What's All This 75mV Stuff Anyhow?

IEEE802.3cg 10 Mb/s Single Twisted Pair Ethernet Task Force

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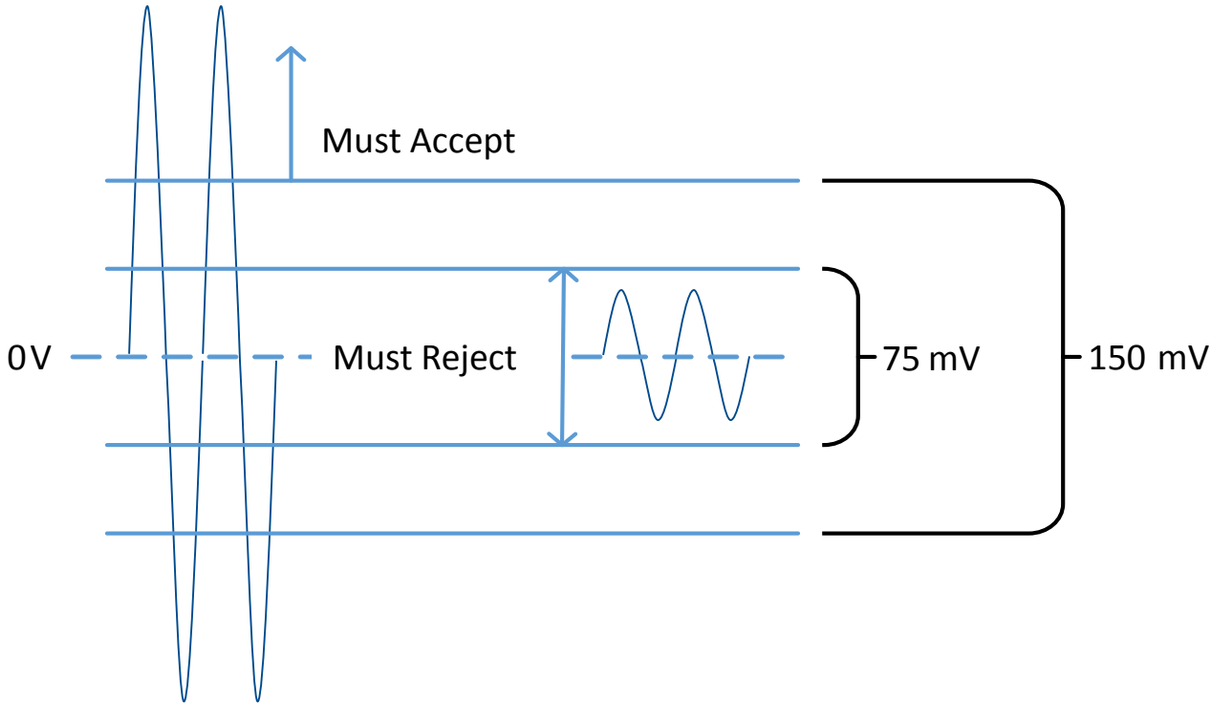
Background

- The value, 75mV, has been used in previous meetings as a basis for the long reach segment noise susceptibility level, but where did it come from, and perhaps more importantly, does it make sense?

- Physical Layer Specs for FF and PROFIBUS-PA
  - IEC 61158-2, Section 12.5.5
  - ISA S50.02, Section 11.4.2 & 3

Signal Voltage Level Definitions

- 75mVp-p is defined as a minimum signal level (sine, 26.5mV RMS)
  - Must reject signals with lower amplitude
  - It is unclear how this value was originally determined (empirically, theoretically)
- 150mVp-p is defined as a must-receive signal level



Signal Noise Level Definitions

- IEC, Section 12.5.5.c) and ISA 11.4.3.c)
  - “white Gaussian additive differential noise in the frequency band 1 kHz to 100 kHz, with a noise density of 70uV/root Hz”

- For the given bandwidth (99 kHz), this yields:
  - 70uV/root Hz * sqrt(99 kHz) = 22 mV RMS

- For the typical FF signal bandwidth (7.8 kHz to 39 kHz) plus 1 pole roll-off, this yields:
  - 70uV/root Hz * sqrt(31.2 kHz * 1.57 * 1.57) = 19.4 mV RMS

Power Supply Noise Level Definitions

- IEC, Section 12.7.3.d-h) and ISA 11.6.2.a-e)
- Allowed Noise Voltage (peak to peak):
  - For the frequency band from 7.8 kHz to 39 kHz
    - 16mVp-p
  - Allowed voltage rises at 6dB/Oct outside of the this band, with the following limits:
    - Low frequency side:
      - Limited to 200mV for I.S. power supply
      - Limited to 2V for non-I.S. power supply
    - High frequency side:
      - Limited to 1.6 volts (occurs at 3.91 MHz)

Other Noise Considerations in Real World FF Installations

- Impedance mismatches caused by grounding and shielding issues are the highest contributor to noise issues in the field, not the cable itself.
  - Shields shorted to ground
  - Unconnected shields
  - Dually connected shields
  - Water / contamination shorting signal lines to each other or to ground

- How do we address this reality?

Summary

- The 75mVp-p “noise” level has its origins in the Foundation Fieldbus / PROFIBUS-PA physical layer specifications.
- However, 75mVp-p is defined as the signal level at which the receiver is guaranteed to reject the signaling.
- The actual receiver noise specification is given as a noise density value, resulting in a tolerable noise level of approximately 20mV RMS.
- The bandwidth for 802.3cg is much wider than FF and will impact the noise calculations.
- Real world signaling issues impact the design of the receiver circuitry, some of which may be out-of-scope for 802.3cg.

Fieldbus Noise Immunity

- According to the current fieldbus specification a field device may not respond to a signal level below 75 mV_{pp} and must respond to a communication signal level above 150 mV_{pp}.
- Therefore noise with an amplitude above 75 mV_{pp} may disturb fieldbus communication.
  - This does typically not happen by significantly disturbing the communication signal itself, which is having a much higher signal amplitude than 75 mV_{pp}, even using long cables.
  - Mainly the communication on the bus is being influenced by disturbing the idle timers due to a noise event, which is higher than the sense level of the receiver.
  - In this case a field device has the opinion that another device is transmitting and therefore does not start its own transmission, running in communication timeouts.
- Nevertheless in most fieldbus applications the communication is working without issues and therefore it could be assumed, that the given in-band noise tolerance of at least 75 mV_{pp} is suitable for industrial fieldbus applications using today's installation and wiring practice.
- Fieldbus segments are mainly influenced by external noise source coming from power applications.
- The noise influence of nearby fieldbus segments is not significant, taking the low signal amplitude of about 1 V_{pp} and a coupling attenuation of at least 50 to 60 dB into account.
- The frequency band for fieldbus applications is roughly between 1 kHz and 100 kHz (the standard shows 7.8 kHz to 39 kHz, but most implementations have a wider frequency range).

Ethernet Noise Immunity

- The measurements provided in the “PHY Ideas” presentation show a noise immunity of about 60 mV_{pp} at the communication frequency (3.75 MHz, for other frequencies the noise immunity is higher) for a typical AWG18/1 fieldbus cable (1032 m) with an insertion loss of the link segment of 22.7 dB.

- Assuming, that a noise immunity of 75 mV_{pp} is suitable for an industrial environment, at least in a frequency range below about 100 kHz and taking the intended cable and the actual installation practice into account, it is assumed, and this still needs to be validated, that also for the 10SPE communication system, operating at a significant higher frequency range, the maximum possible cable length for an equivalent noise immunity could be estimated.

- Assuming a signal amplitude of 2 V_{pp} (+1 V, 0 V, -1 V) using a 3-PAM and taking into account, that an insertion loss of 22.7 dB @ 3.75 MHz leads to a noise immunity of approx. 60 mV_{pp}, a noise immunity of 75 mV_{pp} is assumed to be reached for a maximum insertion loss of:

$$IL\,[dB] = 22.7\,dB\; - 20\;\cdot \log\left(\frac{75\;mV_{pp}}{60\;mV_{pp}}\right) = 20.8\,dB\;@\;3.75\;MHz$$