ISI Interference

In telecommunication, **inter symbol interference** (**ISI**) is a form of distortion of a signal in which one symbol interferes with subsequent symbols. This is an unwanted phenomenon as the previous symbols have similar effect as noise, thus making the communication less reliable. The spreading of the pulse beyond its allotted time interval causes it to interfere with neighboring pulses.[1] ISI is usually caused by multipath propagation.

The presence of ISI in the system introduces errors in the decision device at the receiver output. Therefore, in the design of the transmitting and receiving filters, the objective is to minimize the effects of ISI, and thereby deliver the digital data to its destination with the smallest error rate possible.

Way to reduce intersymbol interference is to include error correcting codes.

Multipath propagation

One of the causes of intersymbol interference is multipath propagation in which a wireless signal from a transmitter reaches the receiver via multiple paths. The causes of this include reflection (for instance, the signal may bounce off buildings), refraction (such as through the foliage of a tree) and atmospheric effects such as atmospheric ducting and ionospheric reflection. Since the various paths can be of different lengths, this results in the different versions of the signal arriving at the receiver at different times. These delays mean that part or all of a given symbol will be spread into the subsequent symbols, thereby interfering with the correct detection of those symbols. Additionally, the various paths often distort the amplitude and/or phase of the signal, thereby causing further interference with the received signal.

Band limited channels

Another cause of intersymbol interference is the transmission of a signal through a band limited channel, i.e., one where the frequency response is zero above a certain frequency (the cutoff frequency). Passing a signal through such a channel results in the removal of frequency components above this cutoff frequency. In addition, components of the frequency below the cutoff frequency may also be attenuated by the channel.

This filtering of the transmitted signal affects the shape of the pulse that arrives at the receiver. The effects of filtering a rectangular pulse not only change the shape of the pulse within the first symbol period, but it is also spread out over the subsequent symbol periods. When a message is transmitted through such a channel, the spread pulse of each individual symbol will interfere with following symbols.

Band limited channels are present in both wired and wireless communications. The limitation is often imposed by the desire to operate multiple independent signals through the same area/cable; due to this, each system is typically allocated a piece of the total bandwidth available. For wireless systems, they may be allocated a slice of the electromagnetic spectrum to transmit in (for example, FM radio is often broadcast in the 87.5 MHz - 108 MHz range). This allocation is usually administered by a government agency; in the case of the United States this is the Federal Communications Commission (FCC). In a wired system, such as an optical fiber cable, the allocation will be decided by the owner of the cable.

The band limiting can also be due to the physical properties of the medium - for instance, the cable being used in a wired system may have a cutoff frequency above which practically none of the transmitted signal will propagate.

Communication systems that transmit data over bandlimited channels usually implement pulse shaping to avoid interference caused by the bandwidth limitation. If the channel frequency response is flat and the shaping filter has a finite bandwidth, it is possible to communicate with no ISI at all. Often the channel response is not known beforehand, and an adaptive equalizer is used to compensate the frequency response.

Techniques to Counter Inter symbol Interference

Inter symbol interference can be countered in telecommunications and data storage.

Systems can be designed to shorten impulse responses that are short enough to reduce the possibility of signals crossing over to other symbols within the transmission. Energy that is intact is then restrained within each symbol and without additional data from other signals in the mix.

Creating transmissions with consecutive raised-cosine impulses can help prevent inter symbol interference. These types of signals can have zero inter symbol interference properties.

Guard periods can be put in place to separate symbols. This prevents symbols from being received out of order or cluttered, preventing inter symbol interference.

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Two important parameters that affect the quality of signal transmission wireless systems are Bandwidth and SNR (Signal to Noise Ratio).

BANDWIDTH

It is a measure of the frequency range that is occupied by a modulated signal (carrier wave + information). The bandwidth of a channel is the frequency range over which it can transmit a signal with reasonable fidelity.

Though there is an infinite spectrum of frequencies available, it is not possible to use every frequency for communication purposes, except only those under a few hundred GHz. Usable frequencies are therefore a limited resource and have to be used wisely to accommodate our vast needs. Government agencies are set up to decide rules to allocate bandwidth for various purposes. For example, a cellular signal has to lie within a specific range of continuous frequencies. While for FM radio the signal lies within a completely different continuous range of frequencies (say 88 to 108 MHz). Typically only FM, and no other form of wireless communication is conducted in this range. Now, Bandwidth is the difference between the upper and lower frequencies in this range of frequencies. Thus it is said that a 20MHz bandwidth is allocated for FM transmission. In this manner, for different purposes, a precise bandwidth is allocated by a regulatory authority regionally.

The diagram below explains the concept of bandwidth:

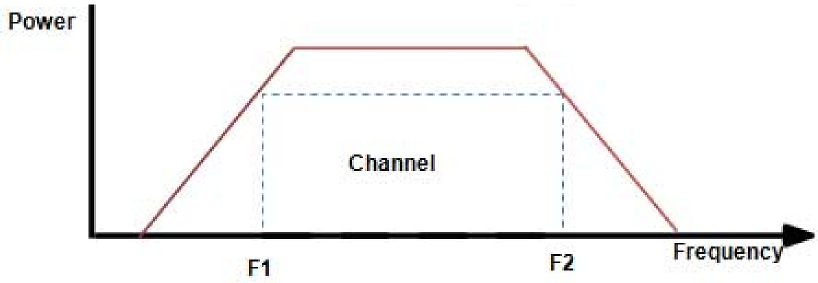

Figure 1 Bandwidth of a channel

SPECTRAL EFFICIENCY

Since frequency spectrum is limited, it has to be utilized efficiently. A given bandwidth is said to be used effectively if maximum information can be transmitted over it. The term Spectral efficiency is used to describe the rate of information being transmitted over a given bandwidth in specific communication systems. Spectral Efficiency may also be called bandwidth efficiency.

If a specific communication systems uses one kilo hertz of bandwidth to transmit 1,000 bits per second, then it has a spectral efficiency or bandwidth efficiency of 1 (bit/s)/Hz.

RADIO CHANNEL CAPACITY

The radio channel capacity is defined as the maximum number of simultaneous users that can be provided in a fixed frequency band. It is therefore an effective measure of the spectrum efficiency of a wireless system. It is the maximum number K0 of simultaneous transmissions that can occur in a fixed frequency band. This parameter is determined by the required signal-to-noise ratio at the input of the receiver and by the channel bandwidth W.

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