

# Adaptive Modulation in Pathloss 5



This document describes the implementation of adaptive modulation in Pathloss 5.

## Adaptive Modulation Radio Data Files

The ANT\_RAD utility program is used to create radio data files. The required specifications and formats for adaptive modulation radios are given in the following sections.

### Basic adaptive modulation radio data specifications

These are organized in three sections. In the examples below, the data entries are organized from the highest modulation state down to the lowest. The order is not important. When the data file is loaded into a link, the data is sorted from high to low modulation using the receive threshold level.

A maximum of 10 modulation states can be specified, The examples below show 5 states

#### First section ASCII file format

```
//ADAPTMOD 1,Mod,RSEC, RXthr, Step up, Step dn, Min C-I, Thruput
ADMOD_1: 256QAM, 5B, -61.00, -51.00, -57.00, , 172 Mbps
ADMOD_2: 128QAM, 5B, -65.00, -55.00, -61.00, , 154 Mbps
ADMOD_3: 64QAM, 5B, -68.00, -59.50, -64.00, , 134 Mbps
ADMOD_4: 16QAM, 4L, -74.00, -62.00, -70.00, , 91 Mbps
ADMOD_5: 4QAM, 2, -81.00, -68.00, -77.00, , 45 Mbps
```

#### First section Ant Rad display

ADAPTMOD 1	Modulation	RSEC	TX (dBm)	RX (dBm)	Step up (dBm)	Step down dBm	Min C-I	Thruput
ADMOD_1	256QAM	5B	11.00	-61.00		-57.00		172
ADMOD_2	128QAM	5B	12.00	-65.00	-55.00	-61.00		154
ADMOD_3	64QAM	5B	13.00	-68.00	-59.50	-64.00		134
ADMOD_4	16QAM	4L	14.00	-74.00	-62.00	-70.00		91
ADMOD_5	4QAM	2	16.00	-81.00	-68.00			45

#### Modulation (text 15 characters)

The modulation and throughput are used together as row headers in adaptive modulation displays and reports. These are both text fields and the formatting should result in a concise informative field e.g “256QAM 172 Mbps”

#### Reference Spectrum Efficiency Class (RSEC) (text 15 characters)

This entry only applies to the ETSI method. RSEC is referred to as Reference Mode in ETSI EN 302 217-1 and ETSI EN 301 217-2-2 and is used in frequency coordination.

The RSEC term is information only. Instead the *Reference state* setting in the program is used to set the power levels. In the ANSI method, this field can be used for any information purpose required.

#### Transmit power (dBm)

Although the transmit power is shown in the first section in the Ant\_Rad display, it is actually part of the transmit power options defined in the third section. The display shows the maximum transmit power for the first power option. To access the power options, click the TX Power (dbm) button on the column header.

A transmit power option specifies the maximum and minimum powers and the ATPC value if the modulation state is the top level. The minimum power and the ATPC values are optional and can be left blank. A maximum TX power value must be specified for each modulation state. Five transmit power options can be entered

If the radio specifications have a single transmit power value for each modulation state, then these values can be entered directly in the first section TX Power (dBm) column in the Ant\_Rad display. In the ASCII file, transmit powers are entered in the third section.

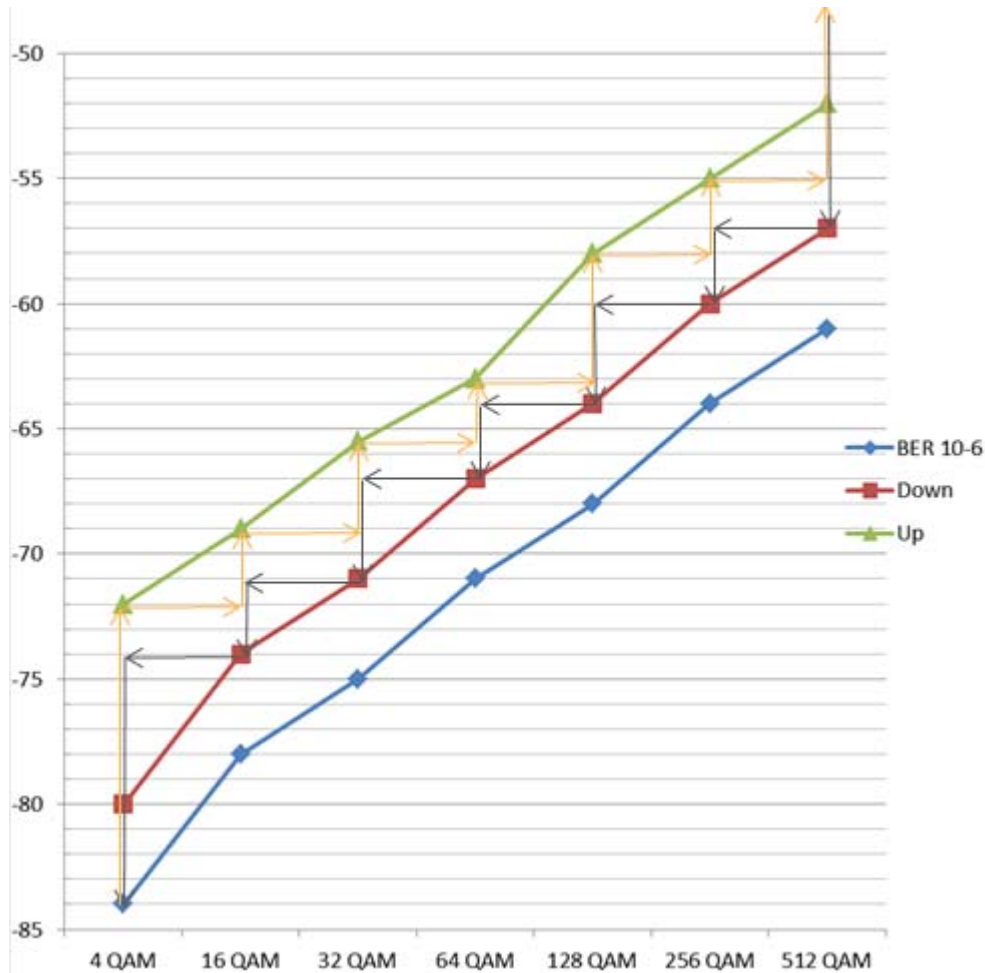
#### Receive threshold level (dBm)

The receive threshold level corresponds to the  $10^{-6}$  BER. This must be specified for each modulation state

#### Step up / Step down levels (dBm)

Under fading conditions, the radio will switch between modulation states to maintain service. The radio's internal switching logic ensures that the transition from one modulation state to the next will be carried out without errors. The actual switching levels requires

some margin above the receive  $10^{-6}$  threshold level as shown in the diagram below. This margin will depend on the fade rate used to determine the margin.



This margin is specified as the Step up and step down levels. Using the values shown in the Ant\_Rad display above, assume that the link is a 256QAM state and the link is fading down. The radio will switch down to the 128 QAM state 4 dB before the 256QAM  $10^{-6}$  threshold is reached. This 4 dB margin translates to a step down level of -57 dBm for the 256 QAM state.

When the link fades up, the radio will not return to the 256 QAM state until there is a 6 dB margin above the 256QAM  $10^{-6}$  threshold. This translates to a step up level of -55 dBm for the 128 QAM state.

The result of these margins is a reduction in the effective threshold level of each modulation state except for the lowest state. This effective threshold for a given state is the average of the step down level of that state and the setup level of the next lower state,

For the 256QAM state, the effective threshold would be  $-(57 + 55)/2 = -56$  dBm. The  $10^{-6}$  threshold of the 256QAM state is -61 dBm. The effect of these margins is a 5 dB reduction in the threshold level.

When the radio data file is loaded into a link, the receive threshold levels will be set to the values calculated from the Step up and Step down levels. Note that these levels are optional; in which case the actual  $10^{-6}$  thresholds will be used; however availability calculations will be very optimistic.

### Minimum Carrier to Interference

This is the minimum C/I value required to remain in the current modulation state. At this time this parameter is not used in the program. The method used in the program is to degrade the interfering threshold level

### Data Throughput (text 15 characters)

This field is combined with the Modulation field to form row headers in adaptive modulation reports and calculation displays.

### Second section ASCII file format

```
//ADAPTMOD 2 DispFM, Sig delay, Sig width, Sig min, Sig nmin, MaxRX, XPIF
ADMOD_1A: 46.00, 6.30, 28.00, 21.00, 21.00, -19.00, 20.00
ADMOD_2A: 47.00, 6.30, 28.00, 22.00, 22.00, -19.00, 17.00
ADMOD_3A: 48.00, 6.30, 28.00, 23.00, 23.00, -19.00, 14.00
ADMOD_4A: 51.00, 6.30, 28.00, 25.00, 25.00, -16.00, 8.00
ADMOD_5A: 55.00, 6.30, 28.00, 29.00, 29.00, -16.00, 2.00
```

### Second section Ant Rad display

ADAPTMOD 2	Disp FM	Sig delay (ns)	Sig width (MHz)	Sig min phase	Sig nonmin phase	Max RX	XPIF
ADMOD_1A	46.00	6.30	28.00	21.00	21.00	-19.00	20.00
ADMOD_2A	47.00	6.30	28.00	22.00	22.00	-19.00	17.00
ADMOD_3A	48.00	6.30	28.00	23.00	23.00	-19.00	14.00
ADMOD_4A	51.00	6.30	28.00	25.00	25.00	-16.00	8.00
ADMOD_5A	55.00	6.30	28.00	29.00	29.00	-16.00	2.00

This section contains the following specifications:

- dispersive fade margin
- equipment signature (delay (ns), width (Mhz) minimum and non minimum phase depth
- maximum receive signal
- cross polarized improvement factor

Normally these specifications would be referenced to a  $10^{-6}$  bit error rate; however, if the receive threshold levels have been modified by the Step up and Step down specifications, then the values for a lower bit rate would be more applicable.

For a typical reduction in the receive threshold of 5 dB, values corresponding to the residual bit error rate could be used. Note that this does not apply to the lowest modulation state.

### Third section ASCII file format

```
//ADAPTMOD 3: txpwrmax1, txpwrmin1, atpcl...
ADMOD_1B:      11.00,      -5.00, 16.00, -6.00, -20.00, 14.00,,,,,,,,,
ADMOD_2B:      12.00,      -5.00, 17.00, -5.00, -20.00, 15.00,,,,,,,,,
ADMOD_3B:      13.00,      -5.00, 18.00, -4.00, -20.00, 16.00,,,,,,,,,
ADMOD_4B:      14.00,      -5.00, 19.00, -3.00, -20.00, 17.00,,,,,,,,,
ADMOD_5B:      16.00,      -5.00, 21.00, -1.00, -20.00, 19.00,,,,,,,,,
```

Third section Ant\_Rad display

	ADMOD_1B	ADMOD_2B	ADMOD_3B	ADMOD_4B	ADMOD_5B
1 Power option	Std	Std	Std	Std	Std
1 Max pwr (dBm)	11.0	12.0	13.0	14.0	16.0
1 Min pwr (dBm)	-5.0	-5.0	-5.0	-5.0	-5.0
1 ATPC top (dB)	16.0	17.0	18.0	19.0	21.0
2 Power option	LP	LP	LP	LP	LP
2 Max pwr (dBm)	-6.0	-5.0	-4.0	-3.0	-1.0
2 Min pwr (dBm)	-20.0	-20.0	-20.0	-20.0	-20.0
2 ATPC top (dB)	14.0	15.0	16.0	17.0	19.0

This section is used for transmit power options. In the Ant\_Rad display, click the TX Power (dBm) button to access this display.

A transmit power option consists of the following parameters

- a description of the option (“Hi”, “Lo”, “Std” ...)
- maximum power (dBm)
- minimum power (dBm)
- ATPC range to be used if this is the top modulation state

The maximum power value of the first option is duplicated in the first section of the Ant\_Rad display. In the case of single power value for each modulation state, the data can be entered there.

### Specifications common to all radio types

#### Noise Floor

The receiver noise floor must be specified to calculate threshold degradation due to external interference or XPIC operation.

```
RX_THRESHOLD_DESCRIPTION:  BER 1e-3, BER 1e-6, RBER, BER_SES
RX_THRESHOLD_BER:         1.0E-3, 1.0E-6, ,
RX_THRESHOLD_DBM:         -66, -65, ,
```

```

NOISE_FIGURE_DB:
    Ttol_RATIO: 32
Ctol_RATIO_BER10-6_3DB: 29
Ctol_RATIO_BER10-3_3DB: 28
    NOISE_FLOOR_KTBF_DBM: -92

```

Receiver data	10-3 BER	10-6 BER
RX_THRESHOLD_DESCRIPTION	BER 1e-3	BER 1e-6
RX_THRESHOLD_BER	1.00E-003	1.00E-006
RX_THRESHOLD_DBM	-66.00	-65.00
MAXIMUM_RXSIGNAL_DBM	-17.00	-19.00
DISPERSIVE_FM_DB	49.00	47.00
SIGNATURE_DELAY_NS	6.30	6.30
SIGNATURE_WIDTH_MHZ	26.00	28.00
SIGNATURE_MINPHASE_DB	23.00	22.00
SIGNATURE_NONMINPHASE_DB	23.00	22.00
NOISE_FIGURE_DB		
Ttol_RATIO	32.00	
Ctol_RATIO_BER10-6_3DB	29.00	
Ctol_RATIO_BER10-3_3DB	28.00	
NOISE_FLOOR_KTBF_DBM	-92.00	

Several methods are available to indirectly calculate the noise floor. For adaptive modulation the direct specification method is preferred

The indirect method are:

- Ttol ratio and the  $10^{-6}$  threshold
- Ctol ration for a 3 dB degradation of the  $10^{-6}$  threshold and the  $10^{-6}$  threshold level
- Ctol ration for a 3 dB degradation of the  $10^{-3}$  threshold and the  $10^{-3}$  threshold level

The combinations must be for the same modulation

### Transmit Power options description

```
TX_POWER_OPTIONS_NAME: Std, LP, , ,
```

Transmit data	Option names are used with all radio types	
TX_POWER_OPTIONS_NAME	Std	LP

### Radio curves for adaptive modulation radios

Interference calculations for adaptive modulation radios use the transmit spectrum - receive selectivity curves to determine the filter improvement in an interference calculation.

Threshold to interference (Ttol) and Interference reduction factor IRF curves will be different for each combination of modulation states are not used.

Provision has been made to allow a transmit spectrum and receive selectivity curve for each modulation state. These curves are designated RX\_SELECTIVITY\_01 to 10 and TX\_EMISSION\_01 to 10. These curves must be in the same order as the modulation states.

In an interference calculation, the TX emission curve is determined as follows:

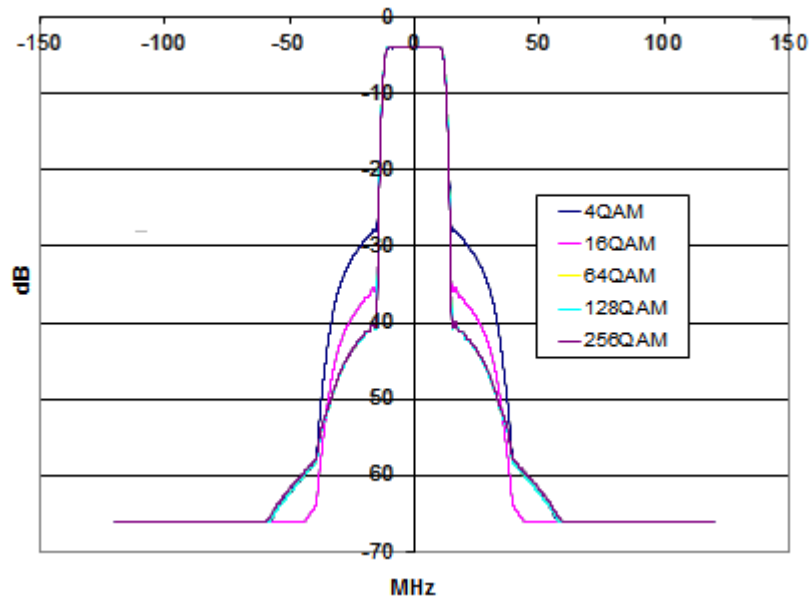
- If a TX emission curve exists for the particular modulation state under test, (TX\_EMISSION\_XX), it will be used.
- If a TX emission curve exists for the file (TX\_EMISSION), it will be used
- If a default TX emission mask based on the 3dB bandwidth exists, it will be used
- Otherwise, the filter improvement will not be calculated

The corresponding RX selectivity is determined as follows:

- If an RX selectivity curve exists for the particular modulation state under test, (RX\_SELECTIVITY\_XX), it will be used.
- If a measured RX selectivity curve exists (RX\_SELECTIVITY), it will be used
- If a Ttol curve for a CW interferer exists, it will be used,
- If a default RX selectivity based on the 3 dB bandwidth exists, it will be used
- Otherwise, the filter improvement will not be calculated

In general, the RX selectivity curve is very similar for each of the modulation states and only one curve is required for the file (RX\_SELECTIVITY)

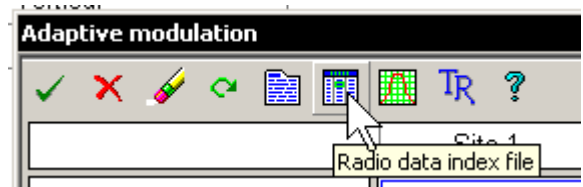
The TX emission curves for the different modulation states differ mostly in the adjacent channel area. as shown below. If only a single TX emission curve for the file is to be used, (TX\_EMISSION), this should correspond to the lowest modulation state.



## Adaptive Modulation Radio Data Files in the Pathloss Program.

### Radio Index File

The first step is to add the radio data files into the *Radio File Index*. This index can be accessed from any radio data entry form in the program.



Click the *Import Radio Index* button and follow the procedures to create an index of the adaptive modulation radio data files. Creating an index is a necessary step for adaptive modulation radios. If a radio lookup table is required, the table must be populated using the *Radio File Index* as it is not possible to enter the specifications manually in the lookup table.





When an adaptive radio data file is entered into the radio data entry form, the user is presented with the display on the right.

### Adaptive modulation states

The user can limit the range of modulation states. The default is all modulation states. The calculations will be limited to the checked states

### Reference state

The reference state must be within the selected range of modulation states. The reference state is used as follows:

- the reference state controls the transmit power for all modulation states in the ETSI mode (See description below)
- the reference state parameters are used for calculations in the *Total time below level for rain and multipath fades* option
- The reference state parameters are used in interference calculations

### Transmit power options

A transmit power option consists of a maximum and minimum value for each modulation state. In addition an ATPC value can be specified which would only be applicable for the top modulation state

### ETSI Option

The ETSI option controls the transmit power levels. When an adaptive modulation radio data file is loaded into the radio data entry form, the reference state will determine the transmit power levels. The reference state is shown in blue text

The transmit power of the reference state is the maximum power for all modulation states. It is not possible to manually change the power levels outside the limits set by the reference state.

The transmission analysis is formatted to show the one way availability.

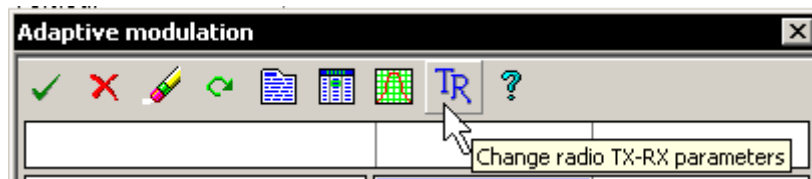
	TX power (dBm)		RX threshold (dBm)	
256QAM 182 Mbps	11.00	11.00	-56.00	-56.00
128QAM 165 Mbps	12.00	12.00	-59.50	-59.50
64QAM 143 Mbps	12.00	12.00	-62.00	-62.00
16QAM 97 Mbps	12.00	12.00	-69.00	-69.00
4QAM 48 Mbps	12.00	12.00	-81.00	-81.00

### ANSI option

In the ANSI option, the transmit powers are not affected by the reference state. The transmission analysis is formatted to show the two way availability.

### Changing Adaptive Modulation Settings

To change any of the settings, click the TR icon on the radio data entry form



### Adaptive modulation Warning Messages

A warning message is generated in the *Transmission Analysis* design section for ANSI adaptive modulation applications under the following conditions:

- a channel bandwidth has been specified in the radio data file
- the minimum data throughput (payload) is determined from the table below using this bandwidth

Channel Bandwidth (MHz)	Minimum Payload (Mb/s)
0.400	1.54
0.800	3.08
1.25	3.08
1.60	6.17
2.50	6.17
3.75	12.3
5.0	18.5

Channel Bandwidth (MHz)	Minimum Payload (Mb/s)
10.0	44.7
20.0	89.4
30.0	89.4 (11 GHz)
30.0	134.1 (6 GHz)
40.0	134.1

- The 2 way link availability corresponding to this data rate must be at least 99.95%