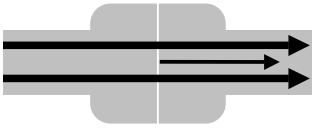


## Inter Modulation Disorder (IMD) - also called Passive Inter Modulation (PIM)

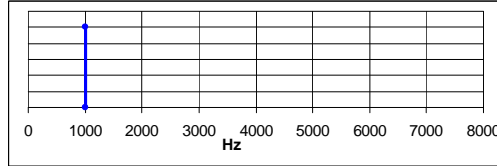


### Introducing Sinus signals



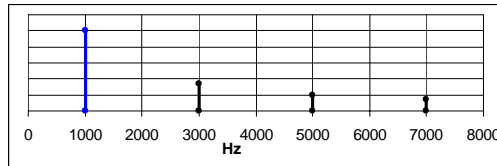
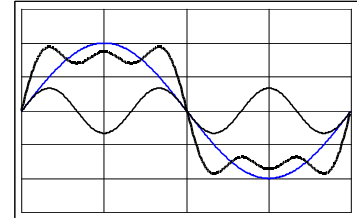
All signals running through connectors and cables consist of sinus oscillations of different frequency and levels. And what does this mean?

A sinus oscillation is a basic form in nature. It is seen in the way a swing goes - in the waves on the ocean - in temperature changes between day and night – yes, the examples are infinite. The number of oscillations per second is described by the word frequency and is measured in Hertz, Hz in short. This means that a signal on 1000Hz has 1000 oscillations each second. Sinus oscillations can have many different levels and frequencies but only one form.



A spectrum analyser measures the frequency and size of a sinus oscillation (fig. left).

But if a signal is distorted on its way, its form changes and shows us that it now contains more frequencies. That is what Passive Intermodulation is all about. For instance a square signal contains countless numbers of frequencies, all with the same basic sinus form. Apart from the basic frequency, it contains frequencies that are 3 times higher, 5 times higher, 7 times higher, 9 times higher and so on. These are called harmonic frequencies. On the figure right is only shown the basic frequency, the 3. Harmonic and the two put together. And already now we can see a square signal taking shape.



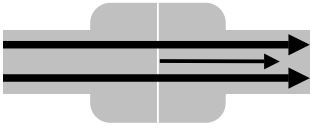
On the spectrum analyser square signals look like this (fig. left).

This shows the importance of protecting the sinus oscillation in their basic form, when running through connectors and cables to prevent disturbing paths on the way.



### But what is passive intermodulation (PIM & IMD)?

Intermodulation designates that two signals mix up and generate new signals at other frequencies. This phenomenon is used on purpose under controlled circumstances in almost all electronics, but then we talk about active intermodulation.



Passive components like connectors and cables should in the theory be linear, which means that they don't change the signal form. Unfortunately they can be a little non-linear and hereby generate an unwanted intermodulation effect. This is called passive intermodulation.

When two signals pass through a non-linear path their sinus forms will be disturbed and cause disturbing signals in two ways:

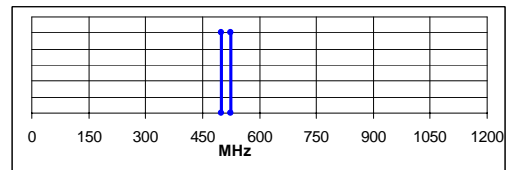
1. Each signal splits up in several signals.
2. All signals mix up and create even more signals.

This is called Passive InterModulation (PIM).

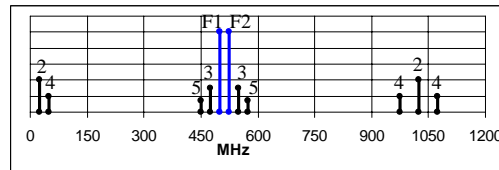
The phenomenon is also known as InterModulation Distortion (IMD) or Common Path Distortion (CPD).

In all cable networks, no matter if it is for CATV or radio communication, it is carefully planned what each channel is meant for. If one of the above mentioned disturbing signals falls within an unwanted channel, there will be noise on this band.

What happens if two signals are exposed to passive intermodulation at the same time? Let us start with two basic signals at 500MHz and 525 MHz respectively, called F1 and F2.



At left a little part of the harmonic signals caused by passive intermodulation are shown. The unequal harmonic signals (3. 5. 7. etc.) are close to the basic frequencies and are disturbing the neighbour channels, while the low equal frequencies (2. 4. 6. etc.) are placed in the return path band and thus disturbing the Internet communication.



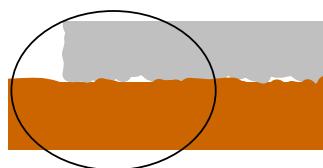
There is a further problem in the CATV networks. Here the channels are placed close to each other and with the same distance between each of them. When these channels start mixing, the following disturbing signals will react on each other and make the situation even worse. Further more PIM problems from different end users will mix as they join up on their way back in the return path.

In radio communication the problem is, that the cables are transmitting strong signals to the antenna - while at the same time - very weak signals are on their way down from antenna to receiver. Since the basic frequencies are of higher amplitude, any PIM noise signal will also be higher and hereby easily disturb the weak signals to the receiver.

### What creates passive intermodulation?

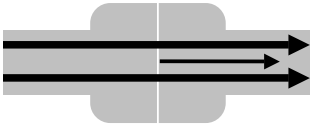
More factors can cause non-linear paths and following intermodulation. The primary reason is bad connections. It is important that the connector is designed with a good contact between the inner - and outer conductor and that creation of corrosion is prevented on the surfaces of the conducting parts. Further more the conducting parts must be clean when installed on the cable.

How can passive intermodulation be created in a connector? When two conducting parts touch each other they are not always 100% in contact.



Electrons flow through the contacting points but can also jump through small leaks (tunnel effect). When this happens the sinus forms are harmed and disturbing signals are created resulting in passive intermodulation.

## IMD-values: dBc, dBm & IP3



Passive intermodulation (PIM) or Common path distortion (CPD) is measured by transmitting at least two strong test carriers into the same cable. The strength of the generated (harmonic) intermodulation signals will then be measured. The third harmonic carrier frequency closest to original carrier frequency is always the strongest. Third harmonic carrier frequency is therefore the one we are looking for. It's called IM3. A measuring result must always show both the original carrier and the generated IM3.

PIM/CPD measurements can be measured in dBm, dBc or IP3-value. So - what is the difference between them?

### **dBm:**

dBm: dBm means the level of a signal compared to 1 mW measured in dB. A signal of 10 dBm is therefore 10 dB stronger than 1 mW.

A PIM measurement in dBm also requires information about the carrier. We are measuring with carriers from 20 dBm (0.1 Watt = 127 dBuV) to 43 dBm (20 watt = 150 dBuV).

### **dBc:**

dBc means the strength of a signal compared to the carrier level measured in dB. A signal of -150dBc is therefore 150 dB lower than the test carriers.

Also here information about the carrier level is needed.

### **IP3-value:**

The advantage of measuring in dBc should be that information about the carrier could be avoided because the measurement is done in relation to the carrier. If we for example lower the carrier, the measured IM3 level should also be lowered respectively so that the common relations between them should remain an equal number of dBc. Unfortunately the true situation is, that any change in the carrier level will triple the change in the IM3-level. If we for example choose to lower the carrier level with 3 dB from 43 dBm to 40 dBm, the resulting IM3 level decreases with 9 dB. Be aware that this improves the dBc result with 6 dB.

The IP3 value takes care of that problem. With the IP 3 value is it now possible to compare different tests performed with various carrier levels. If we imagine that we could continue to raise the carrier level, the measured IM3 value would soon or later be equal to the carrier level (remember that the IM3 level is raising 3 times faster than the carrier level!). The IP3 value is therefore the "fictive" point where the two signals will meet. And that is why IP3 stands for

### **Intercept Point IM3.**

This simplified IP3 formula can be used in relation to our connectors:  
IP3 value in dBm = 0,5\* (3\* carrier – IM3).

