MO-180

MODULADOR SFN/MFN DVB-T/H

SFN/MFN DVB-T/H MODULATOR

- 0 MI1505 -

PROMAX

SAFETY NOTES

Read the user's manual before using the equipment, mainly " SAFETY RULES " paragraph.

The symbol ⚠ on the equipment means "SEE USER'S MANUAL". In this manual may also appear as a Caution or Warning symbol.

Warning and Caution statements may appear in this manual to avoid injury hazard or damage to this product or other property.

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SFN/MFN DVB-T/H MODULATOR
MO-180

[1]

1 GENERAL

1.1 General description

The **MO-180** is an SFN/MFN DVB-T/H modulator fully compliant with the DVB-T/H standards ETSI EN 300 744 v1.5.1 (including annex F referring to DVB-H), ETSI TS 101 191 v1.4.1 (SFN synchronisation) and ETSI EN 300 468 v1.8.1 (DVB-SI). The modulator inputs consist of an MPEG-2 transport stream (TS) in DVB-SPI or DVB-ASI format, a 10 MHz GPS reference and a 1pps GPS reference. The GPS inputs are used in combination with the Megaframe Initialisation Packet (MIP) embedded in the transport streams for SFN synchronisation purposes. The outputs are DVB-T/H signals COFDM-modulated and up-converted to IF and RF.

The **MO-180** supports 2k, 4k and 8k modes, as well as hierarchical transmission, and it could be used in Multi Frequency Networks (MFN) and Signal Frequency Networks (SFN). Digital coding and modulation are implemented by means of programmable logic devices using intellectual property developed by PROMAX. This makes the design highly flexible, allowing to tailor it to any particular application, and offering plenty of features at low cost.

Highlights of this product are:

- Fully compliant with the DVB-T/H standard.
- Seamless automatic switching between DVB-ASI inputs.
- 2k, 4k and 8k carriers.
- Hierarchical and non-hierarchical modulations.
- SFN and MFN (Master and Slave operation) modes.
- Filtering of up to 16 TS PIDs.
- Channel bandwidth of 5, 6, 7 and 8 MHz (user selectable).
- Locks to internal/external 10 MHz reference or to incoming TS data rate.
- Frequency agile (resolution of 1 Hz).
- Crest factor reduction followed by non-linear pre-distortion.
- High MER (> 38 dB in RF typical, > 43 dB in IF typical).

[1] *Trade Mark of the DVB Digital Video Broadcasting Project (4660).*

English

1.2 Functional description

The **MO-180** is a professional SFN/MFN DVB-T/H modulator contained in a 19" 1U chassis. The unit has three selectable MPEG-2 TS inputs (two serial ASI inputs and one parallel SPI input). Either of these inputs can be used to modulate the COFDM signal in both hierarchical (one TS input) and non-hierarchical (two TS inputs) modes. An additional test TS can be generated internally in the modulator. This allows to generate compliant DVB-T/H signals even in the absence of a valid TS input.

The modulator has a one pulse per second GPS input (1pps) and a 10 MHz GPS input. These are used in combination with the Megaframe Initialization Packet (MIP) carried in the transport streams to achieve synchronisation inside an SFN network. The 10 MHz input can also be used in MFN networks to frequency lock the IF and RF outputs to a common reference. A loop-through 10 MHz output is also available. The input impedance of both the 1pps and 10 MHz inputs can be set to 50 Ω or high impedance.

In MFN networks we can operate the modulator in master and slave modes. In slave MFN mode, the useful bit rate at the TS input to the COFDM modulator has to be the one defined in document ETSI EN 300 744 for each choice of DVB-T/H transmission parameters. The modulator automatically synchronises its internal clock to the incoming TS packet rate. The slave mode allows to use one TS input with constant bit rate in non-hierarchical modes. When using hierarchy, the user has to choose which TS (HP or LP) the selected TS input is mapped to. This is the stream the modulator actually synchronises to. The other hierarchical TS is generated internally as a PRBS test sequence.

The input bit rate in slave mode should be within 0.1‰ of the values specified in the DVB-T/H standard (see Section 4.14 for actual figures) and approximately constant. This operating mode is useful when re-modulating an off-air DVB-T/H signal with the same parameters without the need to demultiplex and re-multiplex the transport stream (as it would be the case in master mode).

The lock-in range of the **MO-180** with respect to the TS rate is typically greater than that of a COFDM demodulator. It's thus possible that the modulator is perfectly synchronised in slave mode and, however, a DVB-T/H receiver is unable to acquire sync.

In master MFN mode, the modulator is locked to either the internal 10 MHz TCXO clock reference or to the external 10 MHz GPS reference. In this mode, the **MO-180** is able to work with any incoming bit rate as long as the net bit rate resulting from dropping all NULL packets present in the stream is strictly lower than the value given in the DVB-T/H specification for the modulation parameters in use (see Section 4.14). The input TS bit rate is adapted (bit rate adaptation) to the useful bit rate required by the DVB-T/H signal by stuffing the TS with NULL packets (packet stuffing). This stuffing process alters the sequence of PCR values embedded in the TS. These values have to be re-stamped for the resultant PCR jitter to remain within the limits specified by the DVB. In hierarchical modes, operating the **MO-180** as master has the added advantage over the slave mode of being able to use any of the three TS inputs as the HP input, LP input or both.

Whenever possible, in master MFN mode it is advised to use an input bit rate considerably lower than the nominal value given in the DVB-T/H specification. Otherwise, an input rate too close to the required value might eventually lead to overflow of the TS packet buffer implemented in the modulator.

In SFN mode, the modulator can be locked to either the external 10 MHz GPS reference, or to the internal 10 MHz TCXO, or to the input HP TS data rate. A loss of sync with the external 10 MHz reference can be used to trigger a swap of the synchronisation over to the input TS rate. This reduces the number of disruptions to the output IF/RF COFDM signals. Periodic or a periodic MIP packets are constantly monitored in the HP TS input so as to dynamically adjust the delay of the modulator for accurate SFN synchronisation. If required, a positive or negative delay offset with 100-ns resolution can be added locally.

In non-hierarchical transmissions the modulator can be instructed to seamlessly switch between ASI inputs when it detects a loss of sync in the currently selected TS input. Additionally, in SFN operation the IF/RF outputs of the modulator can be optionally muted in the presence of processing errors.

The modulator can be configured to generate any of the transmission modes listed in the DVB-T/H specification. In hierarchical modes, the HP and LP streams can be encoded with different convolution code rates. The channel bandwidth can be set by the user to 5, 6, 7 or 8 MHz as required by the application. Several test modes are available in the **MO-180** (blanking of carriers, single tone output, test TS generation, CBER and VBER injection).

Many of the configuration parameters can be optionally obtained from the MIP packet embedded in the input transport stream. This can be done in both MFN and SFN operation. By setting the Transmitter ID of the modulator we can extract from the MIP the configuration parameters which are addressed to a particular transmitter and which may differ from those of the rest of the network. The ID and centre frequency of the network can be updated in the corresponding entries of the Network Information Table (NIT).

In MFN operation, the **MO-180** is capable of filtering out up to 16 Program Elementary Streams (PES) identified by their PIDs. The MPEG-2 TS is not actually re-multiplexed because the TS tables are not updated, only the PES's are eliminated to help reduce the bit rate. This feature finds its application in, for example, trans-modulating a high-bit-rate DVB-S or DVB-C signal to DVB-T/H.

DVB-H specific options are native or in-depth interleaving for 2k and 4k carriers, and signalling of the use of time slicing and/or MPE-FEC in any of the modulated transport streams via the TPS bits transmitted in the COFDM signal. Although also optional in DVB-T, the cell ID is a mandatory parameter that needs to be defined for any DVB-H signal.

The modulator is frequency agile. The user can select an RF output frequency between 45 and 875 MHz in steps of 1 Hz. In normal operation, the IF output frequency is internally set by the modulator and varies between 32 and 36 MHz depending on the selected RF frequency. The RF output can be switched off, in which case the IF frequency is fixed at 36 MHz. The polarity of the IF/RF spectrum (inverted or non-inverted) can be selected by the user. The spectrum of the COFDM signal is spectrally shaped using a raised cosine window in order to reduce the amount of out-of-band spurious components. There is a trade-off between the size of the window and the reduction in adjacent channel interference. The choice of window size has been optimised for each combination of FFT and guard interval lengths.

The **MO-180** has been designed to work in both Multi Frequency Networks (MFN) and Single Frequency Networks (SFN). The MER measured at IF is typically above 43 dB regardless of the channel bandwidth. In RF the typical MER that can be measured with a high-end DVB-T/H receiver lies above 38 dB.

The operation of the **MO-180** is done via the front panel LCD display and controls. The modulator can be easily configured by navigating through a rather intuitive set of menus. A couple of LEDs located on the front panel signal the existence of errors in the modulator or whether the equipment is properly powered.

1.3 Specifications ⚠

INPUTS

MPEG-2 Transport Stream	Two DVB-ASI inputs, 75 Ω female BNC. One DVB-SPI input, LVDS DB-25. TS packets of length 188 or 204 bytes (automatic detection). Support for burst and continuous packet mode.
GPS Inputs	
10 MHz input	High impedance / 50 Ω female BNC. Min. 50 mV, max. +3.3V.

1pps input	High impedance / 50 Ω female BNC. Selectable active edge (high or low). Minimum 2 V, max. 5 V.
Synchronisation	
Master MFN	Internal 10 MHz TCXO or external 10 MHz GPS reference. Input TS bit rate strictly below the value given in the DVB-T/H specification. Packet stuffing for bit rate adaptation and PCR re-stamping are carried out automatically.
Slave MFN	Input TS bit rate constant and equal to the value given in the DVB-T/H document ±0.1‰ (no stuffing).
SFN	External 10 MHz reference or input TS data rate. Automatic seamless switching between ASI inputs in the event of a sync loss.

IF OUTPUT

Type	50 Ω BNC female connector.
Frequency range	Variable between 32 and 36 MHz in steps of 1 Hz; fixed at 36 MHz when RF output is off.
Spectrum polarity	Selectable via front panel controls.
Power level (average)	0 dBm (107 dBμV on 50 Ω), fixed
In-band amplitude ripple	< 0.2 dB
In-band group delay ripple	< 10 ns
Frequency stability	Better than 2 ppm
Out-of-band spectral characteristics[1]	
@ ± 3.805 MHz	0 dBc
@ ± 4.25 MHz	–46 dBc (2k), –56 dBc (4k), –56 dBc (8k)
@ ± 5.25 MHz	–56 dBc
IQ amplitude imbalance	< 0.02%
IQ quadrature error	< 0.02º
Central carrier suppression	< –55 dBc
Harmonics and spurious	< –60 dBc
MER	> 43 dB
Muting in the presence of errors	SFN only

[1] Frequencies are referred to the central frequency for an 8 MHz channel. Peak levels measured using a 3 kHz bandwidth are referred to the carriers located on either side of the spectrum. Values shown are the worst case and correspond to guard intervals of 1/32.

RF OUTPUT

Type	50 Ω N-type female connector.
Frequency range	Adjustable between 45 and 875 MHz in 1 Hz steps.
Spectrum polarity	Selectable via front panel controls.
Power level (average)	Approximately -27 dBm on 50 Ω with no attenuation. Variable attenuation of 0 to 60 dB in steps of 1 Db.
Level of harmonics and spurious	< –50 dBc.
Frequency stability	Better than 5 ppm.
MER	> 38 dB typical.
Phase noise	Better than –94 dBc/Hz @ 1 kHz.
Muting in the presence of errors	SFN only.

DVB-T/H PARAMETERS

Number of carriers	2k, 4k, 8k.
Guard intervals	1/4, 1/8, 1/16, 1/32.
Code rates (HP&LP)	1/2, 2/3, 3/4, 5/6, 7/8.
Symbol interleaver	Native and in-depth (2k & 4k DVB-H only).
Constellations	QPSK, 16QAM, 64QAM.
Hierarchical modes	16QAM and 64QAM constellations with constellation ratio α = 1, 2 or 4.
Network topology	MFN and SFN.
TPS signalling	Cell ID, DVB-H's time-slicing and MPE-FEC.
Channel bandwidth	5, 6, 7 and 8 MHz.
Parameter extraction	MIP packet or local programming

PROCESSING DELAYS

MFN	The static delay may be adjusted between 0 and 1 second with a resolution given by the DVB-T/H elementary clock period.
SFN	Dynamic delay automatically calculated from the 10 MHz GPS reference, the 1pps signal and the MIP packet embedded in the HP TS multiplex. The resolution is 100 ns. A positive or negative local delay offset may be added as long as the total delay is never greater than 1 s or lower than the inherent latency of the modulator Synchronisation accuracy better than ±200 ns. Rough estimate of the network delay from the SFN adapter output to the modulator TS inputs

TEST MODES

Carrier blanking	Blank a number of carriers (start index to stop index) within the COFDM ensemble.
Pilot carriers	Generate the pilot carriers only (continual and TPS).

Single carrier	Generate a single carrier at the channel central frequency whose level equals the average COFDM output power or is set to the maximum available. This is intended for signal level alignment
TS packet generation	Internal generation of test TS using PRBS sequences of length 15 or 23 embedded within NULL packets as specified in document ETSI TR 101 290.
PRBS generation	Map a PRBS sequence into constellation points following the guidelines of document ETSI TR 101 290.
Bit error injection	Inject bit errors at the input to the constellation mapper (results in a non-zero CBER before the Viterbi decoder) or at the input to the convolutional encoder (results in a non-zero VBER after the Viterbi decoder).

CREST FACTOR REDUCTION

Crest Factor range	8 to 11 dB in 0.1 dB steps.

NON-LINEAR PRE-DISTORTER

Correction bandwidth	> 3·the DVB-T/H complex sample rate[2]
Number of correction points	2 to 16 using linear interpolation
AM-AM table	–12 dB to +12 dB for the abscissae, –6 dB to +6 dB for the ordinates, both in 0.1 dB steps
AM-PM table	–12 dB to +12 dB for the abscissae in 0.1 dB steps, –30° to +30° in steps of 0.1° for the ordinates

ETHERNET INTERFACE

Connector	RJ45 with activity indicator LEDs.
Standard	10BASE-T or 100BASE-TX (auto-sensing).

POWER SUPPLY

Voltage	100 – 130 V_{AC}; 200 – 250 V_{AC}
Frequency	50 - 60 Hz.
Consumption	20 W.

OPERATING ENVIRONMENTAL CONDITIONS

Indoor use only	
Altitude	Up to 2000 m
Temperature range	From 0°C to 40 °C
Max. relative humidity	80 % (up to 31°C),decreasing linearly up to 50% at 40 °C

English

[2] For instance, for an 8 MHz channel the correction bandwidth is greater than 3 x 64/7 = 27.4 MHz.

MECHANICAL FEATURES

Dimensions	19" (W.) x 1.75" (H.) x 15" (D.)
Weight	6.5 kg

2 SAFETY RULES ⚠

2.1 General safety rules

* **The safety could not be assured if the instructions for use are not closely followed.**

* Use this equipment connected **only to systems with their negative of measurement connected to ground potential**.

* This is a **class I** equipment, for safety reasons plug it to a supply line with the corresponding **ground terminal**

* This equipment can be used in **Overvoltage Category II** installations and **Pollution Degree 1** environments.

* When using some of the following accessories **use only the specified ones** to ensure safety.

  Power cord CA005

* Observe all **specified ratings** both of supply and measurement.

* Remember that voltages higher than **70 V DC** or **33 V AC rms** are dangerous.

* Use this instrument under the **specified environmental conditions**.

* **The user is only authorized to** carry out the following maintenance operations:

  Replace the fuses of the **specified type and value.**

  On the Maintenance paragraph the proper instructions are given.

  Any other change on the equipment should be carried out by qualified personnel.

* **The negative of measurement** is at ground potential.

* **Do not obstruct the ventilation system** of the instrument.

* Use for the signal inputs/outputs, specially when working with high levels, appropriate low radiation cables.

* Follow the **cleaning instructions** described in the Maintenance paragraph.

* Symbols related with safety:

DIRECT CURRENT

ALTERNATING CURRENT

DIRECT AND ALTERNATING

GROUND TERMINAL

PROTECTIVE CONDUCTOR

FRAME TERMINAL

EQUIPOTENTIALITY

ON (Supply)

OFF (Supply)

DOUBLE INSULATION
(Class II Protection)

CAUTION
(Risk of electric shock)

CAUTION REFER TO MANUAL

FUSE

2.2 Descriptive Examples of Over-Voltage Categories

Cat I Low voltage installations isolated from the mains

Cat II Portable domestic installations

Cat III Fixed domestic installations

Cat IV Industrial installations

English

3 INSTALLATION

3.1 Power Supply

The **MO-180** is an equipment powered through the mains for its operation.

3.1.1 Operation using the Mains

Connect the instrument to the mains through the AC voltage connector [15] located on the **MO-180** rear panel.

Check if the mains voltage is according to the equipment specifications.

3.2 Installation and Start-up

The **MO-180** modulator is designed for use as a rack-mounted 19 inches device (1U chassis).

Switch the main switch [16] located in the rear panel to position I (power on). After a successfully start up, the equipment emits four acoustic tones to indicate that it is ready to begin operation. When the equipment is connected to the mains, the green LED **LINE** [3] remains lit.

Please see Sections 4.1 y 0 for a description of the front and rear panels.

4 OPERATING INSTRUCTIONS

WARNING:

The following described functions could be modified based on software updates of the equipment, carried out after manufacturing and the publication of this manual.

4.1 Front panel description

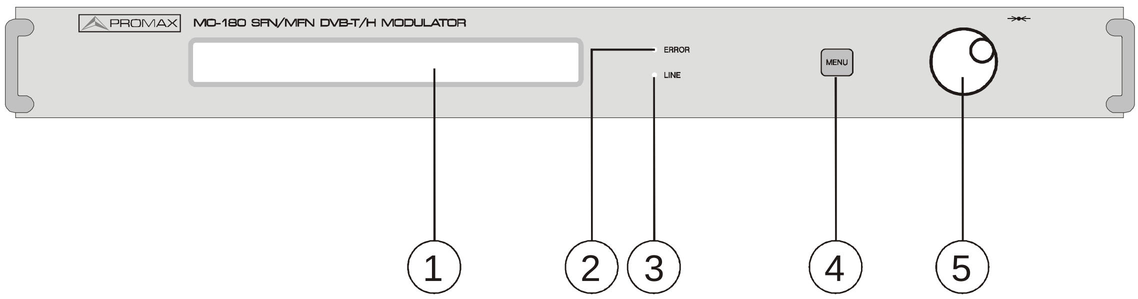


Figure1.- Front panel

[1] LCD display
With 2x40 characters crisply clear due to its white LED backlight.

[2] ERROR
RED LED has a couple of functions. For each operating second, the first tenth of that second indicates whether there are sync problems in the modulator (ON) or not (OFF). Examples are loss of TS sync or invalid input bit rates.

The remaining nine tenths of a second, the RED LED shows whether errors lasting more than 5 seconds (since the last time the error counter was cleared) are detected (ON).

[3] LINE
A GREEN LED indicator shows when the power supply is **ON**.

[4] MENU
The **MENU** key allows the user to enter and exit the menu functions, and to modify the equipment functional parameters (modulation parameters, output frequency and level, and other configuration and setup functions).

[5] Rotary encoder button.
This has many different functions: Moving accross the different display menus and sub-menus, and validating selected options.

English

When the rotary encoder is pressed, and we are modifying any equipment function, the option currently being shown on the LCD panel is selected. Turning the encoder clockwise or counter clockwise allows us to navigate through each menu function and option available in the **MO-180**.

4.2 Rear panel description

The rear panel shows, from right to left, the mains socket for AC voltage input, the fan air outlet, an RJ-45 connector for remote control via Ethernet, a parallel DVB-SPI TS input, one 10 MHz GPS loop-through output, one 10 MHz GPS input, one GPS 1pps input, two DVB-ASI TS inputs, an IF (nominally 36 MHz) output and the main RF output, at the frequency and level chosen by the user.

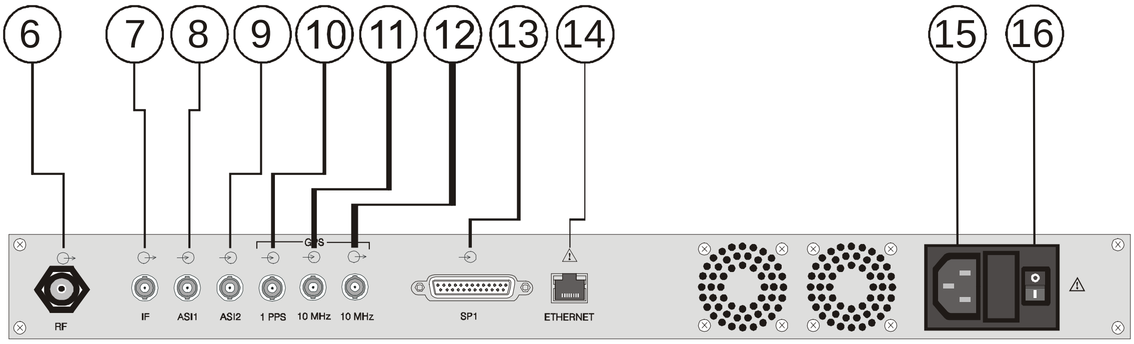


Figure 2.- Rear panel view.

[6] RF output, 50 Ω, female N-type connector.

[7] IF output, 50 Ω, female BNC.

[8] ASI1 input, 75 Ω, female BNC.
DVB-ASI input number 1.

[9] ASI2 input, 75 Ω, female BNC.
DVB-ASI input number 2.

[10] 1PPS GPS input, 50 Ω or high impedance, female BNC.

[11] 10 MHz GPS input, 50 Ω or high impedance, female BNC.

[12] 10 MHz GPS output, female BNC.

[13] Parallel TS input, DB-25
DVB-SPI input.

[14] ETHERNET connector.

[15] AC voltage connector
Supplies power to the equipment.

[16] Mains switch
Switch on or off the power supply.

NOTE: The actual IF frequency value varies between 32 and 36 MHz, depending on the RF frequency. When a fixed 36 MHz is needed, the RF output of the modulator has to be disabled in the RF menu.

4.3 Menu functions

After start up, the equipment display shows information regarding the main operating conditions, as can be seen in the following example:

FREQ: 650000000 Hz ATT: 10 dB
FFT:8K CONST:64QAM BW:8 MHz GUARD:1/4

FREQ: 650000000 Hz ATT: 10 dB
TEST: NONE TS: Master (204)

Here the RF frequency is 650 MHz, the 1-dB step RF attenuator is set to 10 dB, the DVB-T/H signal has 8K carriers, occupies 8 MHz and uses a 64 QAM constellation with a guard interval of 1/4. No test mode is selected (NONE) and the operation mode of the **MO-180** is set to master. Packets of length 204 bytes are currently being detected on the selected TS input.

After a few seconds, the display changes its contents to show the working time and error count information, as follows:

MO-180 PROMAX ELECTRONICA, S.A.
Working: 01:13:55 ERR: 0

The text on the upper line (the name of the company, in the example above) could be customised via the remote control port to the user's needs, allowing for an easy identification of the equipment or for some piece of advice.

The main display alternates every 5 seconds the previous information with the following:

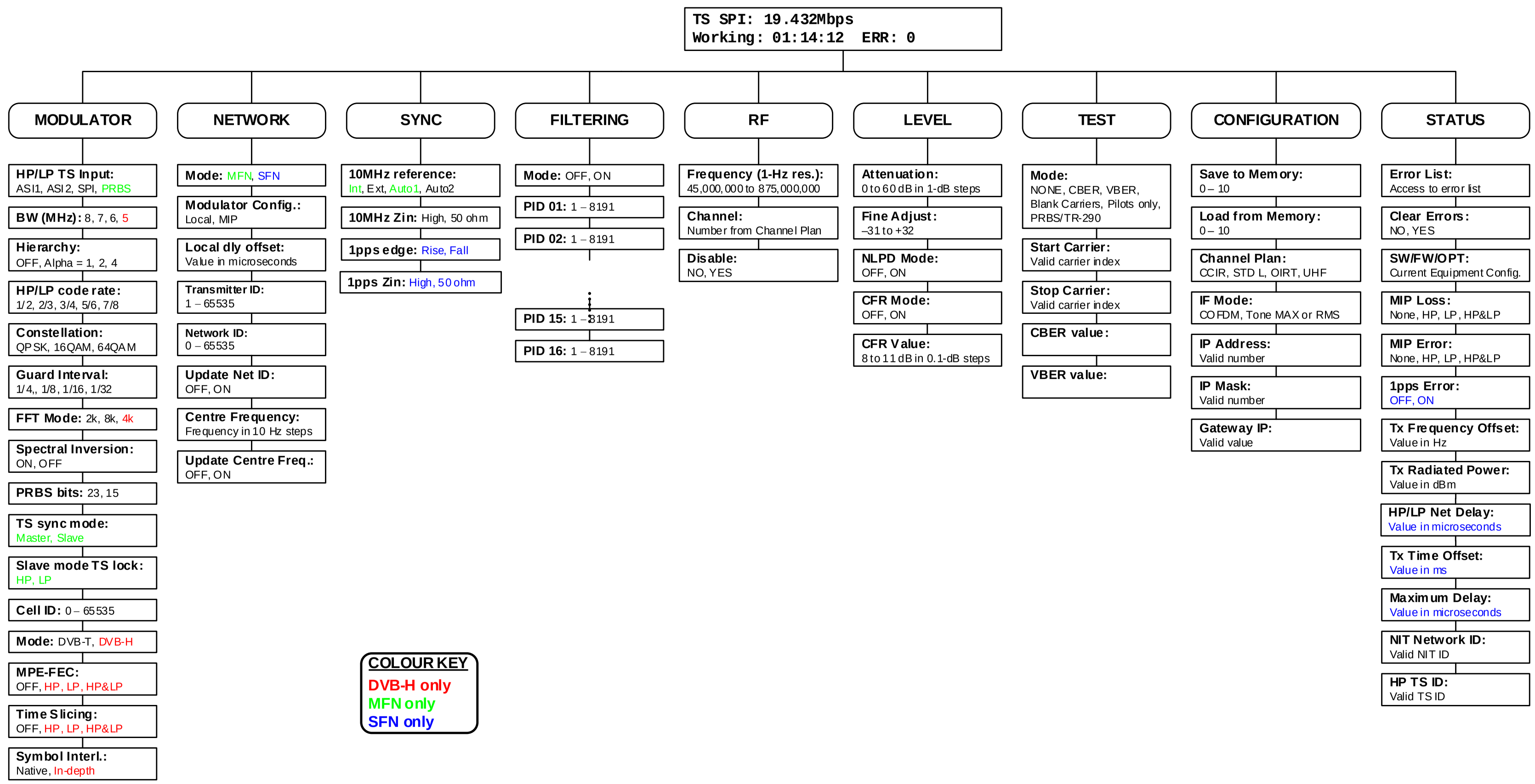
TS SPI: 19.432Mbps
Working: 01:14:12 ERR: 0

This represents an averaged estimate of the net bit rate of the selected transport stream. That is, in slave mode or SFN operation this is directly the raw bit rate of the input TS as it arrives at the modulator. In master MFN operation, this is the bit rate of the TS resulting from stripping the input TS off all NULL packets. In the case that the input contains only NULL packets, the estimated bit rate will be effectively 0 Mbps! The bit rate estimate is expressed in Mbps with three decimal places, i.e. with a resolution of 1 kbps.

Pressing the MENU key, allows us to enter the main menu level. Pressing MENU again, takes us to the main status display. This main menu level uses the first text line to give some advice on the operation assigned to each control, and the second line to display the selectable options and functions.

MENU: back PUSH: select TURN: next/prev.
MODULATOR

Turning the encoder clockwise or counter-clockwise cycles through the submenu entries. The menu tree is hierarchically organised as shown in the chart on page 19.


TS SPI: 19.432Mbps
Working: 01:14:12 ERR: 0
MODULATOR
HP/LP TS Input: ASI1, ASI2, SPI, PRBS
BW (MHz): 8, 7, 6, 5
Hierarchy: OFF, Alpha = 1, 2, 4
HP/LP code rate: 1/2, 2/3, 3/4, 5/6, 7/8
Constellation: QPSK, 16QAM, 64QAM
Guard Interval: 1/4,, 1/8, 1/16, 1/32
FFT Mode: 2k, 8k, 4k
Spectral Inversion: ON, OFF
PRBS bits: 23, 15
TS sync mode: Master, Slave
Slave mode TS lock: HP, LP
Cell ID: 0 – 65535
Mode: DVB-T, DVB-H
MPE-FEC: OFF, HP, LP, HP&LP
Time Slicing: OFF, HP, LP, HP&LP
Symbol Interl.: Native, In-depth
NETWORK
Mode: MFN, SFN
Modulator Config.: Local, MIP
Local dly offset: Value in microseconds
Transmitter ID: 1 – 65535
Network ID: 0 – 65535
Update Net ID: OFF, ON
Centre Frequency: Frequency in 10 Hz steps
Update Centre Freq.: OFF, ON
SYNC
10MHz reference: Int, Ext, Auto1, Auto2
10MHz Zin: High, 50 ohm
1pps edge: Rise, Fall
1pps Zin: High, 50 ohm
FILTERING
Mode: OFF, ON
PID 01: 1 – 8191
PID 02: 1 – 8191
PID 15: 1 – 8191
PID 16: 1 – 8191
RF
Frequency (1-Hz res.): 45,000,000 to 875,000,000
Channel: Number from Channel Plan
Disable: NO, YES
LEVEL
Attenuation: 0 to 60 dB in 1-dB steps
Fine Adjust: –31 to +32
NLPD Mode: OFF, ON
CFR Mode: OFF, ON
CFR Value: 8 to 11 dB in 0.1-dB steps
TEST
Mode: NONE, CBER, VBER, Blank Carriers, Pilots only, PRBS/TR-290
Start Carrier: Valid carrier index
Stop Carrier: Valid carrier index
CBER value:
VBER value:
CONFIGURATION
Save to Memory: 0 – 10
Load from Memory: 0 – 10
Channel Plan: CCIR, STD L, OIRT, UHF
IF Mode: COFDM, Tone MAX or RMS
IP Address: Valid number
IP Mask: Valid number
Gateway IP: Valid value
STATUS
Error List: Access to error list
Clear Errors: NO, YES
SW/FW/OPT: Current Equipment Config.
MIP Loss: None, HP, LP, HP&LP
MIP Error: None, HP, LP, HP&LP
1pps Error: OFF, ON
Tx Frequency Offset: Value in Hz
Tx Radiated Power: Value in dBm
HP/LP Net Delay: Value in microseconds
Tx Time Offset: Value in ms
Maximum Delay: Value in microseconds
NIT Network ID: Valid NIT ID
HP TS ID: Valid TS ID
COLOUR KEY
DVB-H only
MFN only
SFN only

English

4.4 MODULATOR functions

At this menu level, the modulator parameters can be modified and customised to the user's needs. When modifying any modulation parameter, changes became active only when confirmed by pressing the encoder function. Instead, pressing the MENU key allows us to cancel the change of option. Let's comment on each function.

HP TS Input

Selects the input used for providing a High Priority (HP) Transport Stream (TS) to the COFDM modulator. Note that in non-hierarchical transmissions, this is the only TS input to the modulator. Options are:

ASI1 Use TS provided at ASI1 input connector (rear panel).

ASI2 Use TS provided at ASI2 input connector (rear panel).

SPI Use parallel TS provided by SPI connector (rear panel).

PRBS Internal test TS at an appropriate bit rate consisting of NULL packets filled with a 15- or 23- bit PRBS sequence as indicated by menu entry "MODULATOR:PRBS bits".

LP TS Input

Selects the input used for providing a Low Priority (LP) Transport Stream (TS) to the COFDM modulator. Note that in non-hierarchical transmissions, this input is not used. Options are:

ASI1 Use TS provided at ASI1 input connector (rear panel).

ASI2 Use TS provided at ASI2 input connector (rear panel).

SPI Use parallel TS provided by SPI connector (rear panel).

PRBS Internal test TS at an appropriate bit rate consisting of NULL packets filled with a 15- or 23- bit PRBS sequence as indicated by menu entry "MODULATOR:PRBS bits".

BW

This option enables output channel bandwidth selection. The COFDM signal can be generated with a BW of 6 MHz, 7 MHz and 8 MHz. In DVB-H ("MODULATOR:Mode" set to DVB-H) a further 5 MHz option appears in this menu.

8 MHz Selects an 8 MHz bandwidth.

7 MHz Selects a 7 MHz bandwidth.

6 MHz Selects a 6 MHz bandwidth.

5 MHz Selects a 5 MHz bandwidth (DVB-H only).

Hierarchy

Using this function the COFDM modulator is switched between hierarchical mode, with different alpha constellation ratios, and non-hierarchical mode operation. The options available are:

OFF Non-hierarchical operation
α=1 Hierarchical constellation with $\alpha = 1$
α=2 Hierarchical constellation with $\alpha = 2$
α=4 hierarchical constellation with $\alpha = 4$

HP Code Rate

Using this function, the user can modify the convolutional code rate for the High Priority (HP) Transport Stream (TS). The available options are 1/2, 2/3, 3/4, 5/6 and 7/8.

LP Code Rate

Using this function, the user can modify the convolutional code rate for the Low Priority (LP) Transport Stream (TS). The available options are 1/2, 2/3, 3/4, 5/6 and 7/8.

Constellation

Here the menu allows the selection of one of the available constellations. Note than in hierarchical modes QPSK is not a valid choice. The options are QPSK, 16QAM and 64QAM.

Guard Interval

This function selects the required guard interval for the COFDM signal. The available values are 1/4, 1/8, 1/16 and 1/32.

FFT Mode

Selection of the required FFT value (number of carriers in the COFDM ensemble). The modulator has these options:

2K 2048 carriers, 1705 active
8K 8192 carriers, 6817 active
4K 4096 carriers, 3409 active. DVB-H operation only (menu entry "MODULATOR:Mode" must be set to DVB-H).

English

Spectral Inversion

This function allows inversion of the spectrum generated in IF and RF. As the IF spectrum is by itself inverted compared to the RF output, the inversion applied is related to the RF output. The possible options are:

- **OFF** Carriers with lower indices occupy the lower frequencies of the RF channel.
- **ON** Carriers with higher indices occupy the lower frequencies of the RF channel.

PRBS bits

Selection of the length in bits of the internally generated pseudorandom sequences:

- **23** PRBS sequences of length $2^{23}–1$ as documented in TR 101 290.
- **15** PRBS sequences of length $2^{15}–1$ as documented in TR 101 290.

TS sync mode

In MFN mode, this selects the mode of operation of the modulator with respect to the incoming TS (see Section 1.2 for further details):

- **Master** The bit rate of the input TS must be lower than the useful bit rate for the choice of DVB-T parameters in use.
- **Slave** The input bit rate must equal the useful bit rate.

Slave mode TS lock

In slave **MFN** mode, this selects the TS input to which the modulator locks its internal clock. Options are:

- **HP** The modulator is synchronised with the HP TS.
- **LP** The modulator is synchronised with the LP TS (hierarchical modes only).

Cell ID

This number from 0 to 65535 serves to identify the cell from which the DVB-T/H signal comes from. Its main application is in DVB-H though its use is optional in DVB-T.

Mode

DVB-H only features are enabled and available through the menu system when the TPS length indicator is set to 33 bits. Otherwise, DVB-T is used as marked by the TPS length indicator being 31 bits. The two extra bits in DVB-H flag the use of time slicing and MPE-FEC (see below). Options are:

DVB-T (31 TPS bits) DVB-T mode with a TPS length indicator of 31 bits.
DVB-H (33 TPS bits) DVB-H mode with a TPS length indicator of 33 bits.

MPE-FEC

In DVB-H, this configures the Multi-Protocol Encapsulation / Forward Error Correction (MPE-FEC) used on top of the DVB-T channel coding. The available options are:

OFF MPE-FEC not used.
HP The HP TS uses MPE-FEC.
LP The LP TS uses MPE-FEC.
HP&LP Both the HP and LP TS use MPE-FEC.

Time slicing

In DVB-H this indicates whether any of the HP or LP transport streams use time slicing:

OFF Time slicing is not used
HP At least one elementary stream within the HP TS uses time slicing.
LP At least one elementary stream within the LP TS uses time slicing.
HP&LP At least one elementary stream within both the HP and LP TS's uses time slicing.

Symbol Interl.

In DVB-H, this selects between the 2k or 4k native symbol interleaver and the DVB-H-only in-depth symbol interleaver. For 8k, the native interleaver is mandatory.

Native Mandatory in DVB-T and 8k DVB-H.
In-depth New symbol interleaver introduced in 2k & 4k DVB-H modes.

4.5 NETWORK functions

The selection of this item allows us to access those functions related to the configuration of the modulator to operate in an MFN or SFN network. Let's review each option.

Mode

Choose whether the modulator is to be used in a Single Frequency Network (SFN) or in a Multi-Frequency Network (MFN). In an SFN the modulator synchronises its internal clock with an external 10 MHz reference or with the input HP transport stream in case an external 10 MHz reference is missing. Proper SFN synchronisation requires a Megaframe Initialisation Packet (MIP) in the incoming TS (or in both transport streams in the case of hierarchical transmissions) and a one-pulse-per-second (1pps) reference. In an MFN, the modulator is synchronised with either the chosen input TS (slave mode) or with the internal/external 10 MHz reference (master mode).

MFN Multi-frequency network with mater or slave synchronisation.

SFN Single frequency network with external synchronisation.

Modulator config.

Some parameters of the modulator (constellation, symbol interleaver, hierarchical modes with parameter α, HP & LP convolutional rates, guard interval, number of carriers, time slicing, MPE-FEC, cell ID and channel bandwidth) may be configured using the values carried on the MIP packet. This applies to both MFN and SFN operation.

Local Configure the modulator using the values entered by the user.

MIP Configure the modulator using the MIP packet.

Local dly offset

In MFN this is the non-negative local delay offset to add to the intrinsic latency of the modulator. The valid range goes from a few ms (the exact number depends on the channel bandwidth, number of carriers, guard interval and symbol interleaver depth) up to 1 second. In SFN this is the positive or negative local delay offset that we add to the dynamic delay automatically calculated by the modulator using the MIP packet, the 1pps signal and the 10 MHz reference clock. The valid range for this offset in SFN is such that the total delay (calculated as the dynamic delay plus the local delay offset plus the transmitter delay offset embedded in the MIP) lies between a few ms and 1 second. The minimum delay depends on the same parameters as in MFN. When the total delay is below the minimum or above the maximum (although clipped at 1s), this is flagged by the modulator as an error. The local delay offset can be set with a resolution of 100 ns.

Transmitter ID

This number identifies a single transmitter inside an SFN or MFN network. This ID can be used in combination with the MIP packet to address a specific transmitter site in order to configure some of its parameters (such as time delay offset, RF frequency offset, radiated power, user-defined private data, cell ID, bandwidth other than 6, 7 and 8 MHz) regardless of what the configuration for the rest of the network might be. An ID of 0 designates *all* transmitters and thus cannot be use to single out a transmitter.

Network ID

This number serves as a unique identification code for DTT networks. The allocation of these codes may be found in document ETSI ETR 162. When "NETWORK:Update NET ID" is ON, the network ID in the actual NIT table (that is, the network of which the TS containing the NIT is part) is replaced with the network ID specified here. The CRC of the NIT table is updated accordingly and the NIT version number is increased by 1.

Update Net ID

The two available options are ON and OFF. When this is set to ON, the network_id field found in the NIT of the actual network (NIT with table_id = 0x40) is replaced with the Network ID specified with the menu entry "NETWORK:Network ID".

Centre Frequency

This represents the centre frequency that replaces the value currently stored in the NIT when "NETWORK:Update Centre Freq." is ON. This frequency is expressed in 10 Hz units.

Update Centre Freq.

When this entry is set to ON, the 32-bit centre_frequency and frequency fields found within NIT descriptors terrestrial_delivery_system_descriptor and cell_frequency_link_descriptor, respectively, of the actual network (NIT with table_id = 0x40) are replaced with the value specified in menu entry "NETWORK:Centre Frequency". The incoming 32-bit CRC field and NIT version are updated accordingly. Note that for the descriptor cell_frequency_link_descriptor (which contains a complete list of cell IDs and frequencies in use in these cells for the TS multiplex described) we pair the centre frequency with the cell ID being currently broadcast using the TPS bits. This cell ID might in turn be either the one extracted from the MIP packet or, alternatively, the one defined with the menu entry "MODULATOR:Cell ID".

4.6 SYNC functions

These set of functions control all synchronisation features of the **MO-180**. In the following the available menu entries are described.

10 MHz reference

This applies to master MFN and SFN operation. In slave MFN operation the modulator clock is always derived from the input TS rate. Several lock modes are defined:

Ext SFN and master MFN. The modulator locks its circuitry to the external 10 MHz input. This might be for instance the clock obtained from the GPS signal by an external professional GPS receiver.

Int Master MFN only. Use the internal 10 MHz TCXO for synchronisation.

Auto1 Master MFN only. The automatic switch over type 1 defaults to the external 10 MHz reference, switching over to the internal TCXO when an external reference is missing. Once the loss of the external 10 MHz reference has triggered the switch over to the internal 10 MHz clock, the 10 MHz loss flag will remain active until a switch over back to the external reference is forced by selecting Auto1 again.

Auto2 SFN and Master MFN. The automatic switch over type 2 works similarly to Auto1. The only difference is that a loss of sync triggers the switchover to a TS data derived clock which is locked to the incoming HP stream as in MFN slave mode.

10 MHz Zin

The input impedance seen from the 10 MHz BNC connector can be set to 50 Ω or to High Z (several MΩ).

1pps edge

In SFN operation this selects the active edge of the one pulse per second signal. The rising edge is commonly used.

1pps Zin

In SFN operation, the input impedance seen from the 1pps BNC connector can be set to 50 Ω or to High Z.

4.7 FILTERING functions

Packet Identification (PID) filtering can be used in an MFN network to reduce the bit rate of an incoming TS in order to accommodate it to the useful bit rate that the modulator can handle in a particular DVB-T/H set-up.

Every Program Elementary Stream (PES) carrying video, audio or data contained in a TS multiplex is identified by a unique PID. The **MO-180** allows the user to eliminate up to 16 PES's from the TS. Note that the MPEG-2 TS is not really re-multiplexed because the system information tables are not updated, only the PES's are dropped to help reduce the bit rate. This feature finds its application in, for example, trans-modulating a high-bit-rate DVB-S or DVB-C signal to DVB-T/H.

Mode

Select ON to enable PID filtering and OFF to disable it.

PID 01 – 16

Up to 16 PIDs can be discarded from the input transport streams. Note that the PID search applies to both the HP and LP inputs. The valid range of decimal values is 1 to 8191. PID 0 is reserved for the Program Association Table (PAT) and cannot be eliminated.

English

4.8 RF functions.

The selection of this item allows us to access those functions related to the RF output. Let's review each option.

Frequency

This function allows the selection of the RF frequency. Changes made by turning the rotary encoder are applied directly to the output, allowing for a smooth tuning of the output frequency.

When entering this function, the display shows the current frequency and the step used to modify it, if the encoder is turned. Frequency increments are positive when turning clockwise and negative when turning counter-clockwise. The LCD panel looks as follows:

MENU: back PUSH: select TURN: next/prev.
RF Frequency: 650000000 Hz <10MHz>

In this case, the current output frequency is 650 MHz and turning clockwise one notch (each notch is marked by an audible tone) will change that value to 660 MHz.

In this situation, each time we press the encoder button, the frequency step will be modified to 1 MHz, 100 kHz, 10 kHz, 1 kHz, 100 Hz, 10 Hz, 1 Hz and again to 10 MHz, allowing a cyclic selection of the desired step value.

To quit this function, the MENU key must be pressed.

Channel

Using the set of channel tables included in the **MO-180** makes the output frequency tuning faster. This allows direct selection of standard frequencies used in most countries.

Entering this function, a list of all available channels is displayed sequentially. Turning the encoder will lead us to the desired one. Pushing the encoder selection key will exit that function.

The channel list is taken from a set of channel plans loaded into the equipment. The available channel plans are displayed and selected from the CONFIGURATION menu, as we'll see later.

Also in this case, frequency changes are applied immediately to the RF stage, allowing an interactive frequency adjustment.

The list of channel plans can be found in Appendix A.

Disable

This option is to disable the RF output. This is performed by introducing a strong attenuation (around 80 dB) to the RF signal. At the same time, the IF frequency is tuned to a nominal value of 36 MHz. The possible values are NO to enable the RF output and YES to disable it.

4.9 LEVEL functions

This menu entry groups the functions related to RF level adjustment. The **MO-180** has a built-in programmable attenuator of 60 dB, in 1 dB steps. At the same time, the nominal RF level can be finely adjusted using a voltage controlled attenuator. This allows to set a reference level using the voltage controlled attenuator, to then apply the mentioned 1 dB attenuation steps to that reference value.

Also included here are the controls for the Crest Factor Reduction algorithm and the Non-Linear Pre-Distorter.

The RF gain structure can be controlled using the following functions.

Attenuation

This function allows to select the RF output level by applying 1 dB attenuation steps, from 0 dB to 60 dB. Turning the encoder clockwise increases the attenuation, reducing the output level. Turning counter-clockwise enables the opposite behaviour.

Level changes are applied immediately to the RF output, to allow smooth and easy adjustment of RF output conditions. Pressing the encoder or MENU key exits this function.

Fine Adjust

Select this function to program the RF output reference level. For a correct reference, adjust the output attenuation to 0 dB, before the fine adjustment.

Changes are also applied in real time. Turning the knob clockwise increases the output level. Turn it counter-clockwise decreases the level.

The displayed characters are integers. The range goes from a maximum attenuation of –31 to a minimum attenuation of +31 (i.e. 0 to 63 attenuation steps).

To exit this function, press the MENU or encoder keys.

4.9.1 Non-Linear Pre-Distorter functions

NLPD Mode

The Non-Linear Pre-Distortion (NLPD) block is enabled when this entry is set to ON.

The NLPD block uses a set of 2 to 16 points to linearly approximate the complex gain curve that is used to counter the AM/AM and AM/PM characteristics of an RF power amplifier. The AM/AM curve defines the amplitude distortion that the amplifier introduces as a function of its input power. The AM/PM curve defines the phase distortion that the amplifier causes as a function of the input power.

The complex correction gain for the n-th point can be expressed as:

$$g_n = \Re(g_n) + j\Im(g_n) = |g_n| \exp(j\theta_n)$$

with n = 0…15. The amplitude of g_n is $|g_n|$ and its phase in radians is θ_n.

Figure 3 shows an example of how to obtain these complex linearising gains. On the x-axis we have the power at the input to the RF power amplifier expressed in dB relative to the RMS power of the COFDM signal (or, alternatively, the RMS test tone which has exactly the same average power but is easier to measure). On the y-axis we have the power measured at the output of the amplifier also referred to the RMS power assuming a normalised gain (0 dB).

English

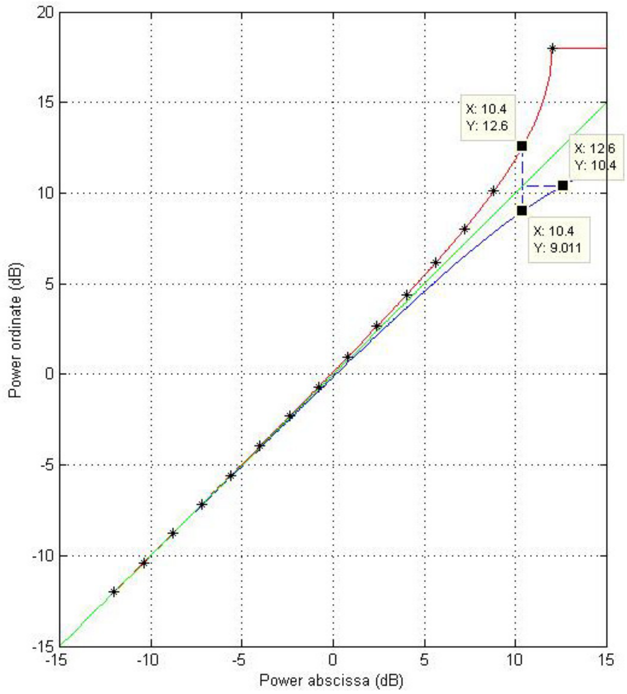


Figure 3.- AM-AM curve of the amplifier we want to linearise (blue); Ideal amplifier with a normalised gain of 0 dB (green); Level at the output of the NLPD block which linearises the amplifier for input powers up to 12 dB (red).

In the case of an ideal amplifier, the AM-AM curve would be a straight line with slope 45° (green line). In practice, however, we have an AM-AM characteristic like the one shown in blue. For instance, a relative input power of P_n = 10.4 dB is attenuated 1.4 dB (9.011 dB, a little bit beyond the 1 dB compression point of the amplifier). In order to linearise the amplifier at this particular input level, we have to increase the amplitude of the input sample by 2.2 dB so that the output power now becomes 10.4 dB. Thus, the amplitude of the correction gain is (red curve):

$$G_n = 20\log_{10}|g_n| = +2.2 \text{ dB @ } P_n = 10.4 \text{ dB}$$

Note: that there is an input power (approximately P_n = 12 dB in this example) beyond which the amplifier cannot be linearised as that would require an infinite correction gain.

The phase θ_n of the complex correction gain can be obtained by simply multiplying by –1 the phase in the AM-PM curve corresponding to an input power of P_n + G_n dB.

The NLPD block allows to define between 2 and 16 points with relative input powers P_n ranging from –12 dB to +12 dB with 0.1 dB of resolution. As mentioned above, these levels are referred to the RMS level of the COFDM signal.

The n-th quantised power abscissa can be obtained from the relative input power P_n in dB as follows:

$$\text{Power abscissa (n)} = \left\lfloor 2330 \times 10^{\frac{P_n}{10}} \right\rfloor \qquad (1)$$

where $\lfloor\cdot\rfloor$ represents the integer part of its argument. The valid range for the power abscissae goes from 147 to 36928. When loading these powers into the modulator, it must be ensured that they are sorted in increasing order, that is, $P_n < P_{n+1} + 0.1$ dB for all n, and that all used abscissae are stored in consecutive indices. In the case of *all* abscissae being 0, the NLPD block is automatically bypassed.

Continuing with the example of figure 3, we show on top of the red correction curve 16 power abscissae P_n ranging from –12 dB to +12 dB in 1.6 dB steps. Points do not have to be equally spaced. In fact, since the NLPD algorithm relies on linear interpolation to calculate the correction gain for levels lying in between the reference points, a better strategy is to use as many points as possible in areas where the behaviour of the amplifier more markedly departs from linearity. For input powers less than $\min(P_n)$, the NLPD block applies the correcting gain corresponding to the point with minimum P_n. For levels greater than $\max(P_n)$, the NLPD block uses the gain associated to the reference point with maximum P_n.

To each input power P_n corresponds a complex correction gain:

$$g_n = |g_n| \exp\left(j \frac{\phi_n}{180} \pi \right)$$

The NLPD block has a correction range of –6 dB to +6 dB with a resolution of 0.1 dB for the gain amplitude $G_n = 20 \log_{10} |g_n|$, and a range of –30° to +30° with a resolution of 0.1° for the gain phase θ_n.

Given G_n (dB) and ϕ_n (°), the *non-negative* gain real ordinates to load into the modulator are computed using:

$$\text{Gain real ordinate (n)} = \left\lfloor 2^{15} 10^{\frac{G_n}{20}} \cos\left(\frac{\phi_n}{180} \pi \right) \right\rfloor \qquad (2)$$

Similarly, the *integer* gain imaginary ordinates are:

$$\text{Gain imag. ordinate (n)} = \begin{cases} \left\lfloor 2^{15} 10^{\frac{G_n}{20}} \sin\left(\frac{\phi_n}{180} \pi \right) \right\rfloor & 0^\circ \le \phi_n \le 30^\circ \\ 2^{16} + \left\lfloor 2^{15} 10^{\frac{G_n}{20}} \sin\left(\frac{\phi_n}{180} \pi \right) \right\rfloor & -30^\circ \le \phi_n < 0^\circ \end{cases} \qquad (3)$$

English

The maximum quantisation error for the P_n's with 0.1 dB of resolution is 0.02 dB. The maximum quantisation error for the G_n's for a resolution of 0.1 dB is less than 0.001 dB. Finally, the maximum quantisation error for the ϕ_n's with 0.1° of resolution is 0.003°.

Figure 4 shows the region of the complex plane containing all the valid correction gains. The separation between the arcs spanning 60° is 0.1 dB.

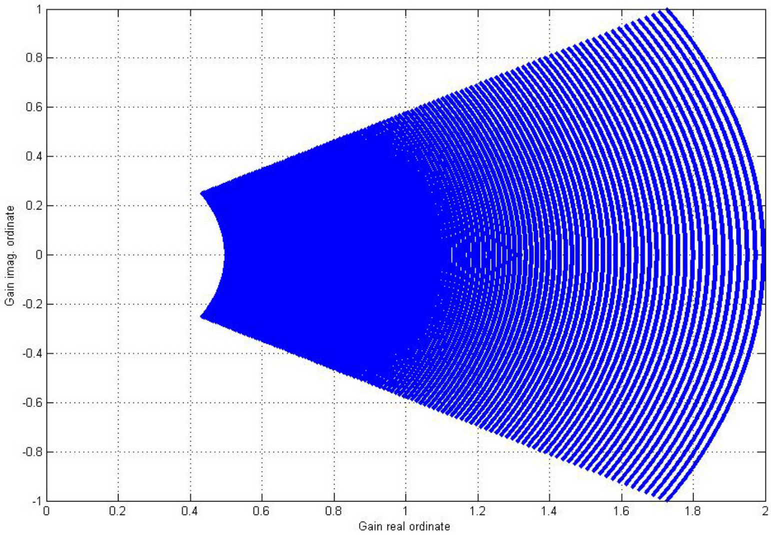


Figure 4: Valid range for the quantised complex correction gains (divided by 32768).

In the following we present another example of how to calculate the complex correcting gains for an RF amplifier modelled using Saleh's model[3]. In this type of model a simple two-parameter function is used to model the AM-AM and AM-PM characteristics of non-linear amplifiers. It was originally developed for TWTA's, but an appropriate selection for the amplitude and phase coefficients (α's and β's) provide a suitable model for solid state amplifiers as well.

The AM-AM and AM-PM functions are defined by:

$$A(r) = \frac{\alpha_a r}{1+\beta_a r^2}$$

$$\Phi(r) = \frac{\alpha_\phi r^2}{1+\beta_\phi r^2}$$

where r is the instantaneous envelope of the signal at the input to the amplifier (envelope power is therefore r^2), A(r) is the AM-AM conversion and $\Phi(r)$ is the AM-PM conversion in degrees.

[3] A.A.M. Saleh, "Frequency-independent and frequency-dependent nonlinear models of TWT amplifiers", *IEEE Trans. Communications*, vol. COM-29, pp.1715-1720, November 1981.

Let's assume we have an RF amplifier with parameters $\alpha_a = 1$, $\beta_a = 0.017$, $\alpha_\phi = 1$ and $\alpha_\phi = 0.05$. These curves are shown in Figure 5. The top plot shows in blue the AM-AM characteristic normalised with respect to the input power (i.e. A(r)/r squared) for powers ranging from –12 to + 18 dB. The bottom plot shows in blue the AM-PM characteristic.

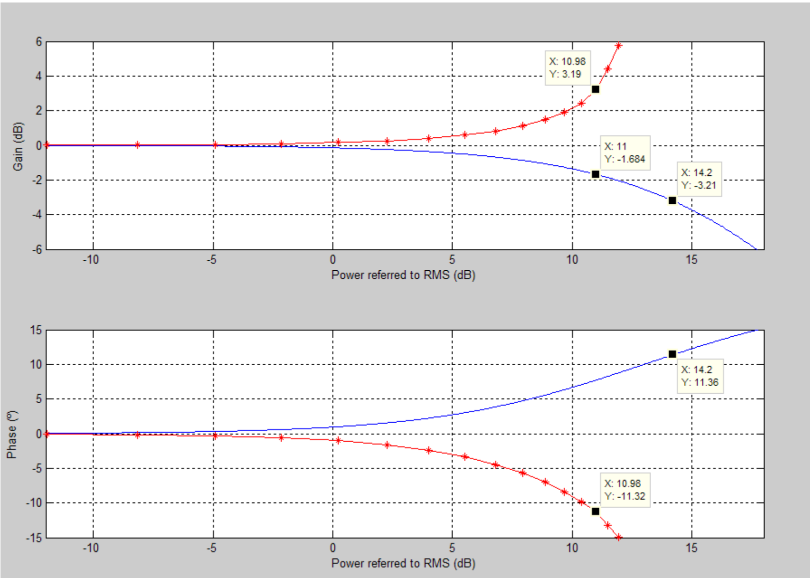


Figure 5.- AM-AM, AM-PM curves based on a Saleh model (blue) and amplitude and phase of the corresponding complex correcting gain (red).

On the same plots in red we show 16 logarithmically-spaced points. This spacing provides more samples in the area where the two curves depart more from linearity and thus where more density of points is needed. Given these 16 abscissae P_n expressed in dB, the complex correcting gains can be obtained as follows:

$$|g_n| = \left| \frac{\alpha_a - \sqrt{\alpha_a^2 - 4\beta_a p_n}}{2\beta_a \sqrt{p_n}} \right|$$

where $p_n = 10^{\frac{P_n}{10}}$. The correcting phases are given by:

$$\phi_n = -\Phi(|g_n|) = \frac{-\alpha_\phi |g_n|^2}{1 + \beta_\phi |g_n|^2}$$

The values computed used the two equations above are shown superimposed on the red curves. The plotted correction gain for each point is $G_n - P_n$. These power abscissae and correction gains as calculated using Eqs. (1) to (3) are collected in Table 1. The three right-most columns would be the ones to be programmed into the modulator.

English

Point	P_n (dB)	$G_n - P_n$ (dB)	θ_n (º)	Power abscissa	Real gain ordinate	Imag gain ordinate
0	–11.94	0.009	–0.06	149	32804	65499
1	–8.17	0.023	–0.15	355	32853	65499
2	–4.93	0.048	–0.32	748	32948	65352
3	–2.16	0.091	–0.6	1417	33112	65188
4	0.22	0.16	–1.04	2451	33371	64933
5	2.26	0.26	–1.64	3923	33750	64569
6	4.01	0.399	–2.43	5873	34276	64083
7	5.52	0.582	–3.38	8302	34976	63468
8	6.81	0.815	–4.49	11173	35880	62720
9	7.91	1.105	–5.7	14415	37029	61838
10	8.86	1.461	–7	17938	38483	60808
11	9.68	1.9	–8.37	21639	40347	59602
12	10.38	2.452	–9.79	25417	42822	58146
13	10.98	3.19	–11.32	29181	46391	56245
14	11.49	4.414	–13.22	32851	53029	53083
15	11.93	5.762	–14.93	36365	61469	49151

Table 1: Power abscissae and complex gain ordinates for the 16 points shown in Figure 5.

IMPORTANT NOTES:

1. When using the non-linear predistorter with **high correction gains** (greater than +4.5 dB), to avoid arithmetic overflow within the predistorter we have to limit the **crest factor** of the COFDM signal to **11 dB**. This can be done using the CFR block that precedes the NLPD block (see Section 4.9.2). This CF has no negative impact on the MER of the COFDM signal which remains the same as when the crest factor corrector is disabled. Overflow within the NLPD is dealt with by hard-clipping the offending samples. Clipping in the NLPD block adds more non-linearities to those already generated by the amplifier (which are in fact the ones the NLPD is trying to counter) and should therefore be avoided at all costs.

2. When the **non-linear pre-distorter is enabled**, the **level** at the IF output **drops 3 dB**. This is done to avoid saturation at the output of the last IF gain block in the current hardware when one or more of the pre-correcting gains are greater than approximately 3 to 4 dB. This has to be taken into account during the obtention of the AM/AM and AM/PM curves of the RF amplifier using the RMS test tone. If the NLPD is enabled, this tone will have 3 dB less power than when the NLPD is disabled.

4.9.2 Crest Factor Reduction functions CFR Mode

The Crest Factor Reduction (CFR) algorithm is enabled when this entry is set to ON. This block precedes the Non-Linear Pre-distorter (NLPD).

CFR Value.

When the Crest Factor Reduction (CFR) algorithm is enabled ("LEVEL:CFR Mode" set to ON), the IF crest factor (ratio between the peak and mean envelope powers) of the COFDM signal can be varied between 8 and 11 dB in 0.1-dB steps.

A peak-windowing algorithm is used to minimise the negative effect clipping the OFDM signal has on both the MER and the upper and lower adjacent channels, which results in lower MER and lower Adjacent Channel Rejection (ACR), both measured in dB.

When the CFR algorithm is disabled ("LEVEL:CFR Mode" set to OFF), the crest factor of the unclipped COFDM signal observed in practice is approximately 13 dB.

When the non-linear predistorter is enabled, the crest factor must be set to 11 dB or less so as to avoid overflow within the predistorter when using high correction gains. A CFR of 11 dB effectively limits the maximum amplitude of the signal attacking the RF amplifier but has a negligible impact on the MER.

4.10 TEST functions

This menu contains a series of parameters used to correctly carry out all types of transmission tests using the **MO-180** modulator.

Mode

Selects the test to be carried out. Available options are:

NONE Normal COFDM output.

CBER Inject channel bit errors to obtain a non-zero BER before the Viterbi decoder (Channel BER, see entry "TEST:CBER value" below).

VBER Inject bit errors to obtain a non-zero BER after the Viterbi decoder (Viterbi BER or simply BER, see entry "TEST:VBER value" below).

Blank carriers Blank carriers starting at index Start Carrier and ending at index Stop Carrier (see entries "TEST:Start Carrier" and "TEST:Stop Carrier" below).

Pilots only Generate a DVB-T signal containing pilot carriers only (continual and TPS).

PRBS/
TR 290 Replace the input to the constellation mapper with a PRBS sequence of length 2^{15}-1 or 2^{23}-1 (see menu entry "MODULATOR:PRBS bits") as specified in document ETSI TR 101 290.

The following two parameters select the carrier interval to blank, in order to make measurements of intermodulation noise and/or noise within the channel.

Start Carrier

Selects the initial index (from 0 to 1704 in 2K, 0 to 6816 in 8k, 0 to 3408 in 4K) of the first carrier to blank within the COFDM ensemble.

Stop Carrier

Selects the final index (from 0 to 1704 in 2k, 0 to 6816 in 8k, 0 to 3408 in 4K) of the last carrier to blank within the COFDM ensemble.

These following two parameters set the amount of errors we inject into the modulator chain:

CBER Value

Channel Bit-Error Ratio to inject at the input of the mapper to constellation points. This yields a non-zero BER before the Viterbi decoder (values from 7.6E-6 to 1.2E-1).

VBER Value

Viterbi BER to inject at the input to the convolutional encoder so that a non-zero BER is obtained at the output of the Viterbi decoder (values from 3.7E-9 to 6.2E-2).

4.11 CONFIGURATION functions

Under this menu entry there is a collection of functions related to the configuration and setup of the whole instrument.

Save to Memory

The **MO-180** has a number of configuration memories that allow to store the modulator parameters as well as the RF frequency and level.

To store the current configuration, turn the encoder to select the desired memory number (from 0 to 10). Press the encoder key to confirm the storing action. Press the MENU key to cancel the action.

This function, as well as the recall option explained hereafter, automatically increments the memory number, to allow to easily store and recall the contents of consecutive memories.

Load from Memory

This is the counterpart function of the previous one. Selecting the desired memory number, a complete equipment configuration can be loaded.

Channel Plan

Use this function to choose among the channel plans included in the **MO-180**. Currently, the available channel plans (an ordered list of channel frequencies) have been translated from the standard analogue channel plans. A complete list of all channel plans has been included at the end of this document (see Appendix A).

The selections displayed using the rotary encoder are:

CCIR (Main west European standard)
STD L (French standard)
OIRT (East European standard)
UHF (Only the UHF part from CCIR, for faster selection)

IF Mode

By using this function, the user can select generating a COFDM signal or a single tone. A single tone can be useful for accurate alignment or testing of external components. The available options are:

COFDM Generate a COFDM DVB-T/H signal.
TONE MAX Generate a single tone at the maximum level available from the **MO-180.**
TONE RMS Generate a single tone at an RMS level equal to the RMS level of the modulated COFDM signal.

IP Address

Specifies the 4-byte IP address associated to the **MO-180**. Default value is 192.168.29.5

IP Mask

Specifies the 4-byte mask used by the subnet the **MO-180** belongs to. Default is 255.255.255.0

Gateway IP

4-byte IP address of the gateway that resolves IP addresses which are not within the subnet. Defaults to 0.0.0.0 (not used).

4.12 STATUS functions

These functions provide information about errors, parameters extracted from the MIP or input TS, software and firmware versions, and SFN synchronisation status.

Error List

During the continuous operation of the **MO-180**, the first 16 errors detected are stored as a reference to identify problems. Usually, no errors are generated, and the display should be as follows:

MENU: back PUSH: select TURN: next/prev.
NO ERRORS

But, during operation, two different kinds of errors are possible (see Section 4.15 for further information):

Errors generated when the modulator is not locked.

These are usually temporary errors related to input transport stream transitions or invalid TS bit rates.

Errors generated due to a circuit failure. When this kind of errors persists, the instrument must be serviced in a **PROMAX** official centre.

See section 4.15 for an explanation of the format used to display the errors.

Clear Errors

Select this function to clear the internal error counter and errors list explained formerly. The possible selections are YES and NO.

SW/FW/OPT

Indicates the software version (SW), fimware version (FW) and options currently enabled in the modulator. For instance, the following display

MENU: back PUSH: select TURN: next/prev.
STATUS SW/FW/OPT: v1.6.29 – 89.01 - _HSF

corresponds to software version 1.6.29, firmware version 89.01 with options DVB-H, SFN and PID filtering installed and enabled.

MIP LOSS

In SFN or MFN using the option of configuring the modulator from the Megaframe Initialisation Packet (MIP), this status flag being active indicates that no MIP has been found in the HP/LP TS's during at least one megaframe.

MIP ERROR

In SFN or MFN using the option of configuring the modulator from the MIP, this status flag being active indicates that a MIP packet has been found in an HP/LP megaframe but it has format errors (using the MPEG-2 TS syntax, this amounts to transport_error_indicator being 1 or payload_unit_start_indicator being 0 or transport_priority being 0 or transport_scrambling_control not being "00" or adapatation_field_control not being "01" or synchronization_id not being "0x00" or section_length < 19 or section_length > 182 or pointer > 10583 in HP or pointer > 7055 in LP).

1pps ERROR

In SFN this status flag being active signals that the number of 10 MHz clock periods between two consecutive active edges of the 1pps signal differs from 10^7.

Tx Frequency Offset

In SFN or MFN using the option of configuring the modulator from the MIP, this is the integer carried in the MIP used to apply a deliberate frequency offset of the central frequency of the transmitted DVB-T signal relative to the centre frequency of the RF channel. The valid range goes from –8388608 Hz to 8388607 Hz. Note that this offset is NOT automatically applied to the modulator output.

Tx Radiated Power

In SFN or MFN using the option of configuring the modulator from the MIP, this is the positive number carried in the MIP which can be used to configure the transmitter Effective Radiated Power (ERP). The valid range is 0 dBm to 6553.5 dBm in steps of 0.1 dBm.

HP/LP Net Delay

In SFN, these are the network delays for the HP and LP transport streams. These delays are expressed in μs with a resolution of 100 ns. Because of the way there are obtained, these values have to be further corrected by subtracting 2 TS packet periods from them.[4] The result is an upper bound on the actual network delay (the error is always strictly less than 1 TS packet period). The network delay is defined as the delay between the (multiple channel) SFN adapter output(s) and the TS input(s) to the modulator.

[4] The TS packet period in μs is easily obtained by dividing 1504 by the useful bit rate of the DVB-T/H mode expressed in Mbits/s. Thus, for instance, for 64QAM, rate 2/3 and guard interval 1/4, we have a TS packet period of 1504/19.9058824 = 75.56 μs. Note that in hierarchical modes we have to deal with the HP and LP TS packet periods separately.

Tx Time Offset

In SFN, this integer corresponds to the positive or negative delay defined by the field tx_time_offset carried on the MIP packet. It is used to automatically apply an offset to the time of the transmitted DVB-T/H signal relative to the reference transmission time calculated as (Synchronization Time Stamp (STS) + maximum_delay + local_delay_offset) modulo 10^7. The valid range is –3.2768 to 3.2767 ms. Note that in any case the total delay is always limited to 1 second.

Maximum delay

In SFN, this non-negative number is the maximum_delay field extracted from the HP MIP packet. In hierarchical modes, the same value should be carried by the LP MIP packet for the modulator to function correctly. It represents the time difference between the time of emission of the start of a megaframe of the DVB-T/H signal from the transmitting antenna and the start of the same megaframe at the (multiple channel) SFN adapter(s) output(s) expressed in 100 ns units. The value of maximum_delay field should be larger than the sum of the longest delay in the primary TS distribution network and the delays in modulators, power transmitters and antenna feeders. The valid range goes from 0 to 1 second.

NIT network ID

This is the ID of the DTT network of which the input TS is part of. When "NETWORK:Update Net ID" is set to ON, this network ID is replaced with the value specified in the menu entry "NETWORK:Network ID". Note that only the NIT network_id label is modified, not the original_network_id which identifies the originating delivery network.

HP TS ID

This is the identifier of the HP transport stream which, together with the orignal_network_id, allows any transport stream to be uniquely identified. This value is extracted from the Program Association Table (PAT).

4.13 Remote control via Ethernet

4.13.1 Assigning an IP address

The **MO-180** has an Ethernet RJ-45 socket which enables the connection of the modulator to an IP network. The network interface installed in the modulator requires an IP address whose value lie within the range of values assigned to the IP network or sub-network we are using.

Here follows a brief explanation of how to assign IP addresses in an IP network. This is by no means a comprehensive description of how to set up an IP network. There are excellent books and on-line resources providing an in-depth coverage of the subject.

There are basically two ways of obtaining an IP address for a network client:

- **Static.** The network client uses the same address every time it connects to the network. A network administrator decides which address is used by each device connected to the network.

- **Dynamic.** A new IP address is assigned every time the equipment is connected to the network. The assignment is usually done by an external IP address server.

Communication with the **MO-180** via an IP network is based on establishing a "virtual" serial connection using the IP network simply as the physical carrier of the serial control commands we use to remotely interact with the modulator. In principle this virtual serial port requires us to specify an static IP address which stays always the same.

Nonetheless, dynamic address assignment is a very useful technique which allows to add new devices to an existing IP network with minimal or no manual configuration at all.

The network client in the **MO-180** supports different dynamic IP assignment protocols:

- **DHCP** (Dynamic Host Configuration Protocol), which is a server/client network protocol that allows IP network devices to automatically configure their network parameters. A DHCP server holds a list of valid IP addresses and assigns them to network clients as needed. When a client is disconnected its address is automatically released and becomes available for any new client logging on to the network.

- **BOOTP** (Bootstrap Protocol) is an UDP network protocol used by network clients to automatically obtain an IP address. This process is typically carried out as part of the boot-up sequence of a network device. This protocol enables dummy terminals with no hard disk to obtain and IP address before starting to load an advanced operating system.

- **AutoIP** or **ZeroConfing** is a set of techniques that automatically create a usable IP address with no need for configuring special servers. Traditional class B networks use the 169.254.x.y set of addresses for this purpose. It is not advised to use this method because the so-generated address might not be visible to the other devices connected to the network.

In static IP address assignment the user can set the 4-byte IP address of the **MO-180** using the menu entries located under the CONFIGURATION menu. Once changed, this will be the IP address assigned to the modulator until it is modified again by the user.

English

It is the responsibility of the user to choose an IP address lying within the valid range of addresses associated to the IP network the **MO-180** is to be connected to. Currently, three classes of networks are commonly used. These networks are distinguished by the number of bytes used to identify the network and also by the numeric range used for the first octet.

- **Class A** networks are identified by the first byte, which ranges from 1 to 126. There is a total of 126 class A networks with a possible number of hosts/clients of 16.5 million.

- **Class B** networks are identified by the first two octets, the first of which ranges from 128 to 192. There is a total of 16384 class B networks, with a total of 65534 hosts per network.

- **Class C** networks are identified by the first three octets, the first of which ranges from 192 to 223. There is a total of 2.1 million class C networks with a maximum of 254 hosts or clients each.

IP addresses 224.x.y.z and above are reserved for special purposes such as multicasting.

Network devices which are not connected to the outside world need not have globally-unique IP addresses. Three reserved private network ranges of IP addresses have been standardised:

- **Class A.** Address range 10.0.0.0 to 10.255.255.255
- **Class B.** Address range 172.16.0.0 to 172.31.255.255
- **Class C.** Address range 192.168.0.0 to 192.168.255.255

Typically the network administrator will divide the private network into subnets. For instance, many ADSL home routers use a default address range of 192.168.0.0 to 192.168.0.255.

Class C is the private address range we should usually default to when connecting the **MO-180** to an IP network.

The way the **MO-180** operates inside an IP network is configured with the following three parameters which can be found under the CONFIGURATION menu:

- **IP address.** This 4-octet number is the IP address of the modulator discussed above. By default the value programmed into the modulator is **192.168.29.5.**

- **IP mask.** The subnet IP mask is used together with the IP address to determine which part of the address is the network address and which part is the modulator address. To do this a bitwise AND operation is performed. Thus the 1's in the IP mask designate the part of the address as being part of the network portion and the 0's mark the part as being part of the **MO-180** address. For instance, with IP mask 255.255.255.0 we indicate that the first 24 bits are used as network address. The value programmed by default is **255.255.255.0**. In an alternative form known as Classless Inter-Domain Routing (CIDR) notation, the default IP address can be also represented as **192.168.29.5/24**.

- **Gateway IP.** A gateway is a network node that transfers data between private networks and other networks (e.g. the Internet), resolving which IP addresses are part of the private network and which are not. This is the 4-byte IP address of the gateway and should be only used if the modulator needs to have access to the Internet or if it is going to be reached by other equipment outside the private network. The default value is **0.0.0.0** which stands for **NOT USED**.

Dynamic addresses cannot be directly selected through the modualtor's menu. To set up a dynamic address we have to choose a special IP address value with which we explicitly indicate the dynamic address assignment method we want to use. For this purpose, octets 1, 2 and 4 are all set to 0. Octet 3 controls whether we want to use BootP, DHCP, AutoIP or a combination of the three. If the third octet is 0 then all three methods are enabled at the same time. To disable any one of them we have to assert the corresponding bit (bit 0 for AutoIP, bit 1 for DHCP and bit 2 for BootP). Thus, for instance, if it is only DHCP that we want to enable (as it typically occurs in practice) the IP address we have to programme into the modulator is 0.0.5.0.

It is not advisable to disable all dynamic address assignment methods (0.0.7.0) since this would make the process of assigning a dynamic IP address to the MO-180 really difficult.

4.13.2 Setting up a virtual serial port

In this section we describe how to remotely access the **MO-180** via a virtual serial connection built over a real Ethernet connection. This involves configuring the network client on the **MO-180** (IP addresses and mask) and opening a serial connection on the remote computer using the appropriate software tools.

As we explained in the previous section, the default IP addresses of the subnet the **MO-180** belongs to are within the range 192.168.29.x with mask 255.255.255.0. If the **MO-180** is connected to another network (e.g. the Internet) via a gateway, the IP address of the gateway should be also specified.

In the simplest scenario, the **MO-180** can be connected directly to a PC equipped with a 10/100 Mbps network card using a cross-over CAT5 UTP RJ45 male/male Ethernet cable. If a LAN network is available, the **MO-180** can be connected to the network using either a hub or, more suitably, a network switch.

The RJ-45 socket on the **MO-180** contains two LEDs. The left bi-colour LED (looking from the rear) is the link LED. When it is off it means there is no link, whereas when it is amber (green) it means that a 10 Mbps (100 Mbps) connection has been detected. The right bi-colour LED is the activity LED. When it is off there is no activity on the Ethernet link. Half-duplex and full-duplex connections are signalled with amber and green colours, respectively.

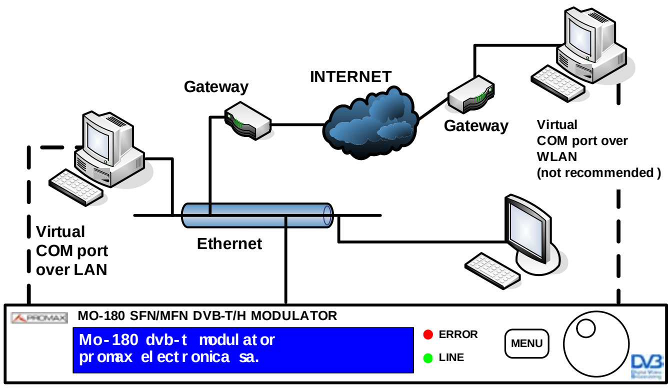


Figure 6.- Connecting the **MO-180** to an Ethernet network.

A software application called COM Port Redirector (CPR) Manager from Lantronix can be found on the CD that came with the **MO-180**. Alternatively, this tool can be freely downloaded from the Lantronix website.

The CPR Manager needs to be installed on the computer that will remotely control the **MO-180** via a virtual serial port. The installation of this software is self-explanatory. The CPR Manager is able to create up to 255 virtual RS-232 serial ports on the computer it is running on, associating a valid COM port number to the IP address of a **MO-180**. The virtual COM port built on top of the Ethernet connection will last for as long as the network connection with the **MO-180** is available. A change in the IP address of the **MO-180** necessarily triggers a change in the virtual COM port configuration or, alternatively, the creation of a new serial port mapped to the new address.

The process of assigning a virtual COM port to a **MO-180** has to be done only once on the computer which will be used to remotely control the modulator. If all modulators connected to a private network are given the same IP address, the CPR Manager will use the same COM port to control each and everyone of them.

These are the steps required to create a virtual serial COM port using CPR Manager:

1. Connect the **MO-180** to the private network using a CAT5 Ethernet cable.

2. Turn on the modulator.

3. Open the CPR Manager application on the computer connected to the network.

4. If the modulator belongs to the same subnetwork as the PC, go to Device on the toolbar and click Search. If redirecting over a Wide Area Network (WAN) or the Internet, both the PC and the **MO-180** must have correct gateway address configured in their IP settings.

5. At the bottom of the screen the window pane called Devices will show the IP address of the modulator together with its MAC address and any other available information.

6. Go to Com Port menu on the toolbar and select Add and Remove. A window displaying a list of numbered COM ports pops up.

7. Select a COM port number from those available and click OK. The dialog box closes. The new COM port appears in red in the Com Ports list identified as New and the word Modified appears at the bottom right of the screen. Its current configuration is shown on the right hand side of the screen.

8. We must configure a new port before it can be used by any communications software. Click on the new COM port in the Com Ports window and the Settings tab appears. Right-click on the IP address of the modulator in the Devices window and select Add to Settings. To save the COM port click on Save Settings in the Com Port menu.

9. Go back to the Com Port List tab. The new COM port is shown along with additional information if available:

   - **IP Address** of the modulator to which the COM port is connected.
   - **Status** of the connection between the COM port and the **MO-180**.

The virtual COM port is now set up and ready to access the modulator or modulators connected to the subnetwork that will respond to its associated IP address.

It is possible to verify the status of a virtual serial connection using CPR Manager. First of all, we have to double check that the modulator we are trying to talk to is turned on and connected to the network.

Then from CPR Manager select the General Tests tab and open the COM port we created. If everything is working all right, the counter of received characters Rx Data will be increased by one for each character received from the modulator. For example, the count will be incremented by one every time the **MO-180** sends a XON code over the virtual serial port (once per second).

If we cannot open the COM port and yet we believe that everything is properly configured, we can do a ping from the MS-DOS command prompt (Windows Startup menu -> Run -> cmd) to the IP address of the modulator. This will tell us whether the **MO-180** is really accessible through the Ethernet connection.

It might be the case that the modulator replies to a ping command but we are unable to open the virtual COM port. It is worthwhile then to check whether this COM port is being used by another programme. If not, a fallback plan consists in deleting the COM port and starting from scratch.

4.13.3 Serial control commands

The virtual COM port created following the steps described in the previous section can be used to remotely control the **MO-180** using a computer. A suitable set of remote control commands enables us to query and change most of the functionality of the modulator using software that controls serial devices such as Windows Hyperterminal.

There is a control protocol to synchronise command reception and validation. A command must be sent once an XON (ASCII 0x11 in hexadecimal) character is received from the modulator. When the modulator detects a complete command, it sends an XOF (0x13) code and, once validated and executed, an ACK (0x06) or NAK (0x15) is sent back to the remote controller.

In order to ensure an error-free communication between the computer and the modulator connected over an Ethernet network, the port settings of the virtual serial port are always the following:

Rate: 19200; Data bits: 8; Parity: None; Stop bits: 1; Flow control: None

The **MO-180** accepts remote commands at any time as long as the instrument is on. It is not necessary to put the **MO-180** in a special remote control mode.
The communication protocol is as follows:

1) The **MO-180** transmits an XON code (0x11) every second. This tells any device that might be listening on the other side of the virtual serial connection that the modulator is ready to receive data.

2) Control commands sent to the modulator have the following format:

   a. Initial character "*" (0x2A).
   b. Set of characters that form the command.
   c. End character CR (carry return, 0x0D).

3) Once a command has been sent, an XOFF will be received, indicating that the transmission of any new command must be held on until the current one is completed.

4) Next, if the format of the sent message is correct and its execution was error-free, an ACK (acknowledged) should be received. Otherwise, a NAK (not acknowledged) will be sent back by the modulator.

5) If the control command was a query, the reply should be received at this point.

6) Once the message has been processed, the MO-180 will issue an XON to indicate that it is ready for new commands.

A typical communication timing diagram would look as follows:

Tx/Rx	PC	MO-180
⇐	XON	Equipment ready for command
⇒	*?NAM<CR>	Command issued by the controller
⇐	XOFF	Command received indication
⇐	ACK	Command accepted / understood
	WAIT…	Execution delay
⇐	*NAMO-180<CR>	Command answer sent
	WAIT	Usually some small delay
⇐	XON	Equipment ready for command

Note: That all characters are transmitted in ASCII code.

Commands should always be sent in capital letters and cannot be edited online, i.e., once a character is received it is stored in the **MO-180** serial buffer and cannot be corrected by sending an erase code.

In communication idle mode (**MO-180** waiting for a command) the modulator will send an XON code once per second to allow synchronisation with the remote controller

Command list.

There are two main types of commands: Interrogative and Control. They are initiated by sending an ‘*’ character, have ASCII text format and always share a similar structure. For instance, the equipment model name can be retrieved by sending “*?NAM<CR>” and the answer is “*NAMO-180” (always without quotes) Some amount of parsing must be applied, to recover the wanted data from the received text (in this particular case, the name is “**MO-180**”).

Appendix B gives a thorough and detailed description of all the serial commands currently implemented in the **MO-180.**

4.14 DVB-T/H useful bit rates

In the following, we present the useful bit rates (Mbits/s or Mbps) for all combinations of guard interval, constellation and convolutional code rates in DVB-T/H systems and channels of 8, 7, 6 and 5 MHz bandwidths. The useful bit rate does not depend on the transmission mode (2k, 4k or 8k).

English

These tables are similar to Tables 17 (8 MHz), E.6 (7 MHz), E.3 (6 MHz) and G.3 (5 MHz) in document ETSI EN 300 744 v 1.5.1 (2004-11), but with 7 digits of accuracy instead of 2 or 3. This additional accuracy is necessary since the bit rate of the input transport streams when operating in slave mode should not deviate more them a 0.1‰ from the values shown herein, otherwise the MO-180 will not lock. For example, for QPSK, code ½ and guard interval of 1/4, the useful bit rate of DVB-T systems for 8 MHz bandwidth channels is 4.9764706 Mbps, thus in slave mode the TS input bit rate to which the modulator is able to sync should be greater than 4.975973 Mbps and lesser than 4.976968 Mbps.

Constellation	Convolutional code	Guard interval			
		1/4	1/8	1/16	1/32
QPSK	1/2	4,9764706	5,5294118	5,8546713	6,0320856
	2/3	6,6352941	7,3725490	7,8062284	8,0427807
	3/4	7,4647059	8,2941176	8,7820069	9,0481283
	5/6	8,2941176	9,2156863	9,7577855	10,0534759
	7/8	8,7088235	9,6764706	10,2456747	10,5561497
16QAM	1/2	9,9529412	11,0588235	11,7093426	12,0641711
	2/3	13,2705882	14,7450980	15,6124567	16,0855615
	3/4	14,9294118	16,5882353	17,5640138	18,0962567
	5/6	16,5882353	18,4313725	19,5155709	20,1069519
	7/8	17,4176471	19,3529412	20,4913495	21,1122995
64QAM	1/2	14,9294118	16,5882353	17,5640138	18,0962567
	2/3	19,9058824	22,1176471	23,4186851	24,1283422
	3/4	22,3941176	24,8823529	26,3460208	27,1443850
	5/6	24,8823529	27,6470588	29,2733564	30,1604278
	7/8	26,1264706	29,0294118	30,7370242	31,6684492

Table 3.- Useful bit rate (Mbps) for DVB-T modes and 8 MHz channel bandwidths.

For hierarchical modulations with an 8 MHz bandwidth, the useful bit rates can be obtained from Table 1 following these indications:

- Sequence of high priority (HP): QPSK values.
- Sequence of low priority (LP), 16QAM: QPSK values.
- Sequence LP, 64QAM: 16QAM values.

Constellation	Convolutional code	Guard interval			
		1/4	1/8	1/16	1/32
QPSK	1/2	4,3544118	4,8382353	5,1228374	5,2780749
	2/3	5,8058824	6,4509804	6,8304498	7,0374332
	3/4	6,5316176	7,2573529	7,6842561	7,9171123
	5/6	7,2573529	8,0637255	8,5380623	8,7967914
	7/8	7,6202206	8,4669118	8,9649654	9,2366310
16QAM	1/2	8,7088235	9,6764706	10,2456747	10,5561497
	2/3	11,6117647	12,9019608	13,6608997	14,0748663
	3/4	13,0632353	14,5147059	15,3685121	15,8342246
	5/6	14,5147059	16,1274510	17,0761246	17,5935829
	7/8	15,2404412	16,9338235	17,9299308	18,4732620
64QAM	1/2	13,0632353	14,5147059	15,3685121	15,8342246
	2/3	17,4176471	19,3529412	20,4913495	21,1122995
	3/4	19,5948529	21,7720588	23,0527682	23,7513369
	5/6	21,7720588	24,1911765	25,6141869	26,3903743
	7/8	22,8606618	25,4007353	26,8948962	27,7098930

Table 4.- Useful bit rate (Mbps) for DVB-T modes and 7 MHz channel bandwidths.

For hierarchical modulations, you must follow the guidelines shown below Table 1.

Constellation	Convolutional code	Guard interval			
		1/4	1/8	1/16	1/32
QPSK	1/2	3,7323529	4,1470588	4,3910035	4,5240642
	2/3	4,9764706	5,5294118	5,8546713	6,0320856
	3/4	5,5985294	6,2205882	6,5865052	6,7860963
	5/6	6,2205882	6,9117647	7,3183391	7,5401070
	7/8	6,5316176	7,2573529	7,6842561	7,9171123
16QAM	1/2	7,4647059	8,2941176	8,7820069	9,0481283
	2/3	9,9529412	11,0588235	11,7093426	12,0641711
	3/4	11,1970588	12,4411765	13,1730104	13,5721925
	5/6	12,4411765	13,8235294	14,6366782	15,0802139
	7/8	13,0632353	14,5147059	15,3685121	15,8342246
64QAM	1/2	11,1970588	12,4411765	13,1730104	13,5721925
	2/3	14,9294118	16,5882353	17,5640138	18,0962567
	3/4	16,7955882	18,6617647	19,7595156	20,3582888
	5/6	18,6617647	20,7352941	21,9550173	22,6203209
	7/8	19,5948529	21,7720588	23,0527682	23,7513369

Table 5.- Useful bit rate (Mbps) for DVB-T modes and 6 MHz channel bandwidths.

For hierarchical modulations, you must follow the guidelines shown below Table 1.

English

Constellation	Convolutional code	Guard interval			
		1/4	1/8	1/16	1/32
QPSK	1/2	3.1102941	3.4558824	3.6591696	3.7700535
	2/3	4.1470588	4.6078431	4.8788927	5.026738
	3/4	4.6654412	5.1838235	5.4887543	5.6550802
	5/6	5.1838235	5.7598039	6.0986159	6.2834225
	7/8	5.4430147	6.0477941	6.4035467	6.5975936
16QAM	1/2	6.2205882	6.9117647	7.3183391	7.540107
	2/3	8.2941176	9.2156863	9.7577855	10.0534759
	3/4	9.3308824	10.3676471	10.9775087	11.3101604
	5/6	10.3676471	11.5196078	12.1972318	12.5668449
	7/8	10.8860294	12.0955882	12.8070934	13.1951872
64QAM	1/2	9.3308824	10.3676471	10.9775087	11.3101604
	2/3	12.4411765	13.8235294	14.6366782	15.0802139
	3/4	13.9963235	15.5514706	16.466263	16.9652406
	5/6	15.5514706	17.2794118	18.2958478	18.8502674
	7/8	16.3290441	18.1433824	19.2106401	19.7927807

Table 6.- Useful bit rate (Mbps) for DVB-H modes and 5 MHz channel bandwidths.

For hierarchical modulations, you must follow the guidelines shown below Table 1.

4.15 Error Information

The **MO-180** can report two types of errors. One type is triggered by some malfunction in the modulator's circuitry. The other type is related to problems encountered in the normal operation of the modulator (e.g. TS or SFN synchronisation problems).

The first 16 errors taking place during the operation of the modulator are internally stored and can be retrieved or deleted by means of two functions in the STATUS menu: Error List and Clear Errors.

This section describes the error list display format and the meaning of the codes that appear in each case for each type of error.

Error types

The control program of the **MO-180** can detect and display up to three types of errors. Some of them correspond to modulator malfunction and must be directly dealt with at a PROMAX's Customers Service Centre (CSC). Others flag up problems in the normal operation of the modulator.

1. **NAK**: An internal device connected to the I^2C bus does not respond to messages from the modulator's central control unit. This type of error is for Promax internal reference. If it occurs repeatedly, the unit should be taken to a Service Centre.
2. **SFN ERROR STATUS**: This corresponds to a problem in the modulator when working in SFN mode. It would typically refer to synchronisation losses or errors in the MIP packet that should be embedded in the input transport stream to achieve perfect SFN synchronisation.
3. **UNLOCKED STATUS**: It covers all the other scenarios in which the modulator's circuitry is working OK but other error events have been detected (e.g. sync losses or non-compliant TS inputs).

SFN ERROR STATUS

The display format for this type of error is as follows:

ERRnn SFN ERROR STATUS: XXYYZZ

When this type of errors occur, the **MO-180** presents an error message on the LCD display starting with the word STATUS and followed by an explanation of the type of error. Under these circumstances, the ERROR LED flashes red for 5 seconds, and then stays lit until Clear Errors under the STATUS menu is set to YES.

The numerical fields above have the following meaning:

XX Hex number whose bits $X_7X_6X_5X_4X_3X_2X_1X_0$ have the following meaning:

Bits	Active	Description
$X_7 \ldots X_3$	–	Should be always 0 ACTION: Not required
X_2	1	NLPD overflow When the NLPD block is used, this bit flags the occurrence of mathematical overflows within the NLPD block. This is usually caused because the correcting gain is outside the valid range or because the crest factor of the OFDM signal is greater than 11 dB. ACTION: NLP overflow should be avoided at all costs

English

Bits	Active	Description
X_1	1	Delay too large In SFN this bit is 1 when the total delay to apply to the transport streams (calculated as tx time offset + local delay offset + maximum delay) is greater than 1 second. In MFN this bit is asserted when the local delay offset is greater than 1 second. In both types of networks the total delay is always internally limited to 1 second. ACTION: Reduce any of the parameters affecting the total delay
X_0	–	Should be always 0 ACTION: Not required

YY Hex number whose bits $Y_7Y_6Y_5Y_4Y_3Y_2Y_1Y_0$ have the following meaning:

Bits	Active	Description
Y_7	1	HP&LP SFN adapter error In SFN hierarchical modes, a single multiple channel SFN adapter must be used to insert the MIP packet into the HP and LP transport streams. When separate MIP inserters are used for the HP and LP TS's, the transmission time stamps will not be the same and the MO-180 will not be able to synchronise its output with the rest of the SFN network ACTION: Use a multiple channel SFN adapter
Y_6	1	LP delay too small This bit is 1 when the delay to be dynamically (SFN) or statically (MFN) applied to the input transport stream is too small (few ms depending on the configuration of the modulator) ACTION: Increase any of the parameters that affect the total delay
Y_5	1	HP delay too small Same as right above but for the HP transport stream ACTION: See above

Bits	Active	Description
Y_4	1	1pps error count. In SFN operation this bit is asserted when the number of 10 MHz clock periods between two consecutive active edges of the 1pps signal differs from 10^7 ACTION: Check whether the 1pps and 10 MHz signals are synced.
Y_3	1	LP MIP CRC error. When a MIP packet is found in the LP TS this bit indicates whether a transmission error has been flagged by the 32-bit CRC decoder implemented in the modulator. In normal operation there should be no errors in the MIP packet and, therefore, this bit should be 0. ACTION: Ensure that the MIP packet has no transmission errors.
Y_2	1	HP MIP CRC error. Same as right above but for the HP transport stream. ACTION: See above.
Y_1	1	LP TS MIP priority mismatch. When using the MIP packet to configure the modulator a discrepancy might exist between the priority of the transport stream (LP) as signalled by the MIP packet and the priority we have selected using the menu entry MODULATOR: LP TS Input. ACTION: Ensure that the selected LP TS is the actual LP TS.
Y_0	1	HP TS MIP priority mismatch Same as right above but for the HP transport stream ACTION: See above

English

ZZ Hex number whose bits $Z_7Z_6Z_5Z_4Z_3Z_2Z_1Z_0$ have the following meaning:

Bits	Active	Description
Z_7	1	LP MIP pointer mismatch. In SFN operation once the modulator is synchronised with the GPS reference and the incoming transport stream, a MIP pointer mismatch is flagged when the local count for the number of packets left until the end of the current megaframe differs from the pointer embedded in the LP MIP packet. In MFN this bit is always 0 ACTION: Ensure that the GPS inputs AND TS inputs are all locked to a common time base (GPS)
Z_6	1	HP MIP pointer mismatch. Same as right above but for the HP transport stream. ACTION: See above.
Z_5	–	LP MP periodic In SFN operation or MFN using config from MIP, this bit indicates whether a periodic (1) or an periodic (0) insertion of the MIP packet in the LP TS is performed ACTION: Not required (informative)
Z_4	–	HP MP periodic Same as right above but for the HP transport stream ACTION: Not required (informative)
Z_3	1	LP MIP error In SFN operation or MFN using config from MIP, this bit is 1 when a MIP packet has been found in the LP TS but it has formatting errors ACTION: Ensure the MIP packet syntax is correct
Z_2	1	HP MIP error Same as right above but for the HP transport stream ACTION: Same as above

Bits	Active	Description
Z_1	1	LP MIP loss In SFN operation or MFN using config from MIP, this bit is 1 when no Megaframe Initialisation Packet (MIP) is found in the LP TS in at least one megaframe period ACTION: Check whether the LP TS has been processed by a MIP inserter
Z_0	1	HP MIP loss Same as right above but for the HP transport stream ACTION: See above

UNLOCKED STATUS

The display format for this type of error is as follows:

ERRnn UNLOCKED STATUS: XXYY (CC…CC)

When this type of errors occur, the **MO-180** presents an error message on the LCD display starting with the word STATUS and followed by an explanation of the type of error. Under these circumstances, the ERROR LED flashes red for 5 seconds, and then stays lit until Clear Errors under the STATUS menu is set to YES.

This type of error either indicates problems with some of the circuitry implementing the modulation process or synchronisation errors with the different input signals.

The numerical fields above have the following meaning:

XX Hex number whose bits $X_7X_6X_5X_4X_3X_2X_1X_0$ have the following meaning:

Bits	Active	Description
X_7	–	Should be always 0 in normal operation. ACTION: Not required.
X_6	1	10 MHz sync loss. In master MFN and SFN modes this bit flags a loss of synchronisation with the 10 MHz internal or external clock reference signal. In automatic switch-over modes 1 and 2, once a loss of sync with the external 10 MHz clock source has occurred, this bit will not be set back to 0 until the user reselects the 10 MHz sync mode. ACTION: Check that the selected 10 MHz clock is working properly.

English

Bits	Active	Description
X_5	1	HP TS buffer full. In master mode these bits are asserted when the input HP TS bit rate is greater than the useful bit rate for the DVB-T/H mode in use. ACTION: Reduce the peak or average bit rate to avoid overflow.
X_4	1	LP TS buffer full. Same as right above but for the LP TS. ACTION: See above.
X_3	1	HP TS sync loss. In master mode when this bit is 1, a loss of synchronisation with the HP transport stream has occurred (2 or more corrupted or missing TS SYNC bytes). ACTION: Check the availability and compliance of the TS input.
X_2	1	LP TS sync loss. Same as right above but for the LP TS. ACTION: See above.
X_1	1	TS sync loss. In MFN slave mode an assertion of this bit indicates a loss of synchronisation with the input transport stream (2 or more corrupted or missing TS SYNC byte). ACTION: Check the availability and compliance of the TS input.
X_0	0	Valid TS rate. In MFN slave mode this bit should be 1 in normal operation. When it is 0 it tells us that the packet rate of the input transport stream is not within approximately 100ppm of the useful bit rate for the DVB-T/H parameters currently being used and thus the modulator is incapable of acquiring lock. ACTION: Check that the input bit rate is within ±0.1‰ of the nominal value given in the DVB-T/H specification.

YY Hex number whose value should always be 0x1B in normal operation. If the value read on the MO-180 display differed from 0x1B this would indicate some failure in one or more of the circuits that are used to implement the modulation process. In such a case, please contact a Promax Customer Service Centre.

CC…CC This decimal number is a global error counter. It counts the number of errors at the moment in which the error message is displayed. Therefore, if an error of any type occurs in a continuous fashion, this counter will have different value whenever we look at some of the first 16 error detected by the modulator.

In relation to the counter value, it should be noted that, in order to detect an error (e.g. the loss of synchronisation with a transport stream input), the equipment waits for this situation to occur for more that 5 seconds. So, it avoids counting errors during transitions between different configurations of the modulator or during brief periods of time when a TS input is not available.

In any case, the total error counter CC…CC does account for each error event, regardless of whether or not it lasts or repeats itself for more than 5 seconds.

4.15.1 Error messages on the top menu level

Apart from the 16 error messages found in the STATUS menu, the MO-180 also outputs several error messages on the LCD display. These messages are shown for the complete duration of the error event and typically require immediate attention from the user.

The following table shows all the error messages that the MO-180 can display together with an explanation of what each message means.

Message	Meaning
MODULATOR ERROR	Generic error which usually implies circuitry malfunction
TS BUFFER FULL	Input TS bit rate too high leading to overflow in the input buffer
TS SYNC LOST	The modulator has lost sync with the transport stream input
INVALID TS RATE	In MFN slave mode the input bit rate is not adequate
10MHz SYNC LOST	Unable to synchronise with the 10 MHz clock reference
SFN ERROR CODE	This is the SFN error code XXYYZZ described on page 48
DELAY TOO SMALL	In SFN or MFN with local delay offset, the total delay to apply to the transport stream is smaller than the minimum latency of the modulator and thus cannot be achieved
DELAY TOO LARGE	In SFN or MFN with local delay offset, the total delay is greater than 1 second
NLPD OVERFLOW	Arithmetic overflow in the Non-Linear Pre-Distorter due to out-of-range correcting complex gains or to a crest factor greater than 11 dB
1PPS SYNC ERROR	In SFN, error in the 1pps internal count usually caused by the 10 MHz and 1pps references not being synchronised with a common time base

English

5 MAINTENANCE

5.1 Mains fuse replacement

The fuseholder is located on the rear panel of the equipment.

Before replacing the fuse disconnect the mains cord.

Take out the fuse holder with screwdriver. Replace the fuse damaged by a suitable new one and place afresh the fuseholder.

Fuse 5x20 2 A T 250 V

THE BREACH OF THESE INSTRUCTIONS COULD DAMAGE THE EQUIPMENT

5.2 Cleaning Recommendations

CAUTION

To clean the cover, take care the instrument is disconnected.

CAUTION

Do not use scented hydrocarbons or chlorized solvents. Such products may attack the materials used in the construction of the cover.

The cover should be cleaned by means of a light solution of detergent and water applied with a soft cloth.

Dry thoroughly before using the system again.

CAUTION

Do not use for the cleaning of the front panel, alcohol or its derivatives. These products can attack the mechanical properties of the materials and diminish their useful time of life.

English

APÉNDICE A: Listas de Canales
APPENDIX A: Channel Plans

Lista de canales CCIR
CCIR channel plan

CHANNEL	FREQ	CHANNEL	FREQ	CHANNEL	FREQ
E02	50500000 Hz	S24	330000000 Hz	C37	602000000 Hz
E03	57500000 Hz	S25	338000000 Hz	C38	610000000 Hz
E04	64500000 Hz	S26	346000000 Hz	C39	618000000 Hz
S01	107500000 Hz	S27	354000000 Hz	C40	626000000 Hz
S02	114500000 Hz	S28	362000000 Hz	C41	634000000 Hz
S03	121500000 Hz	S29	370000000 Hz	C42	642000000 Hz
S04	128500000 Hz	S30	378000000 Hz	C43	650000000 Hz
S05	135500000 Hz	S31	386000000 Hz	C44	658000000 Hz
S06	142500000 Hz	S32	394000000 Hz	C45	666000000 Hz
S07	149500000 Hz	S33	402000000 Hz	C46	674000000 Hz
S08	156500000 Hz	S34	410000000 Hz	C47	682000000 Hz
S09	163500000 Hz	S35	418000000 Hz	C48	690000000 Hz
S10	170500000 Hz	S36	426000000 Hz	C49	698000000 Hz
E05	177500000 Hz	S37	434000000 Hz	C50	706000000 Hz
E06	184500000 Hz	S38	442000000 Hz	C51	714000000 Hz
E07	191500000 Hz	S39	450000000 Hz	C52	722000000 Hz
E08	198500000 Hz	S40	458000000 Hz	C53	730000000 Hz
E09	205500000 Hz	S41	466000000 Hz	C54	738000000 Hz
E10	212500000 Hz	C21	474000000 Hz	C55	746000000 Hz
E11	219500000 Hz	C22	482000000 Hz	C56	754000000 Hz
E12	226500000 Hz	C23	490000000 Hz	C57	762000000 Hz
S11	233500000 Hz	C24	498000000 Hz	C58	770000000 Hz
S12	240500000 Hz	C25	506000000 Hz	C59	778000000 Hz
S13	247500000 Hz	C26	514000000 Hz	C60	786000000 Hz
S14	254500000 Hz	C27	522000000 Hz	C61	794000000 Hz
S15	261500000 Hz	C28	530000000 Hz	C62	802000000 Hz
S16	268500000 Hz	C29	538000000 Hz	C63	810000000 Hz
S17	275500000 Hz	C30	546000000 Hz	C64	818000000 Hz
S18	282500000 Hz	C31	554000000 Hz	C65	826000000 Hz
S19	289500000 Hz	C32	562000000 Hz	C66	834000000 Hz
S20	296500000 Hz	C33	570000000 Hz	C67	842000000 Hz
S21	306000000 Hz	C34	578000000 Hz	C68	850000000 Hz
S22	314000000 Hz	C35	586000000 Hz	C69	858000000 Hz
S23	322000000 Hz	C36	594000000 Hz		

Lista de canales OIRT
OIRT channel plan

CHANNEL	FREQ	CHANNEL	FREQ	CHANNEL	FREQ
I	52500000 Hz	C30	546000000 Hz	C51	714000000 Hz
II	62000000 Hz	C31	554000000 Hz	C52	722000000 Hz
III	80000000 Hz	C32	562000000 Hz	C53	730000000 Hz
IV	88000000 Hz	C33	570000000 Hz	C54	738000000 Hz
V	96000000 Hz	C34	578000000 Hz	C55	746000000 Hz
VI	178000000 Hz	C35	586000000 Hz	C56	754000000 Hz
VII	186000000 Hz	C36	594000000 Hz	C57	762000000 Hz
VIII	194000000 Hz	C37	602000000 Hz	C58	770000000 Hz
IX	202000000 Hz	C38	610000000 Hz	C59	778000000 Hz
X	210000000 Hz	C39	618000000 Hz	C60	786000000 Hz
XI	218000000 Hz	C40	626000000 Hz	C61	794000000 Hz
XII	226000000 Hz	C41	634000000 Hz	C62	802000000 Hz
C21	474000000 Hz	C42	642000000 Hz	C63	810000000 Hz
C22	482000000 Hz	C43	650000000 Hz	C64	818000000 Hz
C23	490000000 Hz	C44	658000000 Hz	C65	826000000 Hz
C24	498000000 Hz	C45	666000000 Hz	C66	834000000 Hz
C25	506000000 Hz	C46	674000000 Hz	C67	842000000 Hz
C26	514000000 Hz	C47	682000000 Hz	C68	850000000 Hz
C27	522000000 Hz	C48	690000000 Hz	C69	858000000 Hz
C28	530000000 Hz	C49	698000000 Hz		
C29	538000000 Hz	C50	706000000 Hz		

Lista de canales UHF
UHF channel plan

CHANNEL	FREQ	CHANNEL	FREQ	CHANNEL	FREQ
C21	474000000 Hz	C38	610000000 Hz	C55	746000000 Hz
C22	482000000 Hz	C39	618000000 Hz	C56	754000000 Hz
C23	490000000 Hz	C40	626000000 Hz	C57	762000000 Hz
C24	498000000 Hz	C41	634000000 Hz	C58	770000000 Hz
C25	506000000 Hz	C42	642000000 Hz	C59	778000000 Hz
C26	514000000 Hz	C43	650000000 Hz	C60	786000000 Hz
C27	522000000 Hz	C44	658000000 Hz	C61	794000000 Hz
C28	530000000 Hz	C45	666000000 Hz	C62	802000000 Hz
C29	538000000 Hz	C46	674000000 Hz	C63	810000000 Hz
C30	546000000 Hz	C47	682000000 Hz	C64	818000000 Hz
C31	554000000 Hz	C48	690000000 Hz	C65	826000000 Hz
C32	562000000 Hz	C49	698000000 Hz	C66	834000000 Hz
C33	570000000 Hz	C50	706000000 Hz	C67	842000000 Hz
C34	578000000 Hz	C51	714000000 Hz	C68	850000000 Hz
C35	586000000 Hz	C52	722000000 Hz	C69	858000000 Hz
C36	594000000 Hz	C53	730000000 Hz		
C37	602000000 Hz	C54	738000000 Hz		

Lista de canales STDL
STDL channel plan

CHANNEL	FREQ	CHANNEL	FREQ	CHANNEL	FREQ
FA	50000000 Hz	C22	482000000 Hz	C46	674000000 Hz
FB	58000000 Hz	C23	490000000 Hz	C47	682000000 Hz
FC1	62750000 Hz	C24	498000000 Hz	C48	690000000 Hz
FC	66000000 Hz	C25	506000000 Hz	C49	698000000 Hz
C05	178750000 Hz	C26	514000000 Hz	C50	706000000 Hz
C06	186750000 Hz	C27	522000000 Hz	C51	714000000 Hz
C07	194750000 Hz	C28	530000000 Hz	C52	722000000 Hz
C08	202750000 Hz	C29	538000000 Hz	C53	730000000 Hz
C09	210750000 Hz	C30	546000000 Hz	C54	738000000 Hz
C10	218750000 Hz	C31	554000000 Hz	C55	746000000 Hz
C11	226750000 Hz	C32	562000000 Hz	C56	754000000 Hz
C12	234750000 Hz	C33	570000000 Hz	C57	762000000 Hz
C13	242750000 Hz	C34	578000000 Hz	C58	770000000 Hz
C14	290750000 Hz	C35	586000000 Hz	C59	778000000 Hz
D01	306000000 Hz	C36	594000000 Hz	C60	786000000 Hz
D02	318000000 Hz	C37	602000000 Hz	C61	794000000 Hz
D03	330000000 Hz	C38	610000000 Hz	C62	802000000 Hz
D04	342000000 Hz	C39	618000000 Hz	C63	810000000 Hz
D05	354000000 Hz	C40	626000000 Hz	C64	818000000 Hz
D06	366000000 Hz	C41	634000000 Hz	C65	826000000 Hz
D07	378000000 Hz	C42	642000000 Hz	C66	834000000 Hz
D08	390000000 Hz	C43	650000000 Hz	C67	842000000 Hz
D09	402000000 Hz	C44	658000000 Hz	C68	850000000 Hz
C21	474000000 Hz	C45	666000000 Hz	C69	858000000 Hz