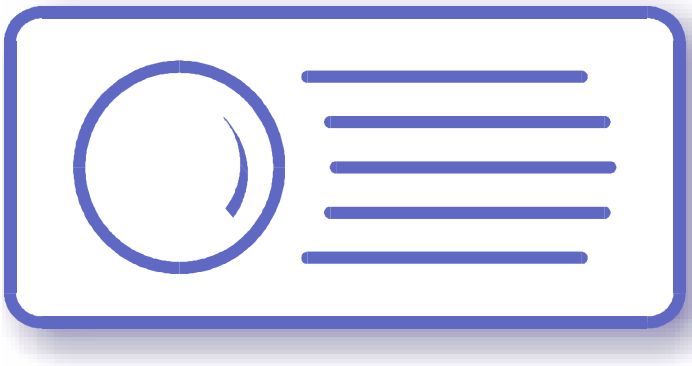

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FLEXMod-411 module

Connectors, pin description and programming protocol

Rev B, July, 27th 2012
Hardware revision 2.00
Firmware version 1.01

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3. The contents of this manual are subject to change without notice.
4. Of the specifications described in this manual, the functions and performance the supply of which is assured with this product are only those that can be confirmed with the separate Basic Firmware attached.
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7. Although our company is endeavoring to improve quality and enhance reliability, semiconductor products will fail with a certain probability. Users are requested to pay due attention to safe design techniques such as redundant design, preventive measures against the spreading of fire, over-current, and malfunctions, so that failure of the products described in this manual will not result in accidents leading to injury or death, fire, or social damage.
8. The product described in this manual is not designed to be radiation-resistant.
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Revision history:

Rev A, Dicember, 16th 2010, abesani@tecnoroll.it
First release

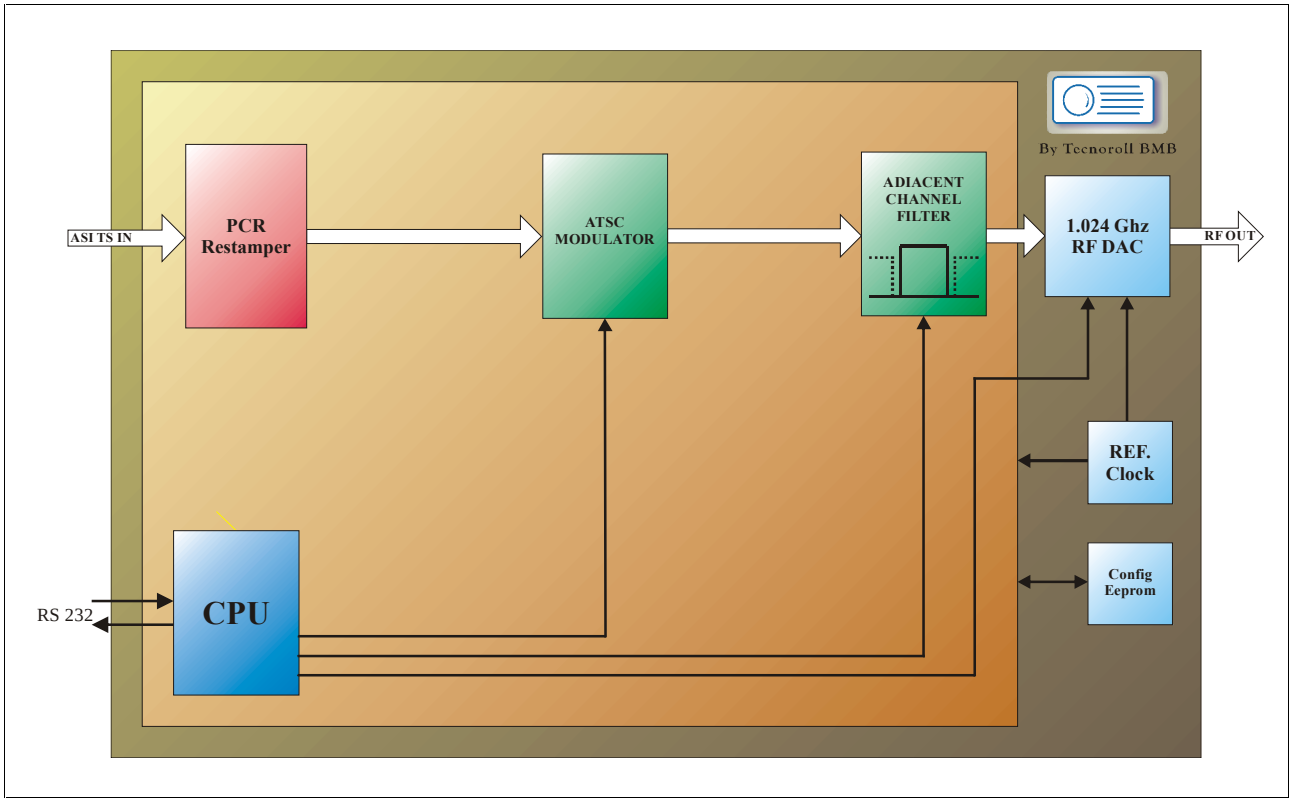
Rev B, July, 27th 2012, abesani@tecnoroll.it
Updated the ASI In sample schematics.

Index

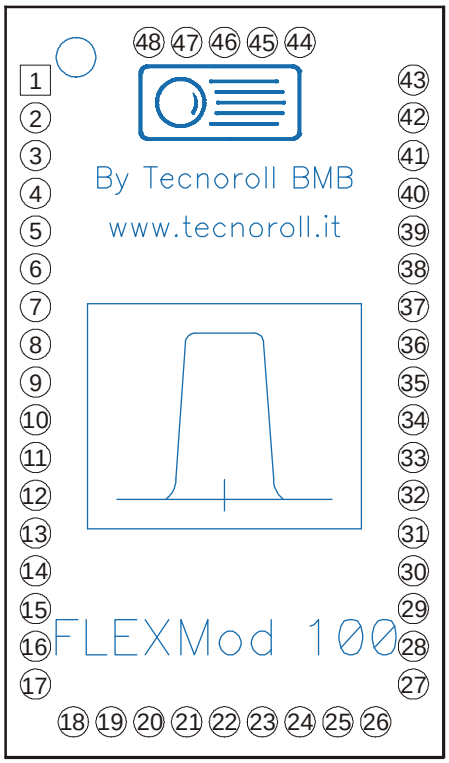
1. FLEXMod Block Diagram

1.1. FLEXMod-411

The FLEXMod-411 is an ATSC (A/53) compliant modulator with an integrated microprocessor, enhanced output filtering and a 1GHz output DAC.



2. Connectors and pin description



FLEXMod-411, Top view

Pin	Symbol	Type	Description
1	GNDA	P	Analog ground
2	1V8A	P	+1.8V Analog Power Supply
3	1V8	P	+1.8V Digital Power Supply
4	GND	P	Digital Ground
5	RSVD	-	Reserved
6	ASI_IN	I_{LVDS+}	LDVS TS ASI Input. Requires Cable equalizer and an adaptation network. See *ASI Input* on page 17 for more information.
7		I_{LVDS-}	
8	RSVD	-	Reserved
9	RSVD	-	Reserved
10	RSVD	-	Reserved
11	RSVD	-	Reserved
12	RSVD	-	Reserved
13	RSVD	-	Reserved
14	RSVD	-	Reserved
15	RSVD	-	Reserved
16	RSVD	-	Reserved
17	RSVD	-	Reserved

Pin	Symbol	Type	Description
18	GND	P	Digital Ground
19	1V2	P	+1.2V Digital Power Supply
20	3V3	P	+3.3V Digital Power Supply
21	TxD	O_3	RS232 TX Line
22	RxD	I_3	RS232 RX Line
23	REF_CLOCK	I_3	Reference clock input.
24	3V3	P	+3.3V Digital Power Supply
25	1V2	P	+1.2V Digital Power Supply
26	GND	P	Digital Ground
27	Flag7	O_3	Flags bit 7 [1]
28	Flag6	O_3	Flags bit 6 [1]
29	Flag5	O_3	Flags bit 5 [1]
30	Flag4	O_3	Flags bit 4 [1]
31	Flag3	O_3	Flags bit 3 [1]
32	Flag2	O_3	Flags bit 2 [1]
33	Flag1	O_3	Flags bit 1 [1]
34	Flag0	O_3	Flags bit 0 [1]
35	RSVD	-	Reserved
36	RSVD	-	Reserved
37	RSVD	-	Reserved
38	RSVD	-	Reserved
39	RSVD	-	Reserved
40	GND	P	Digital Ground
41	3V3	P	+3.3V Digital Power Supply
42	3V3A	P	+3.3V Analog Power Supply
43	GNDA	P	Analog ground
44	GNDA	P	Analog ground
45	$\overline{\text{IFOUT}}$	O_a	Analog output (current mode): Open source DAC complementary output source. Connect through 50Ω to GNDA.
46	GNDA	P	Analog ground
47	IFOUT	O_a	Analog output (current mode): Open source DAC output source. Connect through 50Ω to GNDA.
48	GNDA	P	Analog ground

See Appendix A on page 23 for *type* description.

[1] Output flags can be set using the *FlagsMatrix* command (see page 12).

3. Serial port usage

The Rs232 serial port allows the configuration and the operation of the FLEXMod boards.
This serial port normally operates at 115200 bps, 8 data bits, 1 stop bit, no parity but the operating baud rate can be changed using the *Baud* command. Regardless of the setting done with the *Baud* command, the FLEXMod-411 will always boot using a baud rate of 115200 bps.

This serial port normally echoes back to the terminal the characters received. When this is not desirable (because you are using a microcontroller, for example) echoing can be disabled using the *ECHO* command (see *Echo* on page 10).
Most of the command used to set values with one or more parameters, returns the current configured value if issued without any parameter.

A list of available commands can be obtained using the *HELP* command.

3.1. HELP

Used for:	FLEXMod Help.
Parameters:	None
Example:	Help ↵
Notes:	Pressing SPACE will pause the help output.

4. FLEXMod system configuration

The configuration setup of the operating parameters is stored in an onboard EEPROM. Commands change the current operating parameters in ram: to make any configuration change permanent, the *SAVE* command (see below) should be issued.

4.1. Save

Used for:	Saves operating parameters into EEPROM.
Parameters:	None
Example:	Save↵
Notes:	-.

4.2. Clear

Used for:	Clears EEPROM values to factory defaults.
Parameters:	None
Example:	Clear↵
Notes:	The factory defaults will be loaded and the system rebooted.

4.3. Reboot

Used for:	Restart the FLEXMod.	
Parameters:	Option	
Example:	Reboot↵	*(Reboot both FPGA and microprocessor)*
	Reboot 0↵	*(Reboot microprocessor only)*
Notes:	-.	

4.4. Baud

Used for:	Changes the serial port baud rate.
Parameters:	BaudRate
Example:	Baud 9600↵ Baud 115200↵
Notes:	Boot baud rate will always be 115200. Nearly all baud rates can be selected up to 3Mbps.

4.5. Echo

Used for:	Activates/Deactivate character echoing.
Parameters:	0 or 1
Example:	Echo 0↵ Echo 1↵
Notes:	Echoing could be disabled to ease the use of a microcontroller. When operating the FLEXMod using a terminal program, having the FLEXMod echoing the characters back simplifies its use.

4.6. GetFWVersion

Used for:	Query FLEXMod product name and firmware version.

Parameters: None
Example: GetFWVersion ↵
Notes: Return value is:
FLEXMod-ATSC
Version:x.xx

4.7. GetSN

Used for: Query FLEXMod serial number.
Parameters: None
Example: GetSN ↵
Notes: Return value is:
SN: xx.xx.xx.xx.xx.xx.xx

4.8. Welcome

Used for: Activates/Deactivate welcome message.
Parameters: 0 to 1
Example: Welcome 0 ↵ *(Welcome message disabled)*
Welcome 1 ↵ *(Standard welcome message)*
Notes: There is a special welcome message sent by the FLEXMod when receiving the first ENTER (CR, 0x0D) character after a boot. This is helpful when using the FLEXMod connected to a USB serial port since the original power-up message will be lost because the USB is not yet connected. It is advisable to disable this welcome message when operating the FLEXMod using a microcontroller.

4.9. Manuf

Used for: Display currently programmed welcome/manufacturer message.
Parameters: None
Example: Manuf ↵
Notes: If no custom welcome/manufacturer message has been programmed, a Tecnoroll srl copyright message will be displayed.

4.10. GetTemp

Used for: Display currently FlexMOD temperature.
Parameters: None
Example: GetTemp ↵
Notes: The temperature is shown in Celsius degree.

4.11. TempAlarm

Used for: Set point for output alarm signal.
Parameters: 0 to 124
Example: TempAlarm 75 ↵
Notes: Temperature is set in Celsius degrees. Output pin OverTEMP, if enabled, will go high when FlexMOD temperature is above this set value.

4.12. FlagsMatrix

Used for: Configure the output of the Modulator flags pins.

Parameters: A,B,C,D,E,F,G,H

Example: FlagsMatrix 0,1,2,3,4,5,6,7↵ *(Default values)*
FlagsMatrix 7,6,5,4,3,2,1,0↵ *(Reversed output: DCD is on flag 7 and so on)*
FlagsMatrix 0,1,2,7,7,5,6,15↵ *(Flag 7 set in case of error: Overflow, Overtemp or Selftest failed)*

Notes: Each letter represent a function (see table below) and is a number 0 to 15, which indicates the Flag output pin to route the function output to (0 to 7, add 8 for inverted output).
Different flags can be output to the same pin, if needed.

A	Carrier detect		E	OverTemp
B	ASI 204 bytes		F	Reserved
C	ASI burst		G	Reserved
D	Overflow		H	Modulator SELFTest OK

Value for STK V1.3 leds is 1985167888 (0x76534210)
Value for STK V1.4 leds is 113726001 (0x06C75231).

5. FLEXMod-411 ATSC modulator configuration

5.1. Freq

Used for: Set ATSC output frequency.
Parameters: 0 to 1024000000.
Example: Freq 36000000↵
Notes: Not all frequencies work. Since the DAC is working at approx 1GHz, frequencies greater than 500 MHz are obtained using the image frequency and modulator performance is not guaranteed.

5.2. Spect

Used for: Set ATSC output spectrum.
Parameters: 0 or 1
Example: Spect 0↵
Notes: Select 1 to invert the output spectrum.

5.3. RFPower

Used for: Set ATSC output power.
Parameters: 0 to 255
Example: Power 128↵
Notes: Programs the AD 9957 output power. Default value is 128.

5.4. PreCorr

Used for: Enables/Disables the digital precorrector function.
Parameters: 0 or 1
Example: Precorr 0↵ *(Disables digital precorrector)*
Precorr 1↵ *(Enables digital precorrector)*
Notes: -.

5.5. PrecLoad

Used for: Loads Digital precorrector table.
Parameters: 1 or 2
Example: PrecLoad 1↵ *(Prepare for loading the Amplitude correction table)*
PrecLoad 2↵ *(Prepare for loading the Phase correction table)*
Notes: Both amplitude and phase correction tables requires 1024 coefficients entered one per line, 0 to 2^{17}-1 for amplitude, -2^{17} to 2^{17}-1 for phase.
Amplitude coefficients are scaled by 2^{17}, so amplitude correction is 0 to (2^{17}-1)/2^{17}=0.99999, while phase coefficients are scaled by 2^{17}/180 degrees, so phase correction is (-2^{17})/(2^{17}/180)=-180 degrees to (2^{17}-1)/(2^{17}/180)=179.99 degrees.
Notes: -.

5.6. PrecList

Used for: Shows the loaded precorrector table.

Parameters:	1 or 2	
Example:	PrecList 1↵	*(Shows Amplitude precorrection table)*
	PrecList 2↵	*(Shows Phase precorrection table)*
Notes:	-.	

5.7. RefClock

Used for:	Selects the reference clock	
Parameters:	0 to 10000000	
Example:	RefClock 1↵	*(Selects 1Hz –PPS- as the reference clock)*
	RefClock 10000↵	*(Selects a 10kHz reference clock)*
	RefClock 0↵	*(Disables reference clock)*
Notes:	Reference clock in in Hz. Valid range is 1 Hz to 10000000 Hz. Use 0 to disable the reference clock.	
	Due to limitations of the signal conditioning circuitry in the Starter Kit, the maximum reference clock for the starter kits only is less than 10 kHz.	

5.8. ForceVCXO

Used for:	Force VCXO Vcontrol.	
Parameters:	0 to 4095	
Example:	ForceVCXO 2048↵	*(Forces the VCXO to half scale)*
Notes:	VCXO value can be changed only if there is no reference clock enabled.	

6. Input Transport Stream configuration

6.1. SetInputASI

Used for:	Select normal or inverted ASI TS input.	
Parameters:	0 to 1	
Example:	SetInputASI 0↵	*(Select ASI TS input)*
	SetInputASI 1↵	*(Select inverted ASI TS input)*
Notes:	Inverted ASI inverts LVDS+ and LVDS- signals.	

6.2. GetASIStatus

Used for:	Show input transport stream status.
Parameters:	None
Example:	GetASIStatus↵
Notes:	Returns ASI_DCD, ASI_188_204, ASI_BURST, ASI_OVERFLOW.

7. FLEXMod module upgrade

The FLEXMod firmware can be user upgraded if needed.
The upgrade procedure is performed with the following steps:

1. Change the baud rate to something faster than 115200. This step is not necessary (the upgrade can also be done at any baud rate) but since the firmware is quite long it is advisable to do this.
2. Issue the *FlashFormat 741852* command which erases the onboard serial flash containing the firmware.
3. Wait for the FLEXMod signaling the end of the flash erasing procedure (it takes normally 10 seconds)
4. Issue the *Upgrade 741852* command and upload the new firmware using the XMODEM protocol.
5. When the upload has been completed, wait for the acknowledge that the upgrade has been successfully completed.
6. Power off and then back on the FLEXMod.

Please note:
Should the procedure fail for any reason, perform the procedure again starting from step 2. **Do not** power off the board since the flash has been erased (or contains an invalid firmware) and hence the board will not work (and could also, in rare occasions, be damaged). Should this happen, the board has to be returned to factory for reprogramming
Note also that this procedure will erase the welcome/manufacturer message.

7.1. FlashFormat

Used for:	Erases the onboard serial flash.
Parameters:	741852
Example:	FlashFormat↵
Notes:	The *741852* parameter is a constant value used to avoid the risk of issuing this command by chance. Do not erase the flash if you are not ready to perform an upgrade procedure. After the flash has been erased, the FLEXMod will not be able to boot. This will also erase the welcome/manufacturer message.

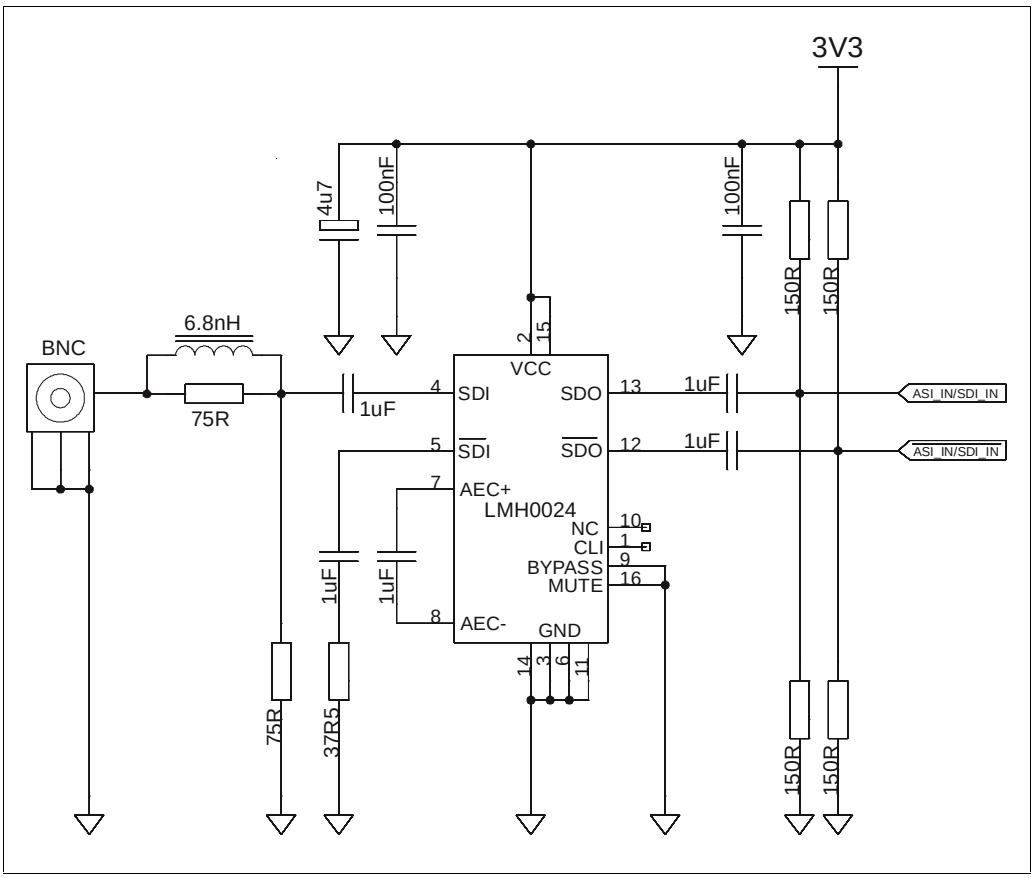
7.2. Upgrade

Used for:	XMODEM upload of a new firmware.
Parameters:	741852
Example:	Upload↵
Notes:	Any terminal software capable of the XMODEM protocol can be used. The *741852* parameter is a constant value used to avoid the risk of issuing this command by chance.

8. Sample schematics

8.1. ASI Input sample schematic

The LDVS TS ASI Input requires a cable equalizer and an adaptation network in order to adjust input levels. Note that ASI_IN is a LVDS signal, so route accordingly. The following schematics is a typical application ASI input:



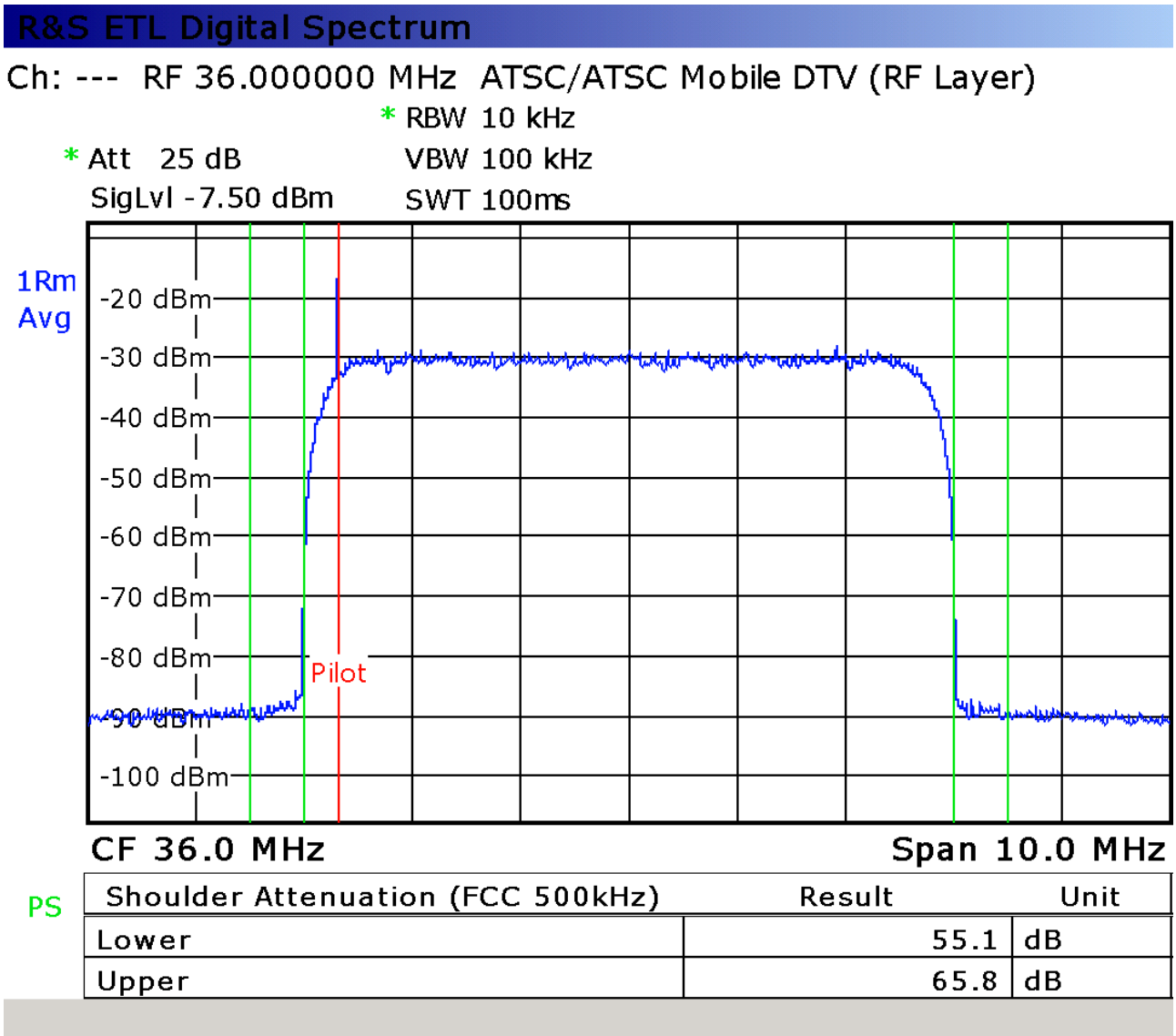
Typical ASI input

9. Power supplies characteristics

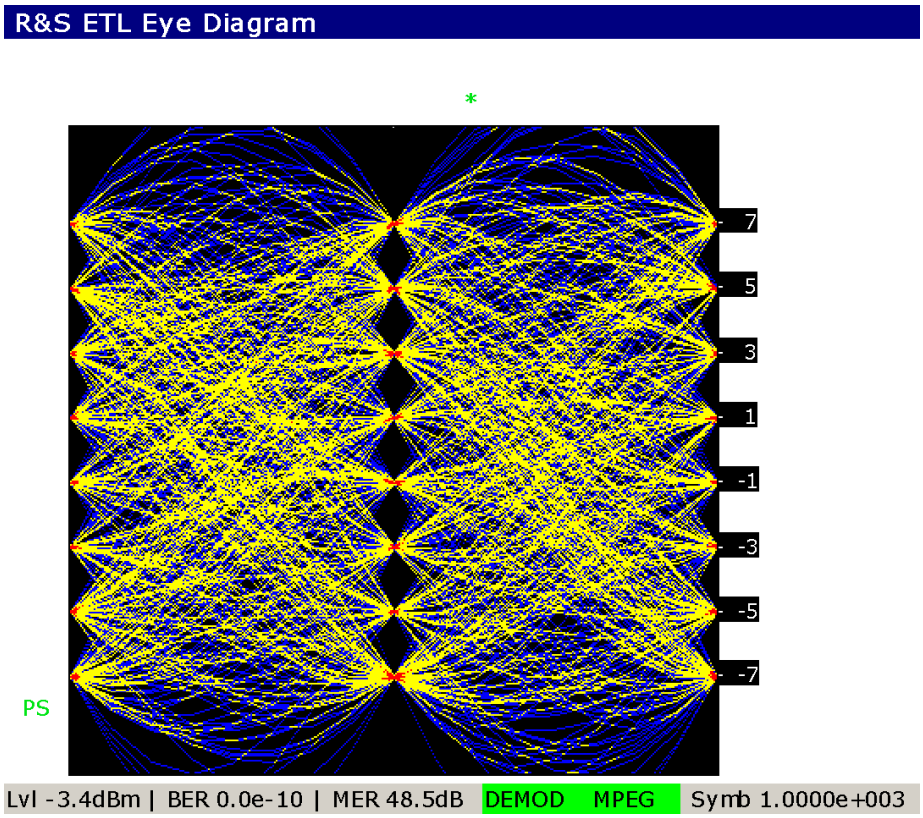
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP.	MAX	UNIT
1V2	Core voltage			640		mA
1V8	DAC voltage			330		mA
1V8A	Analog voltage			110		mA
3V3	I/O voltage			140		mA
3V3A	Analog voltage			90		mA

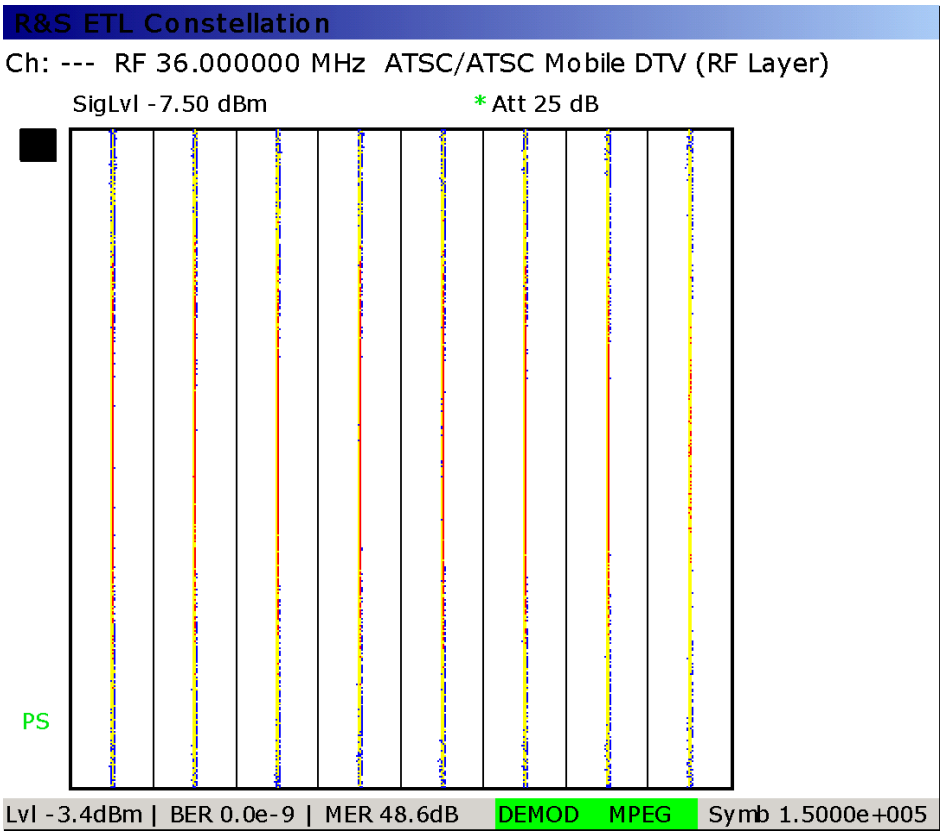
10. Alphabetical command list

11. Typical output characteristics

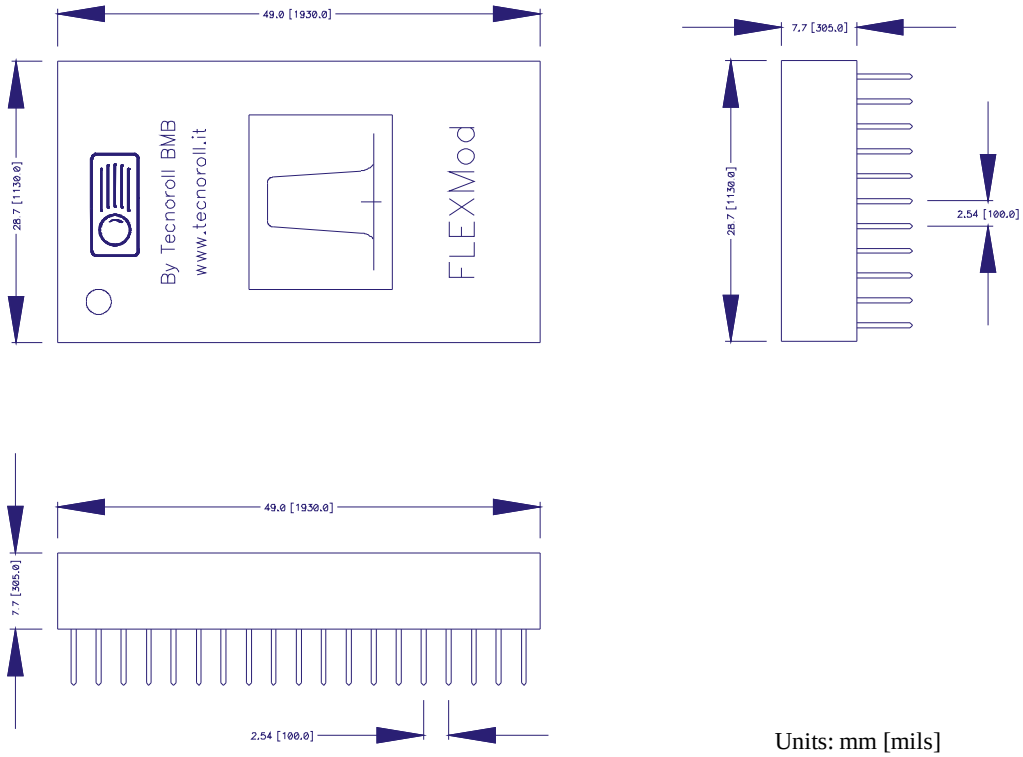


Typical output spectrum at 36MHz

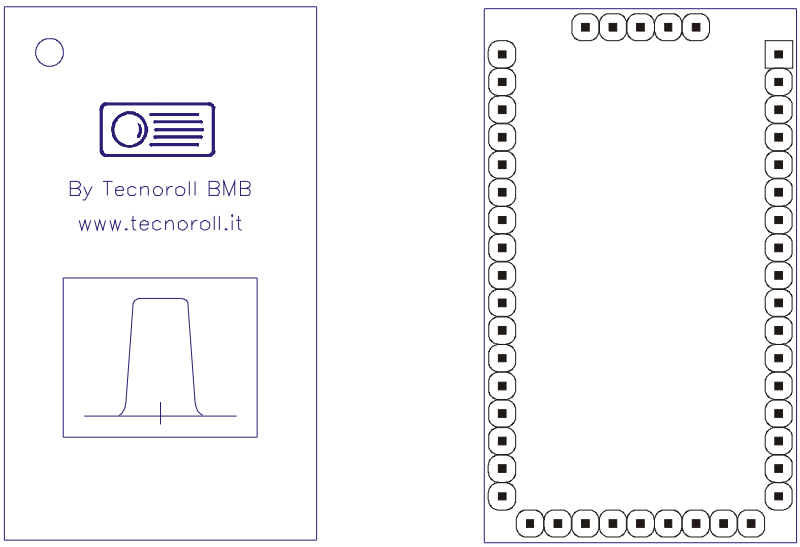

R&S ETL Eye Diagram
*
7
5
3
1
-1
-3
-5
-7
PS
Lvl -3.4dBm | BER 0.0e-10 | MER 48.5dB
DEMOD
MPEG
Symb 1.0000e+003


R&S ETL Constellation
Ch: --- RF 36.000000 MHz ATSC/ATSC Mobile DTV (RF Layer)
SigLvl -7.50 dBm
* Att 25 dB
PS
Lvl -3.4dBm | BER 0.0e-9 | MER 48.6dB
DEMOD
MPEG
Symb 1.5000e+005

12. Packaging information



Units: mm [mils]
Controlling dimensions: mm

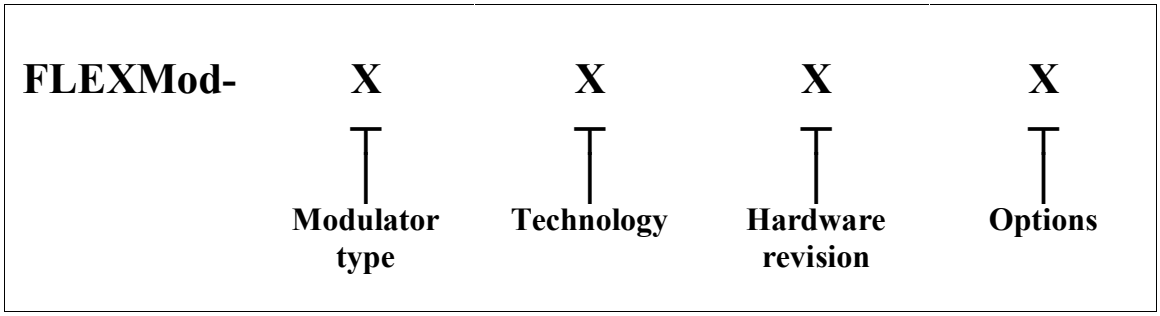


Top View Bottom View

Appendix A 'Type' description for connector pins

Type	Description
I_a	Analog input
I_5	5V compatible input
I_3	3.3V compatible input
$I_{3/5}$	3.3V compatible input, 5V tolerant
$I_{LVDS\pm}$	Positive/Negative LVDS input
O_a	Analog output
O_3	3.3V output
O_5	5V output
OC_3	3.3V output, Open Collector
$O_{LVDS\pm}$	Positive/Negative LVDS output
P	Power supply line
P_o	Power supply output line

Appendix B FLEXMod Product Identification System



Modulator type	
0	Unprogrammed hardware
1	DVB-T MFN: *ETSI EN 300 744* compliant COFDM modulator.
2	DVB-S: *ETSI EN 300 421* compliant QPSK modulator.
3	DVB-C: *ETSI EN 300 429* compliant QAM modulator.
4	ATSC (A/53) compliant modulator.
5	DVB-S/S2: *ETSI EN 300 421/302 307* compliant QPSK/8PSK/16,32APSK modulator.
6	DVB-T SFN: *ETSI EN 300 744/TS 101 191* compliant COFDM modulator.
9	Transport Stream Converter/Remultiplexer
AV101	DVB-T MFN: ETSI EN 300 744 compliant COFDM TR391AV Controller
AV201	DVB-S: ETSI EN 300 421 compliant QPSK TR391AV Controller
AV301	DVB-C: ETSI EN 300 429 compliant QAM TR391AV Controller

Technology	
0	Reference clock: 1.024 GHz.
1	Professional tunable reference clock (VCXO): 1.024 GHz.
2	Professional tunable reference clock (VCXO): 1.024 GHz and SFN input FIFO
8	Reference clock: 16 MHz.

Options	
P	Premium type.
N	Unboxed (naked) version.

Examples:
FLEXMod-101 Consumer grade DVB-T modulator, reference clock 1.024GHz, HW revision 1
FLEXMod-281 Consumer grade DVB-S modulator, reference clock 16MHz, HW revision 1