

MO-270

DTMB MODULATOR



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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APPENDIX A: Channel Plans



DTMB MODULATOR MO-270

1 GENERAL

1.1 General description

The **MO-270** is a **DTMB** modulator fully compliant with the standard **GB20600-2006**. The modulator input is an **MPEG-2** transport stream (**TS**) in **ASI** format. The outputs are **DTMB** signals up converted to **IF** and **RF**.

The **MO-270** supports **Single Carrier** and **Multicarrier** modes and can be used in **Multi Frequency Networks (MFN)**. Digital coding and modulation are implemented by means of programmable logic devices based on **PROMAX** own technology. This makes the design highly flexible, allowing it to tailor it to any particular application, and offering plenty of features at low cost.

Highlights of this product are:

- Single Carrier and Multicarrier mode of operation.
- High frequency resolution (in steps of 1 Hz).
- High MER.

1.2 Functional description

The **MO-270** is a general purpose **DTMB modulator** contained in a 19" 1U chassis. The unit has two serial **MPEG-2 TS-ASI** inputs. Either of these inputs can be used to modulate the **DTMB** signal. An additional **test TS** can be generated internally in the modulator. This allows generating compliant **DTMB** signals even in the absence of a valid **TS** input.

The **MO-270** is able to work with any incoming bit rate as long as this is strictly lower than the value given in the **DTMB** specification for the modulation parameters in use (See section '*4.10 DTMB useful bit rates*'). The input **TS** bit rate is adapted (bit rate adaptation) to the useful bit rate required by the **DTMB** 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 acceptable limits specified by the **DTMB**.

Whenever possible, it is advised to use an input bit rate considerably lower than the nominal value given in the **DTMB** 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.

The modulator can be configured to generate any of the transmission modes listed in the **DTMB** specification. Several test modes are available in the **MO-270** (single tone output and test **TS** generation).

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 31 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 **MO-270** has been designed to work in Multi Frequency Networks (**MFN**). Single Frequency Network (**SFN**) operation is not currently supported.

The **MO-270** can add white Gaussian noise to the **DTMB** signal with a given Carrier-to-Noise Ratio (C/N). This random noise is generated digitally and is available on both **IF** and **RF** outputs. The noise bandwidth is more than twice the bandwidth of the **DTMB** signal.

The noise generator can be easily switched on and off. When it is on, the user can select the C/N ratio. The valid range is 3 to 40 dB in 0.1 dB steps. Because both noise and signal are generated in the digital domain, the accuracy of the so-simulated C/N ratio is very high.

The average power of the noise within the signal bandwidth can be easily measured at the output of the modulator by switching the useful signal off (Menu entry Suppress Carrier: NO / (YES)). Obviously, the measured noise power will be approximately C/N dB below the **DTMB** signal power. Note that the **DTMB** signal power remains the same regardless of whether noise is added or not at the output.

The channel simulator implemented in the **MO-270** allows the user to simulate both dynamic and static multipath scenarios. Up to 6 echoes (including the main path) of variable amplitude, delay, phase and Doppler frequency can be selected.

The time-varying complex-baseband channel is simulated in the digital domain according to the following equation:

$$h(t; \tau) = \rho_1 e^{j(2\pi f_{D,1}t + \phi_1)} + \sum_{n=2}^6 \rho_n e^{j(2\pi f_{D,n}t + \phi_n)} \delta(t - \tau_n)$$

Echoes 2 to 6 have amplitude ρ_n , constant phase ϕ_n , delay τ_n , and pure Doppler frequency $f_{D,n}$. Echo number 1 has amplitude ρ_1 , constant phase ϕ_1 , and Doppler frequency $f_{D,1}$. Its delay is assumed 0 and therefore it is taken as the time base reference for all the other echoes.

When $f_{D,n} = 0$ for all n , the channel does not vary in time and $h(t;\tau) = h(\tau)$. This is the channel used to characterise fixed or roof-top reception. It's usually nonetheless useful to add some Doppler (1 or 2 Hz) to a static channel in order to slowly stir its phase.

For echo number n , $n = 1...6$, its amplitude ρ_n is computed using the following formula:

$$\rho_n = \frac{10^{\frac{A_n}{20}}}{\sqrt{\sum_{n=1}^6 10^{\frac{A_n}{10}}}}$$

where A_n is the amplitude of echo number n referred to the echo of maximum amplitude of the channel and expressed in dBc (valid range is 0 dBc down to -40 dBc in 0.1 dB steps). Note that the echo of maximum amplitude is not necessarily the first echo as happens, for instance, when pre-echoes are present in the channel. The above formula normalises the channel so that the total power of the DTMB signal (sum of echoes) remains equal to the nominal DTMB signal power when no echoes are present.

The range of echo delays goes from 0 to 541.6 μ s and can be incremented in steps of 0.1 μ s for each of the six echoes.

The echo phase is fixed, ranging between 0° and 359.9° in 0.1° steps.

The Doppler frequency has a valid range of -830 Hz to $+830$ Hz in $+0.1$ Hz steps. Note that, depending on the output frequency in use (36 MHz **IF** or **RF**), the same baseband Doppler frequency may correspond to different vehicle speeds.

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 31 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 operation of the **MO-270** 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 ASI inputs, 75 Ω female BNC.
TS packets of length 188 or 204 bytes.
(automatic detection).
Support for burst and continuous packet mode.

Operating modes

Input TS bit rate strictly below the value given in the DTMB specification.
Packet stuffing for bit rate adaptation and PCR re-stamping are carried out automatically.

IF OUTPUT

Type

50 Ω BNC female connector.

Frequency range

Variable between 31 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 dB μ V) fixed.

In-band amplitude ripple

< 0.5 dB.

In-band group delay ripple

<10 ns.

Frequency stability

20 ppm.

MER

> 43 dB.

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 80 dB μ V with no attenuation.
Variable attenuation of 0 to 60 dB in steps of 1 dB.

Frequency stability

20 ppm.

MER

> 38 dB.

SSB phase noise

≤ -87 dBc/Hz @ 2 kHz.

DTMB PARAMETERS

Carrier Mode

Single, Multicarrier.

Frame Header Length

420, 595, 945 symbols.

Frame Header Phase

Fixed, Rotating.

FEC rates

0.4, 0.6, 0.8.

Constellations

4QAM-NR, 4QAM, 16QAM, 32QAM, 64QAM.

Time Interleaving

240, 720.

MFN operation

Available.

NOISE GENERATOR

Characteristics

Bandwidth

C/N

Fully digital complex baseband generation. Both signal and/or noise can be switched off.
 Flat within twice the bandwidth of the DTMB signal (± 1 dB of flatness within the DTMB bandwidth).
 3 to 40 dB in 0.1 dB steps (noise power varies whilst the DTMB signal power remains constant).

CHANNEL SIMULATOR

Characteristics

Number of taps

Profiles

Amplitudes

Delays

Doppler

Phase

Fully digital complex baseband generation.
 6 echoes, which may be switched on/off individually.
 Pure Doppler shift or constant phase.
 0 to -40 dBc in 0.1 dB steps.
 0 to 541.6 μ s in steps of 100 ns - 8 MHz channels
 -830 to 830 Hz in 0.1 Hz steps.
 0 to 359.9° in 0.1° steps.

TEST MODES

Single carrier (R.M.S Tone)

TS packet generation

Generate a single carrier at the channel central frequency whose level equals the average DTMB output power. This is intended for signal level alignment.
 Internal generation of test TS using PRBS sequences of length 15 or 23 embedded within NULL packets.

NOISE GENERATOR

Characteristics

Bandwidth

C/N

Fully digital complex baseband generation. Both signal noise can be switched off.
 Flat within twice the bandwidth of the DTMB signal (± 1 dB of flatness within the DTMB bandwidth).
 3 to 40 dB in 0.1 dB steps (noise power varies whilst the DTMB signal power remains constant).

ECHOES GENERATOR

Amplitude	From 0 down to -40 dBc in 0.1 steps.
Phase	From 0° to 359.9° in 0.1 steps.
Doppler	Static (0 Hz) / Dinamic (from +- 830 Hz).
Delay	Variable in 100 ns steps.

RS-232C INTERFACE**POWER SUPPLY**

Voltage	90 - 250 VAC.
Frequency	50 - 60 Hz.
Consumption	20W.

OPERATING ENVIRONMENTAL CONDITIONS**Indoor use**

Altitude	Up to 2000 m.
Temperature range	From 5 °C to 40 °C.
Max. relative humidity	80 % (up to 31°C), decreasing lineally up to 50% at 40 °C.

MECHANICAL FEATURES

Dimensions	19" (W.) x 1.75" (H.) x 15" (D.).
Weight	6.3 kg.

RECOMMENDATIONS ABOUT THE PACKING

It is recommended to keep all the packing material in order to return the equipment, if necessary, to the Technical Service.

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		ON (Supply)
	ALTERNATING CURRENT		OFF (Supply)
	DIRECT AND ALTERNATING		DOUBLE INSULATION (Class II protection)
	GROUND TERMINAL		CAUTION (Risk of electric shock)
	PROTECTIVE CONDUCTOR		CAUTION REFER TO MANUAL
	FRAME TERMINAL		FUSE
	EQUIPOTENTIALITY		

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.

3 INSTALLATION

3.1 Power Supply

The **MO-270** is 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 [12] located on the **MO-270** rear panel.

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

3.2 Installation and Start-up

The **MO-270** modulator is designed for use as a rack-mounted 19 inches device (1U chassis).

Switch the main switch [13] 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.

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

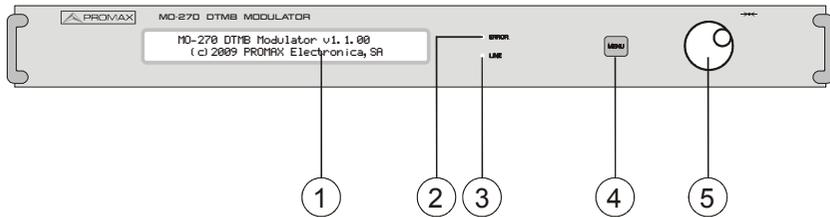


Figure 1.- Front panel.

[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 across the different display menus and sub-menus, and validating selected options.

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 (CW) or counter clockwise (CCW) allows us to navigate through each menu function and option available in the **MO-270**.

4.2 Rear panel description

The rear panel shows, from right to left, the mains socket for AC voltage input, the fan air outlet, a DB-9 connector for remote control via an RS-232C COM port, two ASI inputs, an IF (nominally 36 MHz) test output and the main RF output, at the frequency and level chosen by the user.

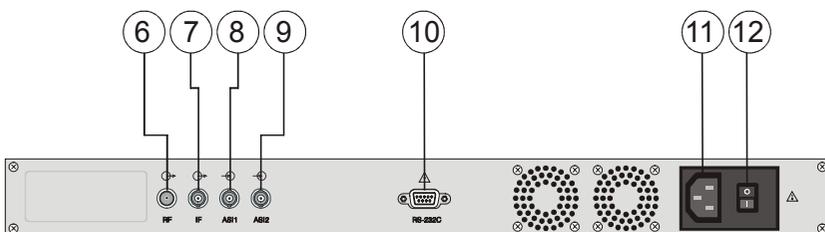


Figure 2.- Rear panel view.

- [6] **RF output, 50Ω, female N-type connector.**
- [7] **IF output, 50Ω, female BNC.**
- [8] **ASI1 input, 75Ω, female BNC.**
ASI input number 1.
- [9] **ASI2 input, 75Ω, female BNC.**
ASI input number 2.
- [10] **RS-232C connector, DB-9.**
DB-9 connector for remote control via an RS-232C COM port.
- [11] **AC voltage connector**
Supplies power to the equipment. Includes the fuse.
- [12] **Mains switch**
Switch on or off the power supply.

NOTE: The actual IF frequency value varies between 31 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: 474000000 Hz ATT: 0 dB
CM: MC CONST: 64QAM FH: 945 TI: 720

Here the RF frequency is 650 MHz, the 1-dB step RF attenuator is set to 10 dB, the DTMB signal is in multicarrier mode, uses a 64 QAM constellation, a frame header length of 945 symbols and time interleaving of 720 symbols.

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

MO-270 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 RS232 port to the user's needs, allowing for an easy identification of the equipment or for some piece of advice.

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 **CW** or **CCW**, cycles through the submenu titles:

1. MODULATOR
2. RF
3. LEVEL
4. TEST
5. CONFIGURATION

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.

- **TS Input:** Selects the input used for providing a Transport Stream (TS) to the **COFDM** modulator. Options are:
 - ASI1: Use TS provided at ASI1 input connector (rear panel).
 - ASI2: Use TS provided at ASI2 input connector (rear panel).
 - PRBS: Use internally generated PRBS data to generate TS test packets.

- **FEC Rate:** Using this function, the user can modify the LDPC code rate for the Transport Stream (TS). The available options are as follows:
 - 0.4
 - 0.6
 - 0.8

- **Constellation:** Here the menu allows the selection of one of the available constellations. The options are:
 - 4QAM-NR
 - 4QAM
 - 16QAM
 - 32QAM
 - 64QAM

- **Frame Header Length:** This function selects the required frame header length for the signal. The available values are:
 - 420 symbols
 - 595 symbols
 - 945 symbols

- **Frame Header Phase:** In this function the rotation of the frame header phase can be selected for PN identification purposes. The options are:
 - Fixed
 - Rotating (only for 420 and 945 frame header length).

- **Time Interleaving:** There are two options for the time interleaving:
 - 240 symbols
 - 720 symbols
- **Carrier Mode:** The modulator has these options:
 - Single Carrier
 - MultiCarrier
- **Pilots:** Insert two pilots at ± 0.5 symbol rate (only in single carrier mode).
 - OFF
 - ON
- **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 $2^{23}-1$.
 - 15: PRBS sequences of length $2^{15}-1$.

4.5 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 CW and negative if CCW. 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 **CW** 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-270** 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 selectable values are:
 - NO
 - YES

4.6 LEVEL functions

This menu item collects the functions related to RF level adjustment. The **MO-270** 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.

That 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 CW increases the attenuation, reducing the output level. Turning CCW 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 **CW** increases the output level. Turn it **CCW** decreases the level.

The displayed characters are integer numbers. 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.

4.7 NOISE

This menu item collects the functions related to the digitally synthesized white noise:

Generator: Turns the noise generator ON/OFF.

C/N: Selects a C/N ratio value from 3 to 40 dB in +0,1 dB steps.

Suppress Carrier: Turns **ON/OFF** the COFDM signal to which the white Gaussian noise is added.

4.8 ECHOES

This menu contains a series of parameters to be defined in order to simulate terrestrial transmission channels:

Generator: Turns the channel simulator ON/OFF.

ECHO 1: Sets the parameters for the first channel tap (Reference Echo). This tap exhibits zero delay and is taken as the reference of the time base for all the other echoes. Note that its amplitude is not necessarily 0 dBc. This allows to define channels with preechoes, i.e.: channel profiles whose tap of maximum amplitude is not the first one.

Press the encoder key to access the first echo parameters definition:

Amplitude: Turns this tap ON/OFF or sets its amplitude level from 0 down to -40 dBc in 0.1 dB steps.

Phase: Tap phase from 0° to 359.9° in 0.1° steps.

Doppler: Doppler shift frequency to define static (0 Hz) or dynamic (from ± 830 Hz) taps.

ECHO *n*: Defines the settings for each channel tap referred to the echo set as reference.

Amplitude: Turns this tap ON/OFF or sets its amplitude level from 0 down to -40 dBc in 0.1 dB steps.

Phase: Tap phase from 0° to 359.9° in 0.1° steps.

Doppler: Doppler shift frequency to define static (0 Hz) or dynamic (from ± 830 Hz) taps.

Delay: Depending on the channel BW, this is the echo delay referred to echo 1 and variable in 100 ns steps.

4.9 CONFIGURATION functions

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

Save to Memory: The **MO-270** 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.

Save C/N & Echoes: The **MO-270** stores in memory the parameters related to C/N & Echoes previously defined. Turn the encoder to select the desired option. Press the encoder key to confirm the storing action. Press the MENU key to cancel the action.

Load C/N & Echoes: Allows to load the previously stored settings.

Channel Plan: Use this function to choose among the channel plans included in the **MO-270**. 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 DTMB signal or a single tone. A single tone can be useful for accurate alignment or testing of external components. The available options are:

- **DTMB:** Generate a DTMB signal.
- **TONE RMS:** Generate a single tone at an RMS level equal to the RMS level of the modulated DTMB signal.

4.10 STATUS

These functions provide information about errors, software and firmware versions.

- **Error List:** During the continuous operation of the **MO-270**, 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 “4.11 Error information”):

- Errors generated when the modulator is not locked to the selected TS input.

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 center.

See section 4.11 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:
 - NO
 - YES
- **Firmware:** Indicates the version firmware included in the equipment. A sample screen looks as follows:

MENU: back PUSH: select TURN: next/prev.
CONFIGURATION Firmware: v1.0.02 - 84.00

4.11 REMOTE control through RS-232 interface

The **MO-270** has an RS-232C compatible serial port to connect to a computer for remote control. A suitable set of remote control commands allows enquiring and changing any functional parameter.

Communication details: There is a control protocol to synchronize command reception and validation. A command must be sent once an XON (coded 0x11: hexadecimal value 11 or 17 in decimal) character is received from the instrument. When the instrument detects a complete command, it sends an XOFF (0x13) code and, once validated and executed, an ACK (0x06) or NAK (0x15) code is sent to the remote controller.

To ensure error-free communication between the two devices, the communication parameters for the serial port on the remote controller are as follows:

Rate: 115200 bauds, Data bits: 8 bits, Parity: None, Stop bits: 1

The **MO-270** accepts remote commands at any time, when the instrument is on. It's not necessary to put the instrument in a special remote control mode. The communication is carried out using the transmitter and receiver data lines on the serial port. Also the control signals CTS and RTS must be connected.

A standard PC computer DB9F to DB9F NULL MODEM serial cable can be used when connecting the instrument to an available COM port.

The communication protocol is as follows:

- 1) **MO-270** transmits a XON code (0x11) every second. The aim is to indicate to any possible remote device that the equipment is ready to receive data.
- 2) At this moment, data streams can be sent to it. Each data stream is made of:
 - Initial character '*' (code 0x2A)
 - Set of characters that describe data message.
 - Final character CR (carry return, code 0x0D)
- 3) Once a data stream has been sent, an XOFF will be received, indicating that the transmission of any new command must wait until completion of the current one.
- 4) Next, if the message format is correct and its execution has no errors, an ACK (acknowledge) should be expected. Otherwise, an NAK (not acknowledge) will be received.
- 5) If the sent message requires an answer, it will be sent at this point.

6) Once completed the message processing, the **MO-270** will send an XON indicating that its ready for a new command.

A typical communication timing diagram would be as follows:

PC	MO-270
1) < XON	(equipment ready for command)
2) *?NA<cr> =>	(command issued by the controller)
3) < XOFF	(command received indication)
4) < ACK	(command accepted / understood)
5) wait ...	(execution delay)
6) < *NAMO-270<cr>	(command answer sent)
7) wait ...	(usually some small delay)
8) < XON	(equipment ready for command)

(All characters are transmitted in ASCII code)

Commands should always be sent in capital letter and cannot be edited online, i.e., once a character is received it is stored in the **MO-270** buffer and cannot be rectified by sending an erase code.

When in communication idle mode (**MO-270** waiting for a command) the instrument will send an XON code at one second intervals, to allow synchronization.

Command list: Commands are classified between interrogative and control commands. They are initiated by sending an "*" character, and have ASCII text format and always share a similar structure. For instance, the equipment model name can be asked by sending "*?NA<cr>" and the answer is "*NAMO-270" (always without quotes) Some amount of parsing must be applied, to recover the wanted data from the answer text (in this case, "MO-270")

Here follows a table with all available commands

Name	Message	Answer	Description and Format
NAM	*?NAM<cr> ⇨	⇨ *NAMMO-270<cr>	Retrieve equipment model.
VER	*?VER<cr> ⇨	⇨ *VERv0.7.10<cr>	Retrieve SW version.
BEP	*BEP<cr>		Acoustic indication.
USR	*USR <i>text</i> <cr>		Set a new USER text to be displayed in the LCD panel. <i>'text'</i> is an ASCII text with a maximum of 32 characters
	*?USR<cr>	*USR <i>text</i> <cr>	Returns the current USER text.
STO	*STO <i>nn</i> <cr>		Save the current configuration to a memory. <i>'nn'</i> is a decimal value from 00 to 11.
RCL	*RCL <i>nn</i> <cr>		Retrieve a configuration from a memory. <i>'nn'</i> is a decimal value from 00 to 11
FRQ	*FRQ <i>nn...n</i> <cr>		Modify the equipment RF frequency. <i>'nn...n'</i> is the frequency value in Hz, written with 9 digits, from 45 to 875 MHz
	*?FRQ<cr>	*FRQ <i>nn...n</i> <cr>	Returns the current RF frequency in Hz and with 9 digits (padding with '0' on the left)
ATT	*ATT <i>nn</i> <cr>		Change the RF output attenuation. <i>'nn'</i> is the new decimal attenuation value in dB
	*?ATT<cr>	*ATT <i>nn</i> <cr>	Returns the current RF attenuation value. <i>'nn'</i> value using 2 decimal digits (padding with '0' on the left)
ERN	*?ERN<cr>	*ERN <i>nn...n</i> <cr>	Retrieve the internal error counter. <i>'nn...n'</i> value using 8 decimal digits (padding with '0' on the left)
ERC	*ERC<cr>		Clear the internal error counter
ERL	*?ERL <i>nn</i> <cr>	*ERL <i>text</i> <cr>	Retrieve an error message. <i>'nn'</i> is the error index in decimal value <i>'text'</i> is the text string in ASCII format
LCK	*?LCK<cr>	*LCK <i>chhhh</i> <cr>	Retrieve the locked status. <i>'c'</i> is the lock test result: 'L' for locked, 'U' for unlocked <i>'hhhh'</i> is an hexadecimal value corresponding to a status code (see the User's Manual for error codes)
TSI	*TSI <i>d</i> <cr>		Sets the modulator TS Input. <i>'d'</i> decimal digit 0:ASI1 1:ASI2 2:TEST
	*?TSI<cr>	*TSI <i>d</i> <cr>	Asks for the current modulator TS input. <i>'d'</i> as before

Name	Message	Answer	Description and Format
MCR	*MCR<cr>		Sets the modulator code rate. 'd' decimal digit 0:0.4 1:0.6, 2:0.8
	*?MCR<cr>	*MCRd<cr>	Asks for the current code rate. 'd' as before
MCO	*MCOd<cr>		Sets the modulator constellation. 'd' decimal digit 0:4QAM-NR, 1:4QAM, 2:16QAM, 3:32QAM, 3:64QAM
	*?MCO<cr>	*MCOd<cr>	Asks for the current modulator constellation. 'd' as before
FHL	*FHLd<cr>		Sets the modulator frame header length. 'd' decimal digit 0:420, 1:595, 2:945
	*?FHL<cr>	*FHLd<cr>	Asks for the current modulator frame header length. 'd' as before
FHP	*FHPd<cr>		Sets the modulator frame header phase. 'd' decimal digit 0:rotating, 1:fixed
	*?FHP<cr>	*FHPd<cr>	Asks for the current modulator frame header phase. 'd' as before
TIN	*TINd<cr>		Sets the modulator time interleaving. 'd' decimal digit 0:240, 1:720
	*?TIN<cr>	*TINd<cr>	Asks for the current time interleaving. 'd' as before
PIL	*PILd<cr>		Sets the modulator pilots (single carrier). 'd' decimal digit 0:OFF, 1:ON
	*?PIL<cr>	*PILd<cr>	Asks for the current pilots state. 'd' as before
CAR	*CARd<cr>		Sets the modulator carrier mode. 'd' decimal digit 0: Multicarrier, 1: Single Carrier
	*?CAR<cr>	*CARd<cr>	Asks for the current modulator carrier mode. 'd' as before
INV	*INVD<cr>		Sets the modulator spectral inversion mode. 'd' decimal digit 0:INV, 1:NO INV
	*?INV<cr>	*INVD<cr>	Asks for the current modulator spectral inversion mode. 'd' as before
MOD	*MODd<cr>		Sets the modulator IF output mode. 'd' decimal digit 0:DTMB, 1: TONE RMS
	*?MOD<cr>	*MODd<cr>	Asks for the current modulator IF output mode. 'd' as before

Name	Message	Answer	Description and Format
FIF	*FIFnn...n<cr>		Modify the equipment IF frequency. 'nn...n' is the frequency value in Hz, written with 8 digits, from 31 to 37 MHz
	*?FIF<cr>	*FIFnn...n<cr>	Returns the current IF frequency in Hz and with 8 digits (padding with '0' on the left)
DIS	*DISd<cr>		Disable the RF output. 'd' decimal digit 0:ENABLE RF, 1:DISABLE RF
	*?DIS<cr>	*DISd<cr>	Asks for the current RF disable state. 'd' as before
MPR	*MPRd<cr>		PRBS of 15 or 23 bits 'd' decimal digit 0:15 bits PRBS 1:23 bits PRBS
	*?MPR<cr>	*MPRd<cr>	Asks for the current PRBS length with 'd' as before
MRE	*MREd<cr>		PCR restamping (master mode) ON/OFF. 'd' decimal digit 0: ON 1: OFF
	*?MRE<cr>	*MREd<cr>	Asks for the current restamping state. 'd' as before
MPL	*?MPL<cr>	*MPLddd <cr>	Asks for the TS packet length detected 'ddd' ASCII text: 188 or 204 bytes.
NOI	*NOId<cr>		Sets the noise generator ON/OFF. 'd' decimal digit 0:OFF, 1:ON
	*?NOI<cr>	*NOId <cr>	Asks for the noise generator state. 'd' as before.
CNR	*CNRddd<cr>		Sets the C/N value (in dB x 10). 'ddd' decimal digits value between 030 and 400 (3.0dB to 40.0dB)
	*?CNR<cr>	*CNRddd <cr>	Asks for the current C/N value. 'ddd' as before.
SIG	*SIGd<cr>		Sets the signal generator ON/OFF. 'd' decimal digit 0: ON, 1:OFF
	*?SIG<cr>	*SIGd <cr>	Asks for the signal generator state. 'd' as before.
ECO	*ECOd<cr>		Sets the echoes generator ON/OFF. 'd' decimal digit 0: OFF, 1:ON
	*?ECO<cr>	*ECOd <cr>	Asks for the signal generator state. 'd' as before.

Name	Message	Answer	Description and Format
EAM	*EAMdaaaa<cr>		Sets the amplitude of the echo. 'd', 'aaaa' decimal digits 'd': selects the echo, value between 0 and 5 a : amplitude value in dBc x 10.
	*?EAMd<cr>	*EAMaaaa <cr>	Asks for the amplitude of the echo. 'd' and 'a' as before.
EPH	*EPHdpppp<cr>		Sets the phase of the echo. 'd', 'pppp' decimal digits 'd': selects the echo, value between 0 and 5 p : phase value in degrees x 10.
	*?EPHd<cr>	*EPHpppp <cr>	Asks for the phase of the echo. 'd' and 'p' as before.
EDO	*EDOsffff<cr>		Sets the Doppler frequency shift of the echo. 'd' 's', 'ffff' decimal digits 'd': selects the echo, value between 0 and 5 s : sign of the sift, '+' '-' f : frequency value in Hz x 10, value between -830.0Hz to 830.0Hz
	*?EDOd<cr>	*EDOsffff <cr>	Asks for the Doppler frequency shift of the echo. 'd', 's' and 'f' as before.
EDL	*EDLdtttt<cr>		Sets the delay of the the echo. 'd', 'tttt' decimal digits 'd': selects the echo, value between 0 and 5 t : delay value in μ s x 10
	*?EDLd<cr>	*EDLtttt <cr>	Asks for the delay of the echo. 'd' and 't' as before.
STE	*STE<cr>		Saves the current configuration of echoes and C/N
RCE	*RCE<cr>		Retrieves the current configuration of echoes and C/N saved before.

4.12 DTMB useful bit rates

At the following tables, you can see the useful bit rates (Mbits/s or Mbps) for all possible combinations of **FEC Rate** and constellation values.

The payload data rate under a signal frame of 4200 symbols (frame header length 420 symbols) is shown on table 1.

Signal Frame Length		Signal frame 4200 symbols		
FEC Rate		0.4	0.6	0.8
MAPPING	4QAM-NR			5.414
	4QAM	5.198	8.122	10.829
	16QAM	10.829	16.243	21658
	32QAM			27.072
	64QAM	16.243	24.365	32.486

Table 1.- System Payload data Rate for 4200 symbols.

The payload data rate under a signal frame of 4375 symbols (frame header length 595 symbols) is shown on table 2.

Signal Frame Length		Signal frame 4375 symbols		
FEC Rate		0.4	0.6	0.8
MAPPING	4QAM-NR			5.198
	4QAM	5.198	7.797	10.396
	16QAM	10.396	15.593	20.791
	32QAM			25.989
	64QAM	15.593	23.390	31.187

Table 2.- System Payload data Rate for 4375 symbols.

The payload data rate under a signal frame of 4725 symbols (frame header length 945 symbols) is shown on table 3.

Signal Frame Length		Signal frame 4725 symbols		
FEC Rate		0.4	0.6	0.8
MAPING	4QAM-NR			4.813
	4QAM	4.813	7.219	9.626
	16QAM	9.626	14.438	19.251
	32QAM			24.064
	64QAM	14.438	21.658	28.877

Table 3.- System Payload data Rate for 4725 symbols.

4.13 Error Information

When using the equipment, operating errors can occur as well as errors related to the loss of synchronization in the **MPEG-2** input transport stream.

The first 16 errors appearing during the instrument operation are internally registered and can be retrieved or erased by means of the functions in **CONFIGURATION** menu.

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

4.13.1 Types of errors

The control program of the **MO-270** can detect and show up to 4 types of errors. Some of them correspond to instrument malfunction and must be directly reported to a **PROMAX's** Customers Service Centre (CSC). Others state incorrect options about modulator input signals.

1. **NAK:** An internal device connected to control I²C bus does not respond to the messages from the microcontroller. It requires service of CSC.
2. **UNKN:** Unknown error. Due to a problem different to the one previously described, the I²C control system cannot be accessed. It requires service of CSC.
3. **BUSY:** The I²C bus controller is busy and has not been possible to recover its operation. It requires service of CSC.
4. **MOD FAIL:** It covers all errors corresponding to the MPEG-2 transport stream inputs not being correctly synchronized and/or not having the right bit rate.

4.13.2 Error Coding

NAK, **BUSY** and **UNKN** are for internal use of Promax. If any of these errors occurs repeatedly, the equipment ought to be taken to a PROMAX's customer service centre for repair.

MOD FAIL: The display format for this type of errors is as follows:

ERR02 MOD FAIL STATUS: XXYY (CCC...C)

When this type of errors occur, the **MO-270** presents an error message on the LCD display starting with the word **STATUS** and followed by an explanation of the type of error (e.g. **TS SYNC LOST**, **TS BUFFER FULL** or **INVALID TS RATE**). Needless to say, in this scenario the **ERROR LED** flashes red for 5 seconds, and then stays lit until the error count is cleared within the **CONFIGURATION** menu.

The numerical fields have the following meaning:

XX: Hexadecimal value composed by several information bits, with meaning according to the modulator configuration. Eight bits compose the data structure. Each bit marks an error status when its value is "1", except when the opposite is indicated:

b7 b6 b5 b4 b3 b2 b1 b0

Bits **b7**, **b6**, **b4**, **b2** and **b1** are always "0".

b5: TS buffer full. The input TS bit rate is above the maximum value. You must reduce the transport stream bit rate.

b3: TS sync lost. The synchronisation with the input TS has been lost. The most probable cause is that an input transport stream is not available or that it has been temporarily disconnected.

b0: It is always "1".

YY: This complementary information is also expressed in hexadecimal. The value of each bit indicates a possible anomaly in the operation of the circuit. In all cases, a deviation with respect to the value of reference indicates a failure in some of the circuits that compose the modulator. Contact technical assistance (CSC) for repair.

The value of reference (all OK) is **1B**, which corresponds to the following value of each bit:

HEX	b7	b6	b5	b4	b3	b2	b1	b0
1B	0	0	0	1	1	0	1	1

Bits **b7** and **b6** are always "0". Bit **b1** is always "1".

A change in bits **b5**, **b4** or **b3**, indicates failure in the **IF** generation circuitry (Digital to Analogue converter).

A change in bits **b2** or **b0** implies failure in the **DTMB** modulator circuitry.

CCC... C: This parameter 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 continuously, this counter will have a different value whenever we look at some of the first 16 errors detected by the equipment.

In relation to this value, it must be noted that, in order to detect an error (for example the loss of synchronization with a TS input), the equipment waits for this situation to occur for more than 5 seconds. So, it avoids errors in the transitions between different modulator functions or temporary TS input disconnections to be counted.

However, the total error counter (**CCC... C**) counts each occurrence, regardless of whether or not it lasts more than 5 seconds.

5 MAINTENANCE

5.1 Mains fuse replacement

The fuseholder is located on the back 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 2A T 250V

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.



APPENDIX A: Channel Plans

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		

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		

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		

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

