

# Televes®



T.OX SERIES

Refs. 2333, 233310  
2334, 233410  
234304, 234310  
2335, 2336

**EN** Optical Fiber Transmitter and Receiver  
with return path channel

User manual



## Optical Fiber Transmitter and Receiver

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## Important safety instructions:

### General installation conditions:

- Before handling or connecting the equipment, please read this manual.
- Do not obstruct the equipment's ventilation system.
- Please allow air circulation around the equipment.
- Do not place the equipment near sources of heat or in excessively moisture conditions.
- Do not place the equipment where it may be affected by strong vibrations or knocks.

### How to use the equipment safely:

- If any liquid or object falls inside the equipment, please contact a specialized technician.
- Do not connect the equipment until all the other connections have been made.

### Instructions for the optical connection:

- For the optical connection, a single mode fibre cable is used with an SC/APC-type connector.
- Remove the dust cap from the optical connector located on the front panel, as well as the one of the connector of the single mode fiber to be connected to the equipment.

- Connect the cable to the device, carefully slotting the guides together for both connectors, pushing the connector all the way in.

### Precautionary measures with the connection point:

- Take special care to avoid damaging the unprotected ends of the connectors, as small scratches, impurities and/or particles of dirt, oil, grease, sweat etc. may significantly affect the quality of the signal.
- To clean the ends of the connectors, wipe with an appropriate cleaning wipe moistened with isopropyl alcohol, specific for the cleaning of optical elements. Make sure the alcohol evaporates fully before connecting.
- Keep the connector covers and cable caps in a safe place in case they are needed in the future.
- Always fit the covers on the connectors of devices that are not connected to cables to prevent the laser beam from damaging the eyes.
- Avoid turning on the transmitter without having the fibre optic cable connected.

## Safety measures

### Warning.-

This product emits an invisible laser beam. Avoid contact with laser radiation. The use of equipment such as binoculars or magnifying glasses may increase damage caused to the eyes.



According to EN60825-1\_ 2007



### Caution

- The use of controls or adjustments, or procedures other than those specified in this manual may result in exposure of body parts to harmful radiation.
- Carefully read and observe the instructions given in this manual, and keep it for future reference.
- Do not use the equipment in any way that does not comply with the operating instructions or in any conditions that exceed the stipulated atmospheric specifications.
- This equipment is not user-serviceable. Should you require assistance, contact our technical service department.
- Never point the laser beam intentionally at people or animals.

## 1. Technical specifications

| Optical transmitters                |                                                               |                 |                | 2333               | 233310  | 2334                  | 233410  | 234304        | 234310  |
|-------------------------------------|---------------------------------------------------------------|-----------------|----------------|--------------------|---------|-----------------------|---------|---------------|---------|
| RF<br>Input/Output                  | Frequency range                                               | Forward channel | MHz            | 87 - 2150          |         |                       |         |               |         |
|                                     |                                                               | Return channel  |                | ----               |         | 1 - 65                |         | ----          |         |
|                                     | Maximum input level for CSO & CTB $\geq 60$ dB <sup>(1)</sup> | 87-862 MHz      | dB $\mu$ V     | 91                 | 87      | 91                    | 87      | 85            | 87      |
|                                     |                                                               | 950-2150 MHz    |                | 80                 |         |                       |         |               |         |
|                                     | Input level regulation margin (in 2 dB steps)                 |                 | dB             | 0-18               |         |                       |         |               |         |
|                                     | Output level regulation margin (in 2 dB steps)                |                 | dB             | ----               |         | 0-18                  |         | ----          |         |
|                                     | Return channel maximum RF output level                        |                 | dB $\mu$ V     | 112 <sup>(2)</sup> |         |                       |         |               |         |
|                                     | Equivalent input noise EIN                                    | 850 MHz         | dBm/Hz         | -150               |         |                       |         |               |         |
|                                     |                                                               | 2000 MHz        |                | - 146              |         |                       |         |               |         |
|                                     | Flatness                                                      |                 | dB             | $\pm 1,5$          |         |                       |         |               |         |
|                                     | Return losses                                                 |                 | dB             | $\geq 10$          |         |                       |         |               |         |
|                                     | Impedance                                                     |                 | ohm            | 75                 |         |                       |         |               |         |
|                                     | Test socket attenuation (typ.)                                |                 | dB             | 16                 |         |                       |         |               |         |
| Optical output<br>(forward channel) | Laser                                                         |                 | type           | MQW-DFB            |         |                       |         |               |         |
|                                     | Wavelength                                                    |                 | nm             | 1310 $\pm$ 20      |         |                       |         | 1550 $\pm$ 20 |         |
|                                     | Output optical power                                          |                 | mW/dBm         | 4 / 6              | 10 / 10 | 4 / 6                 | 10 / 10 | 2,5 / 4       | 10 / 10 |
| Optical input<br>(return channel)   | Optical device                                                |                 | type           | ----               |         | InGaAs Pin Photodiode |         | ----          |         |
|                                     | Wavelength                                                    |                 | nm             | ----               |         | 1200 -1600            |         | ----          |         |
|                                     | Detection bandwidth                                           |                 | MHz            | ----               |         | 1 - 3000              |         | ----          |         |
|                                     | Max. Optical power received                                   |                 | mW/dBm         | ----               |         | 2 / 3                 |         | ----          |         |
| General                             | Powering/Consumption                                          | 12 Vdc          | mA             | 210                | 270     | 310                   | 330     | 265           | 325     |
|                                     |                                                               | 24 Vdc          |                | 104                | 140     | 160                   | 170     | 140           | 160     |
|                                     | RF connectors                                                 |                 | type           | female F           |         |                       |         |               |         |
|                                     | Optical connectors                                            |                 |                | SC/APC             |         |                       |         |               |         |
|                                     | Operating temperature                                         |                 | $^{\circ}$ C   | -5 ... +45         |         |                       |         |               |         |
|                                     | Weight                                                        |                 | grs.           | 850                |         | 900                   |         | 850           |         |
| Dimensions                          |                                                               | mm              | 50 x 217 x 175 |                    |         |                       |         |               |         |

(1) Input: 41 TV CH CENELEC and 1 complete satellite transponder. The input attenuator in 0dB position.

(2) Measurement made according to standard DIN45004B.

| Optical receivers                  |                                                                                                                                |                 |        | 2335                  | 2336        |    |
|------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|-----------------|--------|-----------------------|-------------|----|
| RF<br>Input/Output                 | Frequency range                                                                                                                | Forward channel | MHz    | 87 - 2150             |             |    |
|                                    |                                                                                                                                | Return channel  |        | ----                  | 1 - 65      |    |
|                                    | Maximum Output Level for CSO and CTB >= 60dB <sup>(1)</sup>                                                                    | 87-862 MHz      | dBµV   | 93                    |             |    |
|                                    |                                                                                                                                | 950-2150 MHz    |        | 90                    |             |    |
|                                    | Output level regulation margin (in 2 dB steps)                                                                                 |                 |        | dB                    | 0 - 18      |    |
|                                    | Maximum input level return path <sup>(2)</sup>                                                                                 |                 |        | dBµV                  | ----        | 95 |
|                                    | Equivalent input noise of the return channel, measured at 30 MHz and the transmitter output connected directly to the receiver |                 |        | dBm/Hz                | -152,5      |    |
|                                    | Flatness                                                                                                                       |                 |        | dB                    | ± 1,5       |    |
|                                    | Return losses                                                                                                                  |                 |        | dB                    | >= 11       |    |
|                                    | Impedance                                                                                                                      |                 |        | ohm                   | 75          |    |
| Optical input<br>(forward channel) | Optical device                                                                                                                 |                 | type   | InGaAs Pin Photodiode |             |    |
|                                    | Wavelength                                                                                                                     |                 | nm     | 1200 -1600            |             |    |
|                                    | Detection bandwidth                                                                                                            |                 | MHz    | 1 - 3000              |             |    |
|                                    | Maximum Optical power received                                                                                                 |                 | mW/dBm | 4 / 6                 |             |    |
| Optical output<br>(return channel) | Laser                                                                                                                          |                 | tipo   | ----                  | Fabry-Perot |    |
|                                    | Wavelength                                                                                                                     |                 | nm     | ----                  | 1310 ± 20   |    |
|                                    | Maximum output power                                                                                                           |                 | mW/dBm | ----                  | 2 / 3       |    |
| General                            | Powering/Consumption                                                                                                           | 12 Vdc          | mA     | 300                   | 355         |    |
|                                    |                                                                                                                                | 24 Vdc          |        | 155                   | 175         |    |
|                                    | RF connectors                                                                                                                  |                 | type   | female F              |             |    |
|                                    | Optical connectors                                                                                                             |                 |        | SC/APC                |             |    |
|                                    | Operating temperature                                                                                                          |                 | °C     | -5 ... +45            |             |    |
|                                    | Weight                                                                                                                         |                 | grs.   | 850                   | 900         |    |
|                                    | Dimensions                                                                                                                     |                 | mm     | 50 x 217 x 175        |             |    |

(1) Output: 42 TV CH CENELEC and 1 complete satellite transponder. The output attenuator in 0dB position.

(2) According to DIN45004B.

## 1.5. Amplifiers technical specifications

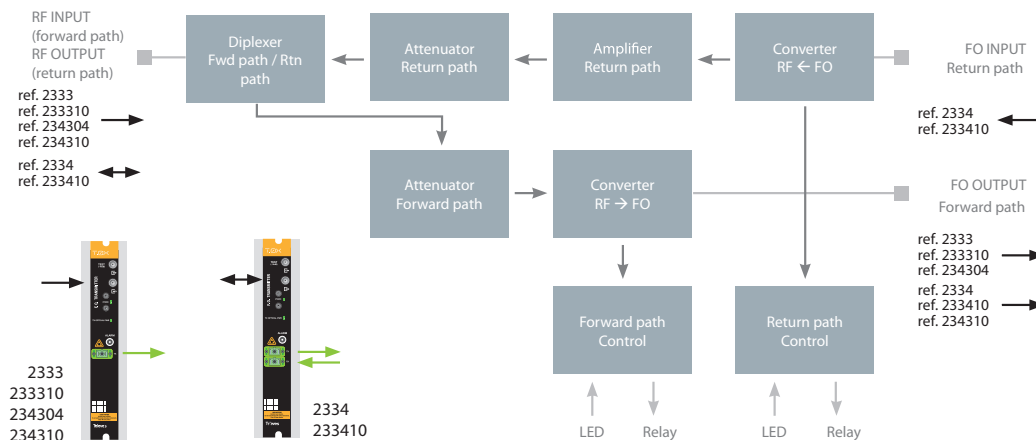
|                   |                           |                          |                        |         |
|-------------------|---------------------------|--------------------------|------------------------|---------|
| Amplifier<br>5575 | Frequency range           | 46 ... 862 MHz           | Connector type         | "F"     |
|                   | Gain                      | 44 ± 2,5 dB              | Powering               | 24 V--- |
|                   | Regulation margin         | 20 dB                    | Consumption at 24 V--- | 450 mA  |
|                   | Output level (at 60 dBc): | 105 dBμV (42 CH CENELEC) | Test socket            | -30 dB  |

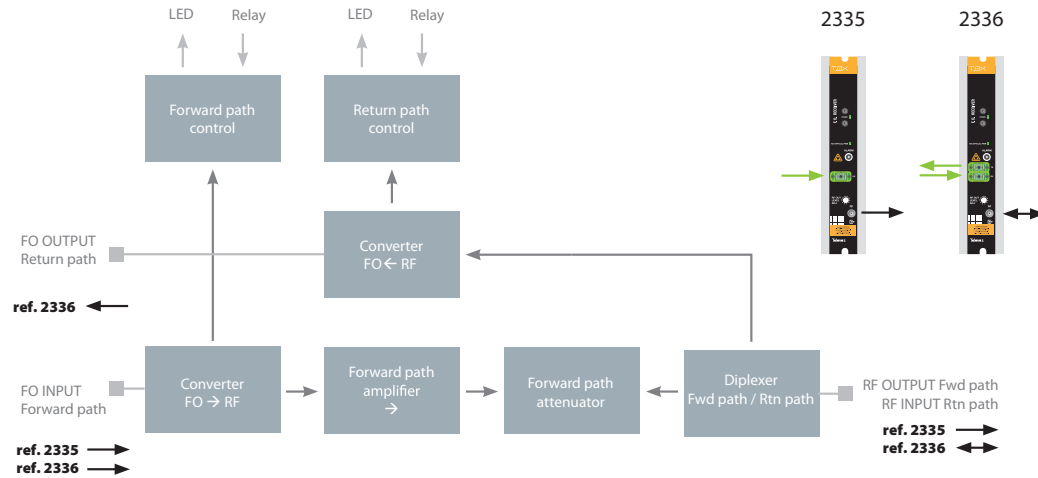
## 1.6. Technical specs. Power Supply Unit

|                           |                |                       |                                            |             |
|---------------------------|----------------|-----------------------|--------------------------------------------|-------------|
| Power Supply Unit<br>5629 | Mains voltage  | 196 - 264 V~ 50/60 Hz | Total max. current<br>(output1 + output2): | 5 A (24V--- |
|                           | Output voltage | 24V---                | Max. current per output                    | 4 A (24V--- |

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## 1.7. Blocks diagrams





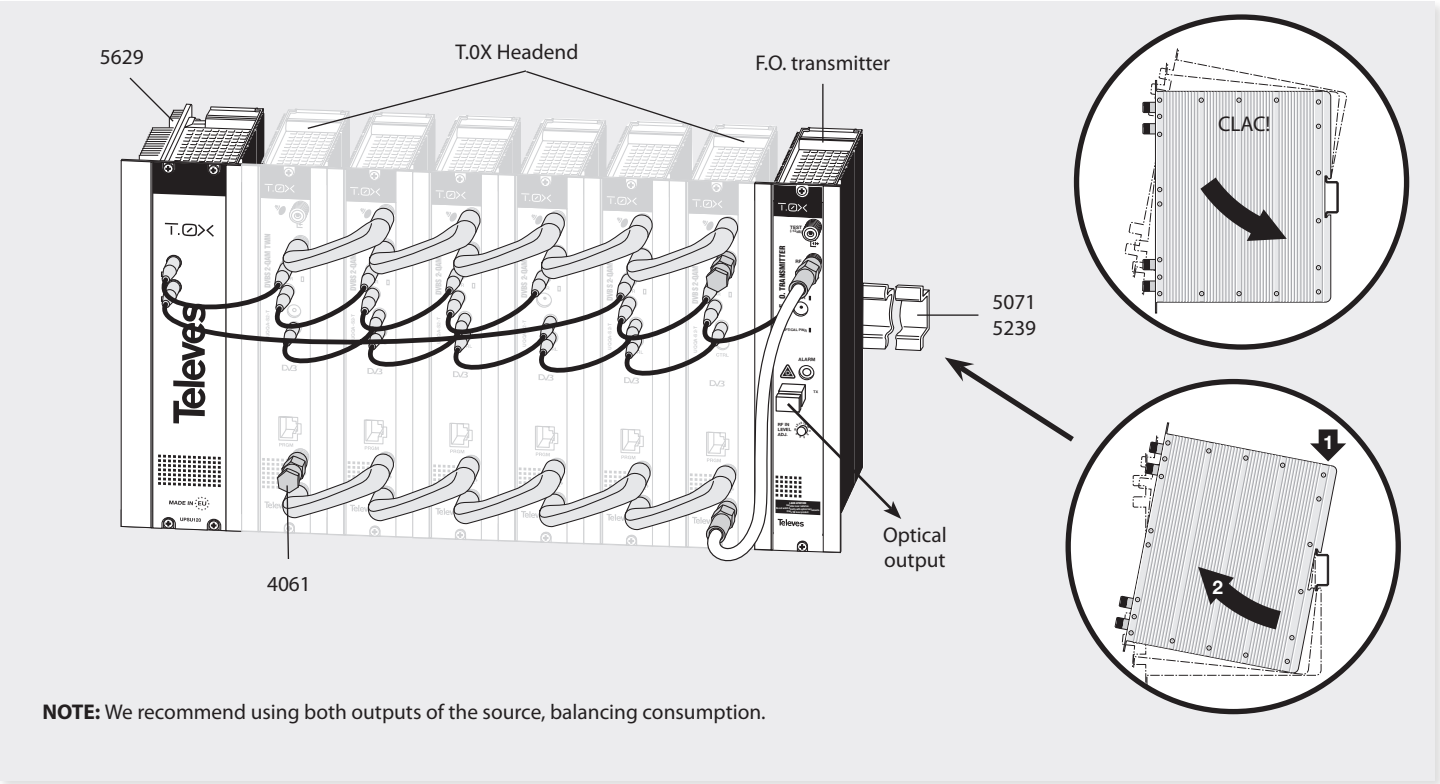


## 2. Description of references

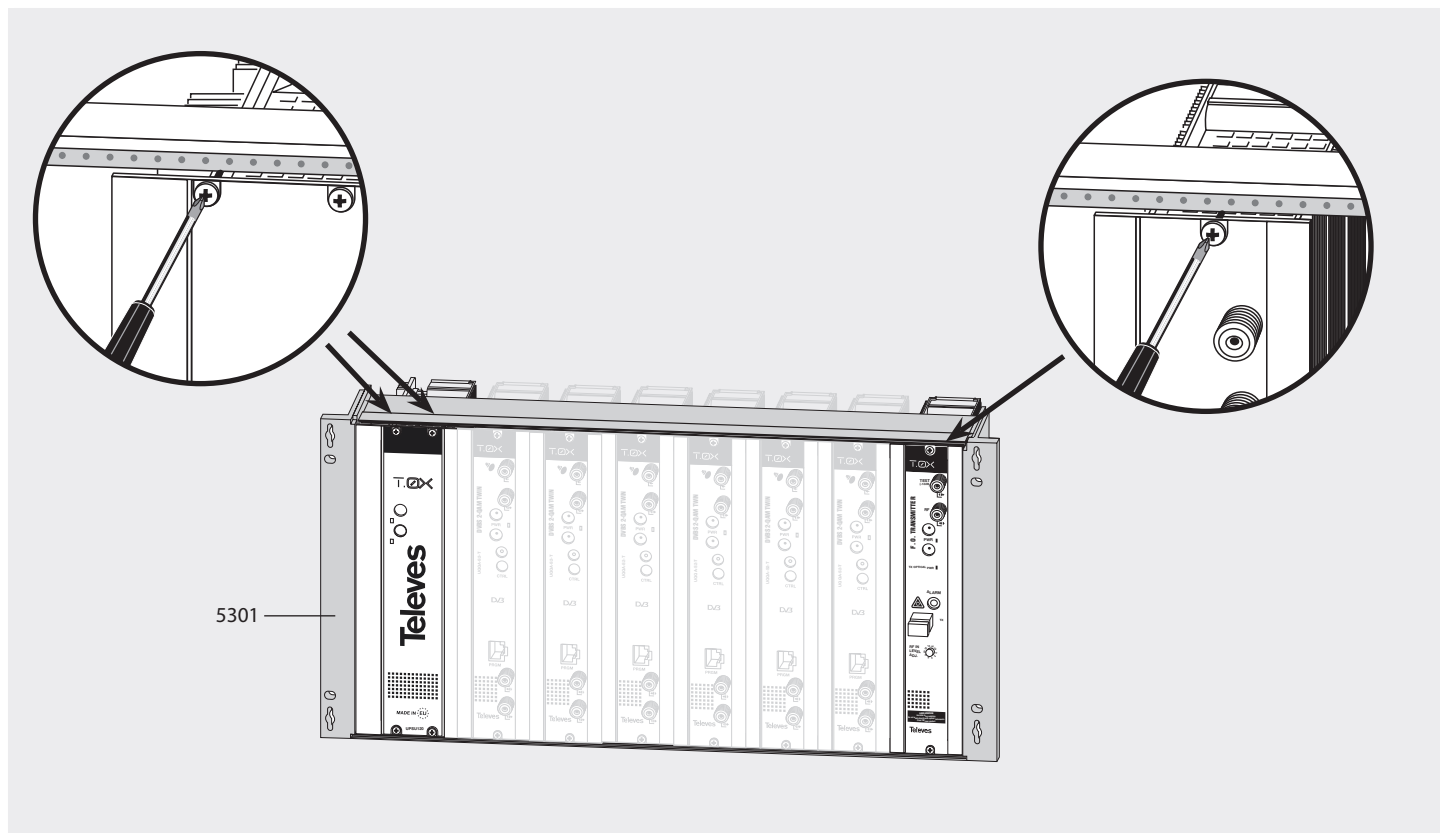
| Product range |                                                                        | Accessoires |                                                            |
|---------------|------------------------------------------------------------------------|-------------|------------------------------------------------------------|
| 2333          | T.0X Optical fiber transmitter 1310 nm                                 | 7234        | Universal programmer                                       |
| 233310        | T.0X Optical fiber transmitter 1310 nm 10dBm                           | 5071        | Wall mounting rail T03-T05-T.0X L=50 cm                    |
| 2334          | T.0X Optical fiber transmitter 1310 nm + Return channel receiver       | 5239        | Wall mounting rail T03-T05-T.0X (12 modules +PSU) L= 56 cm |
| 233410        | T.0X Optical fiber transmitter 1310 nm 10dBm + Return channel receiver | 5301        | 19" rack frame                                             |
| 234304        | T.0X Optical fiber transmitter 1550 nm 4dBm                            | 507202      | T.0X cabinet with ventilation unit (7 modules + PSU)       |
| 234310        | T.0X Optical fiber transmitter 1550 nm 10dBm                           | 4061        | F terminal load DC-blocked                                 |
| 2335          | T.0X Optical fiber receiver 1200-1600 nm                               | 4058        | F terminal load                                            |
| 2336          | T.0X Optical fiber receiver + Return channel transmitter               | 422601      | T05 to T.0X powering adapter lead L=40 cm                  |
| 2337          | T.0X 2 way optical splitter                                            | 422602      | T05 to T.0X BUS adapter lead L=40 cm                       |
| 2339          | T.0X 4 way optical splitter                                            | 422603      | Control BUS lead T.0X L=1 m                                |
| 234401        | T.0X 8 way optical splitter 1310/1550 nm 10dB                          | 5673        | Face plate 50 mm                                           |
| 234501        | T.0X 16 way optical splitter 1310/1550 nm 14dB                         |             |                                                            |
| 234601        | T.0X 32 way optical splitter 1310/1550 nm 17dB                         |             |                                                            |
| 5629          | T.0X Power Supply Unit 24V/5A                                          |             |                                                            |

### 3. Mounting

#### 3.1. Wall mounting



### 3.2. 19" rack mounting



4. Description of elements

4.1. Optical transmitter

1

2

3

4

5

6

7

8

10

Ref. 2333

Ref. 233310

Ref. 234304

Ref. 234310

1

2

3

4

5

6

7

8

10

11

exposure to harmful radiation

Ref. 2334

Ref. 233410

LASER APERTURE  
CLASS 1M LASER

1. Test output (-16dB)

2. RF Input

87 - 2150 MHz (forward channel)

5 - 65 MHz (return channel)

3. Powering

4. ON power indicator LED

5. Forward channel power indicator LED

6. Return channel power indicator LED

7. Alarm connector

8. Forward channel optical output

9. Return channel optical input

10. Forward channel RF attenuation

11. Return channel RF attenuation

Masa

+12 ... 24V

LED ON

Indicates

TX Optical PW

Optical power delivered by the equipment from:  
(5,5 & 6,5 dBm => refs. 2333 & 2334)  
(9,5 & 10,5 dBm => refs. 233310 & 233410)  
(3,5 & 4,5 dBm => refs. 234304 & 234310)

RX Optical PW

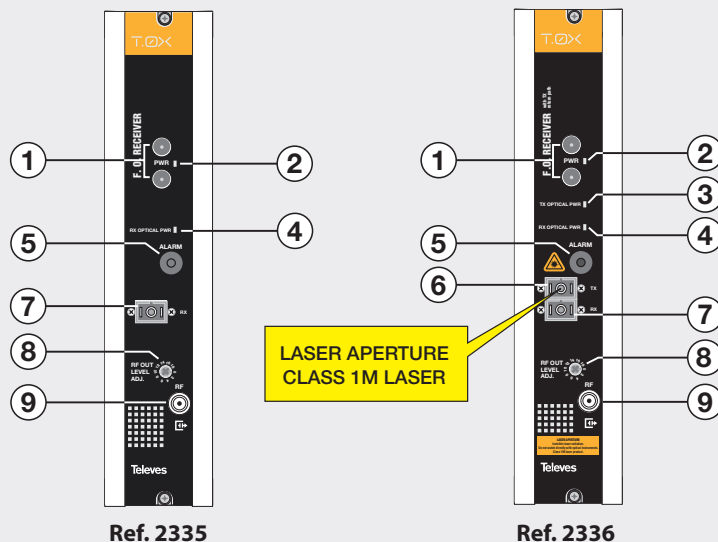
Optical level received by the return channel from  
3 dBm to -7 dBm.

!

Caution

The use of control or adjustment devices, or operating parameters other than those specified in this manual, can cause exposure to harmful radiation.

## 4.2. Optical receiver



1. Powering
2. ON power indicator LED
3. Forward channel power indicator LED
4. Return channel power indicator LED
5. Alarm connector
6. Return channel optical output
7. Forward channel optical input
8. Forward channel attenuation
9. RF output
  - 87 - 2150 MHz (forward channel)
  - 5 - 65 MHz (return channel)

Masa  +12 ... 24V

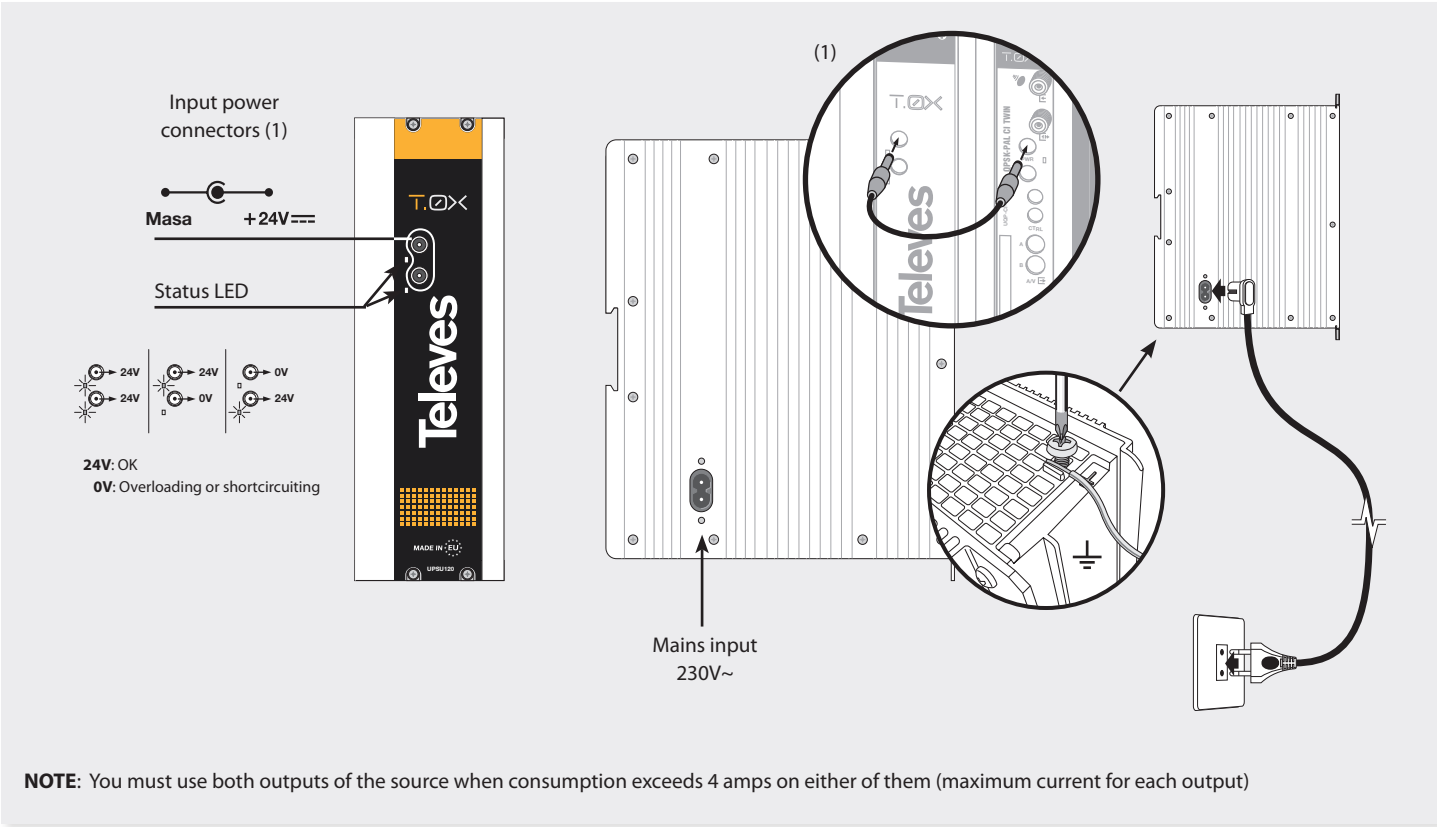


### Caution

The use of control or adjustment devices, or operating parameters other than those specified in this manual, can cause exposure to harmful radiation.

| LED ON        | Indicates                                                                  |
|---------------|----------------------------------------------------------------------------|
| RX Optical PW | Input optical power on the device from 5 dBm and -10 dBm.                  |
| TX Optical PW | Optical level broadcast on the return channel between 2.5 dBm and 3.5 dBm. |

4.3. Power Supply Unit



**NOTE:** You must use both outputs of the source when consumption exceeds 4 amps on either of them (maximum current for each output)

## 5. Examples of application

Correct use of the devices.

There are several basic concepts that should not be forgotten. The technical specifications are a set of maximums to be handled with some care.

To calculate the RF level which must excite the transmitter, use the data in the table shown below and the following formulas:

$$\text{EIN} = \text{EINn} + 10 \times \log(\text{BW}) \quad [1]$$

$$\text{C/N} = \text{Vin} - \text{EIN} \quad [2]$$

where:

- **EIN** is the equivalent input noise. That is, the noise in RF, which would have to be present at the input of the transmitter in an ideal optic system that did not add noise, so as to obtain the same level of noise at the output of the receiver of the real system (It always add noise).
- **EINn** is the EIN for a bandwidth of 1Hz.
- **BW** is the bandwidth of the RF signal.
- **Vin** is the RF input level, and is given in dBm.

Here are some examples.

| Opt. Link<br>attenuation<br>(dB) | Gain<br>at 870 MHz<br>(dB) | EINn<br>(dBm/Hz) | Gain<br>at 1.5 GHz<br>(dB) | EINn<br>(dBm/Hz) | Gain<br>at 2.15 GHz<br>(dB) | EINn<br>(dBm/Hz) |
|----------------------------------|----------------------------|------------------|----------------------------|------------------|-----------------------------|------------------|
| 0                                | 16.2                       | -150.4           | 17.0                       | -150.4           | 17.4                        | -146.4           |
| 2                                | 12.3                       | -148.4           | 13.13                      | -148.9           | 13.4                        | -145.7           |
| 4                                | 8.7                        | -146.6           | 9.4                        | -147.0           | 9.7                         | -144.9           |
| 4.5                              | 7.7                        | -145.85          | 8.4                        | -146.3           | 8.7                         | -144.6           |
| 5                                | 6.6                        | -144.9           | 7.4                        | -145.6           | 7.7                         | -144.2           |
| 5.5                              | 5.6                        | -144.1           | 6.4                        | -144.8           | 6.7                         | -143.7           |
| 6                                | 4.6                        | -143.3           | 5.4                        | -144.1           | 5.7                         | -143.2           |
| 6.5                              | 3.6                        | -142.5           | 4.4                        | -143.2           | 4.7                         | -142.7           |
| 7                                | 2.6                        | -141.6           | 3.4                        | -142.4           | 3.7                         | -142.1           |
| 7.5                              | 1.6                        | -140.8           | 2.4                        | -141.6           | 2.7                         | -141.5           |
| 8                                | 0.6                        | -139.9           | 1.4                        | -140.7           | 1.7                         | -140.8           |
| 8.5                              | -0.3                       | -139.1           | 0.4                        | -139.8           | 0.7                         | -140.1           |
| 9                                | -1.3                       | -138.2           | -0.5                       | -139.1           | -0.3                        | -139.4           |
| 9.5                              | -2.3                       | -137.25          | -1.5                       | -138.1           | -1.3                        | -138.7           |
| 10                               | -3.3                       | -136.35          | -2.5                       | -137.2           | -2.2                        | -138.0           |
| 10.5                             | -4.3                       | -135.4           | -3.5                       | -136.3           | -3.2                        | -137.2           |
| 11                               | -5.3                       | -134.5           | -4.5                       | -135.5           | -4.3                        | -136.3           |
| 11.5                             | -6.3                       | -133.5           | -5.5                       | -134.47          | -5.3                        | -135.5           |
| 12                               | -7.3                       | -132.55          | -6.5                       | -133.5           | -6.3                        | -134.6           |
| 12.5                             | -8.3                       | -131.6           | -7.5                       | -132.57          | -7.3                        | -133.7           |
| 13                               | -9.3                       | -130.6           | -8.5                       | -131.6           | -8.3                        | -132.8           |
| 13.5                             | -10.3                      | -129.7           | -9.5                       | -130.65          | -9.3                        | -131.9           |
| 14                               | -11.3                      | -128.7           | -10.5                      | -129.67          | -10.3                       | -131.0           |
| 14.5                             | -12.3                      | -127.7           | -11.5                      | -128.7           | -11.3                       | -130.1           |
| 15                               | -13.3                      | -126.7           | -12.5                      | -127.7           | -12.3                       | -129.2           |
| 15.5                             | -14.3                      | -125.8           | -13.5                      | -126.7           | -13.3                       | -128.2           |
| 16                               | -15.3                      | -124.8           | -14.5                      | -125.7           | -14.3                       | -127.3           |
| 16.5                             | -16.3                      | -123.8           | -15.5                      | -124.8           | -15.3                       | -126.3           |
| 17                               | -17.3                      | -122.8           | -16.5                      | -123.8           | -16.3                       | -125.4           |

Measurements made with a transmitter that delivers 6.1 dBm, followed by a reel of fiber of 5 km long and an optical attenuator connected between the end of the reel of fiber and optical receiver input.

**Example 1**

Calculate the C / N at the output of the optical receiver (C/N of the link), in the installation of the figure below:

This is a link where the optical signal is split between 4 fibers of 1 km, using a splitter ref. 2339. The signal received at the other end is converted back to RF by means of the optical receiver ref. 2335.

The channel levels that excite the transmitter are:

- 83 dBμV (-26 dBm 42CH CENELEC) **analog channels, TV band.**

- 73 dBμV (-36 dBm) **digitales channels, SAT band.**

Analog terrestrial channel bandwidth: 5 MHz

Satellite digital transponder bandwidth: 27 MHz

On the other hand:

- 1 km optical fiber is equivalent to 0.4 dB of attenuation.
- The splitter features 6.8 dB loss.
- The 2 fiber optic connectors represent 0.8 dB (2 × 0.4).

Therefore, total losses of the optical fiber link are:

*FO losses+Optical splitter losses+Connectors losses*

This is:  $0.4 + 6.8 + 0.8 = 8 \text{ dB}$

Now we use the formulas and data given in the table above.

For the TV band, we consider the column of the *Gain at 807 MHz*. This column intersects with the row of 8 dB of loss calculated for the optical fiber

link in the value of 0.6 dB, which would correspond  $EIN_n = -139.9 \text{ dB/Hz}$ .

Apply the formula [1] and we obtain:

$$EIN_{TV} = -139.9 + 10 \times \log(5 \times 10^6) = -72.91 \text{ dBm}$$

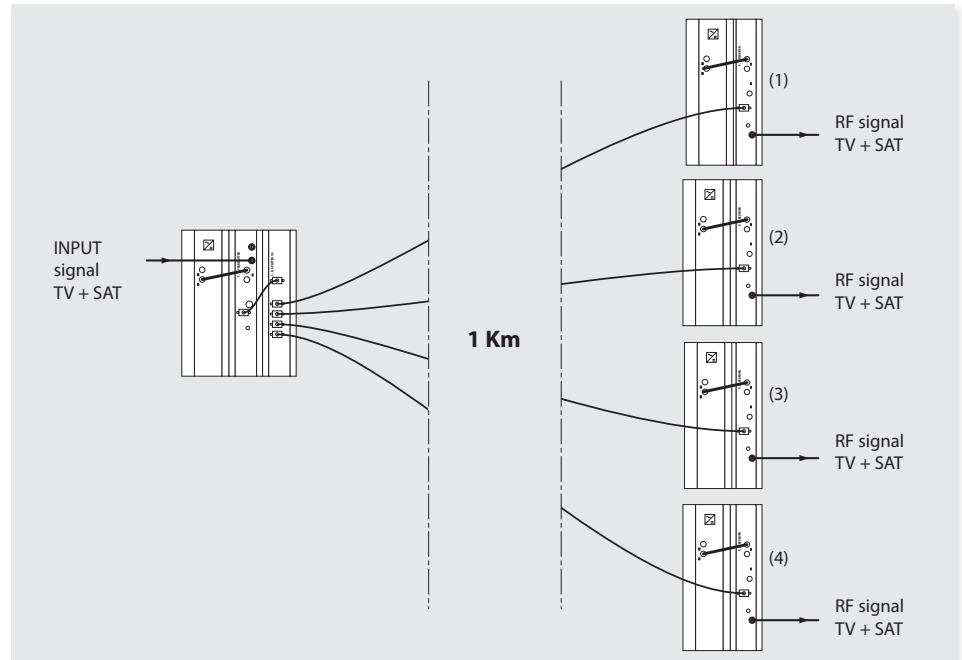
Now apply the formula [2] to calculate the C/N, as follows:

$$C/N_{TV} = V_{in} - EIN_{TV}$$

$$C/N_{TV} = -26 \text{ dBm} - (-72.9 \text{ dBm}) = -26 + 72.9$$

$$\text{Then, } C/N_{TV} = 46.9 \text{ dB}$$

In practice, having satellite channels, simultaneously with the TV ones, makes the latter worse their C/N in 1 dB.





Now we do the calculation for digital satellite channels, following the same process above, but by looking at the column *Gain at 2.1 GHz* of the table (band in which are delivered digital channels) and the following results :

$$\text{EINn} = -140.8 \text{ dB/Hz}$$

$$\text{EIN}_{\text{SAT}} = -140.8 + 10 \times \log(27 \times 10^6) = -65.7 \text{ dBm}$$

As the input level is -36 dBm, C/N is:

$$\text{C/N}_{\text{SAT}} = -36 - (-65.7) = -36 + 65.7$$

$$\text{C/N}_{\text{SAT}} = 29.7 \text{ dB}$$

### Example 2

Let's repeat the example above but applied to an installation with a 32 output optical splitter. The channels will be **digital only**.

Thus, the TV channels will be COFDM channels with a **C/N<sub>COFDM</sub> = 23 dB**.

SAT channels will be DVB-S2, with a **C/N<sub>DVBS2</sub> = 14 dB**.

The **level of excitation** of the transmitter will be the same for TV and SAT: **79 dBμV** (-30dBm).

The bandwidth will be now:

For COFDM:  $\text{BW} = 8 \times 10^6 \text{ Hz}$  (8 MHz)

For SAT:  $\text{BW} = 27 \times 10^6 \text{ Hz}$  (27 MHz)

As in Example 1, the attenuations are:

- 1 km of fiber is 0.4 dB.
- The 32 output optical splitter represents about 16 dB

- The 2 fiber optic connectors represent 0.8 dB.
- Therefore, the total losses of the fiber optics are:

$$0.4 + 16 + 0.8 = 17.2 \text{ dB}$$

(let's take 17 dB for this case, maximum value shown in the table)

The table provides the following information:

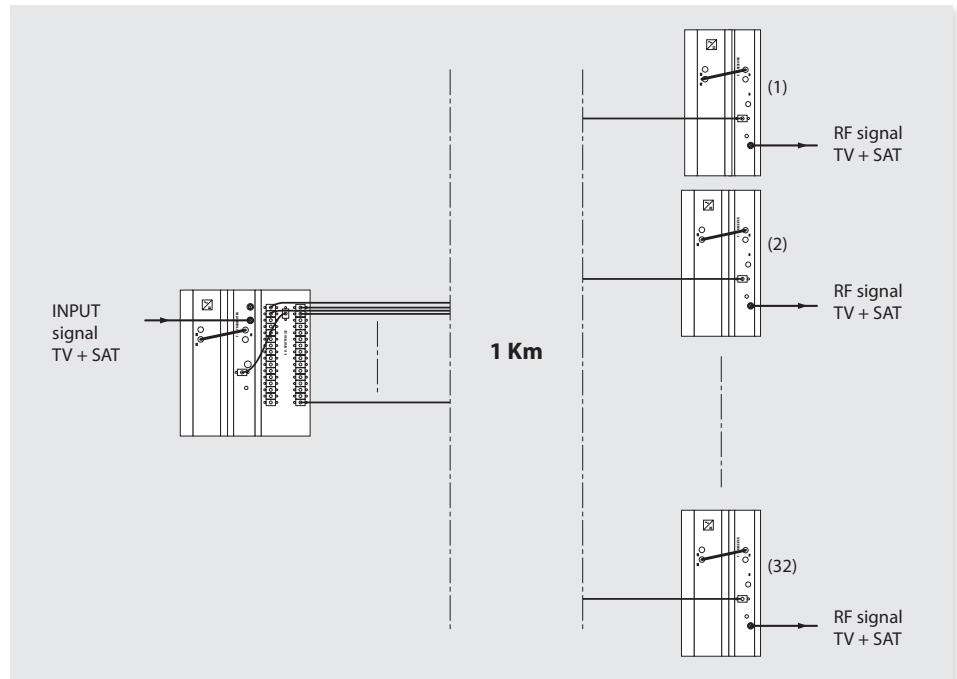
For the TV band, in the column *Gain at 807 MHz*

$$\text{EINn (TV)} = -122.8 \text{ dBm/Hz}$$

$$\text{G(807 MHz)} = -17.3 \text{ dB}$$

And for SAT band, look in the *Gain at 2.1 GHz* column.

$$\text{EINn(SAT)} = -125.4 \text{ dBm/Hz}$$



$G(2.1\text{ GHz}) = -16.3\text{ dB}$

Therefore, the RF signal level delivered by the receiver is:

$V_{out_{rcvr}}\text{ (dB}\mu\text{V)} = V_{in_{xmtfr}}\text{ (dB}\mu\text{V)} + G\text{ (dB)}$

This is:

$V_{out_{rcvr}}\text{ TERR (dB}\mu\text{V)} = 79 - 17.3 = 61.7\text{ dB}\mu\text{V}$

$V_{out_{rcvr}}\text{ SAT (dB}\mu\text{V)} = 79 - 16.3 = 62.7\text{ dB}\mu\text{V}$

Applying the formula [1]:

$EIN_{TV} = EINn(TV) + 10 \times \log(8 \times 10^6)\text{ [dBm]}$

$EIN_{TV} = -122.8 + 69$

**$EIN_{TV} = -53.8\text{ dBm}$**

And by the formula [2] is obtained:

**$C/N_{TV} = -30\text{ dBm} - (-53.8\text{ dBm}) = 23.8\text{ dB en TV}$**

Likewise, we calculate the C/N for SAT channels, resulting in:

**$EIN_{SAT} = -51.1\text{ dBm}$**

**$C/N_{SAT} = -30 - (-51.1) = 21.1\text{ dB en SAT}$**

If we estimate the value of the C / N for TV very tight, you can increase the excitement level of the transmitter a couple of dB, since there is enough margin before the system begins to distort.

RETURN CHANNEL

For the return channel transmitter, the table of attenuations, link gain and equivalent noise is:

| Link attenuation (dB) | Gain at 30 MHz (dB) | EINn (dBm/Hz) |
|-----------------------|---------------------|---------------|
| 0                     | 23                  | -152.5        |
| 3                     | 16.6                | -149.5        |
| 4                     | 14.6                | -147.6        |
| 5                     | 12.7                | -145.7        |
| 6                     | 10.7                | -143.9        |
| 7                     | 8.7                 | -141.9        |
| 8                     | 6.7                 | -140          |
| 9                     | 4.7                 | -138.1        |
| 10                    | 2.6                 | -136          |
| 11                    | 0.4                 | -133.4        |
| 12                    | -1.5                | -132          |
| 13                    | -3.5                | -130.5        |
| 14                    | -5.5                | -128.5        |

*Measurements made with a transmitter that delivers 2.9dBm followed by an optical attenuator connected between the transmitter and the optical receiver.*

Use the formulas 1 and 2 for making calculations. The calculation process is the same as in the case of the forward channel.

## 6. Tables for attenuation and gain installations calculation

### Refs. 2333, 2334 (TRANSMISSION)

| Opt. Link<br>attenuation<br>(dB) | Popt IN in RX<br>(dBm) | Gain<br>at 870 MHz<br>(dB) | EINn<br>(dBm/Hz) | Gain<br>at 1.5 GHz<br>(dB) | EINn<br>(dBm/Hz) | Gain<br>at 2.15 GHz<br>(dB) | EINn<br>(dBm/Hz) |
|----------------------------------|------------------------|----------------------------|------------------|----------------------------|------------------|-----------------------------|------------------|
| 0                                | 6                      | 16,2                       | -150,4           | 17                         | -150,4           | 17,4                        | -146,4           |
| 2                                | 4                      | 12,3                       | -148,4           | 13,13                      | -148,9           | 13,4                        | -145,7           |
| 4                                | 2                      | 8,7                        | -146,6           | 9,4                        | -147             | 9,7                         | -144,9           |
| 4,5                              | 1,5                    | 7,7                        | -145,85          | 8,4                        | -146,3           | 8,7                         | -144,6           |
| 5                                | 1                      | 6,6                        | -144,9           | 7,4                        | -145,6           | 7,7                         | -144,2           |
| 5,5                              | 0,5                    | 5,6                        | -144,1           | 6,4                        | -144,8           | 6,7                         | -143,7           |
| 6                                | 0                      | 4,6                        | -143,3           | 5,4                        | -144,1           | 5,7                         | -143,2           |
| 6,5                              | -0,5                   | 3,6                        | -142,5           | 4,4                        | -143,2           | 4,7                         | -142,7           |
| 7                                | -1                     | 2,6                        | -141,6           | 3,4                        | -142,4           | 3,7                         | -142,1           |
| 7,5                              | -1,5                   | 1,6                        | -140,8           | 2,4                        | -141,6           | 2,7                         | -141,5           |
| 8                                | -2                     | 0,6                        | -139,9           | 1,4                        | -140,7           | 1,7                         | -140,8           |
| 8,5                              | -2,5                   | -0,3                       | -139,1           | 0,4                        | -139,8           | 0,7                         | -140,1           |
| 9                                | -3                     | -1,3                       | -138,2           | -0,5                       | -139,1           | -0,3                        | -139,4           |
| 9,5                              | -3,5                   | -2,3                       | -137,25          | -1,5                       | -138,1           | -1,3                        | -138,7           |
| 10                               | -4                     | -3,3                       | -136,35          | -2,5                       | -137,2           | -2,2                        | -138             |
| 10,5                             | -4,5                   | -4,3                       | -135,4           | -3,5                       | -136,3           | -3,2                        | -137,2           |
| 11                               | -5                     | -5,3                       | -134,5           | -4,5                       | -135,5           | -4,3                        | -136,3           |
| 11,5                             | -5,5                   | -6,3                       | -133,5           | -5,5                       | -134,47          | -5,3                        | -135,5           |
| 12                               | -6                     | -7,3                       | -132,55          | -6,5                       | -133,5           | -6,3                        | -134,6           |
| 12,5                             | -6,5                   | -8,3                       | -131,6           | -7,5                       | -132,57          | -7,3                        | -133,7           |
| 13                               | -7                     | -9,3                       | -130,6           | -8,5                       | -131,6           | -8,3                        | -132,8           |
| 13,5                             | -7,5                   | -10,3                      | -129,7           | -9,5                       | -130,65          | -9,3                        | -131,9           |
| 14                               | -8                     | -11,3                      | -128,7           | -10,5                      | -129,67          | -10,3                       | -131             |
| 14,5                             | -8,5                   | -12,3                      | -127,7           | -11,5                      | -128,7           | -11,3                       | -130,1           |
| 15                               | -9                     | -13,3                      | -126,7           | -12,5                      | -127,7           | -12,3                       | -129,2           |
| 15,5                             | -9,5                   | -14,3                      | -125,8           | -13,5                      | -126,7           | -13,3                       | -128,2           |
| 16                               | -10                    | -15,3                      | -124,8           | -14,5                      | -125,7           | -14,3                       | -127,3           |
| 16,5                             | -10,5                  | -16,3                      | -123,8           | -15,5                      | -124,8           | -15,3                       | -126,3           |
| 17                               | -11                    | -17,3                      | -122,8           | -16,5                      | -123,8           | -16,3                       | -125,4           |

Measurements made with a transmitter that delivers 6.1 dBm, followed by a reel of fiber of 5 km long and an optical attenuator connected between the end of the reel of fiber and optical receiver input.

### Ref. 2334 (RETURN)

| Link attenuat.<br>(dB) | Gain at 30 MHz<br>(dB) | EINn<br>(dBm/Hz) |
|------------------------|------------------------|------------------|
| 0                      | 23                     | -152,5           |
| 3                      | 16,6                   | -149,5           |
| 4                      | 14,6                   | -147,6           |
| 5                      | 12,7                   | -145,7           |
| 6                      | 10,7                   | -143,9           |
| 7                      | 8,7                    | -141,9           |
| 8                      | 6,7                    | -140             |
| 9                      | 4,7                    | -138,1           |
| 10                     | 2,6                    | -136             |
| 11                     | 0,4                    | -133,4           |
| 12                     | -1,5                   | -132             |
| 13                     | -3,5                   | -130,5           |
| 14                     | -5,5                   | -128,5           |

Measurements made with a transmitter that delivers 2.9dBm followed by an optical attenuator connected between the transmitter and the optical receiver.

**Refs. 233310, 233410 (TRANSMISSION)**

| Opt. Link attenuation (dB) | Popt IN in RX (dBm) | Gain at 870 MHz (dB) | EINn (dBm/Hz) | Gain at 1.5 GHz (dB) | EINn (dBm/Hz) | Gain at 2.15 GHz (dB) | EINn (dBm/Hz) |
|----------------------------|---------------------|----------------------|---------------|----------------------|---------------|-----------------------|---------------|
| 6                          | 4                   | 7,5                  | -144,8        | 8,1                  | -144,1        | 6,7                   | -142,7        |
| 6,5                        | 3,5                 | 6,5                  | -144,2        | 7,1                  | -143,6        | 5,7                   | -142,4        |
| 7                          | 3                   | 5,5                  | -143,5        | 6,1                  | -143,1        | 4,7                   | -142          |
| 7,5                        | 2,5                 | 4,5                  | -142,6        | 5,1                  | -142,6        | 3,7                   | -141,7        |
| 8                          | 2                   | 3,5                  | -142          | 4,1                  | -142,1        | 2,7                   | -141,2        |
| 8,5                        | 1,5                 | 2,5                  | -141,3        | 3,1                  | -141,4        | 1,7                   | -141          |
| 9                          | 1                   | 1,5                  | -140,5        | 2,1                  | -140,8        | 0,7                   | -140,5        |
| 9,5                        | 0,5                 | 0,5                  | -139,8        | 1,1                  | -140,2        | -0,3                  | -140          |
| 10                         | 0                   | -0,5                 | -139          | 0,1                  | -139,5        | -1,3                  | -139,2        |
| 10,5                       | -0,5                | -1,5                 | -138,2        | -0,9                 | -138,7        | -2,3                  | -138,9        |
| 11                         | -1                  | -2,5                 | -137,4        | -1,9                 | -138,1        | -3,3                  | -138,3        |
| 11,5                       | -1,5                | -3,5                 | -136,5        | -2,9                 | -137,3        | -4,3                  | -137,7        |
| 12                         | -2                  | -4,5                 | -135,8        | -3,9                 | -136,6        | -5,3                  | -137          |
| 12,5                       | -2,5                | -5,5                 | -134,8        | -4,9                 | -135,5        | -6,3                  | -136,2        |
| 13                         | -3                  | -6,5                 | -133,9        | -5,9                 | -134,7        | -7,3                  | -135,4        |
| 13,5                       | -3,5                | -7,5                 | -132,9        | -6,9                 | -133,6        | -8,3                  | -134,5        |
| 14                         | -4                  | -8,5                 | -132,1        | -7,9                 | -132,8        | -9,3                  | -133,7        |
| 14,4                       | -4,5                | -9,5                 | -131,2        | -8,9                 | -132          | -10,3                 | -133          |
| 15                         | -5                  | -10,5                | -130,2        | -9,9                 | -131,1        | -11,3                 | -132,2        |
| 15,5                       | -5,5                | -11,5                | -129,4        | -10,9                | -130,1        | -12,2                 | -131,5        |
| 16                         | -6                  | -12,5                | -128,4        | -11,9                | -129,3        | -13,3                 | -130,6        |
| 16,5                       | -6,5                | -13,5                | -127,5        | -12,9                | -128,4        | -14,3                 | -130          |
| 17                         | -7                  | -14,5                | -126,6        | -13,9                | -127,6        | -15,3                 | -129          |
| 17,5                       | -7,5                | -15,5                | -125,7        | -14,9                | -126,6        | -16,3                 | -128,1        |
| 18                         | -8                  | -16,5                | -124,7        | -15,9                | -125,6        | -17,3                 | -127,3        |
| 18,5                       | -8,5                | -17,5                | -123,6        | -16,9                | -124,7        | -18,3                 | -126,2        |
| 19                         | -9                  | -18,5                | -122,6        | -17,9                | -123,7        | -19,3                 | -125,3        |

Measurements made with a transmitter that delivers 10 dBm, followed by a reel of fiber of 5 km long and an optical attenuator connected between the end of the reel of fiber and optical receiver input.

**Ref. 233410 (RETURN)**

| Link attenuat. (dB) | Gain at 30 MHz (dB) | EINn (dBm/Hz) |
|---------------------|---------------------|---------------|
| 0                   | 23                  | -152,5        |
| 3                   | 16,6                | -149,5        |
| 4                   | 14,6                | -147,6        |
| 5                   | 12,7                | -145,7        |
| 6                   | 10,7                | -143,9        |
| 7                   | 8,7                 | -141,9        |
| 8                   | 6,7                 | -140          |
| 9                   | 4,7                 | -138,1        |
| 10                  | 2,6                 | -136          |
| 11                  | 0,4                 | -133,4        |
| 12                  | -1,5                | -132          |
| 13                  | -3,5                | -130,5        |
| 14                  | -5,5                | -128,5        |

Measurements made with a transmitter that delivers 2.9dBm followed by an optical attenuator connected between the transmitter and the optical receiver.

## Ref. 234304 (TRANSMISSION)

| Opt. Link<br>attenuation<br>(dB) | Popt IN in RX<br>(dBm) | Gain<br>at 870 MHz<br>(dB) | EINn<br>(dBm/Hz) | Gain<br>at 1.5 GHz<br>(dB) | EINn<br>(dBm/Hz) | Gain<br>at 2.15 GHz<br>(dB) | EINn<br>(dBm/Hz) |
|----------------------------------|------------------------|----------------------------|------------------|----------------------------|------------------|-----------------------------|------------------|
| 1,7                              | 2,5                    | 14,3                       | -149,7           | 15                         | -148,8           | 14                          | -146,6           |
| 2,2                              | 2                      | 13,4                       | -149,3           | 14                         | -148,5           | 13,1                        | -146,5           |
| 2,7                              | 1,5                    | 12,4                       | -148,8           | 13                         | -148,2           | 12,1                        | -146,3           |
| 3,2                              | 1                      | 11,4                       | -148,4           | 12                         | -147,7           | 11,1                        | -146,1           |
| 3,7                              | 0,5                    | 10,4                       | -147,7           | 11                         | -147,3           | 10,2                        | -146             |
| 4,2                              | 0                      | 9,4                        | -147,1           | 10                         | -146,8           | 9,2                         | -145,7           |
| 4,7                              | -0,5                   | 8,4                        | -146,5           | 9                          | -146,3           | 8,2                         | -145,5           |
| 5,2                              | -1                     | 7,4                        | -145,8           | 8                          | -145,8           | 7,16                        | -145,2           |
| 5,7                              | -1,5                   | 6,4                        | -145,1           | 7,1                        | -145,3           | 6,16                        | -144,8           |
| 6,2                              | -2                     | 5,5                        | -144,5           | 6,1                        | -144,6           | 5,1                         | -144,4           |
| 6,7                              | -2,5                   | 4,5                        | -143,7           | 5,1                        | -144             | 4,2                         | -144             |
| 7,2                              | -3                     | 3,6                        | -143             | 4,2                        | -143,4           | 3,3                         | -143,6           |
| 7,7                              | -3,5                   | 2,5                        | -142,1           | 3,2                        | -142,7           | 2,2                         | -143             |
| 8,2                              | -4                     | 1,6                        | -141,3           | 2,2                        | -141,9           | 1,3                         | -142,5           |
| 8,7                              | -4,5                   | 0,5                        | -140,5           | 1,1                        | -141,1           | 0,2                         | -141,9           |
| 9,2                              | -5                     | -0,5                       | -139,6           | 0,1                        | -140             | -0,8                        | -141,4           |
| 9,7                              | -5,5                   | -1,4                       | -138,8           | -0,75                      | -139,6           | -1,7                        | -140,7           |
| 10,2                             | -6                     | -2,4                       | -137,8           | -1,7                       | -138,7           | -2,7                        | -140             |
| 10,7                             | -6,5                   | -3,3                       | -137,1           | -2,7                       | -137,8           | -3,6                        | -139,4           |
| 11,2                             | -7                     | -4,3                       | -136,1           | -3,7                       | -137             | -4,7                        | -138,6           |
| 11,7                             | -7,5                   | -5,3                       | -135,1           | -4,7                       | -136             | -5,7                        | -137,8           |
| 12,2                             | -8                     | -6,4                       | -134,2           | -5,8                       | -135             | -6,7                        | -137             |
| 12,7                             | -8,5                   | -7,4                       | -133,2           | -6,8                       | -134,1           | -7,7                        | -136,2           |
| 13,2                             | -9                     | -8,4                       | -132,3           | -7,7                       | -133,3           | -8,7                        | -135,3           |
| 13,7                             | -9,5                   | -9,4                       | -131,3           | -8,7                       | -132,3           | -9,7                        | -134,5           |
| 14,2                             | -10                    | -10,4                      | -130,4           | -9,7                       | -131,4           | -10,7                       | -133,6           |
| 14,7                             | -10,5                  | -11,4                      | -129,4           | -10,7                      | -130,4           | -11,7                       | -132,7           |
| 15,2                             | -11                    | -12,4                      | -128,4           | -11,7                      | -129,5           | -12,7                       | -131,8           |
| 15,7                             | -11,5                  | -13,4                      | -127,5           | -12,7                      | -128,5           | -13,7                       | -130,9           |
| 16,2                             | -12                    | -14,3                      | -126,6           | -13,7                      | -127,6           | -14,6                       | -130,1           |

Measurements made with a transmitter that delivers 4 dBm, followed by a reel of fiber of 5 km long and an optical attenuator connected between the end of the reel of fiber and optical receiver input.

**Ref. 234310 (TRANSMISSION)**

| Opt. Link attenuation (dB) | Popt IN in RX (dBm) | Gain at 870 MHz (dB) | EINn (dBm/Hz) | Gain at 1.5 GHz (dB) | EINn (dBm/Hz) | Gain at 2.15 GHz (dB) | EINn (dBm/Hz) |
|----------------------------|---------------------|----------------------|---------------|----------------------|---------------|-----------------------|---------------|
| 6                          | 4                   | 6                    | -142,9        | 6,2                  | -142,4        | 5                     | -141,2        |
| 6,5                        | 3,5                 | 5                    | -142,3        | 5,2                  | -141,9        | 4                     | -140,5        |
| 7                          | 3                   | 4                    | -141,5        | 4,2                  | -141,4        | 3                     | -140,2        |
| 7,5                        | 2,5                 | 3                    | -140,9        | 3,2                  | -141          | 2                     | -139,7        |
| 8                          | 2                   | 2                    | -140,1        | 2,2                  | -140,2        | 1                     | -139          |
| 8,5                        | 1,5                 | 1                    | -139,4        | 1,2                  | -139,6        | 0                     | -138,3        |
| 9                          | 1                   | 0                    | -138,6        | 0,2                  | -138,8        | -1                    | -137,5        |
| 9,5                        | 0,5                 | -1                   | -137,9        | -0,8                 | -138          | -2                    | -136,7        |
| 10                         | 0                   | -2                   | -137          | -1,8                 | -137,2        | -3                    | -136          |
| 10,5                       | -0,5                | -3                   | -136,2        | -2,8                 | -136,4        | -4                    | -135,2        |
| 11                         | -1                  | -4                   | -135,4        | -3,8                 | -135,5        | -5                    | -134,3        |
| 11,5                       | -1,5                | -5                   | -134,5        | -4,8                 | -134,6        | -6                    | -133,5        |
| 12                         | -2                  | -6                   | -133,7        | -5,8                 | -133,9        | -7                    | -132,6        |
| 12,5                       | -2,5                | -7                   | -132,8        | -6,8                 | -133          | -8                    | -131,7        |
| 13                         | -3                  | -8                   | -131,9        | -7,8                 | -132,2        | -9                    | -130,8        |
| 13,5                       | -3,5                | -9                   | -131          | -8,8                 | -131,3        | -10                   | -130          |
| 14                         | -4                  | -10                  | -130,1        | -9,8                 | -130,3        | -11                   | -129,1        |
| 14,4                       | -4,5                | -11                  | -129,2        | -10,8                | -129,4        | -12                   | -128,2        |
| 15                         | -5                  | -12                  | -128,3        | -11,8                | -128,4        | -13                   | -127,3        |
| 15,5                       | -5,5                | -13                  | -127,4        | -12,8                | -127,5        | -14                   | -126,4        |
| 16                         | -6                  | -14                  | -126,5        | -13,8                | -126,7        | -15                   | -125,5        |
| 16,5                       | -6,5                | -15                  | -125,5        | -14,8                | -125,7        | -16                   | -124,6        |
| 17                         | -7                  | -16                  | -124,6        | -15,8                | -124,8        | -17                   | -123,6        |
| 17,5                       | -7,5                | -17                  | -123,7        | -16,8                | -123,8        | -18                   | -122,6        |
| 18                         | -8                  | -18                  | -122,8        | -17,8                | -122,8        | -19                   | -121,7        |
| 18,5                       | -8,5                | -19                  | -121,7        | -18,8                | -121,9        | -21                   | -120,7        |
| 19                         | -9                  | -20                  | -120,8        | -19,8                | -120,9        | -22                   | -118,8        |

Measurements made with a transmitter that delivers 10 dBm, followed by a reel of fiber of 5 km long and an optical attenuator connected between the end of the reel of fiber and optical receiver input.



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