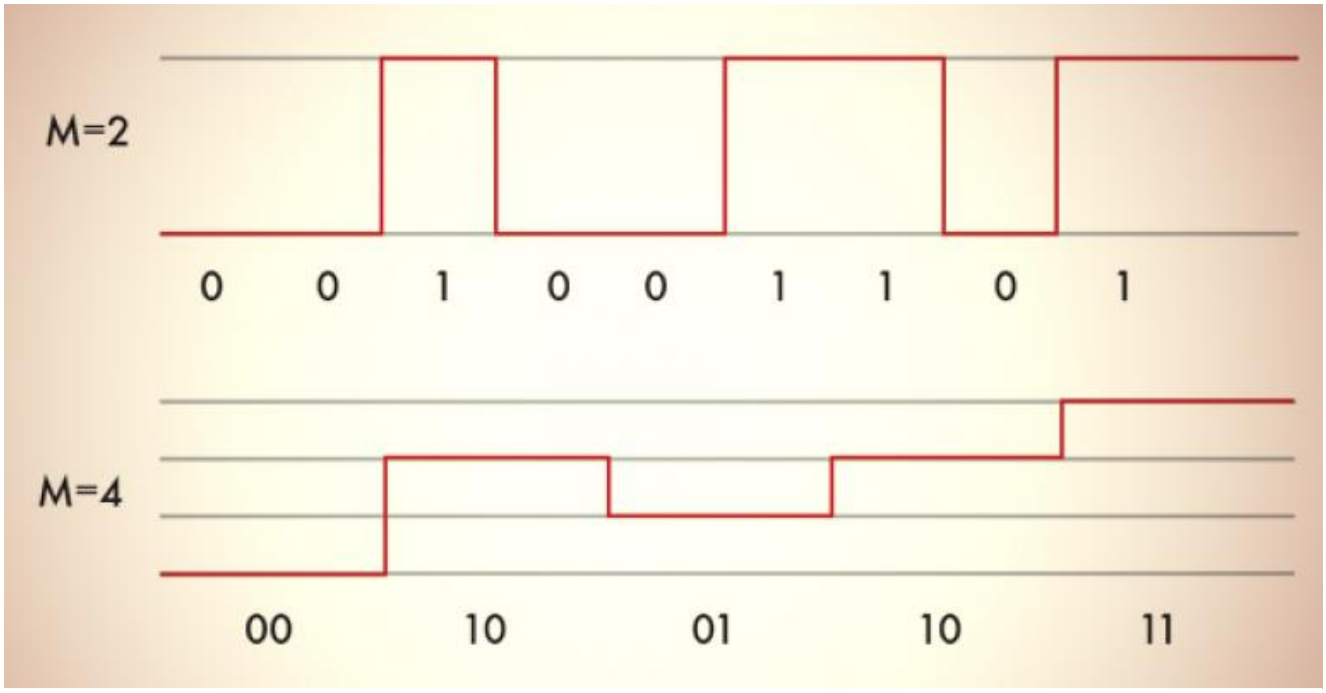
ELECTRONIC DESIGN



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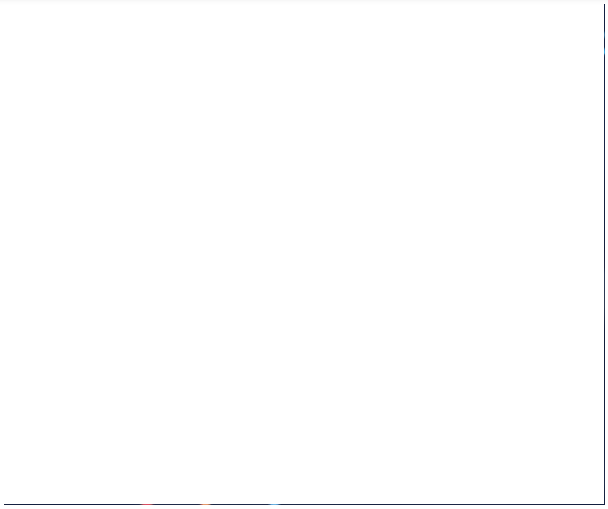
What's the Difference Between NRZ and PAM?

PAM-4 may be to used to reach 400-Gb/s Ethernet, as well as being a good fit for other high-speed serial interfaces like Fibre Channel. So what’s the difference between the usual non-return to zero (NRZ) and pulse amplitude modulation (PAM)?

William G. Wong | Jun 08, 2015



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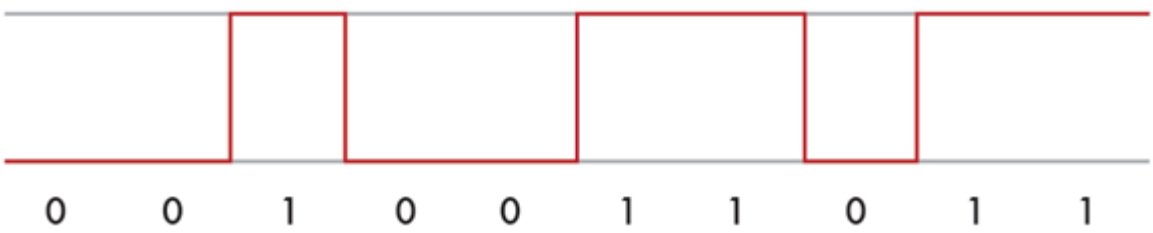
PAM-4, which could be a catalyst for reaching 400-Gb/s Ethernet, will also likely find homes in high-speed serial interfaces such as FibreChannel. Pulse amplitude modulation (PAM) is a way to pack more bits into the same amount of time on a serial channel.

The usual mechanism used in serial communications is the binary non-return to zero (NRZ). NRZ tracks the values being sent; therefore, an idle state, where all the bits are the same value, leaves the signal at the same level during the idle time *(Fig. 1)*. NRZ differs from return to zero (RZ), which transitions to the 0 level for each bit. RZ is self-clocking, but it requires more bandwidth.

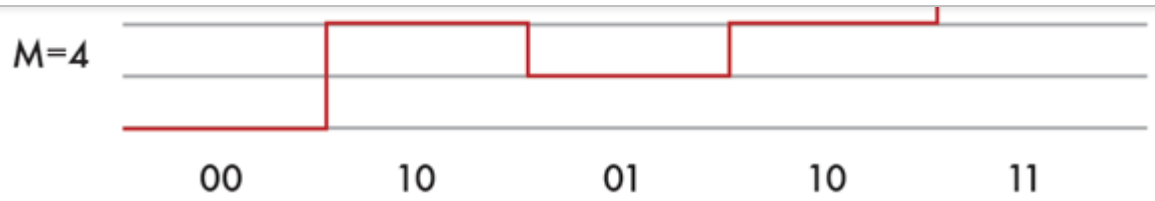


1. NRZ transmissions are easy to understand: 0 is a low level and 1 is a high level.

An alternative to NRZ is NRZ Inverted (NRZI), in which a 1 bit is indicated by a transition from one level to another. An idle using a 1 value will result in the signal cycling each bit.

NRZ and NRZI aren't inherently self-clocking, but there are ways to address this issue. One is to use bit stuffing, which forces a transition after a set number of bits. Another approach is to only allow particular patterns that will have sufficient transitions to maintain an accurate clock at the receiver. Manchester encoding is one example of the latter. Ethernet, for instance, employs an 8B/10B Manchester code that encodes 8 bits of data using 10-bit codes. The 10-bit codes are chosen to give the data characteristics necessary for clock recovery from the data.

Encoding more data into the same timeframe can be done using different signaling levels. Such multi-level signaling (MLS) or pulse amplitude modulation (PAM) can have multiple distinct levels. Actually, NRZ is a two-level MLS or PAM-2 system. PAM-4 *(Fig. 2)* has four distinct levels to encode two bits of data, essentially doubling the bandwidth of a connection.



2. A 4-level MLS, also known as PAM-4, has four distinct levels to encode two bits of data.

Of course, there's no such thing as a free lunch. Generating or decoding more than two levels is typically more difficult, and often requires better or more complex hardware. Likewise, for high-speed signals, random and induced noise becomes a significant factor. The approach begins to pay off when there's an escalation in

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Is Technology Bad for You?

Smartphone addiction, internet-enabled social-media frenzy, texting while driving, looming AI concerns—without changes, more are questioning where all of this is headed.

Lou Frenzel | Jul 05, 2018

Technology is a good thing....right? I've always thought it was. After all it has given us radio, TV, computers, and the internet. And more recently it has delivered smartphones, social media, robots, and streaming music and video. How could all of this not be a good thing and how could we not like it?

Well, there's growing evidence that some technology is bad for us. Technology has changed us in numerous ways over the last few years, and many of these changes are not so positive. Below are some examples of technology that's having a negative

Distraction: Smartphones are so engaging or addictive that people just can't put them down. The worst example of this is texting while driving. Just talking is distraction enough for some, but this talk problem has at least been alleviated with the popular Bluetooth hands-free app in most new vehicles today. Yet texting continues to cause accidents and deaths.

And not all distraction is while driving. At a recent family get-together, seven of us siblings were all sitting around talking, but each was also engaged with a smartphone or iPad, some with earphones. We were distracted and attention seemed to be elsewhere. This is so typical of gatherings today. Sad…

Too much screen time: When we analyze what we do all day we find that for perhaps a third of our day or more is sitting in front of video screen of some sort. We focus on our PCs at work, check our smartphones all day, watch TV at night, or browse on our iPads. We take our phones to the dinner table and keep them by the bedside. Paranoia sets in if we miss some communication. That brings up the question, what did we do before all those screens? Talk, go to meetings, read, listen to music, play outdoors, work on our hobbies, engage with the kids? Or what?

Smartphone interaction: Two recent *Wall Street Journal* articles point out the psychological impact that the smartphone has had on people. One article introduces a growing problem that clinical psychologists call smartphone anxiety. It's the unnatural angst caused by not having your smartphone with you or nearby. Real anxiety occurs for many when your battery level drops to 20% or less or when you realize you didn't bring along your charger cable.

- Another smartphone-related problem is one that seems to affect teenage girls

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