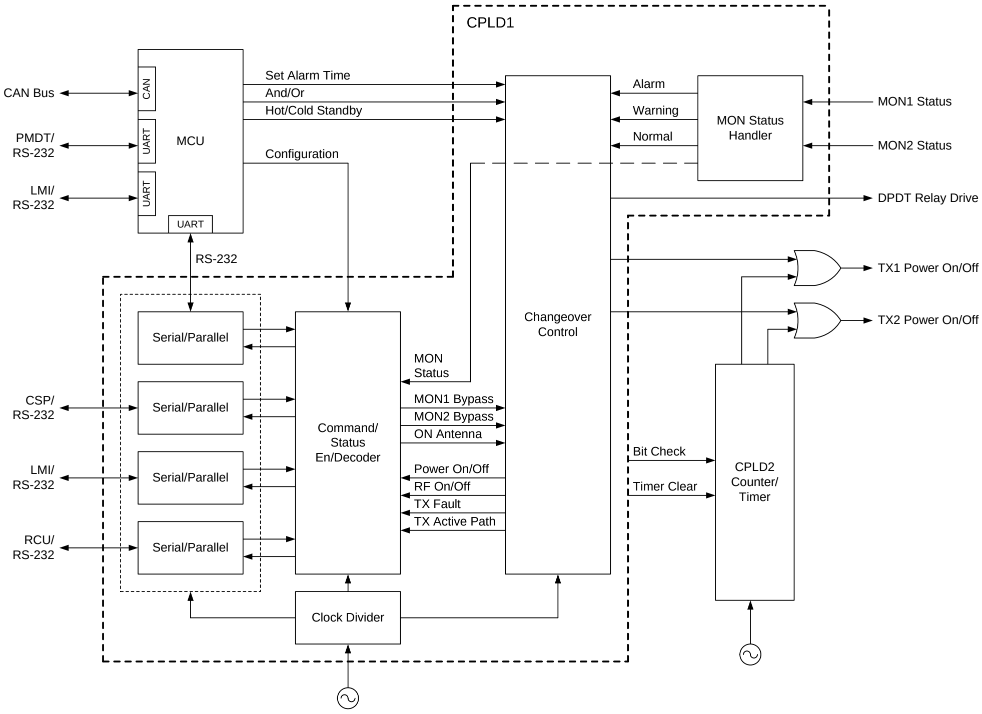

Figure 3-26. SCU Block Diagram

3.4.3. CSP

<u>OVERVIEW</u>

The Control and Status Panel (CSP) consists of push buttons and light emitting diode (LED) indicators for control and display of the system status and configuration. Figure 3-27 shows the CSP Front Panel.

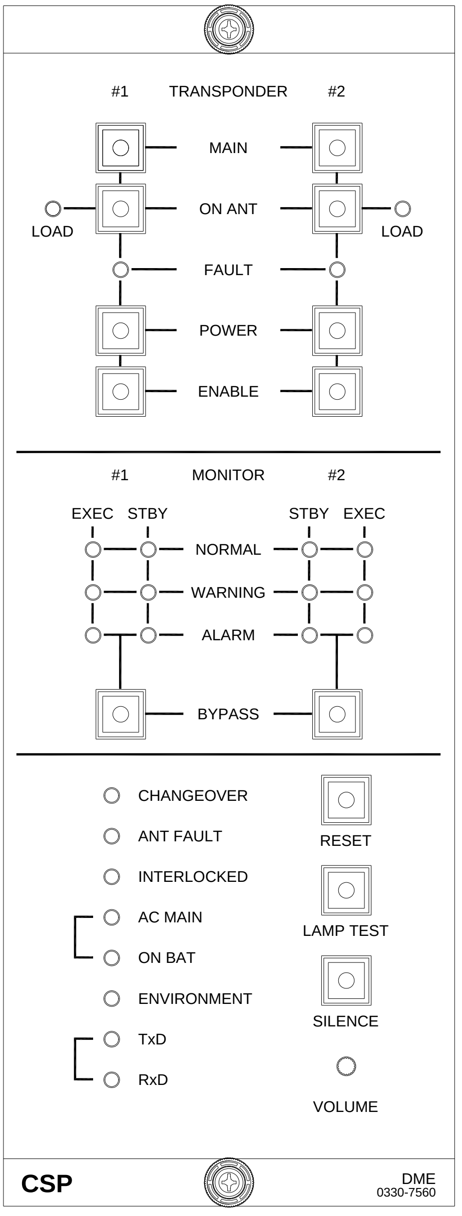

Figure 3-27. CSP Front Layout

There are 5 push button controls and 2 LED indicators for each transmitter- TX1 and TX2.

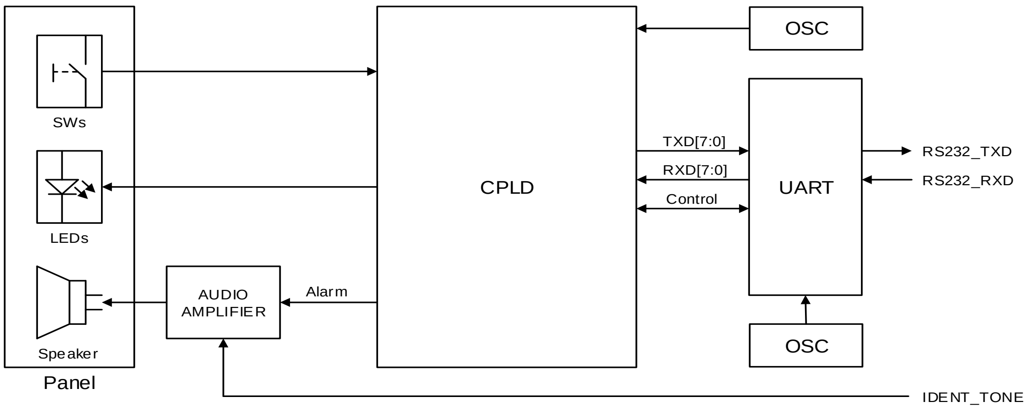

Figure 3-28. CSP Simplified Block Diagram

<u>DESCRIPTION</u>

The CSP indications for the monitors provide control and display of EXEC (executive) monitor. Each monitor reports the alarm status to CSP and consists of 4 push buttons and 18 LEDs (3 for each monitor). The LEDs for each monitor indicate the normal, warning and alarm states depending on the parameter values measured and tolerance limits set.

There are LEDs to indicate CHANGEOVER in case there has been changeover of transmitter, ANT FAULT for indicating fault in the antenna, and INTERLOCKED to indicate an active interlock in case of mutual exclusive operation on different ILS systems.

The active power source is indicated by either of the 2 LEDs – AC MAIN or ON BAT.

The TxD and RxD LEDs indicate transmission and reception of signals respectively.

There are push buttons for RESET to reset the active transmitter and SILENCE to mute the system. The LAMP TEST switch causes all installed front panel indicator lamps, including those normally inactive in a single-equipment system, to illuminate, so as to avoid confusion with “dark” lamps when performing this test.

A potentiometer knob VOLUME, below the silence button provides volume adjustment.

The Block diagram of CSP is shown in Figure 3-29. The front end panel consists of push-button switches and LEDs and a speaker to hear IDENT tone. The microprocessor logic based on a large-scale complex programmable logic device (CPLD) processes the input commands via switches and indicates the status information via the LEDs.

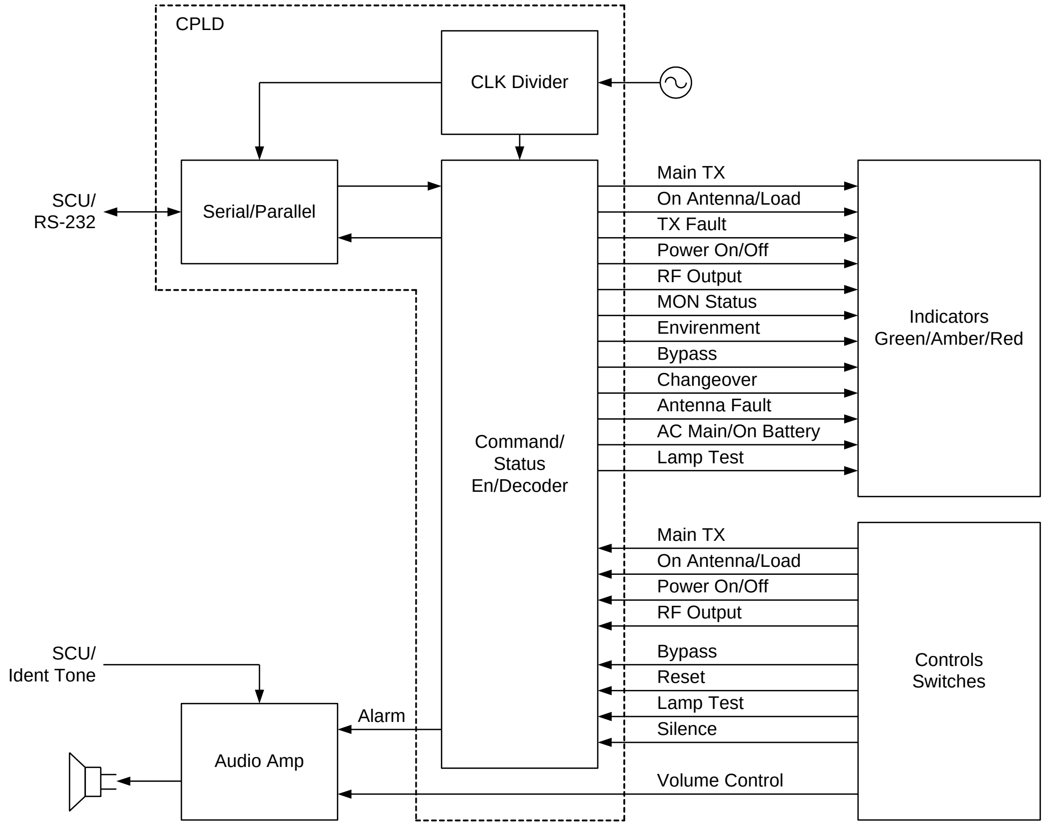

Figure 3-29. CSP Block Diagram

3.4.4. LMI

OVERVIEW

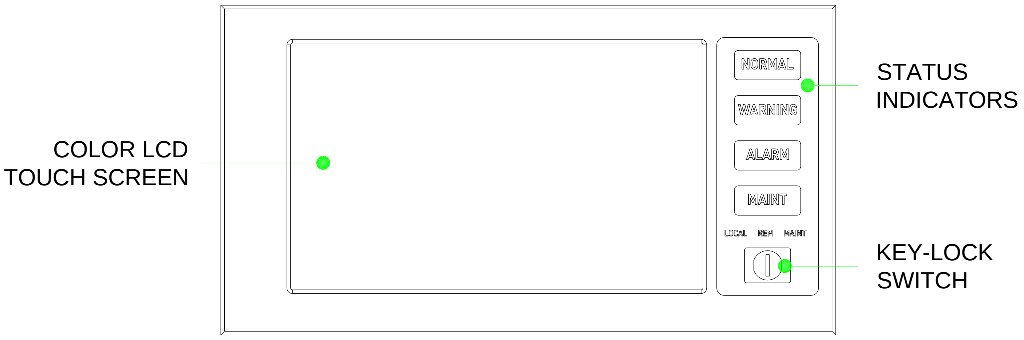

Figure 3-30. LMI Front Layout

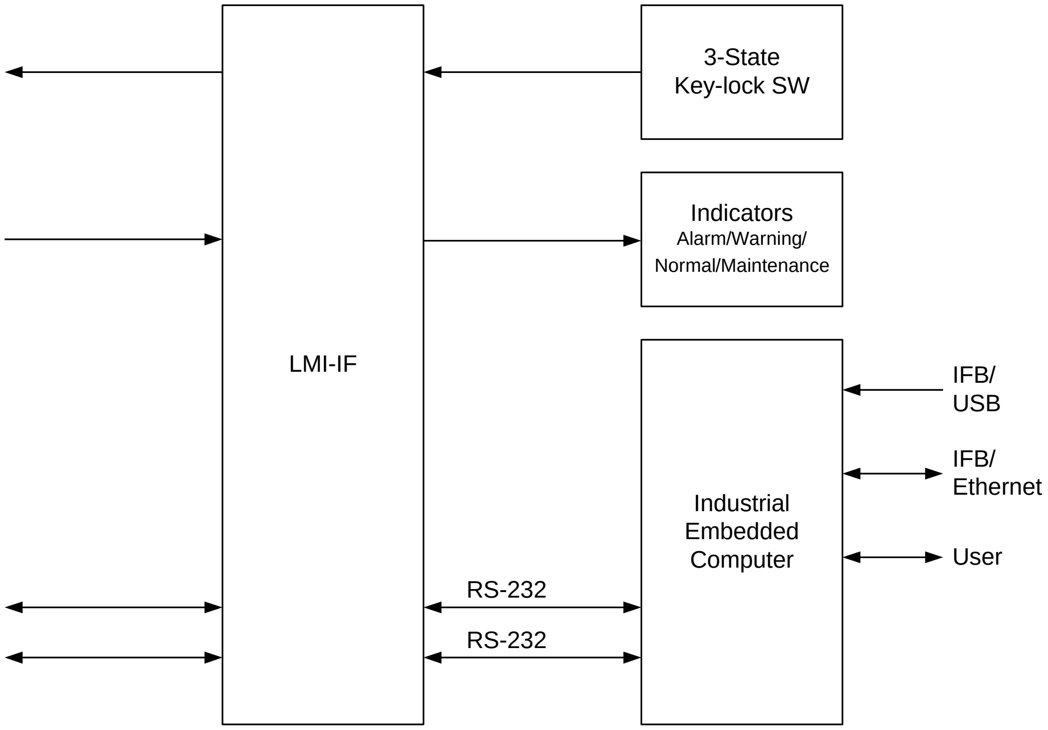

Figure 3-31. LMI Simplified Block Diagram

DESCRIPTION

The Local Maintenance Interface (LMI) consists of a 10.4” color TFT LCD with touchscreen, light emitting diode (LED) indicators. With the LCD display in combination with the touchscreen, the system status, parameters, monitor data and configuration can be displayed and modified.

LMI has the following functions:

- Equipment status and change settings

LMI displays the system status, power supply status and shelter status. It also displays the TX configuration settings and monitor settings.

LMI receives commands from the operator via GUI and exchanges it with SCU to carry out changes in the system setting such as TX setting, monitor setting, any setting needed to be changed in sensors inside the shelter and settings of the individual units.

- Log history and query

The status of the equipment and individual units are saved in a event log file. The queries made by operator are also recorded in a log file. These information can be used at a later time using LMI to check history of commands and events.

- Unit Firmware Upgrade

It is possible to upgrade firmware for all units SCU, PMM, EMU, MSG, MON with the microcontroller MCU.

- Communication Interface with an embedded computer

LMI consists of an operator interface GUI in the form of a touch screen display with embedded computer. It is installed on the top of rack door.

It provides USB, Ethernet and RS 232 communication interface with PMDT, and RS-232, RS - 485 communication interface with SCU.

3.4.5. IFB

OVERVIEW

The Interface Board (IFB) acts as an interface between devices inside and outside the equipment.

It has the following functions.

- Interface board between devices

IFB acts as an interface between the various units inside the equipment such as SCU, LMI, EMU, MSG, VAU, and FFMC. It also acts as an interface for communicating with external units such as Sensors, collocation equipment, PMDT (maintenance PC, RCU (remote control and monitoring), remote voice, FFM (Far Field Monitor), and any other external devices.

IFB provides various interface signals via RS-232, RS-485, USB, modem (telephone line), Ethernet, CAN, It also provides additional 8-channel analog input/output and 16-channel digital input/output ports which are reserved for future use.

- Surge Protection

IFB uses surge protection to protect the equipment from any unexpected incoming high voltages.

- Photo Coupling

Digital input and output signals are photo coupled for insulation from outside.

- ASU power supply interruption

In case both TX1 and TX2 shutdown, the SCU is directed to block the +28V DC power being supplied to ASU.

DESCRIPTION

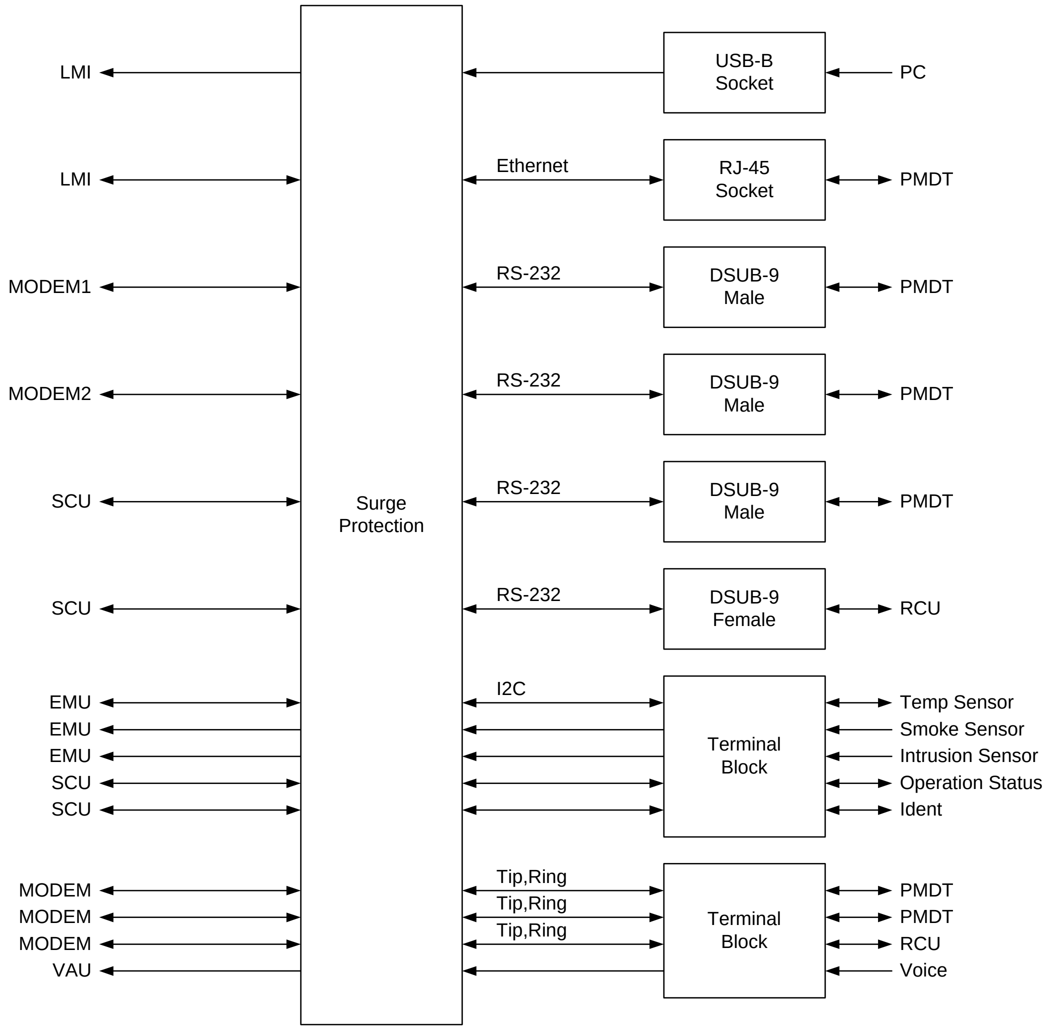

Figure 3-32. IFB Block Diagram

3.4.6. MODEM

OVERVIEW

The Modems provide a communication medium to connect to maintenance PC PMDT. There are two types of modems used for ILS equipment.

- High-Speed (up to 33.6kbps) leased-line/dialup Modem
- Low-speed (1200 bps) FSK leased-line modem

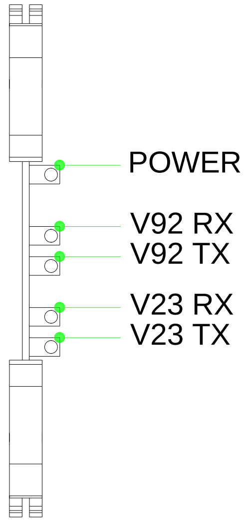

Figure 3-33 Modem Front View

DESCRIPTION

Figure 3-34 shows the block diagram of MODEM.

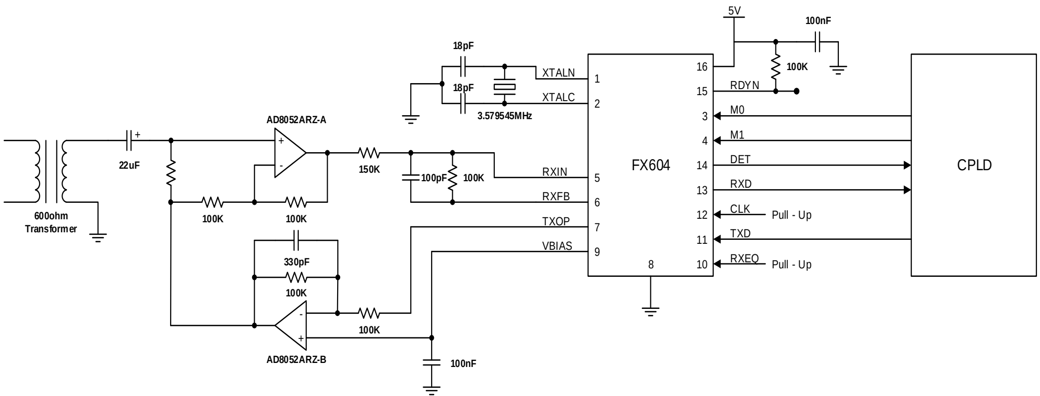

Figure 3-34 Modem Block Diagram

3.4.7. DC/DC-A

The DC/DC-A converter provides the multi-voltage dc power which is needed for the auxiliary electronics subrack. Two DC/DC-A converters are connected in parallel to provide redundancy and current boost. The main functions of DC/DC-A are as follows:

- DC/DC conversion

  The DC/DC-A unit receives +28V DC input from either AC/DC or battery backup source via PMU subrack and converts it into +5V, +15V, -15V output voltages.

- Monitor the output current and voltage

  A monitor IC monitors the status of the input voltage and output current and the measured values are conveyed to the SCU

- BITE and Alarm signal

  A BITE signal is generated to check any abnormal state in the SCU and an alarm is generated and Fault LED (Red) is ON, if any value is outside the tolerance limit.

- Presence Detector (PD)

  It is possible to determine if any unit has been detached by the signal associated with revision check.

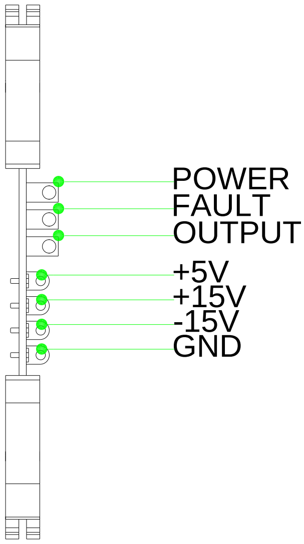

Figure 3-35. DC/DC-A Front View

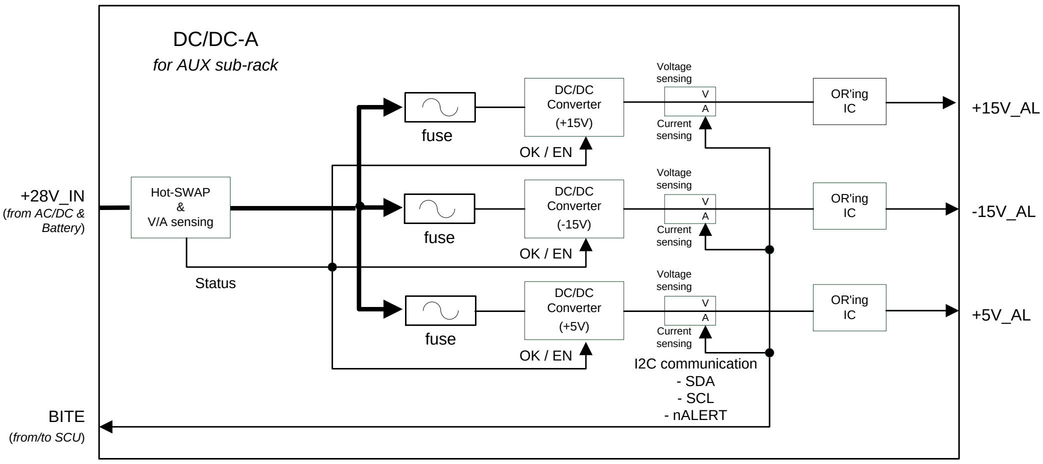

Figure 3-36. DC/DC-A Block Diagram

3.5. POWER SUPPLY

3.5.1. OVERVIEW

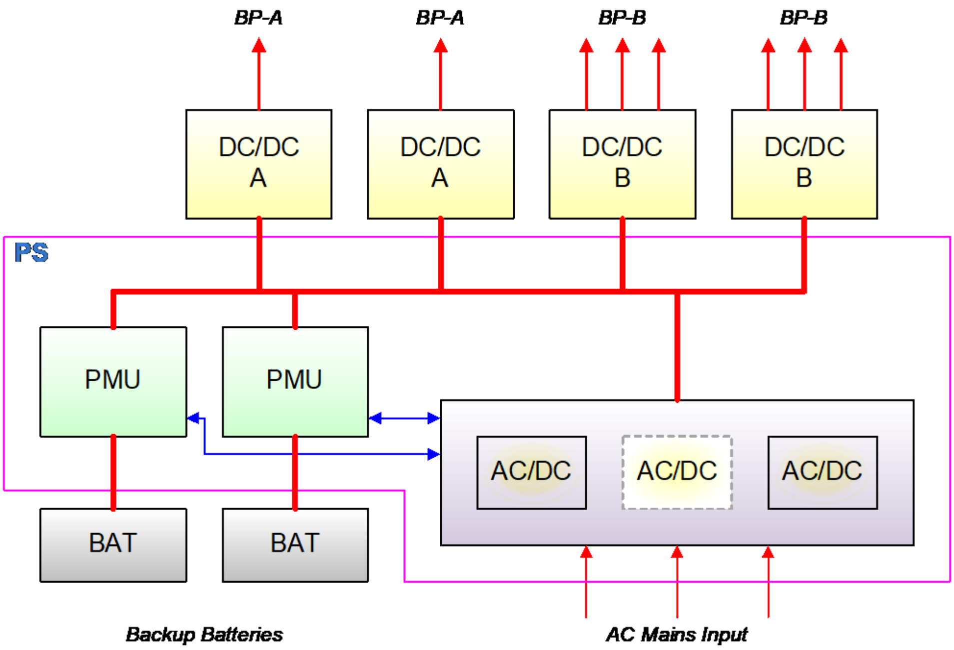

Figure 3-37. Power Supply Block Diagram

3.5.2. AC/DC

OVERVIEW

The 300 DME system uses readily accessible Commercial-Off-The-Shelf AC/DC units to ensure recent standards. The AC/DC is a switched-mode power supply (SMPS), which takes 110V/220V AC mains power input and converts it into 28V DC. The 28V power source is fed to the multi-voltage DC/DC converters and also used to charge external backup batteries.

For safety, both over-voltage protection and over-current protection circuits are included.

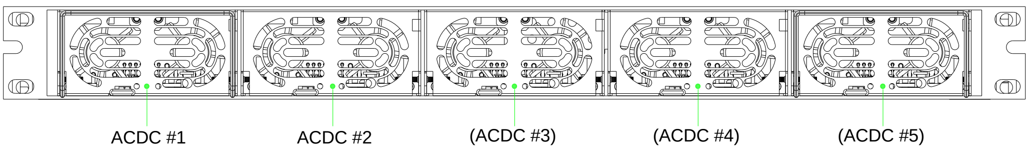

Figure 3-38. AC/DC Front View

3.5.3. PMU

OVERVIEW

The Power Monitoring Unit (PMU) manages the power supplied to the equipment. Two PMU devices are used in order to improve the reliability of the system and either of the two can be used to monitor the AC/DC output. With the help of 7-segment display battery temperature, battery current, battery voltage, AC/DC current, AC/DC voltage, etc. can be displayed. There are selection buttons available in PMU to allow the operator to select the measured value to be displayed on the seven-segment display.

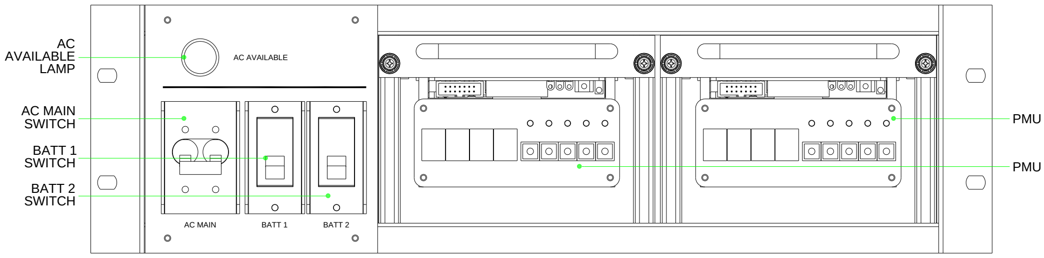

Figure 3-39. PMU Subrack, Front View

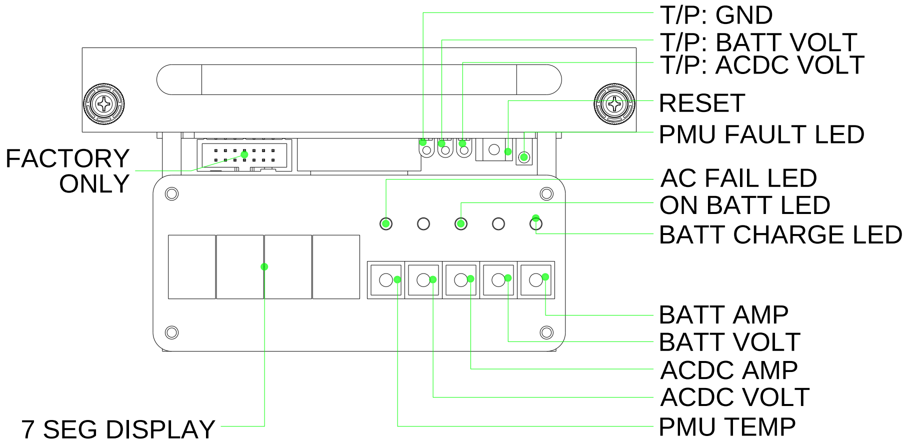

Figure 3-40. PMU, Front View

DESCRIPTION

The PMU performs the following functions.

PM Bus Monitoring

The maximum permitted voltage and the output voltage of the AC/DC is set and can be read at the display along with current value and temperature.

An AC/DC fault signal is generated if the input/output voltages falls above or below the set value or the equipment gets overheated due to fan failure. The SCU stores the status register value from PMU and generates an alarm in case of fault.

If the AC/DC unit has malfunctioned, the PMU switches the power to battery power source. However, the DC/DC is supplied power by the PMU by OR-ing the output of the two PMU in order to improve the reliability. Either of the two PMUs work as master or slave depending on their state and are used to monitor the AC/DC.

Battery Monitoring and charging control

The PMU monitors the charge and discharge state of the battery by measuring its output voltage and current.

The PMU transmits alarm information to SCU in case the output voltage of 22V battery decreases and turns off the battery power when it reaches 20V.

Reporting Monitoring results to SCU

The PMU monitors and reports the values of output voltage of AC/DC, current, temperature, fan status, to SCU via CAN bus. PMU also communicates any fault occurred to the SCU.

PMU monitors the output and the current status of the battery and reports it to SCU via CAN bus. Depending on the voltage values, PMU communicates with SCU via CAN bus whether to use AC/DC or battery as the power source.

Any fault in PMU functioning is also reported to the SCU.

Each time hardware in a unit is changed, a revision status signal is generated for the value changed and sent to SCU.

SCU receives a control for setting the various parameters of the PMU through the monitor results sent to SCU via CAN bus.

Control and status indicators on the front panel

PMU provides LED display for any fault occurrence, power of AC/DC, charging of battery and PMU status.

PMU provides a 7-segment display for the voltage and current measurements.

Acts as an Interface

PMU uses PM Bus (I2C interface) for communicating with AC/DC and communicates via CAN with other units outside the power supply unit.

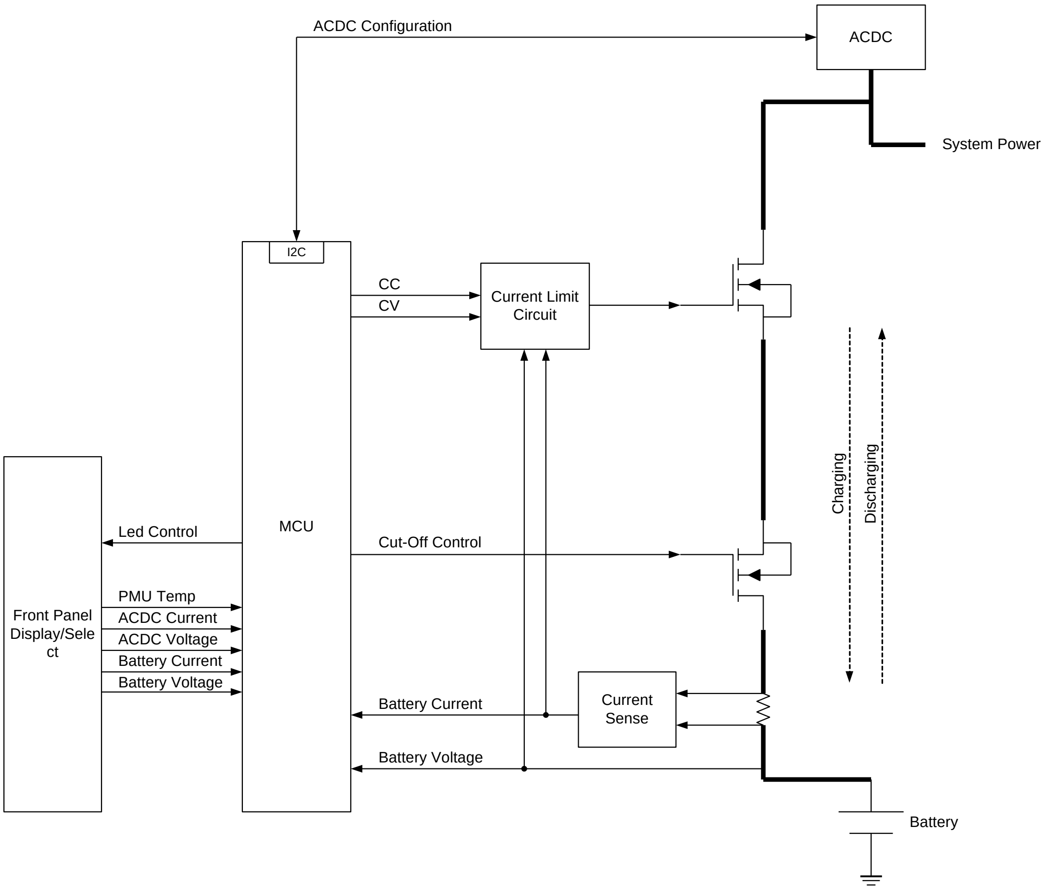

Figure 3-41. PMU Block Diagram

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4. OPERATION

4.1. INTRODUCTION

The standard operation is carried out using a PMDT PC via RS-232 modem. The basic operation is available locally to the operator using a local maintenance interface (LMI). The Local Maintenance Interface (LMI) consists of a 10.4" color TFT LCD with touchscreen and light emitting diode (LED) indicators. With the LCD touchscreen display, the system status and configuration can be displayed and modified. The PMDT carries out the parameter adjustments and maintenance procedures.

4.2. CONTROL AND INDICATORS

4.2.1. LOCAL MAINTENANCE INTERFACE (LMI)

Figure 4-1 shows the LMI screen. Table 4-1 describes the control and indicators on LMI. The LMI located on the front door of cabinet consists of the following controls and indications.

- A 10.4" color TFT LCD with touchscreen for indication of status of transmitters, monitors, measured parameter values, etc.
- Four indication lamps for the main system- NORMAL, WARNING, ALARM AND MAINTENANCE.
- A key-lock switch to select three operational modes of the station- LOCAL, REMOTE and MAINTENANCE, for operation from local site, remote site and in maintenance mode respectively.

Table 4-1. LMI Control and Indicators

CONTROL/ INDICATOR	COLOR/ POSITION	FUNCTION	REMARKS
NORMAL	Green	The transmitters and monitors are switched ON and serviceable for normal operation. There is no Warning or Alarm	
WARNING	Amber	The equipment is operating on battery supply BITE warning MON 1 and MON2 are in maintenance/bypass mode	Standby bypass
ALARM	Red	MON1 and MON2 are in Alarm state CSP fault MON 1 and MON2 are in bypass/maintenance mode	There is fault in either transmitter (or antenna) which initiates changeover. If both TX have fault, the system shuts down. The monitors are in executive bypass mode.
MAINT	Green	The equipment is under maintenance mode, either Local or remote.	

Key-Lock Switch	LOCAL	The equipment is enabled for Local operation.	Equipment is not in operation. Parameter values can be read remotely.
Key-Lock Switch	REM	The equipment is enabled for Remote control.	Equipment is in operation but local control commands at LMI are disabled. Parameter values can be read locally.
Key-Lock Switch	MAINT	The equipment is in maintenance mode. MON bypass is set and Alarm indication is switched ON.	Equipment is not in operation.

4.2.2. CONTROL STATUS PANEL, CSP

The Control and Status Panel has the following controls and indications as described below. Figure 4-1 shows the CSP Front Panel.

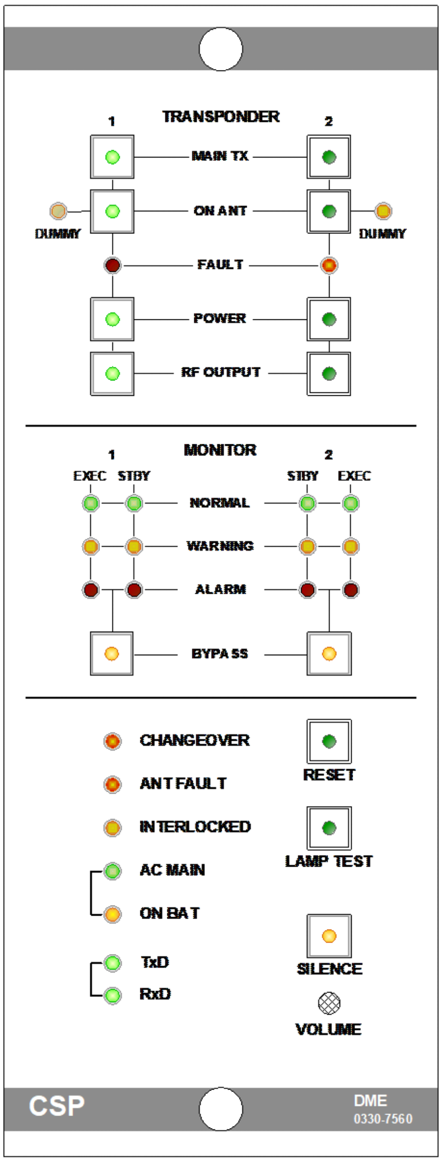

Figure 4-1. CSP Front Panel

4.2.3. DC/DC-A

Figure 4-7 shows the DC/DC-A Front Panel.

The Table 4-2 describes the control and indicators on the DC/DC-A

Table 4-2. Control and Indicators on DC/DC-A

No	Name	I/O	Type	Description
1	POWER	O	ON / OFF	Input Power Status Power ON = LED ON (Green)
2	FAULT	O	ON / OFF	Indicates fault if the input voltage is below the set limit Alarm = LED ON (Red)
3	OUTPUT	O	ON / OFF	Indicates that the DC output voltage is at least the minimum set value

				Output =LED ON (Green)
4	+5V_TP	O	DC+5V	Red color, Test Point Port (+5V)
5	+15V_TP	O	DC+15V	Red color, Test Point Port (+15V)
6	-15V_TP	O	DC-15V	Red color, Test Point Port (-15V)
7	GND	O	GND	Black color, Test Point Port (Ground)

4.2.4. PMU

Figure 4-8 shows the PMU Front Panel.

The Table 4-3 describes the control and indicators on the PMU.

Table 4-3. Control and Indicators on PMU

Item	Type	Description
Temperature	O	Display select indicator: PMU Temperature
AC/DC Voltage	O	Display select indicator: AC/DC Output Voltage
AC/DC Current	O	Display select indicator: AC/DC Output Current
Battery Voltage	O	Display select indicator: Battery Voltage
Battery Current	O	Display select indicator: Battery Current
Battery In Use	O	Battery Discharging indicator
AC Fail	O	AC Fail indicator
Button1_selected	O	Display select button: PMU Temperature
Button2_selected	O	Display select button: AC/DC output voltage
Button3_selected	O	Display select button: AC/DC output current
Button4_selected	O	Display select button: Battery voltage
Button5_selected	O	Display select button: Battery current

4.2.5. FAN

Figure 4-9 shows the FAN Front Panel.

The Table 4-4 describes the control and indicators on the FAN.

Table 4-4. Control and Indicators on FAN

No	Name	I/O	Type	Description

1	LED1	O	ON / OFF	+ 28V power supply status Power ON = LED ON (Green)
2	LED2	O	ON / OFF	FAN1 status Alarm = LED ON (Red), Normal = LED OFF
3	LED3	O	ON / OFF	FAN2 status Alarm = LED ON (Red), Normal = LED OFF
4	LED4	O	ON / OFF	FAN3 status Alarm = LED ON (Red) Normal = LED OFF
5	LED5	O	ON / OFF	FAN4 status Alarm = LED ON (Red), Normal = LED OFF

4.2.6. DC/DC

Figure 4-10 shows the DC/DC Front Panel.

The Table 4-5 describes the control and indicators on the DC/DC.

Table 4-5. Control and Indicators on DC/DC

No	Name	I/O	Type	Description
1	POWER	O	ON / OFF	Input Power Status Power ON = LED ON (Green)
2	FAULT	O	ON / OFF	Indicates fault that the input voltage is below the set limit Alarm = LED ON (Red)
3	OUTPUT	O	ON / OFF	Indicates the DC output voltage is at least the minimum set value Output =LED ON (Green)
4	ADJ1	O	DC (variable)	Port for adjusting the output voltage of the main DC + 28V
5	ADJ2	O	DC (variable)	Port for adjusting the output voltage of the main DC + 50V (only VOR, DME)
6	+5V_TP	O	DC+5V	Red color, Test Point Port (+5V)
7	+8V_TP	O	DC+8V	Red color, Test Point Port (+8V)
8	+15V_TP	O	DC+15V	Red color, Test Point Port (+15V)
9	-15V_TP	O	DC-15V	Red color, Test Point Port (-15V)
10	+28V_TP	O	DC+28V	Red color, Test Point Port (+28V)
11	+50V_TP	O	DC+50V	Red color, Test Point Port (+50V, only VOR, DME)

12	GND	O	GND	Black color, Test Point Port (Ground)

4.2.7. SCU

Figure 4-11 shows the SCU Front Panel.

The Table 4-6 describes the control and indicators on the SCU.

Table 4-6. Control and Indicators on SCU

No	Name	I/O	Type	Description
1	LED_CSP_RS232_RX	I	RS-232	UART-CSP Receive Data Indicator Green LED
2	LED_CSP_RS232_TX	O	RS-232	UART-CSP Transmit Data Indicator Red LED
3	LED_LMI_RS232_RX	I	RS-232	UART-LMI Receive Data Indicator Green LED
4	LED_LMI_RS232_TX	O	RS-232	UART-LMI Transmit Data Indicator Red LED
5	LED_PMDT_RS232_RX	I	RS-232	UART-PMDT Receive Data Indicator Green LED
6	LED_PMDT_RS232_TX	O	RS-232	UART-PMDT Transmit Data Indicator Red LED
7	LED_CAN_RXD	I	CAN	CAN Receive Data Indicator Green LED
8	LED_CAN_TXD	O	CAN	CAN Transmit Data Indicator Red LED
9	LED_PMDT_MD_RXD	I	TTL	MODEM Receive Data Indicator Green LED
10	LED_PMDT_MD_TXD	O	TTL	MODEM Transmit Data Indicator Red LED
11	LED_PMDT_ETH_TXD	O	TTL	Ethernet Transmit Data Indicator Red LED
12	LED_PMDT_ETH_RXD	I	TTL	Ethernet Receive Data Indicator Green LED

4.3. TURN ON AND SHUTDOWN PROCEDURES

4.3.1. TURN ON PROCEDURE

This section provides the procedure to Turn ON the DME equipment and to verify a normal operating state.

The following conditions should be verified before turning ON the equipment.

- Backup Battery	BATT 1 and BATT 2	Verify switched OFF
- AC/DC	AC MAIN	Verify switched OFF, LED OFF
- LMI	Key-Lock Switch	Verify set to LOCAL

- LMI Key-Lock Switch Verify

4.3.2. INDICATIONS DURING NORMAL OPERATION

4.3.3. SHUTDOWN PROCEDURE / TURN OFF PROCEDURE

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5. STANDARDS AND TOLERANCES

5.1. INTRODUCTION

This section lists and describes the MOPIENS 310/320 DME standards and tolerances.

5.2. 310/320 DME STANDARDS AND TOLERANCES

Table 5-1 provides the system standards and tolerances for the performance checks and maintenance procedures of 310/320 DME. It is advisable that these parameters be checked at the recommended intervals and maintenance procedures are performed on schedule for efficient performance of the equipment.

Table 5-1. Standards and Tolerances of 310/320 DME

Parameter	Standard	Tolerance Limit
TRANSMITTER		
Rated Power Output	100 W (310 DME) 1000 W (320 DME)	-3 dB -3 dB
Frequency	Assigned frequency	±0.001 %
Pulse Spacing	12 µs (CH X) 30 µs (CH Y)	±0.1 µs ±0.1 µs
Pulse Shape - Pulse Duration - Rise Time - Pulse Decay Time	 3.5 µs 2.5 µs 2.5 µs	 ± 0.5 µs ± 0.5 µs -1 µs / +0.5 µs
Pulse Rate	> 700 pp/s	
Reply Delay	50 µs (CH X) 56 µs (CH Y)	±0.2 µs ±0.2 µs
Ident	1350 pp/s	± 10 pp/s
SUPPLY VOLTAGES		
AC Voltage	110/220 V	9V to 265V 47 Hz to 63 Hz
DC Voltage	5 V 8 V 15 V -15 V 28 V 50 V	4.75 V to 5.25 V 7.6 V to 8.4 V 14.25 V to 15.25 V -15.25 V to -14.25 V 26.7 V to 29.4 V 47.5 V to 52.5 V
Backup Battery	24 V	
VSWR	≤ 1.5:1	

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6. PERIODIC MAINTENANCE

This section describes the required performance checks that must be conducted in order to ensure safe operation of MOPIENS 310/320 DME equipment. The supervising personnel are responsible for scheduling these performance checks based on the recommended intervals. The intervals given for the performance checks in Table 6-1, however, are not intended to replace, substitute for or supersede their official regulations or directives which should be consulted for final authority.

The supervisor shall notify the responsible authorities, such as air traffic control tower for example, of possible alarm indication or interruption of DME navigation service during the maintenance work.

6.1. SAFETY PRECAUTIONS

The purpose of safety precautions is to protect persons and property, and therefore all attentions must be given to them.

If improperly handled, the equipment may be damaged resulting in reduced performance and lifetime since MOPIENS 310/320 DME equipment contains modules and parts equipped with ESD-sensitive semiconductor components. When replacing modules and parts containing ESD-sensitive components, special precautionary measures should be taken during removal, transport and installation in order to prevent damage to the components. For protection against ESD, the use of appropriate kits is recommended, such as portable static-dissipative field kit with dissipative mat, wrist band, and ground wire or equivalent protection connected to same potential as the equipment.

Work should not be carried out outside the shelter or on the antenna system during a storm due to the danger of injury by lightning.

6.2. TEST EQUIPMENT REQUIREMENT

The test equipment inherent errors should be at least five times smaller than the specified tolerances. Given below is the recommended list of test equipment, or equivalent, to make the measurements:

Table 6-1. Test Equipment Required

Equipment	Manufacturer	Model
USB Power Sensor	Rohde & Schwarz	NRP-Z81
USB Power Sensor Adaptor	Rohde & Schwarz	NRP-Z4
Spectrum Analyzer	Advantest	R3267
Frequency Counter	Keysight	53132
Digital Multi-Meter	FLUKE	187
Digital Oscilloscope (Digital Storage Oscilloscope)	TEKTRONIX (or LeCroy)	TDS1012B (or Wavejet 354)
Avionic Signal Generator	AEROFLEX	IFR 2030

RF Directional Coupler	ACS Microwave	ADC 1127 ADNSM
High Power Attenuator(fixed 30dB)	Any	
Network Analyzer	Keysight	8753ES

6.3. ON-SITE PERFORMANCE CHECKS

Table 6-2. Performance Check

<table>
<tr><th colspan="3" rowspan="2">Performance Check</th><th colspan="2">Reference Paragraph</th></tr>
<tr><th>Standards and Tolerance</th><th>Maintenance/ Performance Check Procedure</th></tr>
<tr><td rowspan="3">MONTHLY</td><td colspan="2">The status of operation</td><td>Normal Operation</td><td>6.3.1</td></tr>
<tr><td colspan="2">Reply Delay</td><td>Table 5-1</td><td>6.3.2</td></tr>
<tr><td colspan="2">Equipment Cleaning</td><td></td><td>6.3.3</td></tr>
<tr><td rowspan="6">QUARTERLY</td><td colspan="2">RF Power</td><td>As established at F/C; ±10%</td><td>6.3.4</td></tr>
<tr><td colspan="2">Reply Pulse Characteristics
1) Pulse Width
2) Pulse Rise & Decay time
3) Pulse Pair Spacing</td><td>Table 5-1</td><td>6.3.5</td></tr>
<tr><td colspan="2">Output Pulse Count
Min PRF - No Interrogation</td><td>Table 5-1</td><td>6.3.6</td></tr>
<tr><td colspan="2">Receiver Sensitivity</td><td>< -91dBm</td><td>6.3.7</td></tr>
<tr><td colspan="2">Monitor Alarm Points
1) Peak Power Output Alarm
2) Output Pulse Count Alarm
(Minimum PRF)
3) Reply Efficiency Alarm
4) Reply Delay Alarm

5) Pulse Pair Spacing Alarm</td><td>-3dB of F/C established value
< 700pp/s

< 70%
50 μs (CH X) ±0.2 μs
56 μs (CH Y) ±0.2 μs
12 μs (CH X) ±0.1 μs
30 μs (CH Y) ±0.1 μs</td><td>6.3.8</td></tr>
<tr><td>POWER SUPPL Y</td><td>AC Voltage
DC Voltage
Backup Battery</td><td>Table 5-1</td><td>6.3.9</td></tr>
<tr><td rowspan="4">ANNUAL</td><td colspan="2">Transmitter Frequency</td><td>Table 5-1</td><td>6.3.10</td></tr>
<tr><td colspan="2">Monitor Alarm Delay</td><td>< 10 sec</td><td>6.3.11</td></tr>
<tr><td colspan="2">Verification of BITE</td><td></td><td>6.3.12</td></tr>
<tr><td colspan="2">Antenna and Equipment Ground Resistance</td><td>< 5Ω</td><td>6.3.13</td></tr>
</table>

	Damage Check		6.3.14

Precautions before Inspection of Equipment

When the performance checks are executed in the shelter, make sure to check the position of Key-Lock Switch on LMI unit. If the Key-Lock Switch is set to “REM”, turn it to “MAINT” or “LOC”. After the performance checks are completed, make sure to turn the Key-Lock Switch to "REM" before leaving the equipment shelter.

6.3.1. Operation Status Check

Check with PMDT??

6.3.2. Reply Delay Check

6.3.2.1. Standards and Tolerances

	Test point	Baseline	Tolerance
System Time Delay	LOG VIDEO	X CH: 50 μsec Y CH: 56 μsec	±0.5 μsec

6.3.2.2. Test Setup

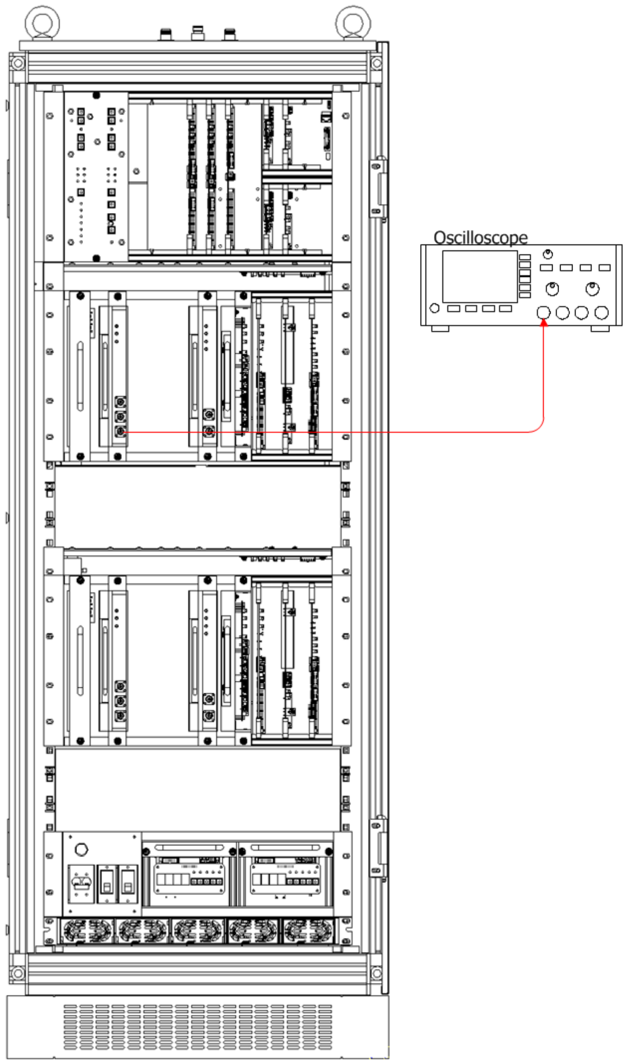

Figure 6-1. Test Setup for System Delay Measurement

6.3.2.3. Test Equipment

- Oscilloscope, Tektronix TDS 3012 or equivalent
- Oscilloscope Probe, 10X, 100 MHz or equivalent
- Test Cable, BNC(M) to BNC(M) 50 Ω Coaxial cable

6.3.2.4. Procedure

a) Connect one end of the test cable to **LOG VIDEO** port on the front panel of RXU

b) Connect the other end of the test cable to CH1 input of the oscilloscope.

c) Connect the grabber of the oscilloscope probe to the **Interrogation Trigger** test point on the MON unit as shown in Figure 6-2.

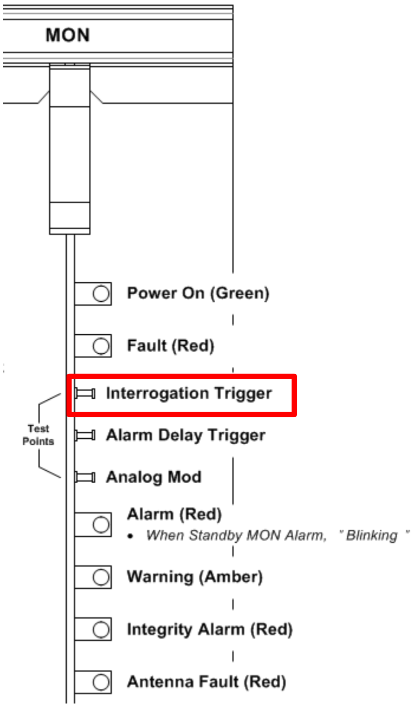

Figure 6-2. Test point for Interrogation Trigger on MON unit

d) Connect the oscilloscope probe to the CH2 input of the oscilloscope.

e) Start PMDT and log in

f) Open Station Setup screen

g) Select **Always** for the item **Auto Delay Calibration** as shown in Figure 6-3 and click on **Apply** button

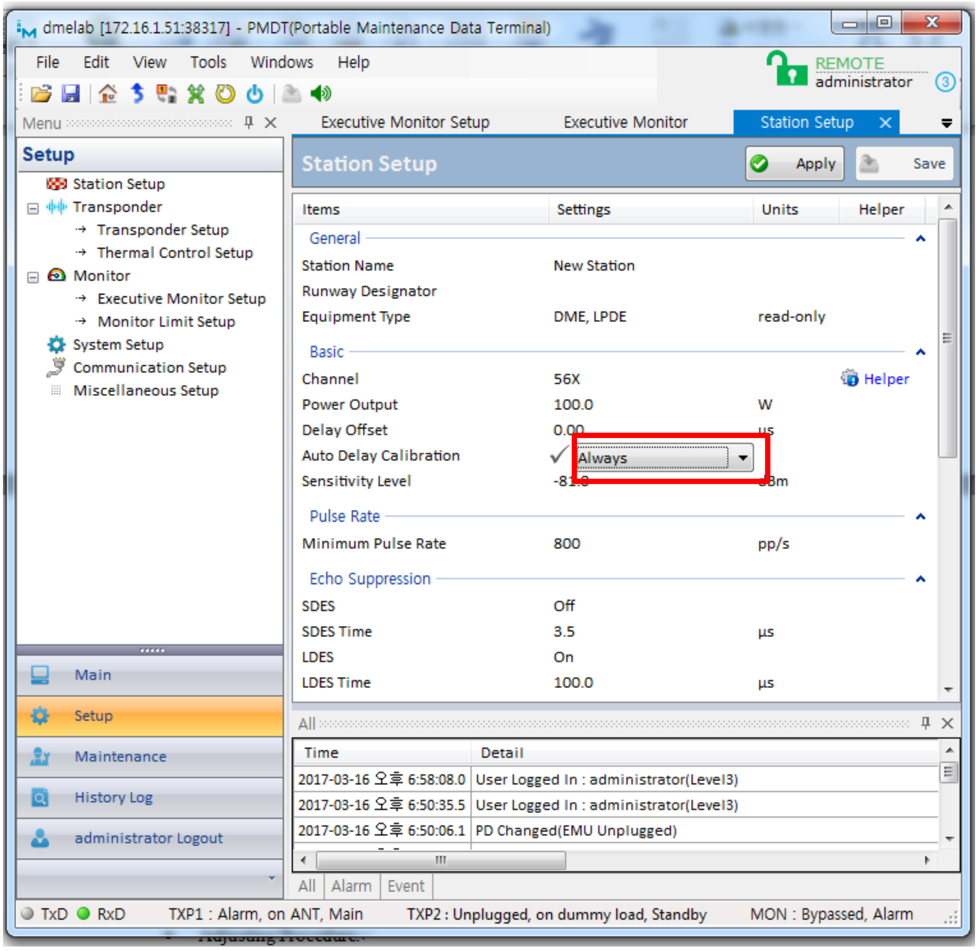

Figure 6-3. Station Setup screen on PMDT

h) Set the oscilloscope as follows and adjust the trigger level accordingly:

- horizontal scale: 10 µs/div
- vertical scale: 0.5V/div
- trigger source: CH2

i) Read peak points from the leading pulses of two pulse pairs on the oscilloscope screen. Find two points at which are on the rising edge and 360 mV down from the peak as shown in Figure 6-4. Measure the time difference between the two points.

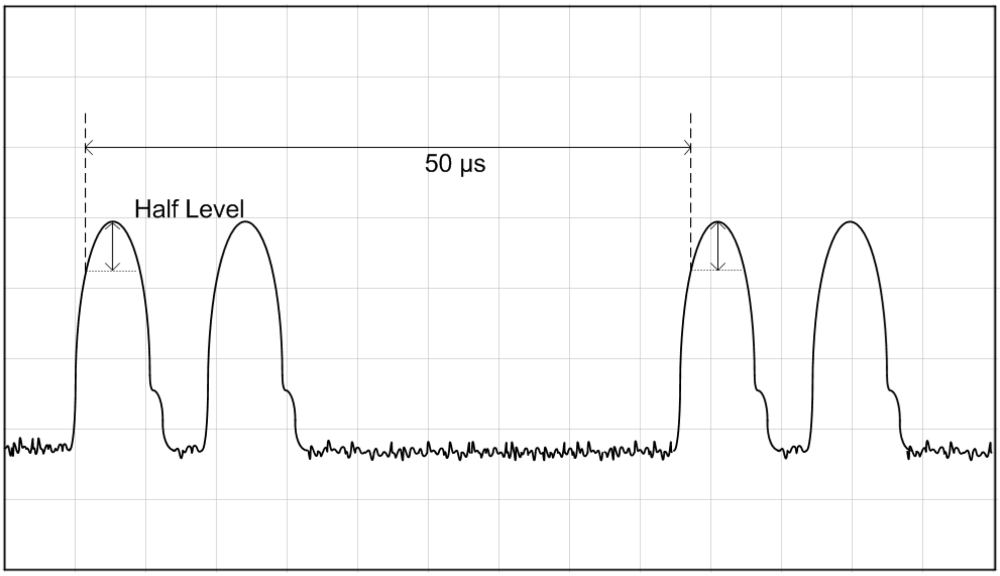

Figure 6-4. Waveforms on oscilloscope

6.3.3. Equipment Cleaning

* Tools required:

- Cleaning aids: brushes and dusters with antistatic material
- Vacuum cleaner
- Others: Ethyl alcohol or Glycol, clean water as required

✓ Notify the air traffic control authorities of possible interruption of DME navigation service

✓ Check the shelter temperature sensor and verify the normal operation of air conditioner, heater and fan(s)

✓ Clean dust from cabinet using air or soft brush. If required, turn off switches on DC/DC and AC/DC converters.

✓ Check the air filters of ventilator(s) or air conditioner. If accumulation of dirt is detected, the air filters should be replaced by new ones to prevent clog.

✓ In case the new filter is out of stock, on an exceptional basis, the dirt may be banged out of the old filter for a limited reuse of it.

✓ In the shelter, do not use a broom but use a vacuum cleaner to avoid transferring dirt into the equipment cabinet and its associated parts.

✓ Remove layers of dirt on the PMDT panel (and CSP or LMI??) with a cloth moistened a little with Ethyl alcohol, Glycol or clean water.

✓ If a visual check detects dust on units or PCB's, they should be dusted using a soft brush with the aid of a vacuum cleaner.

✓ On completion of cleaning work, turn on the equipment and verify normal operation.

6.3.4. RF Power Output Check

6.3.4.1. Standards and Tolerances

	Test point	Baseline	Tolerance
Transmitter peak power output	ANT (J2)	Assigned power	± 1dB

6.3.4.2. Test Setup

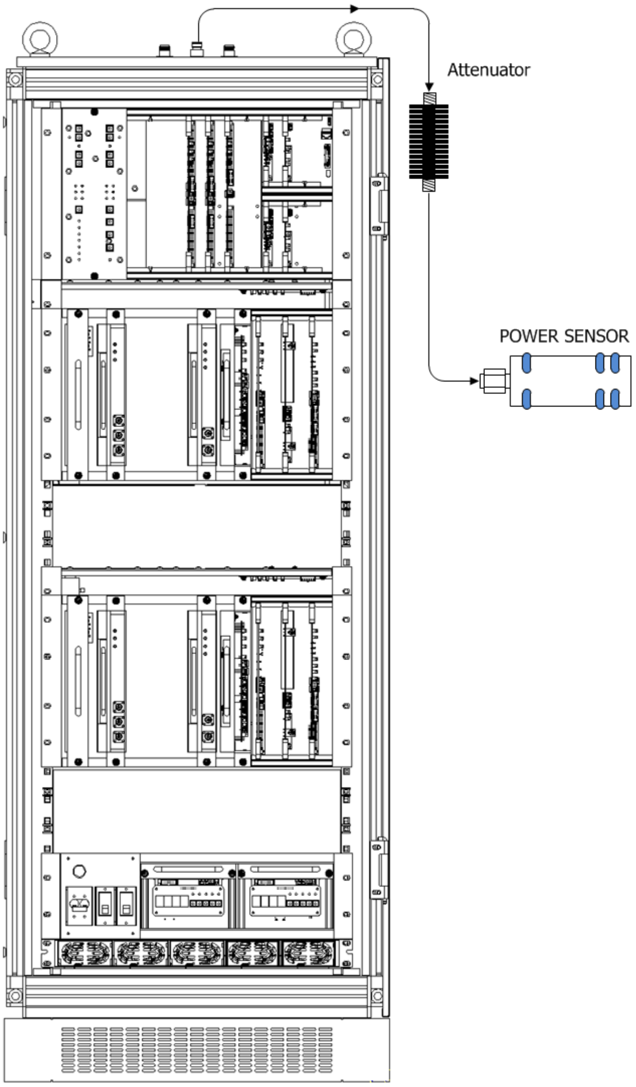

Figure 6-5. Test Setup for Power Output Measurement

6.3.4.3. Test Equipment

- Wideband peak power sensor, R&S ERP-Z81 or equivalent
- RF power attenuator: 50 dB, 50Ω, 250 W continuous; can be substituted by a RF directional coupler with 50 dB couple ratio and an appropriate dummy load.

- Test Cable: N(M) to N(M) 50 Ω Coaxial Cable with known loss at the test frequency

6.3.4.4. Procedure

a) Disable RF output using CSP or PMDT and turn off the equipment.

b) Remove the cable for the antenna

c) Connect one end of the test cable to J2, Antenna port connector on the top of the equipment cabinet

d) Connect the other end of the test cable to input port of the power attenuator

e) Connect the peak power sensor to the output port of the power attenuator

f) Consulting the power sensor manual, set the offset value, 50 dB + cable loss to the power sensor

g) Turn on the equipment back and bypass the monitor

h) Enable RF output using CSP or PMDT

i) Read and note the peak power output

6.3.5. Reply Pulse Characteristics Check

6.3.6. Output Pulse Count Check

6.3.7. Receiver Sensitivity Check

6.3.8. Monitor Alarm Points Check

6.3.9. Power Supply Check

6.3.9.1. Standards and Tolerances

- DC/DC–A

	Test point	Baseline	Tolerance
DC/DC-A Output Voltages	+ 5 V	+ 5 V	± 0.25 V
	+ 15 V	+ 15 V	± 0.75 V
	- 15 V	- 15 V	± 0.75 V

- DC/DC

	Test point	Baseline	Tolerance
DC/DC Output Voltages	+ 5 V	+ 5 V	± 0.25 V
	+ 15 V	+ 15 V	± 0.75 V
	- 15 V	- 15 V	± 0.75 V
	+ 8 V	+ 8 V	± 0.4 V
	+ 50 V	+ 50 V	± 2.5 V

- AC/DC

	Test point	Baseline	Tolerance
AC/DC Output Voltage	TP ACDC VOLT on PMU	+ 28 V	± 1.4 V

6.3.9.2. Test Setup

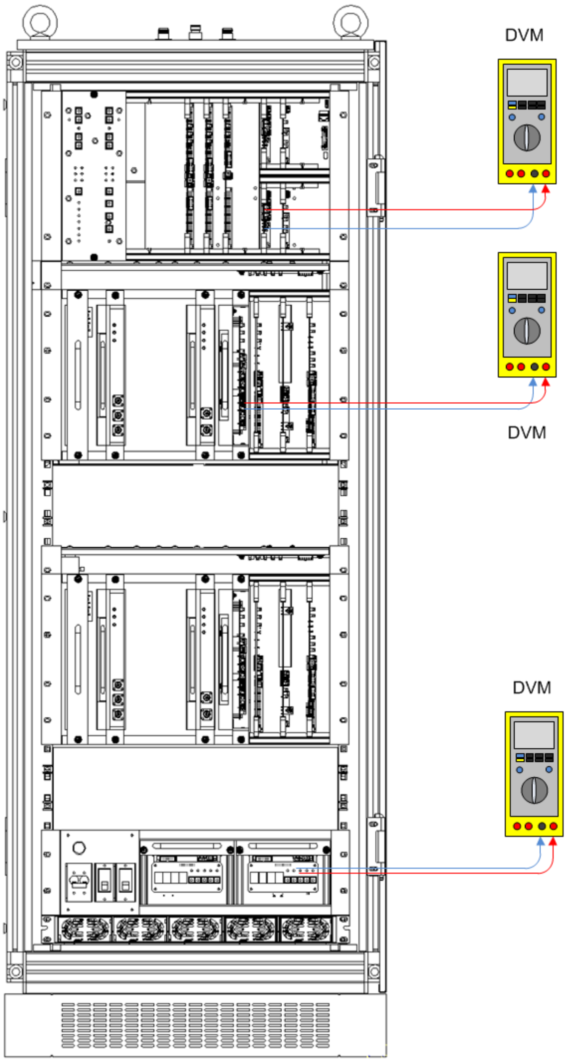

Figure 6-6. Test Setup for power supply measurement

6.3.9.3. Test Equipment

- Digital Multimeter (DMM) or Voltmeter (DVM)
- Test leads

6.3.9.4. Procedure

<u>AC/DC Output Voltages</u>

a) Insert the negative tip (black) of the test leads into the tip jack, **GND** on the front panel of the PMU as shown in Figure 6-7.

b) Insert positive tip (red) of the test leads into the tip jack, **ACDC VOLT** on the front panel of the PMU as shown in Figure 6-7.

c) Read and note the measured value.

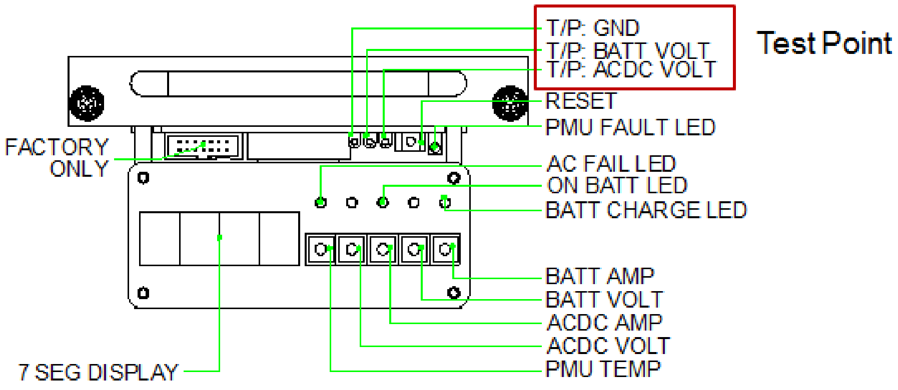

Figure 6-7. Test points on the front panel of PMU

<u>DC/DC-A Voltages</u>

a) Insert the negative tip (black) of the test leads into the tip jack, **GND** on the front of the DC/DC-A unit as shown in Figure 6-8.

b) Insert positive tip (red) of the test leads into the tip jack, **+5V** on the front of the DC/DC-A Figure 6-8.

c) Read and note the measured value.

d) Repeat above steps for the test points, **+15V** and **-15V**.

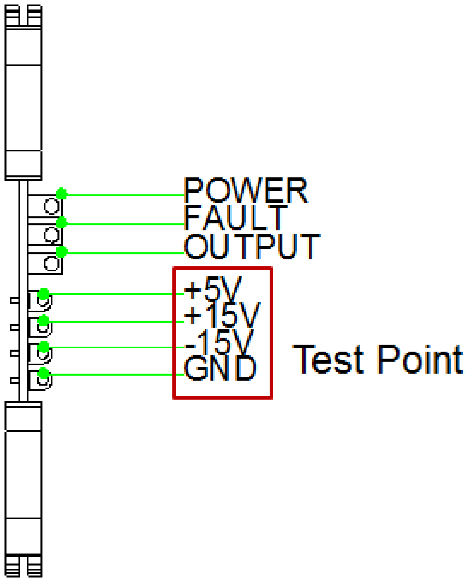

Figure 6-8. Test Points on DC/DC-A

DC/DC #1, #2 Voltages

a) Insert the negative tip (black) of the test leads into the tip jack, **GND** on the front of the DC/DC unit as shown in Figure 6-9.

b) Insert positive tip (red) of the test leads into the tip jack, **+5V** on the front of the DC/DC as shown in Figure 6-9.

c) Read and note the measured value.

d) Repeat above steps for the test points, **+8V**, **+15V**, **-15V, +28V, +50V**.

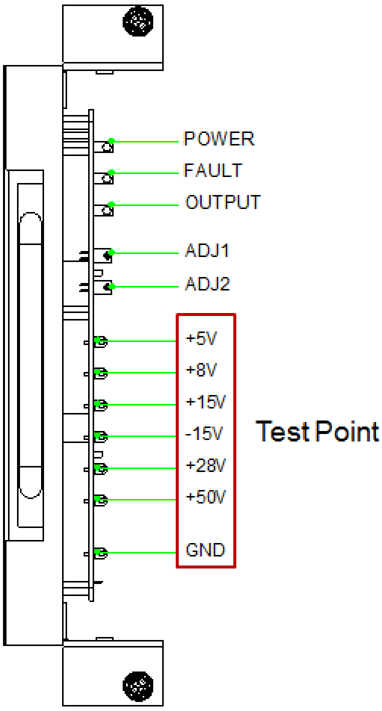

Figure 6-9. Test points on DC/DC

6.3.10. Transmitter Frequency Check

6.3.10.1. Standards and Tolerances

	Test point	Baseline	Tolerance
Transmitter Frequency	TX FREQ	Assigned frequency	±0.002%

6.3.10.2. Test Setup

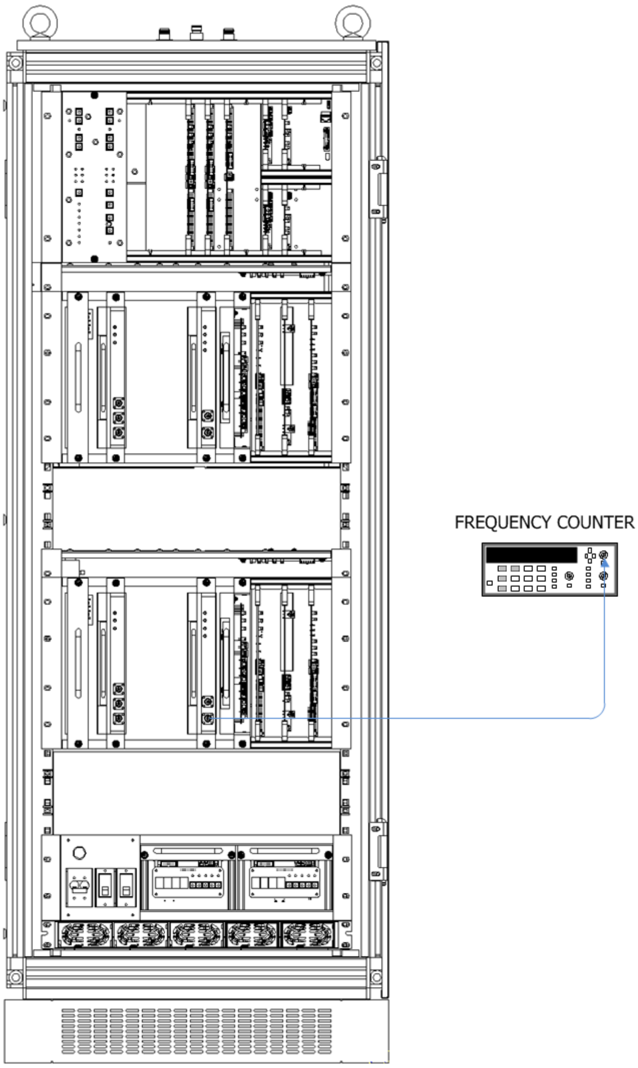

Figure 6-10. Test Setup for Transmit Frequency Measurement

6.3.10.3. Test Equipment

- Frequency Counter: 1.5 GHz minimum, Keysight 53131A with option 030 or equivalent
- Test Cable: BNC(M) to BNC(M) 50 Ω Coaxial Cable

6.3.10.4. Procedure

a) Connect one end of the test cable to **TX FREQ** port on the front panel of TXU as shown in Figure 6-11.

b) Connect the other end of the test cable to the appropriate input port of the frequency counter.

c) Read and note the reading

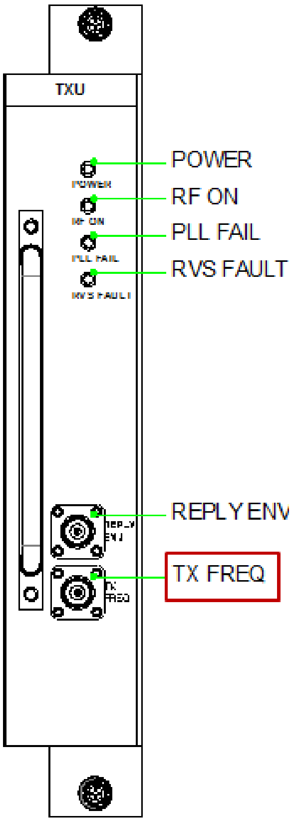

Figure 6-11. Test Point: TX FREQ on front panel of TXU

6.3.11. Monitor Alarm Delay Check

6.3.12. BITE Certification Check

6.3.13. Antenna and Equipment Ground Resistance Check

6.3.14. Damage Check for Equipment, Shelter and Antenna

✓ Check tightness of all internal and external RF cable connections

✓ Check antenna distribution, connectors and supporting pedestals

✓ Remove the dust, corrosion and foreign dirt, if any

✓ Check the mounting solidity and tightness of all mechanical parts (nuts & bolts)

- ✓ Check for sign of corrosion of antenna elements including any sign of salinity
- ✓ Check for signs of cracks or breakage of coaxial feed cables
- ✓ Check antenna obstruction lights

6.4. OTHER ON-SITE MAINTENANCE

Though parts of the following activities are listed in Table 6-2 of section 6.3 above, they should be checked or performed from time to time whenever required.

The other maintenance tasks include periodic cleaning and inspection of the shelter and equipment.

It also includes inspection of batteries for corrosion or any kind of deterioration. Periodic checks and tightening of RF and battery connections should also be done to ensure continuous and efficient operation of the equipment.

Check air filters in shelter vent and air conditioning unit. Clean or replace any part if required.

Check the installed environmental sensors to ensure normal functioning.

Perform a complete visual inspection of the equipment, antenna array and distribution network assembly.

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7. CORRECTIVE MAINTENANCE

This section includes information for locating and troubleshooting faults at the site for normal system operation.

7.1. FAULT LOCATION

Identify the symptom and locate the fault

✓ List the symptoms monitored and described by the technicians.

✓ Check the status of operation with PMDT.

✓ Locate the faulty module or unit.

✓ Perform a careful visual inspection of the suspected module or unit.

✓ Check for signs of excessive heat

- Check that all ICs are firmly seated in their sockets and that the ICs have no bent pins
- Check that PCB edge connectors are clean and seated fully
- Check the ribbon-cable connectors (if any)
- Check the remote control line
- Check power supply which is frequently a very common source of faults.

✓ If the fault is suspected outside the equipment cabinet or shelter, check coaxial feed cables for antenna distribution.

✓ Identify and use the proper test equipment.

✓ Check signals of the suspected module or unit using the test equipment.

7.2. TROUBLESHOOTING

This section provides general information for the site specialists to restore a faulty system to a ready-to-operate condition with the least possible delay.

** Details will be supplemented.*

7.3. OFF-SITE MAINTENANCE OF SRU's

Most of the modules equipped in this equipment are SRU′s and not user-serviceable. The module and unit repair is to be performed off site; i.e. at the factory or authorized repair shop. Defective modules are, therefore, to be returned to the factory or repair shop.

Modules to be shipped to the factory or repair shop for service must always be identified by module number and serial number. Special care must be given to the packing of module to prevent any possible damage during its transportation to the factory or back to the site.

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8. PARTS LIST

8.1. INTRODUCTION

A list of the modules and units used in the 310/320 DME is shown in Table 8-1 for dual configuration.

Table 8-1. 310/320 DME single equipment configuration part list

Unit Reference	Unit Name	P/N
1	Electronic Cabinet	0331-7002 (310 DME) 0332-7002 (320 DME)
1A1	AUX Rack	0330-7010
1A1A1	CSP	0330-7560
1A1A2	SCU	0130-7520
1A1A3	SCU	0130-7520
1A1A4	EMU	0130-7540
1A1A5	DC/DC-A	0130-7720
1A1A6	DC/DC-A	0130-7720
1A1A7	Modem	0130-7420
1A1A8	Modem	0130-7430
1A1A9	BP-A	0330-3010
1A2	TX1 Rack	0330-7020
1A2A1	DPX	0330-7120
1A2A2	RXU	0330-7180
1A2A3	HPA	0332-7150
1A2A4	TXU	0330-7140
1A2A4	DC/DC	0330-7710
1A2A6	TCU	0330-7570
1A2A7	RFG	0330-7190
1A2A8	MON	0330-7550

1A2A9	FAN	0130-7910
1A2A10	BP-BL	0330-3021
1A2A11	BP-BR	0330-3022
1A3	TX2 Rack	0330-7020
1A3A1	DPX	0330-7120
1A3A2	RXU	0330-7180
1A3A3	HPA	0332-7150
1A3A4	TXU	0330-7140
1A3A5	DC/DC	0330-7710
1A3A6	TCU	0330-7570
1A3A7	RFG	0330-7190
1A3A8	MON	0330-7550
1A3A9	FAN	0130-7910
1A3A10	BP-BL	0330-3021
1A3A11	BP-BR	0330-3022
1A4	PMU Rack	0130-7030
1A4A1	PMU	0130-7730
1A4A3	BP-PM	0130-3030
1A5	AC/DC Rack	3151-0017
1A5A1	AC/DC	3151-0016
1A6	LMI	0130-7530
1A6A1	IEC-1000	3157-0001

1A6A2	Interface	0130-7530
1A7	IFB	0130-3410
1A8	VSWR Monitor	0130-7310
1A9	RF Detector	0330-7330
1A10	RF Detectors	0332-7330

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9. INSTALLATION AND SETUP

9.1. INTRODUCTION

The site must be carefully selected and prepared for the installation of DME. Prior to the installation work, the equipment should be removed from shipping containers and unpacked for inspection as soon as possible to ensure that it is complete and intact in terms of numerical quantity and mechanical quality. Any discrepancy or damage shall be immediately reported. Each inspected item is to be repacked to prevent damage and kept in a dry storage until they are unpacked again as needed during the installation procedure.

Equipment grounding, main commercial power supplies, antenna mast and the input/output (I/O) connections shall be ready as appropriate. Depending on the beacon configuration selected and the options used, it may be necessary to connect the facility to the associated equipment or to other equipment.

9.2. SAFETY PRECAUTIONS

To avoid any possible accidents, strict attention should be paid to safety regulations issued by the local authorities and the following safety rules should be observed:

- Keep the safety tools (given below) ready and wear them as considered appropriate.
  - Goggles, safety gloves, sturdy shoes, safety helmets and etc.
- For emergency situation, everyone working on the installation site should be aware of:
  - escape routes (Escape routes should always be cleared)
  - the places where the First Aid Kit and Fire Extinguisher are kept in, and
  - emergency contacts such as the nearest casualty doctor, eye specialist and fire station.
- Any pointed or sharp objects are to be removed from clothing pockets while working on the site.
- Remove chains and rings especially when working with electrical devices.
- Beware of electricity.
  - Electrical devices and extension cables should be checked before you use them.
  - Fuses are to be removed before working on the main power supply.
- Alcohol is strictly prohibited.
  - Do not allow any type of alcohol to be carried into the installation site.
  - Anyone under the influence of alcohol will not be tolerated on the installation site.
- Orderly arrangement and proper use of tools
  - Sand off burr from chisels and punches.
  - Test striking tools for tightness of fit.
  - Always check ladders and planks carefully before use.
  - Do not tread on protruding plank sections.
  - Remove protruding nails, strips, etc. immediately.
  - Never leave objects on scaffolding or ladders.

- Erect sturdy scaffolding and frames and always test them thoroughly before using them.

- When the shelter (equipment room) is unoccupied, it should be locked.

9.3. INSTALLATION SITE SELECTION

In general, it is recommended to select the highest ground with level terrain in the vicinity of proposed DME site. An ideal site is that all objects are cleared for a radius of at least 3000 feet (915 meters), and no obstructions extend above the horizontal plane of the antenna within the service range of the facility. In reality, however, it is not possible to locate a site which fully satisfies such ideal requirements. Instead, every effort must be made to achieve the best site selection as far as possible.

The general location is initially determined by the type of facility; i.e. a terminal facility or an en route facility. The location of a terminal facility is constrained by the location of the airport and the orientation of the runway. The location of en route facility is determined largely by the location of the airways which they serve and, to a lesser extent, by the distance to other facilities serving the same airways. With respect to general requirements, a good site for ILS or VOR installation also satisfies the DME site requirements. Consequently the criteria for siting of ILS or VOR will be broadly applied to the site selection for collocation of DME with ILS or VOR. For reference, given below are some restrictions for siting of VOR:

- Obstructions within 1000 feet of the antenna are to be removed.

- No groups of trees should be within a 1000-foot radius or subtend a vertical angle of more than 2 degrees as measured from the antenna.

- Single trees, however, of moderate height (up to 30 feet or 9 meters) may be tolerated beyond 500 feet.

- At mountain top sites, no trees within 1000 feet should be visible from the antenna array.

- Ordinary farm-type wire fences about 4-feet high are not permitted within 200 feet of the antenna. At mountain top sites, however, wire fences may be permitted within 200 feet of the antenna if they do not extend above the line of sight from the top of the antenna to the edge of the level area; i.e. they are within the shadow area of the ground counterpoise.

- Fences of the chain type (6 feet or more in height) are not permitted within 500 feet of the antenna.

- No wire fence should extend more than 0.5 degree above the horizontal beyond 500 feet of the antenna.

- The above three requirements may be relaxed for fences essentially radial to the antenna.

- Power and control line extensions should be installed underground for a minimum distance of 600 feet (approximately 183 meters) from the antenna.

- Beyond 600 feet (approximately 183 meters), however, overhead power and control lines may be installed but should be essentially radial to the antenna for a minimum distance of 1200 feet (approximately 366 meters).

- No conductor should extend more than 0.5 degree above the horizontal plane containing the antennas, unless they are essentially radial (within ±10 degrees) to the antenna array.
- At mountain top sites, the conductors will be permitted within 1200 feet (approximately 366 meters) of the antenna, provided they do not extend above the conical surface formed by the top of the antenna and the edge of the leveled area.
- No structures should be permitted within 1000 feet of the antenna, except for buildings such as the transmitter building at a mountain top site located on a slope below the ground level of the antenna so that they are not visible from the antenna.
- Partly or entirely metallic structures shall not subtend vertical angles of 1.2 degrees or more as measured from ground elevation at the antenna site.
- Wooden structures with negligible metallic content and little prospect of future metallic additions (such as roofs and wiring) may be tolerated if subtending vertical angles of less than 2.5 degrees.
- However, at airports, where a single hangar or line of hangars, administrative buildings, etc., may have considerable length, it is necessary to look upon such structures as producing interference in the same manner as power and telephone lines, and the criteria for power, control, and telephone lines will apply.

The selection of the DME location for combination with ILS facility also depends on nearby obstacles, clearance, and runway configuration.

The site selection guidelines above are only general recommendations. The final site decision should be made locally, prior to and during installation.

EQUIPMENT SITE LOCATION

The ground beacon may be installed in a control room or inside a shelter that complies with the environmental temperature, humidity, and pressure values listed in section 4. The equipment has the following overall dimensions:

- Height: 1600 mm
- Width: 580 mm
- Depth: 610 mm

The equipment requires the following clearances:

- If rear access is required, there must be at least 24 inches between the rear part of the beacon and the wall and any piece of equipment.
- A minimum of 24 inches between the top of the beacon and the ceiling of the control room or the shelter to leave space for the external connection cables and to allow access to the antenna connector and to the antenna probes connectors.
- A minimum of 4 feet between the front of the beacon and the wall and any other piece of equipment to allow the operator to open the front door.

The base must be able to support the total weight of the equipment--about 400 pounds (200 kilograms), including the optional modules, within the range of dynamic stress envisaged for the equipment.

The beacon does not normally need securing; however, if it is to be secured to the base, use four M12 bolts.

9.4. GROUNDING

9.4.1. GENERAL

The type of grounding implemented is dependent on the local terrain. Consequently it is only possible to provide general guidelines here. Grounding conductors or rods are metallic elements of a particular form which are either driven into the ground or laid in the ground so as to cover a relatively large area. All connections in the ground must be welded and protected against corrosion. The ground resistance required for a DME (or other navigation installations) can be given as < 5 Ω. This resistance can only be measured precisely with the aid of special ground resistance measuring equipment. The exact measuring procedure is described in the operating instructions for these devices. When estimating the ground resistance the length and extent of the network laid are the crucial points, not the cross−sectional area of the conductors. Favorable resistance conditions are provided by arable land and loamy ground (ground resistivity 100 Ω per meter). The data specified below applies to these conditions. With other types of terrain the factors below must be taken into consideration (increase in the resistance with respect to the basic values stated).

- Moist sandy soil 2x
- Dry sandy soil 5 to 10x
- Gravel or stones up to 30x

If the ground is not chemically neutral, e.g. if it is salty, it may be necessary to coat all metal parts laid in the ground with lead or to use a sufficiently non-corrosive steel (e.g. V2A). The different types are as follows:

9.4.2. GROUND RODS

Ground rods are either pipes or U, L or T-shaped profiles driven vertically into the ground and 1 to 2 m in length. It is necessary to connect several ground rods together in order to reduce the grounding resistance. The minimum spacing is twice the length of each ground rod.

- Material: Steel (hot galvanized) Pipe 30 x 3 mm

Bracket L 65 x 65 x 7 mm

U−profile U 65 DIN 1026

T−profile T 60 DIN 1024

- Probable grounding resistance of a rod: Length 1 m approx. 70 Ω

Length 2 m approx. 40 Ω

The material, cross sectional areas and grounding resistance of the connecting leads to the shelter should be as for strip ground conductors. When pipe-type grounding rods are fastened with clamps, screws at least M10 in size should be used.

9.4.3. GROUND PLATES

Ground plates are solid perforated sheet metal plates with dimensions of approx. 0.5 x 1 m or 1 x 1 m, which are embedded vertically in the ground. The top edge of the plates should always be at least 1 m below the surface. Several ground plates must be connected in parallel in order to reduce the grounding resistance. The minimum spacing should be 3 m. Material:

- Sheet steel (hot galvanized) min. thickness 3 mm

- Sheet copper min. thickness 2 mm

The ground resistance of a plate 1 m^2 is approx. 30 Ω.

9.4.4. ESTIMATING THE GROUND RESISTANCE

They should be considered as parallel resistances. The resulting grounding resistance should then be calculated as follows: $1/R_{res} = 1/R_1 + 1/R_2 + 1/R_3 + ... + 1/R_n$. Taking into account the nature of the terrain satisfactory grounding conditions can be assumed if the ground resistance calculated from the base data is < 5 Ω. If the value calculated is 5 Ω or more, measuring the ground resistance is recommended.

9.4.5. MEASURING THE GROUND RESISTANCE

Three measurements must be performed over a large area in order to determine the ground resistance precisely. The distance between two auxiliary grounds required must be large in relation to the complete ground network of the navigation installation. Two steel rods approx. 1 m long should be used as auxiliary grounds (reinforcing bars); these should be driven into the ground with only a few centimeters remaining at the designated points. It is essential that the rods are of equal length and are driven in to the same depth.

Measurements are performed as shown in the diagram below:

E = Installation ground

H_1= Auxiliary ground 1

H_2= Auxiliary ground 2

M_1= Measured value 1

M_2= Measured value 2

M_3= Measured value 3

Measured value 1: Resistance between installation ground and auxiliary ground 1

Measured value 2: Resistance between auxiliary ground 1 and auxiliary ground 2

Measured value 3: Resistance between installation ground and auxiliary ground 2

When the three measurements have been performed the ground resistance is calculated as follows:

Ground resistance = (corr. meas. 1 + corr. meas. 3 − corr. meas. 2) / 2

The measurement is falsified by the resistance of the two test leads. The cross−sectional area of the test leads should not be less than 1.5 mm^2 in order to ensure an adequate breaking strength. With this cross−sectional area and an assumed length of 2 x 25 m = 50 m, the falsifying resistance would be 0.58 Ω. This resistance should therefore be measured and deducted from measured values 1, 2 and 3. The measured values corrected in this manner are entered into the above formula.

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