

DTR100
Multimode Integrated Transmitter and Receiver for
ATC applications

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DTR 100

Multimode Integrated Transmitter and Receiver for ATC Applications

1. INTRODUCTION

The future VHF communications scenario in the ATC environment is complex and still on the move.

For this reason, traditional radio equipment have to be substituted by multi-mode ones, which will be able to be easily updated and re-configured in terms of modulations, channel spacing and interface to external controllers. The DTR 100 has been developed on a DSP-based, software radio approach, in order to satisfy both present and future ATC communications requirements. Moreover, its high grade of immunity to external interference meets co-siting requirements in critical installations.

The basic product idea is to develop an *"Integrated Transmitter and Receiver"*, instead of the classical "Transceiver".

It can be used as classical Transceiver with internal antenna relay, or like an "integrated in one shelf" Transmitter and Receiver, with separated VCO but sharing the common modules, i.e. Base Band, Command and Control, Power Supply and Line Interfaces. This configuration has all the advantages of separated Transmitter and Receiver but with a consistent money and space saving. This architecture is also optimised for VDL digital modes, in particular for modes 2 and 4, in which stringent requirements about turnaround times, from TX to RX and vice-versa, have to be satisfied. Anyway separated Transmitter (DT 100) and Receiver (DR 100) are available for dedicated TX and Rx sites.

1.1 GENERAL FEATURES

1.1.1 Frequency band and modes of operations

The DTR 100 operates in the 108÷156 MHz band, which includes:

- *The traditional ICAO band (117,975 ÷ 136.975 MHz);*
- *The military upper band (137 ÷ 156 MHz);*
- *The future VDL - 4 band (108 ÷ 136.975 MHz).*

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The equipment is set-up configurable for various modes of operation. This means that the new radio allows the change of modulation standard without manual intervention on the radio hardware configuration.

1.1.2 Amplitude Modulation with 25 kHz channel spacing

It is possible to select the channel spacing, with consequent change of performances (e.g.: RF features, audio circuits performances), by local or remote set-up configuration command, without manual intervention on hardware configuration.

With 25 kHz channel spacing, the following features are provided:

- AM-DSB modulation and demodulation (A3E), according to ETS 300 676 and ICAO annex 10 requirements;
- Carrier offset facility, set-up selectable from 2 to 5 frequencies, according to ICAO annex 10 requirements;
- A Noise Blanker, implemented by DSP technique, is set-up selectable.

1.1.3 Amplitude Modulation with 8,33 kHz channel spacing

With 8.33 kHz channel spacing, the following features are provided:

- The passage from 25 kHz channel spacing to 8,33 kHz is accomplished by the insertion of an IF digital filter, without use of additional hardware modules;
- AM-DSB modulation and demodulation with narrow-band features, according to ETS 300 676 and ICAO annex 10 requirements;
- A Noise Blanker, implemented by DSP technique, is set-up selectable.

1.1.4 ACARS mode

The equipment can support ACARS data link protocol in two different ways:

- By connection to a commercially available external modem (AM-DATA mode);
- By AM-MSK modulation and demodulation @ 2.4 Kbit/s, supporting physical level of ACARS data link protocol (character oriented according to ARINC 618 requirements).

1.1.5 VHF data link mode 2

The VHF Data link mode 2 allows point to point data link between airborne radio equipment and ground stations.

It is based on D8PSK modulation, in 25 kHz channel spacing; the physical media access is realized on CSMA scheme, featuring p-persistency algorithm for access optimisation.

When operating in VDL 2, the equipment provides full support to physical layer functionality, according to ICAO annex 10, ICAO Manual on VHF Digital Link (VDL) mode 2 Technical Specifications, and ETSI EN 301 841-1. This includes following tasks:

- D8PSK modulation and demodulation @ 31.5 Kbit/s
- Scrambling and de-scrambling

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- Packet header handling
- Interleaving
- Reed-Solomon channel coding and decoding
- Signal quality evaluation
- Channel sensing process handling with proper “busy/idle” information towards the link layer

The Media Access Control sub-layer (part of link layer), and therefore the channel access handling, is anyway implemented inside the equipment, according to previously mentioned ICAO reference documents and ETSI EN 301 841-2.

1.1.6 VHF data link mode 2 GBAS

The VHF Data link **mode 2 GBAS (Ground Based Augmentation System)** allows ground stations transmission data towards airborne radio equipment.

It is based on D8PSK modulation, in 25 kHz channel spacing as VHF Data link mode 2; but it is based on TDMA scheme in which a 500 ms frame is divided into 8 slots.

Concerning ground stations, this mode is intended as transmission only. A receiver may be used as monitoring of the ground station transmission.

When operating in VDL 2 GBAS, the equipment provides full support to physical layer functionality, according to RTCA DO246.

1.1.7 VHF data link mode 3

The VHF Data link mode 3 allows up to 4 simultaneous connections, with several combinations of digital voice and data, in 25 kHz channel spacing.

It is based on D8PSK modulation as the VDL 2, while the physical media access is realized on TDMA scheme, each frame composed by 4 timeslots (3 timeslots in a special sub-mode configuration intended for long range coverage tasks).

When operating in VDL 3, the equipment provides full support to physical layer functionality, according to ICAO annex 10, ICAO Manual on VHF Digital Link (VDL) mode 3 Technical Specifications, and FAA-E-2938 v.3.0. This includes following tasks:

- D8PSK modulation and demodulation @ 31.5 kbit/s;
- Scrambling and de-scrambling;
- Training sequence detection and management;
- Packet header handling, included FEC header channel coding;
- Synchronisation of TDMA timing to an external UTC time source.

According to FAA-E-2938 v.3.0, the Media Access Control, and therefore the TDMA framing structure handling, is implemented outside the equipment.

1.1.8 VHF data link mode 4

The VHF Data link mode 4 (this standard formerly known as STDMA protocol) allows operating data links onto a common shared channel resource, in 25 kHz channel spacing.

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This application is targeted to VHF data networks for CNS/ATM broadcast applications like ADS-B, TIS-B, FIS-B, GRAS and it shall provide support to point-to-point communications.

VDL 4 is based on GFSK modulation, while the physical media access is realised on a self-organising TDMA scheme.

When operating in VDL 4, the equipment provides full support to physical, MAC and VSS sublayers functionality, according to ICAO annex 10, ICAO Manual on VHF Digital Link (VDL) mode 4 Technical Specifications, and ETSI EN301 842-1. This includes following tasks:

- GFSK modulation and demodulation @19.2 Kbit/s (in alternative, D8PSK @31.5 Kbit/s selectable).
- VDL 4 superframes synchronisation to the "1-minute" absolute time marking of an external GNSS reference (or equivalent UTC-slaved source).
- Scrambling and de-scrambling.
- Management of bursts reception and transmission.
- Channel (intended as timeslot) sensing process handling with proper "busy/idle" information towards the link layer.
- Channel access schemes handling, e.g.:
 - Superframe block reservation;
 - Fixed access;
 - Periodic + incremental broadcast reservation.

2. DTR 100 ARCHITECTURE

2.1 GENERAL ARCHITECTURE

The DTR100 is composed of independent modules, each of them dedicated to a specific function. The equipment can be provided in different configurations according to the type of fitted modules. The following block diagram (figure 1) highlights the modularity of DTR100.

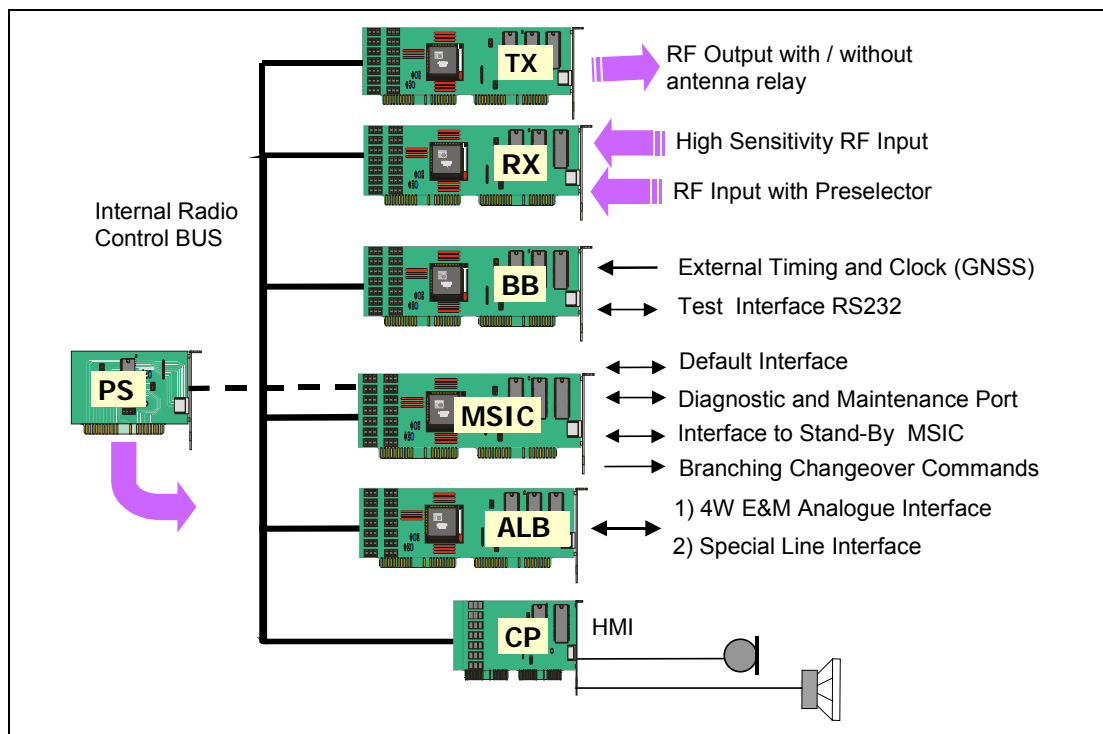


Figure 1: DTR100 block diagram

A set of main modules composes the transceiver "radio section". These modules are common to any DTR100 version:

- **Receiver module (RX).**
- **Transmitter module (TX).**
- **Base Band module (BB).**
- **Power Supply Unit (PSU).**

The operation and maintenance and local management functions are carried out by means of specific "management" modules, which are available in different configurations:

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- IMC/MSIC cards.
- Control Panel (standard and enhanced HMI).

The interface to external voice switching device (for analogue operating modes), or data link external networks, modems or station controllers (for VDL modes), are carried out by means of specific "line interfacing" cards:

- Line Barrier card (e.g. ALB_S, ALB_M).

This modular architecture allows for:

- Easy reconfiguration for transaction to any VDL modes application;
- Availability of a wide range of interface options toward external transport networks;
- Low MTTR, and easy on-field maintenance, carried out by modules direct replacing.

2.2 MODULES DESCRIPTION

2.2.1 Power Supply module (PS)

The PSU module (Power Supply Unit) generates all the voltages necessary for equipment operation; it is fed by the 115/230 VAC main voltage, and by the nominal +24 VDC backup voltage. PSU module provides the following main functions:

- Generation of +28 VDC, +13.5 VDC, +5 VDC, +3.3 VDC for all the modules.
- Over-voltage and under-voltage protection on output line.
- Output alarms generation.

Separate front panel switches are present for AC and DC supplies with its own indication. The AC is the primary power source, while the DC is the backup source, which is activated during an AC fault by an automatic line voltage switchover.

2.2.2 Receiver module (RX)

The RX module provides the full down-conversion and amplification of received RF signals and A/D conversion of the AM-DSB/D8PSK/GFSK analogue signal into a digitised I and Q format data stream.

Data stream is then sent to the Baseband module for processing via RS422 serial interface.

The RX module is based on a dual-conversion heterodyne layout, and provides the following main functions:

- RF signal Front-end filtering (band filtering/channel pre-selection).
- Received signal AM-DSB/D8PSK/GFSK selection and filtering.
- Conversion of received signal to digitised Baseband I and Q format.
- Channel synthesis for 25 kHz (AM-DSB and VDL digital modes) and 8.33 kHz (AM-DSB only)

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- Frequency programming in the range 108 to 156 MHz.
- AGC and muting functions.
- 10 MHz Reference clock filtering/recovering (clock from RF-motherboard is filtered by a local PLL, to avoid interference). This clock is used for microcontroller operations and synthesizers reference.
- Alarms and measurements collection by microcontroller.
- O&M connection with external master unit (e.g. MSIC or IMC), via RS485 interface (RCB).

The RX module is physically divided into separate boards:

- RX Board, that is functionally divided into a RF section and a digital section.
- Front-end Board, that hosts separately the RF front-end circuits.

2.2.2.1 Front-End board

Receiver features two separates RF inputs (high and low sensitivity), incoming from SMA ports on the equipment rear side, which are selected by a command (NB_WB signal) incoming from digital section.

RF signals, incoming from SMA ports, are then sent to the front-end stage.

Its function is to fulfil specifications related to the sensitivity, as providing image frequency and unwanted signal rejection.

2.2.2.2 RX board

The RX board hosts part of RF section and the digital section.

The RF section provides complete reception of RF path from the front-end input stage and transmission to IF stages. It also provides signal analogue to digital conversion.

The whole RF section is designed to receive signals within the 108 to 156 MHz frequency range. This is achieved by means of a super-heterodyne double-conversion layout.

The digital part of RX board performs three main functions:

- System control, diagnostic and communication with an external unit;
- Internal timings generation;
- Output of acquired I/Q samples through two serial lines.

2.2.3 Transmitter and Power Amplifier module (TX)

The TX/PA module provides to up-convert modulates signals, amplify it to rated 50 W CW output level with the appropriate linearity requirements, and control the output signal parameters.

I and Q format input data stream is received from the Baseband Module via an RS422 serial interface.

The TX/PA Module provides the following main functions:

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- Conversion of I and Q digital samples incoming from the Baseband module, into analogue signals to modulate them at required carrier frequency according to selected operating mode (AM-DSB, D8PSK or GFSK).
- 50 W (+47 dBm) CW RF power output, step-adjustable.
- Protection from excessive VSWR (higher than 3), with protection reset on timer expiring.
- Channel synthesis for 25 kHz (AM-DSB and VDL digital modes) and 8.33 kHz (AM-DSB only)
- Frequency programming in the range 108 to 156 MHz.
- Support for 2, 3, 4 and 5 offset channel scheme, by offset introduced on the SINTX board managed by microcontroller.
- 10 MHz Reference clock filtering/recovering (clock from RF-motherboard is filtered by a local PLL). This clock is used for microcontroller operations and synthesizers reference.
- Coaxial RF switch for common allocation of TX and RX path onto the same radiating system, still keeping available separate TX output if required.
- Monitoring of the main board parameters, e.g. forward power, reverse power and temperature.
- Alarms and measurements collection by microcontroller.
- O&M connection with external master unit (e.g. MSIC or IMC), via RS485 serial interface (RCB).

The TX module is physically divided into separate boards:

- TX board, which hosts the digital section and the exciter and modulator analogue and digital circuits.
- PA board, which hosts the RF power amplifier section.
- SYNTAX board, which hosts the RF VCO unit.

These sub-modules are mechanically coupled and they have their own connector towards the RF-motherboard. The RF outputs of the SINTX board are connected to the TX board by coaxial cables.

2.2.3.1 TX board

The TX board hosts the digital section and the modulator analogue circuits (RF section).

The digital section provides the following main functions:

- Conversion of I/Q digital samples incoming from the Baseband module, into analogue signals to modulate them at required carrier frequency according to selected operating mode (AM-DSB, D8PSK or GFSK).
- Control, management and diagnostic of the entire TX/PA module (alarms and measurements).
- Support to communication with the other modules.

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2.2.3.2 SINTX board and RF switch

The SINTX board features a dual PLL synthesiser with VCO and provides the generation of TX frequency.

The SINTX board also hosts the LED indicators driver and the RF coaxial switch driver. These drivers control respectively the LEDs on the module front panel, and the RF coaxial switch.

The coaxial RF switch (optional) allows for arrangement of the transmitter and receiver RF ports onto a common RF path, if "transceiver" layout is desired. This is achieved by external cabling suitable to route the RX and TX antenna ports to coaxial RF switch NC and NO inputs, respectively.

2.2.4 Base Band module (BB)

The Baseband module is the main processing module. It performs the signal processing and associated controls for receive and transmission processes in any of operating modes.

Moreover the Baseband module provides all reference signal clocks (locally generated, or slaved to an external GPS/GNSS interface) for the RX and TX modules operating.

The Baseband signal processing operations depend on the equipment-operating mode (analogue AM-DSB or digital modes VDL 2,3 and 4).

In addition the Baseband module features a service port on the front side allowing local O&M facility, via RS232 serial data line. This port also allows for reference oscillator alignment.

2.2.4.1 Analogue mode

In the analogues AM-DSB 25 KHz, AM-DSB 8.33 KHz and AM-DATA operating modes, the Baseband module performs operations listed below.

In transmission path:

- Modulation index control (not active in AM-DATA).
- LF filtering. Low-pass filter width depends on channel spacing operating mode (speech-only 25 KHz, speech-only 8.33 KHz, AM-DATA).
- Ramp-up and ramp-down control, referred to TX RF output power rise time and shaping.
- I/Q pre distortion for RF power stage linearity.
- PTT and transmitter power stage control signals management.

In receive path:

- Noise blanking functionality (not active in AM-DATA).
- AM-DSB demodulation and phase interpolation.
- Radio Frequency and Audio Frequency AGC (including RSSI measure and output level adjustment).
- Squelch and Muting functionality.

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- Channel selection.
- Sampling frequency conversion.

Functions common to transmission and receive paths:

- TX and RX Control signals management.

2.2.4.2 Digital mode

In digital VDL 2,3 and 4 operating modes, the Baseband module must satisfy all the Physical Layer requirements for data frame construction and digital modulation. Moreover in VDL 2 operating mode, Baseband also manages the upper layer (MAC layer) protocol.

In transmission path:

- D8PSK/GFSK modulation and Raised Cosine filtering.
- Channel coding.
- Data interleaving and scrambling. Only for VDL 2. In VDL 3 and 4 operating mode, interleaving operation is not required.
- Ramp-up and ramp-down control.
- I/Q pre distortion for RF power stage linearity.
- PTT and transmitter power stage control signals management.
- MAC layer protocol management.

In receive path:

- D8PSK/GFSK demodulation.
- Channel decoding.
- De-scrambling and de-interleaving procedure. Only for VDL 2. In VDL 3 and 4 operating mode, de-interleaving operation is not required.
- Channel sensing (CSMA). The Baseband module performs this access operation only in VDL 2 mode. In VDL 3 and 4 modes, the access procedures and all related functions are realized outside the DTR100.
- Bit Error Rate (BER) estimating.
- Signal quality measurements (BER, RSSI).
- Sampling frequency conversion and symbol synchronization.

2.2.5 Management modules

The "management" cards are those sub-units dedicated to the implementation and supporting of the equipment O&M functions. Their task is interfacing and supporting communication with external systems, monitoring and control operations of transceiver functions, and handling of the DTR100 configuration. Two types of management cards are available:

- IMC.
- MSIC.

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2.2.5.1 IMC card

The IMC (Interface and Management Card) performs the following functions:

- System configuration, control and monitoring. The IMC card operates monitoring and configuring all the modules within the equipment.
- Signalling to/from external controller. IMC performs exchanging information with external remote-controlling device, which may perform configuration, monitoring and control of the equipment.
- Data interface to Ground Station Computers for digital modes;
- Software upgrading and downloading. The IMC card provides support for software upgrading and downloading of each radio boards.
- Control Panel Management. Control Panel (CP) interface is connected to the IMC card, by using an RS232 serial communication line.
- Control signal routing. The IMC implements the routing of control signals (PTT, Squelch, etc.) and of synchronous serial lines, incoming from the Line Barrier or from the IMC microcontroller itself.
- Antenna Distribution System controls. The IMC provides an optocoupled signal input/output for connection with the antenna distribution system control device.
- Sleep/Wake-Up functionality. The IMC provides the sleep/wake-up signal, used to force in a low-power mode the modules when they are operating in idle mode (stand-by);
- Embedded main/standby selection: this is an optional functionality which allows two DTR 100 to be connected in a "1+1" configuration, in analogue mode, without the use of an external "changeover device". It is possible to select an "uniform ageing" switching criterion.

2.2.5.2 MSIC card

The MSIC (Main Stand-by Interface Card) provides more processing power than IMC, due to its MPC860 microprocessor. It performs the following functionality:

- MSIC module is the "Radio Control BUS" master controller (by means of an internal; RS485 connection), while all other modules (TXPA, RX, BB and LB) are slaved to it;
- MSIC handles the software downloading procedures, in order to update both MSIC software and the software/firmware loaded in each module. This operation can be made – by protection of a password – both from the local test interface and from a remote Network Management Station.
- MSIC controls Line Barriers modules;
- It executes the appropriate operation, testing and maintenance procedures associated to the command, control and configuration of the DTR 100. The access to these procedures depends on access type (local/remote), and interface type, according to the following table 1:

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Access type	Interface used	Available O&M functionality
REMOTE	Any Line Barrier, or Default Interface on MSIC module	Complete
REMOTE	RS422/RS485 diagnostic and maintenance port	Complete
LOCAL	Control panel display	Only a customer-defined limited subset
LOCAL	RS232 test interface	Complete

Table 1: C&C module functionality

- If the DTR 100 is configured for VDL operations, or for Analogue mode but with a digital interface, the MSIC module manages the packet multiplexing/demultiplexing on digital interface:
 - VDL packets (or PCM voice) for the external controller link;
 - O&M messages;
 - Timing information.
 The physical interface can be according to system requirements:
 - A Line Barrier;
 - The Default Interface on the MSIC module;
- Embedded main/standby selection: this is an optional functionality which allows two DTR 100 to be connected in a "1+1" configuration, in analogue mode, without the use of an external "changeover device". It is possible to select an "uniform ageing" switching criterion.

2.2.6 Line Barrier module (LB)

The LB family modules permit to extend the usability of the DTR 100 to the following system scenarios.

2.2.6.1 Analogue systems

- DTR 100 directly connected to a VSCS by means of Analogue, dedicated telephone lines (the default case);
- DTR 100 directly connected to a VSCS by means of a digital transport network (E1 / T1 interface);
- DTR 100 couple connected in "1+1" configuration (by means of a special "Analogue Line Barrier").

2.2.6.2 Digital systems

- DTR 100 connected to the Ground Computer by means of a LAN network (ETHERNET protocol);
- DTR 100 connected to the Ground Computer by means of a T1/E1 interface.

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2.2.6.3 ALB used in the DTR100

Functionality performed by the ALB is the following:

BASIC FUNCTIONS, achieved by a "standard" ALB (ALB M card):

- DAC and ADC functionality. Digital to analogue and analogue to digital conversion with audio filtering.
- Baseband interfacing. Synchronous serial line interface ALB with Baseband module.
- Electronic regulation of the AF level on telecommunication line interface (TELCO).
- PTT/Squelch coding. ALB card allows realising this function into universal E&M (Ear and Mouth) interfaces.
- Control Panel Interface. ALB provides an interface towards the Control Panel, and an audio balanced interface towards the Control Panel for local audio operation.

OPTIONAL FUNCTIONS, to be realised by the use of a "system" ALB (ALB S card):

- Line matching. ALB allows a 600 ohm telephone interface for TX path and configurable 600/1200/2400 ohm telephone interface for RX path.
- Main/Standby changeover and Primary / backup line selection. ALB module allows primary / backup line changeover algorithm and the activation of Main / Standby changeover on DTR100 control module command (IMC or MSIC card). Then it requires an interface towards another ALB for Main / Standby radio and primary / backup line changeover, in order to provide a distributed 2x2 audio switch. This configuration allows connection on both lines according to main/stand-by and primary/backup changeover algorithm (as shown in the following figure). ALB also provides lines disconnection for changeover operations in case of board failure or external (IMC / MSIC) command. Moreover the ALB handles an audio delay on both primary and backup lines.

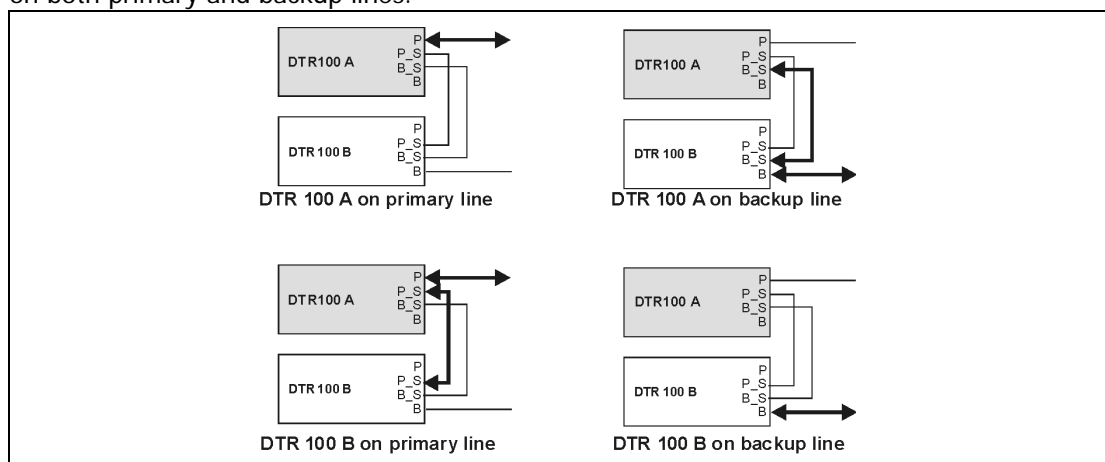


Figure 2: ALB-S switching matrix configuration

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- Electronic regulation of the Telephone Line interface (on both primary and backup lines).
- PTT/Squelch coding. ALB module allows realizing this function by tones (disabled in AM-DATA mode) for both primary and backup lines.
- Call Maintenance in-band tone generation/detection. This function is realized on both primary and backup lines and it is disabled in AM-DATA mode.
- FSK mode. Data from/to an RS485 diagnostic serial line are converted into mark/space tones in order to realize a low bit-rate FSK modem on telephone lines.
- Radio Interfacing. ALB is connected, towards the radio, by means RS422 serial interface (which carries TX and RX audio frames), the PTT and Squelch signals and the RS485 internal radio BUS for module control and configuration.

If a 2W interface is required on customer's demand, it shall be achieved by use of an additional module.

2.2.6.4 Use of tones and E&M signalling

Interface type	PTT/Squelch coding	Call maintenance criterion
4WE&M	E&M	In-band tone, alternative to voice
4W	In-band tones	In-band tone, alternative to voice

Table 2: E&M signalling

2.2.7 Control Panel (CP)

CP_STD module is the equipment-operator interface facility, in the standard version. It features both LCD display and 4-key pad for access to equipment parameter editing, and performs the interface between display/keyboard and IMC/MSIC cards. It also allows for the interface between the ancillary audio devices (e.g. headset) and the internal analogue audio bus (connected to ALB).

CP_STD module performs the following main functions:

- Electret microphone front-end (noise gating, expander, AGC, compressor);
- Earphone audio amplifier.
- Loudspeaker audio amplifier.
- Display driver interface from RS232 to TTL bus.
- Keyboard interface from TTL to RS232 bus.

As option it is available a colour touch-screen display, with more diagnostic capability. In this case, the loudspeaker is external.

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2.2.8 Composition rules

The DTR 100 “core” modules are PS-TX-RX-BB-MSIC/IMC. This is the configuration for a VDL integrated transmitter and receiver connected to a ground computer by means of the “default interface” only.

- If analogue mode of operation is required, and no changeover must be provided, the ALB_M module has to be added, while the management of the DTR 100 is performed by the RS422/RS485 diagnostic port;
- If DTR100 has to be provided in 1+1 configuration, or if special interface towards the voice switch is required, the ALB_S module has to be added;
- If special requirements about DTR 100 networking have to be satisfied, other Line Barriers can be added (e.g., E1 interface);
- For digital modes of operation with full handling of VDL layer-2 functionality, MSIC module is used.

2.3 MECHANICAL DETAILS

The equipment is designed on full-modularity philosophy, allowing easy replacement of defective modules in case of failure, with negligible MTTR figure.

Chassis is arranged in a metallic frame equipped with relevant rack-fitting hardware.

2.3.1 Dimensions and colour

All modules described above, are housed in a standard shelf with the following features:

- Height: 3U (133.35 mm) units;
- Width: 84TE for 19” rack standard fitting;
- Depth: 38533 mm;
- Weight: 136 Kg.
- Colour: RAL 5005 light blue

2.3.2 Connectors

Function	Position	Type
RF connectors:	Rear	<ul style="list-style-type: none"> • RX input high sensitivity: SMA-type • RX input standard: SMA-type • TX output port: N-type • RF coaxial switch N.C. & N.O. : 2xSMA-type • RF coaxial switch common: N-type
Analogue lines connections:	Rear	8 poles RJ45 type
IMC data:	Rear	8 poles RJ45 type
IMC control facilities:	Rear	2x8 poles RJ45 type
RS 485 DIAG interface:	Rear	8 poles RJ45 type

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TEST interface:	Front	12 poles HIROSE RP17 type
HEADPHONE / MIC & PTT:	Front	12 poles HIROSE RP17 type
Service interface:	Rear	9 poles D type
AC power supply:	Rear	IEC 320 socket
DC power supply:	Rear	Single pole cable lock
GPS/GNSS interface:	Rear	9 poles D type
10 MHz external reference interface:	Rear	SMA type

Table 3: DTR100 connectors

2.3.3 Modules allocation and accessibility

All modules are allocated as detailed in the following figures 4, and photos 1 and 2:

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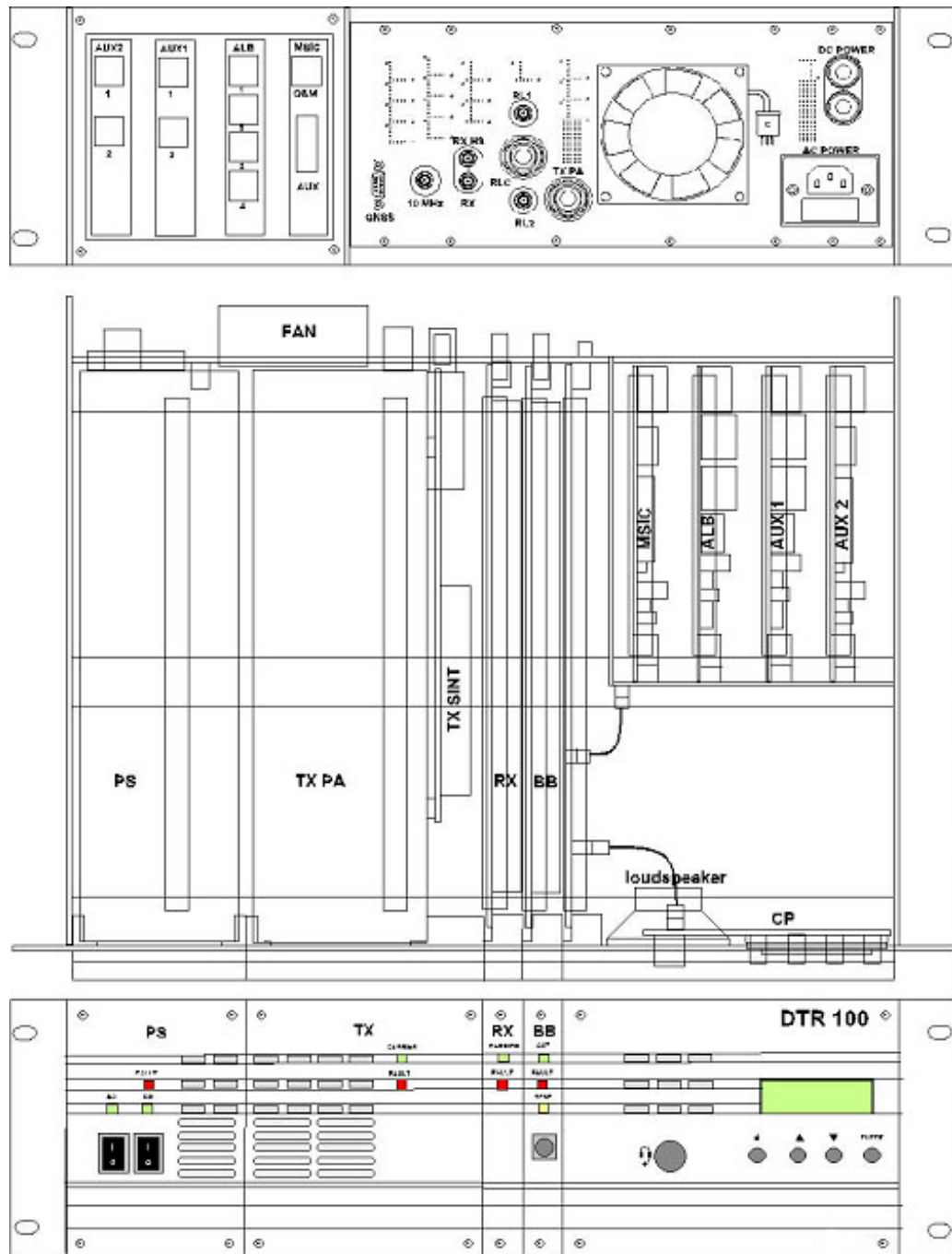


Figure 3: modules allocation

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The DTR 100 front view is the following:

“Standard HMI” display version



Photo 1: standard version

“Enhanced HMI”: ¼ VGA touch-screen display version



Photo 2: enhanced version

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3. TRANSMITTER ELECTRICAL FEATURES

3.1 GENERAL

Features	Description and Value				
Output Power:	Selectable from 40 dBm to 47 dBm (0.5 dB steps)				
Frequency Stability:	<ul style="list-style-type: none"> ± 1 ppm ≤ ±0.3 ppm (option) external high precision source 				
RF Power Rise Time:	<ul style="list-style-type: none"> Reference time (rt): centre of the first symbol of the synchronisation sequence Output power level = - 40 dBc @ 5,5 symbol periods before (rt) 90% of nominal output power @ 2 symbol periods after (rt) 				
RF Power Release Time:	<ul style="list-style-type: none"> Reference time (rt): centre of the last information symbol. Output power = -40 dBc @ 2 symbol periods after (rt) 				
Transmitter Power Leakage:	Transmitter in OFF state ≤ - 83 dBm				
VSWR	Feature referred to 2 :1; unconditionally stable up to 3:1				
Transmitter Protection:	Operation with short / open circuit without any damage. TX/PA shut down when the VSWR ≥ 3:1 (nominal).				
Transmitter Duty Cycle:	The transmitter can work in two set-up selectable modes: <ul style="list-style-type: none"> Discontinuous mode with set-up selectable TX timeout (0 to 5 minutes) Continuous mode : 100% at maximum power output 				
Intermodulation Attenuation:	Interfering signal level = - 20 dBc Third order intermodulation products level ≤ - 50 dBc				
Conducted Spurious Emission:	Frequency range	Tx St-by (dBm)	Tx active mode (dBm)		
	From 9 to 150 kHz	- 57	- 46		
	From > 150 kHz to 30 MHz	- 57	- 46		
	From > 30 MHz to 1GHz	- 57	- 36 harmonics - 46 non-harmonic		
	From > 1 to 4 GHz	- 47	- 30 harmonics - 40 non-harmonic		
Spectral Emissions:	Offset (kHz)	25	50	100	1000
	Power (dBm):	18	- 28	- 38	- 65
	Note: at ±25 kHz, the spectral emission is measured on a 16 kHz bandwidth				

Table 4: transmitter electrical features

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3.1.1 AM modulation performance

Features	Description and Value
L.F. Input Range Level:	set-up selectable from -30 dBm to +10 dBm
Modulation Compression:	According to ETSI EN 300 676
maximum modulation depth:	95%
Distortion:	$\leq 5\%$ @ 90% modulation 1 kHz test tone @ 50 W RF power
Noise:	$N/(S+N) \geq 45$ dB @ 80% modulation (1 kHz tone)
Residual Fm Modulation :	± 1 kHz
L.F. frequency response:	According to ETSI EN 300 676 <ul style="list-style-type: none"> • 25kHz spacing: 300Hz to 3400Hz (-4dB to +2dB wrt 1kHz level) • 8.33kHz spacing: 350Hz to 2.5kHz (-4dB to +2dB wrt 1kHz level)
Group delay (AM-Wide Band):	< 60 ms @ 1,2 kHz & 2,4kHz
Keying Time (Local /Remote):	≤ 35 ms

Table 5: AM modulation performance

3.1.2 D8PSK modulation performance

Features	Description and Value
Symbol rate:	10,500 symbols/sec ± 2 ppm
Bit rate:	31.5 kbit/s
Error vector modulation:	$\leq 6\%$

Table 6: D8PSK modulation performance

3.1.3 GFSK modulation performance

Features	Description and Value
Bit Rate:	19,200 bps $\pm 0.005\%$
Modulation index:	0.25 ± 0.03
BT:	0.28 ± 0.03

Table 7: GFSK modulation performance

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4. RECEIVER ELECTRICAL FEATURES

4.1 GENERAL

Features	Description and Value			
Input impedance:	50 ohm			
Sensitivity:	<ul style="list-style-type: none"> 25 kHz and 8.33 kHz AM-DSB modulation: 12 dB SINAD with - 107dBm, @30% AM 25 KHz D8PSK modulation: - 100 dBm with uncorrected BER = 10^{-3} 25 kHz GFSK modulation: - 100 dBm with uncorrected BER = 10^{-4} 			
Receiver dynamic range:	Digital / Analogue mode		Analogue mode	
	nominal performances up to - 7 dBm RF input		up to +13 dBm RF signal with 3 dB degradation	
Frequency stability:	± 1 ppm (VCO standard) Frequency stability can be monitored by the test interface connector			
Adjacent channel rejection:	25 kHz (Analogue and digital modes)		8.33 kHz	
	- 80 dB @ ± 10 kHz		- 60 dB @ ± 3.5 kHz	
Image and spurious response rejection:	≥ 80 dB			
Spurious emissions:	Environ. phenomena	Freq. range	Test limits Rx	Reference bandwidth
	According to ETSI EN 300 676			
Cross modulation rejection:	AM (25 & 8,33 kHz) ≥ 85 dB @ ± 1 MHz (interfering signal offset)			
Third order intermodulation rejection:	≥ 75 dB @ ± 500 kHz			
Receiver overvoltage protection:	+ 25 dBm			
Blocking:	Adjacent channel protection: 60 dB, according to ETSI EN 300 676			
	nominal receiver performance: -104 dBm wanted input signal with the following alternative unwanted signals:			
	• Level:	-10 dBm	-4 dBm	-4dBm
	• Modulation:	none	none	none
	• Band (MHz):	108 to156 MHz	108 to 156 MHz	87.5 to 107.9 MHz
	• Offset	± 500 kHz		
	• Guard margin	-----	3 MHz	10 MHz
AGC features:	AM (8,33 & 25 kHz) modulation			
	<ul style="list-style-type: none"> demodulated signal variation: ± 3 dB from - 107 dBm to - 7 dBm stabilisation time: ≤ 40 msec D8PSK modulation <ul style="list-style-type: none"> Nominal BER performances: from - 100 dBm to - 7 dBm stabilisation time: ≤ 238 msec (2,5 symbols @ 10,5 ksymb/sec) 			

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AM modulation Noise immunity:	6 dB degradation of sensitivity with: <ul style="list-style-type: none"> • wanted signal : modulation 90% @ 1 kHz • interference signal: <ul style="list-style-type: none"> - co-channel pulsed signal - pulse repetition: 60 Hz - pulse width: 10 msec - waveform: Rise and decay time \leq 1 msec - RF peak amplitude: 90 dBμV x msec
--	---

Table 8: receiver electrical features

4.1.1 AM demodulation performance

Features	Description and Value
Squelch functionality:	RSSI-based and C/N based <ul style="list-style-type: none"> • C/N threshold: 5 dB to 20 dB SINAD • RSSI threshold: -107 to -67 dBm • Squelch hysteresis: 2 dB to 8 dB range • L.F. level squelch attenuation: 60 dB Carrier Override <ul style="list-style-type: none"> • Override threshold: - 107 to -67 dBm
Audio Frequency output:	<ul style="list-style-type: none"> • -30 to +10 dBm (line interface) • 2W (loudspeaker)
Automatic audio level control:	Audio variation: \leq 2 dB (modulation from 30% to 95%)
Distortion:	\leq 5%
Audio noise:	$N/(S+N) \geq$ 45 dB @ 80% modulation (1 kHz tone)
Group delay (AM-Wide Band):	$<$ 60 ms @ 1,2 kHz & 2,4kHz

Table 9: AM demodulation performance

4.1.2 D8PSK and GFSK demodulation performance

Feature	Description and Value
Frequency capture range:	\pm 826 Hz.
Symbol rate capture range:	50 ppm
Doppler rate:	Nominal performances with: <ul style="list-style-type: none"> • doppler frequency variation = 18 Hz/sec • doppler shift range = \pm 282 Hz

Table 10: D8PSK and GFSK demodulation performance

5. DTR 100 INTERFACES

5.1 STANDARD INTERFACES

5.1.1 GPS/GNSS – Synchronisation Interface

- RS232 for UTC time information;
- 1 pps TTL square-wave as high stability reference for TDMA/STDMA frame synchronisation;
- Typical precision: 0.001 ppm.

This interface is located on BB module.

5.1.2 10 MHz external reference

It is possible to synchronise the internal reference clock for TX and Rx VCO with a high stability source, this interface is located on BB module.

5.1.3 Microphone/headphone interface

Input/output on the CP module.

5.1.4 Analogue remote interface

- 600 ohm balanced output to VSCS, or any Remote Command Unit;
- PTT/Squelch are received /sent by E&M configurable interface

This functionality is handled by Analogue Line Barrier module.

5.1.5 Diagnostic interface

The interface speed can be configured up to 56 Kbit/s. At higher protocol levels, the DTR 100 acts like a slave peripheral, which has to be connected to a master controller, through a proprietary protocol. The "management" card (IMC/MSIC) handles this interface.

5.1.6 Test interface

This is an RS232 interface, which allows a Local Management Terminal for Operation, Testing and Maintenance purpose. The terminal can be a "dumb" terminal or a PC with terminal emulator software.

The access is protected by appropriate login/logout procedures, together with a password exchange.

5.1.7 Default interface

This interface is used in VDL modes, with the following features:

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- Physical layer: synchronous RS422; max. bit rate : 128 Kbit/s (programmable);
- Link layer: HDLC;
- Upper layers:
 - **VDL2**: according to ARINC 750-3 ASIP interface (VDL2). This requires the packet multiplexing of VDL data, O&M data and external timing information.
 - **VDL3**: according to FAA MDR-RIU ICD standard
 - **VDL4**: proprietary protocol.

The "management" card (IMC/MSIC) handles this interface.

5.2 SPECIAL INTERFACES

5.2.1 Analogue interface with embedded changeover unit

This enhanced Line Barrier module performs the same functions as the "Analogue remote interface", with the following additional interfaces:

- Configurable 600/1200/2400 ohm telephone interface for RX path.
- PTT/Squelch in-band tones are programmable (default : 2040 Hz);
- In order to allow line presence detection by an external controller (VSCS), a "call maintenance tone", with programmable frequency, can be generated by this module in absence of DTR 100 reception;
- This module can be connected to another module in a different DTR 100, by means of changeover relays, in order to achieve "1+1" configurations without the use of an external changeover unit.

A dedicated Line Barrier module performs this functionality.

5.2.2 Optional digital interfaces

These interfaces are optional and can be hosted in other Line Barrier modules:

- ETHERNET 10 / 100 base T interface for VDL modes;
- T1/E1 interface, according to ITU-T G.703 / G.704 physical layer requirements, for both Analogue and VDL modes.

5.2.3 Antenna Relay

The relay can be used for Tx / Rx switching, if the transceiver configuration is chosen, or Tx Main / Tx Stand-By service, for separated Tx / Rx configuration. The switching command automatically comes from "management" card (IMC/MSIC).

6. OPERATION

6.1 AVAILABILITY

The DTR 100 Mean-Time-Between-Failure (MTBF) is greater than or equal to 45,000 hours and 10 years life cycle.

6.2 MONITORING AND CONTROL

6.2.1 Front panel LEDs

	GREEN	RED	YELLOW
Power Supply:	PS OK	PS ALARM	
Transmission:	Power Amplifier is transmitting	TX OR-ALARM	
Reception:	Carrier detection	RX OR-ALARM	
BB:	When lit, the radio equipment is in ACTIVE state, i.e. it is the radio which transmits/receives in a main/stby couple	OR-ALARM of BB, MSIC and LB modules	When lit, the radio equipment is in OFFLINE state

Table 11: front panel LEDs

6.2.2 Frequency management

- The DTR100 radio equipment permanently stores a table with at least 120 pre-set channels;
- A proper frequency-channel association command allows to store the required frequencies;
- It is possible to independently select the frequency or the channel, if a proper association exists for the specified channel;
- The selected frequency is coordinated with the mode of operation, which has the priority over the frequency. Therefore, if the radio equipment is in AM-8.33 kHz mode, it does not accept 25 kHz- spaced frequencies;
- The channel labelling for frequency displaying on CP is aligned to the EUROCONTROL indication.

6.2.3 Control Panel functionality

The following information are presented:

- Frequency/channel;
- Mode of operation;
- Active / not active (in general : status);

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- Local/Remote;
- Alarm status (if any);
- Offset mode indication;
- Squelch on/off.

It is also possible to perform and monitor all radio equipment settings, type of alarm and measurements.

6.2.4 DTR100 radio equipment parameters

6.2.4.1 Commands and settings

1. Power-On Self Test
2. SW/HW/FW configuration management
3. Configuration read-back: it is possible to determine which modules are allocated inside the radio equipment, with which HW/FW/SW versions.
4. Local/Remote control setting
5. RF relay switch mode (Main/Stby or TX/RX)
6. Alarm / alert threshold settings
7. Set mode of operation
8. Set equipment status (active – not active – offline : it can be useful for site certification and testing)
9. Set highest tunable frequency (137 /156 MHz)
10. Set frequency
11. Set channel
12. Frequency – channel association
13. Set single channel mode
14. Offset mode setting (order and offset value)
15. PTT time-out setting
16. Set PTT (to be enabled in OFFLINE status only)
17. Tx power level setting
18. Modulation depth setting
19. Tx line attenuation (primary and backup)
20. RX input selection (high sensitivity / low sensitivity)
21. RX line attenuation (primary and backup)
22. Squelch On/Off
23. Squelch thresholds setting (RSSI – C/N – override)
24. Squelch hysteresis threshold setting
25. Noise blanker activate / deactivate
26. VDL2 physical layer parameters setting (max. AVLC frame length)
27. VDL2 MAC layer parameters setting (persistence “p” – TM1 – TM2 – M1)
28. VDL2 AVLC frame address list
29. VDL2 GBAS Station Slot Identifier (SSID)

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30. VDL4 physical layer parameters setting (max. transmission length)
31. VDL4 MAC layer parameters setting (M1 - M2inc - M2limit)
32. VDL3 physical layer and T1 interface parameters setting

6.2.4.2 Monitoring parameters

The same as previous paragraph list (GET instead of SET)

6.2.4.3 Alarms / Alerts

Each module of the DTR100 radio equipment reports its fault condition, or "alert" state of some measurement. More detailed alarms/alerts are obtained on request:

1. High VSWR
2. RF amplifier excessive temperature
3. Excessive RF residual carrier (D8PSK)
4. TX low power
5. Synthesizer unlocked
6. Absence of TCXO signal
7. Absence of GNSS signal (VDL2, VDL2-LAAS, VDL4)
8. Bad built in test response (all modules)
9. DSP and/or FPGA error (relevant modules)
10. Power supply alarms: absence of inputs (220V, 24V), and absence of outputs (13.5, 5, 3.3V); PS overload

6.2.4.4 Measurements and notifications

1. TX RF output power
2. Current VSWR
3. Modulation depth
4. RX field level (RSSI)
5. Status of primary / backup line (if ALB_S is used)
6. Signal quality notification (AM / VDL2 / VDL4);
7. BER estimation (VDL modes);
8. Channel / slot busy or idle condition (VDL2 / VDL4)
9. Channel occupancy (VDL2 only)
10. VDL3 physical layer monitoring parameters
11. In-Service Time
12. RF amplifier temperature
13. Power Supply (AC and DC)

6.2.5 Embedded main/standby configuration

This is in general valid whenever the ALB_S is used.

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6.2.5.1 Settings

1. Number of PTT transactions (for TX uniform aging);
2. Number of connecting lines;
3. Manual changeover;
4. ALB_S parameters configuration:
 - Primary line handling:
 - Presence;
 - PTT/Squelch mode (tones / E&M);
 - PTT/Squelch tones frequency, threshold and amplitude;
 - FSK enable/disable;
 - FSK tones amplitude and threshold;
 - Call maintenance tone enable/disable;
 - CM tone frequency, threshold, amplitude and insertion delay;
 - Line delay equalization
 - Backup line handling: same as previous

6.2.5.2 Status

1. Line status;
2. Changeover status

6.2.6 Line Barrier modules control and monitoring parameters

When a digital line barrier is used (e.g., the T1/E1), the external TDMA frame synchronization source is selectable between the 1-pps coming from the GNSS interface, and a proper timing signal coming from the LB module.

6.2.7 Testing requirements

These measurements require external test fixtures.

- Loopback test of primary and/or backup line (presence of ALB_S);
- Transmitter modulation index or EVM measurements;
- Receiver SINAD or BER measurements;
- Frequency reference monitoring.

6.2.8 Software downloading

All relevant operating parameters, together with the SW/FW relevant for each mode of operation, are downloadable either from a local management terminal (on TEST interface), or from the remote RS485 diagnostic O&M port.

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6.2.9 Event logging

It is possible to maintain a LOG file of alarms, alerts and operations in "local" mode inside the DTR100 radio equipment, whenever MSIC module is fitted.

6.2.10 Local / Remote operations

It is possible to put the DTR100 radio equipment in OFFLINE status for local operation. When the radio equipment is handled locally, the remote operator is notified about it and can only perform monitoring – and not setting - operation.

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7. ENVIRONMENTAL CONDITIONS

Function	Value
Temperature / humidity:	<ul style="list-style-type: none"> • Temperature range: -20° to + 50° C • Relative humidity: 5 to 90%
Non-operating / storage environment:	<ul style="list-style-type: none"> • Temperature range: -40° to + 70° C • Relative humidity: 100%
Altitude (operational):	15000 ft. (MLS)
EMI / RFI:	<ul style="list-style-type: none"> • According to CEI-EN specifications for CE marking • According to ETSI 300 489 specifications
Safety:	According to EN 60950 (4 th edition – 2000) and EN60215 specifications

Table 12: environmental conditions

7.1 POWER SUPPLY CONDITIONS

Function	Value
Power supply:	<ul style="list-style-type: none"> • AC: Nominal 110/230 V (full range: 88 to 265 V); 50/60 Hz • DC backup: 24 V (full range: 21 to 32 V)
Power consumption:	<ul style="list-style-type: none"> • 350 W maximum (transmission state) • 50 W (standby and RX state)

Table 13: power supply conditions

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