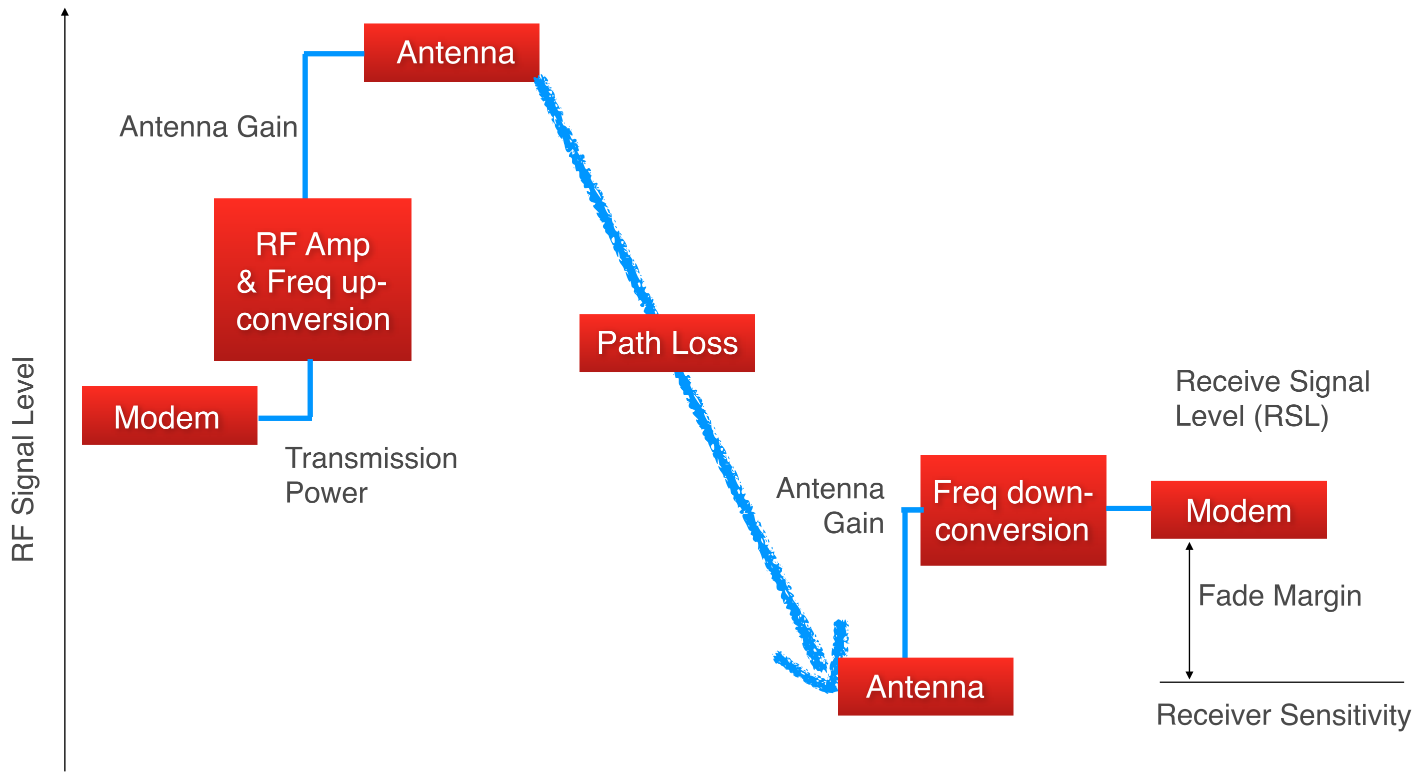
SPECTRONITE
COMMUNICATIONS TECHNOLOGY

LinkProtect

Improving point-to-point wireless links robustness with LinkProtect™ technology

Background

Wireless transmission performances depend of the quality of all transmission elements.
A link budget describes all different elements at stake influencing the overall quality of a link.
Below diagram represents such a link budget and all variations of the RF signal.



System is operating safely as long as RSL exceeds receiver sensitivity. As path loss varies with transmission environment conditions e.g. temperature, humidity, multi path effect, sizing a point-to-point link means provisioning sufficient Fade Margin to compensate for these variabilities.

Point-to-point wireless links operation variables are as follow:
- operating frequency (varies typically between 6 GHz and 42 GHz).
- channel bandwidth (typ. 3.5 MHz to 56 MHz)
- modulation (typ. QPSK to 1024QAM)

Transmission system performances are primarily characterised by:
- receiver sensitivity
- maximum transmission power

Link performance is estimated by the computation of its estimated operation time over a given period and is referred to as link availability. Typical availability are 99.99% (or 4x9's), meaning a cumulated 52 minutes yearly outage, 99.999% (or 5x9's) for a 5.2 min yearly outage or 99,9999% for a 30 seconds yearly outage.

As most point-to-point links are designed for 99.99% or at best 99.999% availability, there remain still a large need for improving link robustness and further improve networks availability. When

planning all links inside a complete network with 99.999% availability, the resulting network outage is indeed much larger than 99.999% since outages don't occur simultaneously for all links in the network.

State-of-the-Art

Several mechanisms are well known for point-to-point links to adapt dynamically to changing transmission conditions.

Adaptive Transmission Power Control (ATPC)

Adaptive transmission power control allows for dynamic variations of the transmission power depending on link conditions. This process does however not add to the link robustness.

Link designs are performed at maximum transmission power. Therefore ATPC rather provides a way to reduce transmit power when in good conditions of operation. It primarily helps improve radios MTBF and reduce power consumption.

Adaptive Modulation

Adaptive modulation has been integrated in point-to-point wireless links to provide higher transmission capacity while overcoming shortfall of increased modulation.

Increasing modulation order provides higher capacity but in the same time, modem sensitivity degrades due to the increased signal complexity and the requirement for higher signal to noise ratio.

Higher order modulations also suffer from RF amplification non-linearity and maximum transmission power has to be decreased to ensure lower signal distortion.

Below diagrams sketches sensitivity variations against channel bandwidth and modulation for a typical system.

	3.5 MHz	7 MHz	14 MHz	28 MHz	56 MHz
QPSK	-94.0	-92.0	-87.5	-85.5	-80.0
16QAM	-89.0	-88.5	-85.5	-80.5	-76.5
32QAM	-85.0	-82.0	-80.0	-75.5	-73.0
64QAM	-81.5	-78.5	-76.5	-72.5	-69.5
128QAM	-79.0	-76.0	-73.5	-70.5	-64.5
256QAM	-75.5	-73.0	-70.5	-66.5	-63.0
512QAM	-73.0	-70.5	-68.5	-62.5	-60.0
1024QAM	-70.0	-67.5	-65.0	-58.5	-56.0

Adaptive modulation provides a significant sensitivity improvement

Sensitivity improvement thanks to adaptive modulation is typically higher than 20dB for 1024QAM capable radios.

The impact of modulation on maximum transmission power is displayed in the table below. When switching down to lowest modulation order, an additional transmission gain in transmission power of up to 10dBm can be achieved (values are typical).

It is not clear however if and how most commercial system reflect the gain in maximum transmission power going down the modulation scale. Indeed, not all manufacturers manage transmission power properly when changing modulations.

Modulation	Maximum Transmit Power
QPSK	26
16QAM	23
32QAM	22
64QAM	20
128QAM	19
256QAM	18
512QAM	17
1024QAM	16

Adaptive modulation provides and additional improvement in maximum transmission power

Adaptive Coding

Additionally to all above techniques, adaptive coding has been integrated into recent systems. Radio frames are indeed coded with Forward Error Correction (FEC) techniques to increase transmission robustness. Typical coding algorithms are Reed-Solomon or LDPC.

When coding, various schemes can be applied. Higher coding rates are indeed more robust, but require more overhead and consequently reduce the overall link throughput.

When used in conjunction adaptive modulation, benefits for increasing coding (overhead / data ratio) is essentially a better granularity between different modulation steps. Higher coding rates would also slightly improve receiver sensitivity.

LinkProtect Principle

In addition to the above mechanisms, LinkProtect provides dynamic channel bandwidth selection.

When conditions degrade, adaptive modulation decreases modulation down to QPSK.
At this stage, any further transmission degradations will cause the link to cut. That is the common behaviour of all current commercial point-to-point microwave systems.

At this stage, LinkProtect provides a unique way of switching the link to narrow channels.
Changing channel bandwidth happens dynamically and triggered by SNR threshhold values.

Looking at the above typical sensitivity tables, switching between a 56MHz to a 7MHz channel provides an immediate improvement of 12dB.

Improvement can be even greater:
- the support of an additional 3.5 MHz channel bandwidth provides an even improved additional gain in terms of sensitivity.
- most radios don't allow for QPSK operation in 28 MHz or 56 MHz channels. The sensitivity gap between16QAM / 56 MHz and QPSK / 7 MHz configurations will be even larger.

Customer Benefits

Every dB is important when planning for a wireless link. For a given configuration (desired throughput and antenna size), a drop by a few dBs will strongly affect link availability.

Following sections detail scenarios for potential customers benefits

Higher link throughput

With the advent of adaptive modulation, link availability is commonly given for the most favorable transmission conditions, meaning smaller order modulation.

For critical links, ensuring a given availability is a key design criterion. For example, a customer might desire the throughput allowed by a 28 MHz channel transmission, while a QPSK / 7 MHz setup might be the only sensitivity value allowing for a 99.99% link availability.

In a fixed channel bandwidth configuration, the maximum available capacity would be available for a 1024QAM / 7 MHz transmission i.e. approx. 50 Mbps.

Allowing for a dynamic bandwidth selection would in that case allow for reaching the desired QPSK / 7 MHz sensitivity value when transmission conditions degrade while providing a bonus throughput with 1024QAM / 56 MHz reaching up to approx. 500Mbps.

Reduction of antenna size

Should a customer want to achieve the highest possible throughput with a system, it will size antennas for a 56 MHz channel operation.

In this channel, link availability will be computed with transmission characteristics as per below example (QPSK / 56 MHz configuration)
- sensitivity = -84 dB
- maximum transmit power 23 dBm.

Should dynamic bandwidth selection provide the ability to switch down to a QPSK / 7 MHz configuration, the new parameters set for link availability computation would be:
- sensitivity = -90.0 dB
- maximum transmit power 26 dBm.

In that case, an increased fade margin of 12 dBm is provided, allowing for the reduction of antenna size by 2 steps.

Higher Link availability

When link throughput is again a strong requirement, widest channels will be used such as 28 MHz or 56 MHz. Best sensitivity will then be achieved for a QPSK modulation.

Enabling channel bandwidth selection will allow again for an additional fade margin and therefore provide the desired link throughput, while enabling higher availability

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About Spectronite

Spectronite strives to bring innovation to the wireless backhaul landscape. We design our products to provide Mobile Operators, ISPs and Private Network Operators with the most efficient way to interconnect their customers and deliver capacity.

Focusing on the most essential performance indicators of a wireless backhaul network, that is maximum capacity and superior uptime, Spectrnonite has brought LinkProtect to the market, thus providing the most robust wireless backhaul available in the market.

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