White Paper

MiMOMax: In Defence of QAM

Busting the Myths Regarding the Usage of QAM versus FM in Utility Applications

► Introduction

- Some of our customers have been advised that QAM is more susceptible to impulse noise than FM and therefore QAM should not be used around power utilities.

- From our perspective, referring back to communications theory and not just someone's opinion or hearsay, we have detailed what we believe to be the facts surrounding various modulation schemes and susceptibility to noise.

- Our position is that FM, or any other constant envelope modulation systems, are not inherently any better than AM systems at rejecting impulse noise. The fundamental proposition is that a noise impulse will generate a disturbance in both the signal phase as well as the signal amplitude. So therefore both systems have similar susceptibility to impulse noise.

► Theory

- Ultimately it is Shannon's capacity theorem,[1] which dictates that if you want to get more information through a system, then you need to have a better signal to noise ratio. No one has yet been able to show this rule to be untrue and our MiMOMax system is no exception. Despite some uninformed opinion, we do not actually break the Shannon Hartley Noise-Information limits, just sail close to them.

- For any system the impulse noise tolerance is a function of the signal to interference ratio. More precisely, it is the closeness of the decision boundaries in the signal constellation that will determine the noise tolerance.

- Under the Shannon rule, higher order modulations, such as 16QAM and greater, require a higher signal to interference ratio than lower order modulations such as QPSK (or FM). However, in each case the performance will be similar, provided the system is designed for the appropriate signal to noise or C/I ratio.

- The required SNR for the 16QAM system, which provides more informational throughput, means that more signal power is needed to achieve the same error rate even without impulse noise. When the system gains are designed

1 http://en.wikipedia.org/wiki/Shannon-Hartley_theorem

correctly, this criterion is met and the additional (impulse) noise required to cause a data error is similar, in both cases.

► *MiMOMax Enhancements*

- The DFE (Decision Feedback Equalisation) demodulation process within the MiMOMax wireless system always optimizes the receiver performance under any given channel condition to provide the best possible signal to noise ratio in any environment, therefore, giving the highest noise immunity possible for a given link at any time.

- Our system also uses Reed-Solomon forward error correction (FEC) to mitigate errors and is capable of correcting up to 2 byte-errors per frame. This provides an additional layer of noise protection above the required C/I and the DFE channel improvements. Additionally, digital systems like the MiMOMax link can also provide intelligent decoding algorithms that assist in providing some additional noise immunity as well as greater throughput.

► *Conclusion*

- The above information has been provided by our CTO, Doug McConnell, in response to the comments that have been forwarded and is supported by Shannon's capacity theorem and backed by our own in-field experience. I hope that this clears up any of the misinformation with respect to FM vs QAM in relation to utility applications.

- In a nutshell, provided that the link gains are sufficient to make up for the loss in sensitivity predicted by Shannon's theorem due to the greater throughput, the noise performance should be the same in both cases.

- Other coding techniques such as forward error correction and clever decoding algorithms can further improve the overall system gains and performance.