**University of Electronic Science and Technology of China**

**Post graduate studies faculty**

**School of electronic engineering**

***Frequency Spectrum***

**prepared by: Mohaned Giess Shokrallah Ahmed **

**ID Number: 201314020106**

**Country: Sudan**

**Supervisor: Dr.jingranlin**

**1- Introduction**

The frequency spectrum of a [time-domain](http://en.wikipedia.org/wiki/Time_domain) [signal](http://en.wikipedia.org/wiki/Signal_(electronics)) is a representation of that signal in the [frequency domain](http://en.wikipedia.org/wiki/Frequency_domain). The frequency spectrum can be generated via a [Fourier transform](http://en.wikipedia.org/wiki/Fourier_transform) of the signal, and the resulting values are usually presented as [amplitude](http://en.wikipedia.org/wiki/Amplitude) and [phase](http://en.wikipedia.org/wiki/Phase_(waves)), both plotted versus [frequency](http://en.wikipedia.org/wiki/Frequency).[[1]](http://en.wikipedia.org/wiki/Frequency_spectrum#cite_note-alexander_sadiku-1)

Any signal that can be represented as an amplitude that varies with time has a corresponding frequency spectrum. This includes familiar concepts such as [visible light](http://en.wikipedia.org/wiki/Visible_light) ([color](http://en.wikipedia.org/wiki/Color)), musical notes, [radio/TV channels](http://en.wikipedia.org/wiki/Radio_frequency), and even the regular rotation of the earth. When these physical phenomena are represented in the form of a frequency spectrum, certain physical descriptions of their internal processes become much simpler. Often, the frequency spectrum clearly shows [harmonics](http://en.wikipedia.org/wiki/Harmonics), visible as distinct spikes or lines at particular frequencies, that provide insight into the mechanisms that generate the entire signal.

**2- Why frequency spectrum is meaningful**

The frequency spectrum have many usage in all field. Here we will see some of it:

**2.1- Broadcasting**

Broadcast frequencies:

* [Long wave AM Radio](http://en.wikipedia.org/wiki/Longwave) = 148.5 kHz – 283.5 kHz (LF)
* [Medium wave AM Radio](http://en.wikipedia.org/wiki/Medium_wave) = 530 kHz – 1710 kHz (MF)
* [Shortwave AM Radio](http://en.wikipedia.org/wiki/Shortwave_bands) = 3 MHz – 30 MHz (HF)

**2.2- Air band**

[Air band](http://en.wikipedia.org/wiki/Airband) refers to VHF frequencies used for navigation and voice communication with aircraft. Trans-oceanic aircraft also carry [HF](http://en.wikipedia.org/wiki/HF) radio and satellite transceivers

**2.3- Marine band**

The greatest incentive for development of radio was the need to communicate with ships out of visual range of shore. From the very early days of radio, large oceangoing vessels carried powerful long-wave and medium-wave transmitters. High-frequency allocations are still designated for ships, although satellite systems have taken over some of the safety applications previously served by [500 kHz](http://en.wikipedia.org/wiki/500_kHz) and other frequencies. [2182 kHz](http://en.wikipedia.org/wiki/2182_kHz) is a medium-wave frequency still used for marine emergency communication.

**2.4- Amateur radio frequencies**

[Amateur radio frequency allocations](http://en.wikipedia.org/wiki/Amateur_radio_frequency_allocations) vary around the world. Several bands are common for amateurs world-wide, usually in the shortwave part of the spectrum. Other bands are national or regional allocations only due to differing allocations for other services, especially in the VHF and UHF parts of the radio bands

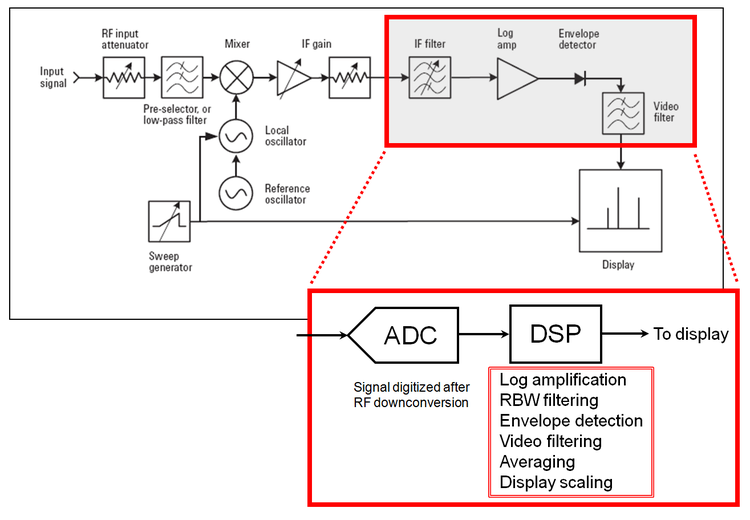
**2.5- Industrial, scientific, medical**

The [ISM bands](http://en.wikipedia.org/wiki/ISM_band) were initially reserved for non-communications uses of RF energy, such as[microwave ovens](http://en.wikipedia.org/wiki/Microwave_oven), radio-frequency heating, and similar purposes. However in recent years the largest use of these bands has been by short-range low-power communications systems, since users do not have to hold a radio operator's license. [Cordless telephones](http://en.wikipedia.org/wiki/Cordless_telephone), [wireless computer networks](http://en.wikipedia.org/wiki/Wi-Fi), [Bluetooth](http://en.wikipedia.org/wiki/Bluetooth) devices, and [garage door openers](http://en.wikipedia.org/wiki/Garage_door_opener) all use the ISM bands. ISM devices do not have regulatory protection against interference from other users of the band.

**3- Some applications of frequency spectrum**

**3.1- Signal Analysis**

A signal analyzer employs digital techniques to extract useful information that is carried by an electrical signal.[[2]](http://en.wikipedia.org/wiki/Signal_analyzer#cite_note-1) In common usage the term is related to both [spectrum analyzers](http://en.wikipedia.org/wiki/Spectrum_analyzer) and[vector signal analyzers](http://en.wikipedia.org/wiki/Vector_signal_analyzer). While [spectrum analyzers](http://en.wikipedia.org/wiki/Spectrum_analyzer) measure the [amplitude](http://en.wikipedia.org/wiki/Amplitude) or magnitude of signals, a signal analyzer with appropriate software or programming can measure any aspect of the signal such as [modulation](http://en.wikipedia.org/wiki/Modulation). Today’s high-frequency signal analyzers achieve good performance by optimizing both the [analog](http://en.wikipedia.org/wiki/Analog_signal) front end and the [digital](http://en.wikipedia.org/wiki/Digital_signal) back end.[[3]](http://en.wikipedia.org/wiki/Signal_analyzer#cite_note-2)

[](http://en.wikipedia.org/wiki/File:Signal_analyzer_block_diagram.png)

[http://bits.wikimedia.org/static-1.23wmf4/skins/common/images/magnify-clip.png](http://en.wikipedia.org/wiki/File:Signal_analyzer_block_diagram.png)

3.1.1- Modern Signal Analyzer Architecture

Modern signal analyzers use [superheterodyne receiver](http://en.wikipedia.org/wiki/Superheterodyne_receiver) to downconvert a portion of the signal spectrum for analysis. As shown in the figure to the right, the signal is first converted to an intermediate frequency and then filtered in order to [band-limit](http://en.wikipedia.org/wiki/Band-limited) the signal and prevent [aliasing](http://en.wikipedia.org/wiki/Aliasing). The downconversion can operate in a swept-tuned mode similar to a traditional [spectrum analyzer](http://en.wikipedia.org/wiki/Spectrum_analyzer), or in a fixed-tuned mode. In the fixed-tuned mode the range of frequencies downconverted does not change and the downconverter output is then [digitized](http://en.wikipedia.org/wiki/Digitizing) for further analysis. The digitizing process typically involves in-phase/quadrature (I/Q) or complex sampling so that all characteristics of the signal are preserved, as opposed to the magnitude-only processing of a [spectrum analyzer](http://en.wikipedia.org/wiki/Spectrum_analyzer). The [sampling rate](http://en.wikipedia.org/wiki/Sampling_rate) of the [digitizing process](http://en.wikipedia.org/wiki/Digitizing) may be varied in relation to the frequency span under consideration or (more typically) the signal may be digitally resampled.

3.1.2-Typical usage

Signal analyzers can perform the operations of both [spectrum analyzers](http://en.wikipedia.org/wiki/Spectrum_analyzer) and [vector signal analyzers](http://en.wikipedia.org/wiki/Vector_signal_analyzer). A signal analyzer can be viewed as a measurement platform, with operations such as spectrum analysis (including [phase noise](http://en.wikipedia.org/wiki/Phase_noise), [power](http://en.wikipedia.org/wiki/Power_(physics)), and [distortion](http://en.wikipedia.org/wiki/Distortion)) and vector signal analysis (including [demodulation](http://en.wikipedia.org/wiki/Demodulation) or modulation quality analysis) performed as measurement applications. These measurement applications can be built into the analyzer platform as measurement firmware or installed as changeable application software

**3.2- Spread spectrum**

In [telecommunication](http://en.wikipedia.org/wiki/Telecommunication) and [radio communication](http://en.wikipedia.org/wiki/Radio_communication), spread-spectrum techniques are methods by which a [signal](http://en.wikipedia.org/wiki/Signal_(electrical_engineering))(e.g. an electrical, electromagnetic, or acoustic signal) generated with a particular [bandwidth](http://en.wikipedia.org/wiki/Bandwidth_(signal_processing)) is deliberately spread in the [frequency domain](http://en.wikipedia.org/wiki/Frequency_domain), resulting in a signal with a wider [bandwidth](http://en.wikipedia.org/wiki/Bandwidth_(signal_processing)). These techniques are used for a variety of reasons, including the establishment of secure communications, increasing resistance to natural [interference](http://en.wikipedia.org/wiki/Interference_(communication)), [noise](http://en.wikipedia.org/wiki/Noise_(electronics)) and [jamming](http://en.wikipedia.org/wiki/Radio_jamming), to prevent detection, and to limit [power flux density](http://en.wikipedia.org/wiki/Spectral_flux_density)

Spread-spectrum telecommunications. This is a technique in which a [telecommunication](http://en.wikipedia.org/wiki/Telecommunication) signal is transmitted on a [bandwidth](http://en.wikipedia.org/wiki/Bandwidth_(signal_processing)) considerably larger than the [frequency](http://en.wikipedia.org/wiki/Frequency) content of the original information. Frequency hopping is a basic modulation technique used in spread spectrum signal transmission.

Spread-spectrum telecommunications is a signal structuring technique that employs [direct sequence](http://en.wikipedia.org/wiki/Direct-sequence_spread_spectrum), [frequency hopping](http://en.wikipedia.org/wiki/Frequency-hopping_spread_spectrum), or a hybrid of these, which can be used for multiple access and/or multiple functions. This technique decreases the potential interference to other receivers while achieving privacy. Spread spectrum generally makes use of a sequential [noise](http://en.wikipedia.org/wiki/Noise)-like signal structure to spread the normally [narrowband](http://en.wikipedia.org/wiki/Narrowband) information signal over a relatively [wideband](http://en.wikipedia.org/wiki/Wideband) (radio) band of frequencies. The receiver correlates the received signals to retrieve the original information signal. Originally there were two motivations: either to resist enemy efforts to jam the communications (anti-jam, or AJ), or to hide the fact that communication was even taking place, sometimes called [low probability of intercept](http://en.wikipedia.org/wiki/Low_probability_of_intercept) (LPI).

[Frequency-hopping spread spectrum](http://en.wikipedia.org/wiki/Frequency-hopping_spread_spectrum) (FHSS), [direct-sequence spread spectrum](http://en.wikipedia.org/wiki/Direct-sequence_spread_spectrum) (DSSS), [time-hopping spread spectrum](http://en.wikipedia.org/wiki/Time-hopping_spread_spectrum) (THSS), [chirp spread spectrum](http://en.wikipedia.org/wiki/Chirp_spread_spectrum) (CSS), and combinations of these techniques are forms of spread spectrum. Each of these techniques employs pseudorandom number sequences — created using [pseudorandom number generators](http://en.wikipedia.org/wiki/Pseudorandom_number_generator) — to determine and control the spreading pattern of the signal across the allocated bandwidth. [Ultra-wideband](http://en.wikipedia.org/wiki/Ultra-wideband) (UWB) is another modulation technique that accomplishes the same purpose, based on transmitting short duration pulses. Wireless standard [IEEE 802.11](http://en.wikipedia.org/wiki/IEEE_802.11) uses either FHSS or DSSS in its radio interface

**3.3- Cognitive Radio**

A cognitive radio is an intelligent radio that can be programmed and configured dynamically. Its [transceiver](http://en.wikipedia.org/wiki/Transceiver) is designed to use the best [wireless channels](http://en.wikipedia.org/wiki/Wireless_channel) in its vicinity. Such a radio automatically detects available channels in [wireless spectrum](http://en.wikipedia.org/wiki/Radio_spectrum), then accordingly changes its [transmission](http://en.wikipedia.org/wiki/Transmission_(telecommunications)) or [reception](http://en.wikipedia.org/wiki/Telecommunication) parameters to allow more concurrent [wireless communications](http://en.wikipedia.org/wiki/Wireless_communications) in a given spectrum band at one location. This process is a form of [dynamic spectrum management](http://en.wikipedia.org/wiki/Dynamic_spectrum_management)

3.3.1-Terminology

Depending on transmission and reception parameters, there are two main types of cognitive radio:

i- Full Cognitive Radio (Mitola radio), in which every possible parameter observable by a wireless node (or network) is considered.[[4]](http://en.wikipedia.org/wiki/Cognitive_radio#cite_note-3)

ii- pectrum-Sensing Cognitive Radio, in which only the radio-frequency spectrum is considered.[[5]](http://en.wikipedia.org/wiki/Cognitive_radio#cite_note-ieeexplore.ieee.org-4).

**4- Conclusion**

Frequency spectrum is meaningful, that is, use in all fields such as radar, communication, and medical. Also its application is very important specially in signal processing

**Referencies:**

[1] Alexander, Charles; Sadiku, Matthew (2004). [Fundamentals of Electric Circuits](http://www.amazon.com/Fundamentals-Electric-Circuits-Charles-Alexander/dp/007249350X) (Second ed.). McGraw-Hill. p. 761. [ISBN](http://en.wikipedia.org/wiki/International_Standard_Book_Number) [0-07-249350-X](http://en.wikipedia.org/wiki/Special:BookSources/0-07-249350-X). "The frequency spectrum of a signal consists of the plots of the amplitudes and phases of the harmonics versus frequency

[2] De Silva, Clarence W. Vibration and Shock Handbook, CRC Press, 2005, p. 16-63

[3] ["Crossing Domain Boundaries"](http://www.evaluationengineering.com/index.php/solutions/instrumentation/crossing-domain-boundaries.html), Lecklider, Tom; Evaluation Engineering, October 2011, accessed October 10, 2011.

[4] [J. Mitola III and G. Q. Maguire, Jr., "Cognitive radio: making software radios more personal," IEEE Personal Communications Magazine, vol. 6, nr. 4, pp. 13–18, Aug. 1999](http://ieeexplore.ieee.org/search/srchabstract.jsp?arnumber=788210&isnumber=17080&punumber=98&k2dockey=788210@ieeejrns&query=%28%28mitola%29%3Cin%3Eau+%29&pos=5&access=no)

[5] [S. Haykin, "Cognitive Radio: Brain-empowered Wireless Communications", IEEE Journal on Selected Areas of Communications, vol. 23, nr. 2, pp. 201–220, Feb. 2005](http://ieeexplore.ieee.org/search/srchabstract.jsp?arnumber=1391031&isnumber=30289&punumber=49&k2dockey=1391031@ieeejrns&query=%28haykin+%3Cin%3E+metadata%29+%3Cand%3E+%2849+%3Cin%3E+punumber%29&pos=0&access=no)