



Where Does It Hertz?

No discussion about communications or computer equipment is complete without talking about how much it “hertz.” People typically want to brag about the frequency or speed of their electronics pain. A hertz is defined as the quantity of cycles an alternating current (AC) signal makes during a single second. So, the 60-hertz power in our walls cycles 60 times each second. Well, this may sound fast, but it is actually near the low end of the spectrum. Frequency is measured in hertz, so when someone asks for a frequency, you can answer them in hertz.

The Man Behind the Pain

The hertz is named for a German professor named Heinrich Hertz (he had nothing to do with rental cars). Pictures I’ve seen in textbooks of Mr. Hertz show him to resemble Uncle Fester of the Adams Family. In the late 1800s, he was the first one to measure and broadcast radio waves. This feat earned him eternal recognition along with the likes of Georg Ohm, James Watt and Andre Ampere who all have electronics terms named after them. When our friend Mr. Hertz was asked about his experiments, he replied: “They are of no use whatsoever.” Now there’s a colossal lack of confidence and foresight (he died at 37 of blood poisoning), as he could have been the Alexander Graham Bell of wireless communications.

How Much is a Lot?

When I was a kid, I threw the word “mega” around to describe things I perceived as unusually large. Much of the time, this was also coupled with an intangible subject of my choosing (i.e., mega-cool, mega-expensive, mega-cute, etc.). Well, I wasn’t too far off the track. When

describing things containing large numbers, early scientists put together a special language of pre-cursors to describe the largeness.

- Kilo** = 1,000 (one thousand)
- Mega** = 1,000,000 (one million)
- Giga** = 1,000,000,000 (one billion)
- Tera** = 1,000,000,000,000 (one trillion)
- Peta** = 10¹⁵ (one with 15 zeros)
- Exa** = 10¹⁸ (one with 18 zeros)

This means that rather than 1,000,000 hertz, you can say megahertz. I believe that this naming approach would also help our politicians make the annual budget sound less painful. If they would only call them “MegaDollars” or “GigaBucks” that big budget might not seem as menacing. Imagine President Clinton announcing that this year’s budget is only 350 GigaBucks, or the deficit is only a few TeraDollars. That doesn’t sound so bad, does it? When buying a house, a real estate agent could say, “It’s only 1.7 MegaDollars,” or a car salesman, “Only 45 KiloBucks for this beauty...”

Hertz-Enomics

Lets imagine that each hertz-cycle represents a penny’s worth of work. If you get paid at 60 hertz, you would be getting

\$0.60 from the company per second. So, at the end of an hour, you would have made \$36 (before taxes). If you get paid at 60 megahertz, you would be getting \$600,000 per second and have \$3.6 million at the end of the hour (just like Bill Gates). If you want to figure your penny-hertz wage, take your weekly salary and divide it by 144,000 (seconds in a standard workweek). Hint: use this number next time you ask for a raise.

The Spectrum

The hertz spectrum is a large one and you can think of it in terms of real estate. A hertz designation (i.e., 60 hertz) is like the street address of a house at #60 on the hertz street. You turn the corner onto this street at zero, working your way through the low hertz district all the way up to exclusive and expensive exahertz mansions (see Figure 1 for a street map). You start with radio waves and work your way through light waves, and then onto X-ray waves.

Computer Lingo

Our friends in the computer business are some of the biggest hertz pushers. We all constantly see ads screaming about the latest 166 or 200 megahertz PC. Megahertz is now used as computer lingo to describe a PC, like Watts are used to describe a stereo system. Don’t get your hertz mixed up with the bytes and bits. Bytes and bits are a measure of information size and storage while hertz is a measure of frequency. In computer lingo, here’s a sweetheart of a system with a bunch of megas, kilos, hertz, bits and bytes: 200 megahertz processor with 64 megabytes of RAM, 4 gigabytes of storage, 512 kilobytes of cache, a 64-bit bus, a 75-hertz monitor, 4 megabytes of VRAM, a 100-megabit Ethernet card, and



Bob Neves has spent the last ten years as the director of technical services for Microtek Laboratories, an independent test facility. Prior to his tenure at Microtek, Bob worked in quality management and engineering in PWB manufacturing. He currently serves as the IPC’s Rigid Board General Committee chairman, Rigid Board Test Method Task Group chairman, Laboratory Qualifications (IPC-QL-653) Committee chairman, member of DESC’s Tiger Team for MIL-P-RRRRR (MIL-PRF-31032), member of Blue Ribbon Committee for MIL-S-XXXXX (MIL-PRF-5X) and convener of IEC TC52 Working Group 10 Printed Wiring Test Methods. You can reach him by e-mail at BobNeves@thetestlab.com or at the company website: <http://www.thetestlab.com>.

a 56-kilobyte ISDN modem. Confused? Join the club. The bits and bytes stuff I will have to save for another column, but the hertz stuff is fairly easy to explain. During each hertz cycle, bits and bytes of information are moved around and processed, so faster hertz figures means more information is processed each second which, in turn, gives better system performance. A 200-megahertz processor allows the bits and bytes to be processed 200,000,000 times each second. Computer and telecommunications information is passed in much the same manner, so you can see that increasing the frequency has a dramatic effect on the amount of information processed during any given period of time.

A World Without Wires

To our friends in the telecommunications industry, hertz is a way of life. Anyone who listens to the phone companies tear themselves (and us) up in the media can see how much they must “hertz!” Hertz is especially important to wireless technologies because both voice and computer data is transferred over the air using some address on hertz street. Lower address frequencies can travel large distances and follow the cur-

vature of the earth, but cannot carry a lot of information. Higher address frequencies travel shorter distances before losing integrity, but they are able to carry a lot more information.

Wireless communication equipment ranges from the low frequency AM radio and Short-wave broadcasts (<30 megahertz) to satellite communication frequencies that run well into the gigahertz range. Most of the new technologies are being developed around the low gigahertz range. Cellular, PCS, Satellite Phones, Digital Satellite Systems (DSS), Pagers, GPS, and a host of other “Three Letter Acronym” communications gear we have never heard of are all in this neighborhood on hertz street.

How the PWB “Hertz”

All this high hertz stuff produces a big impact on the PWB industry. Both the Dielectric Constant and Impedance of a PWB is effected by the addresses on hertz street. At high hertz, PWB traces behave less like conductors and more like radio frequency transmission lines. These issues must be taken into account when designing and building high frequency circuitry. As the boom in the telecommunications and computer industry contin-

ues to make high hertz equipment the norm, these issues will continue to become more complex. Stay informed and make sure you know where it “hertz.”

<i>Who's Who on Hertz Street</i>	
.5-1.7 megahertz:	AM Radio
1.7-30 megahertz:	Shortwave, Ham & CB
54-88 megahertz:	TV Channels 2-6
88-108 megahertz:	FM Radio
144-148 megahertz:	Ham
150-174 megahertz:	Police, weather
174-216 megahertz:	TV Channels 7-13
222-225 megahertz:	Ham
225-400 megahertz:	Military, Space
420-450 megahertz:	Ham
470-824 megahertz:	TV channels 14-69
824-894 megahertz:	Cellular
894-896 megahertz:	Airplane Phones
928-932 megahertz:	Pagers
1 gigahertz-1 terahertz:	Microwaves
1 terahertz-0.8 petahertz:	Infrared light
0.8-1.1 petahertz:	visible light
1.1-1500 petahertz:	ultraviolet light
1500 petahertz—	
MEGA exahertz:	X-Rays, Gamma rays