Implementation of Frequency-Hop for 2.4 GHz Wireless Communication System

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Abstract:
FHSS is a component of spread spectrum technology. FHSS uses Industrial, Scientific and Medical (ISM) waveband for communication which is license free [4]. FHSS Transceiver model provide secure communication over the trail of communication. Its robustness against third party interception is thanks to use of PN sequence generator. supported the introduction of frequency-hopping communication system and its mathematic model, a simulation model was built using MATLAB. This paper researches the issues of a recurrence bouncing spread range (FHSS) and manages usage by and by. The FHSS procedure is valuable for stifling obstruction, making capture attempt troublesome, obliging blurring and multipath channels, and giving a numerous entrance ability. The beneficiary demodulates the got signal by the transporter frequencies that change simultaneously depending on a similar recurrence bouncing arrangement and makes an identification of it.

Keywords — FHSS, PN Sequence Generator, BFSK, GSM, CDMA, RF.

I. INTRODUCTION

Advanced digital wireless networks carrying multiple channels of high fidelity music and voice multiplexed with data are in operation for the first time. The networks, operating from a PC or as stand-alone systems, are fundamentally changing the commercial and professional audio industries by intimately combining frequency hopping technology and digital audio. Wireless audio is a particularly difficult challenge that requires higher transmission reliability than wireless data networks because errors are audible and unacceptable. In wireless data transmission, the data can be retransmitted when errors are detected. In the commercial sound industry, these new digital wireless networks are providing a true design and operational paradigm shift. Advantages such as faster installations, flexibility in cable-free design, high quality multiple audio and data channels, built-in drivers for light-emitting diode (LED) visual signs for compliance with the Americans with Disabilities Act (ADA), data security with real-time supervision and lower costs are changing the industry forever. This article defines the technological contribution of the wireless distributed audio and data systems and compares it with the recent distributed (networked) computing revolution in the commercial public information systems industry. The wireless audio-visual and emergency system (WAVESª) is described, and the direction these wireless systems are heading is proposed.

The purpose of implementing information technologies is to reengineer processes, so that care is delivered more cost effectively and efficiently, not to reengineer people to do things differently as required by the information system.

Satellite systems have the advantage of worldwide coverage and offer a variety of data transfer speeds, even though satellite links have the disadvantage of high operating cost. A few analog radio telemedicine systems were developed for the support of aircraft and ships in isolated areas.

Infrared waves cannot penetrate walls or structures, so direct line of sight is required between transmitter and receiver. Range is limited to approximately 30 feet per sensor, so multiple sensors are required. The infrared content of ambient light can interfere with IR radiation and, if extensive, can overload the receiver photodiode and drive it beyond its operating point. Three sources of ambient light are daylight, incandescent illumination, and fluorescent lamps, all of which potentially interfere with IR communications. Fluorescent light is the common method of lighting in office environments and poses the most serious problem for IR communications.

At higher frequencies, signal transmission through walls is more difficult. This feature is advantageous in wireless LAN applications where confinement of the signal within a room or building is a desirable privacy feature. Also, at higher frequencies the relationship between cell boundaries and the physical layout of the building is more easily determined, facilitating the planning of wireless LAN cell assignments within the building.

The term wireless refers to telecommunication technology, in which the radio waves [1], infrared waves and microwaves, instead of cables or wires, are used to carry a signal to connect communication devices. Wireless technology is rapidly evolving, and is playing an ever-increasing role in the lives of people throughout the world [1].

A. Wireless Technologies

Telemedicine, as a concept, was introduced about 30 years ago, when telephone and fax machines were the first telecommunication means used. In recent years, several telemedicine applications have been successfully implemented over wired communication technologies like POTS (Plain Old Telephone System) and ISDN (Integrated Services Digital Network). However, nowadays, modem means of wireless telecommunication, such as the GSM (Group Special Mobil Global System for Mobile Communications), GPRS (General Packet Radio Service), and the forthcoming UMTS (Universal Mobile Telecommunications Systems) mobile telephony standards, as well as satellite communications, allow the operation of wireless telemedicine systems, freeing the medical personnel and/or the subject monitored from being bound to fixed locations [2]-[4].

GSM is a system currently in use, and is the second-generation (2G) of mobile-communication networks. When it is in the standard mode of operation, it provides data-transfer speeds of up to 9.6 kbps [5], which is the current maximum rate of GSM. The available bandwidth of GSM is not sufficient for still images and ECG data of the patient.

The greatest obstacle to achieving wireless multimegabit data communication rates is the lack of a suitable frequency band for reliable high-speed communication. The existing ISM bands [6] assigned for multiple-user applications are suitable for Wireless Local Area Network (wireless LAN), but they are restricted to spread-spectrum technology [7].

Wireless LAN [8] is a flexible data-communications system, implemented as an extension to or as an alternative for a wired LAN. Using radio frequency technology, wireless LANs transmit and receive data over the air, minimizing the need for wired connections. Thus, wireless LANs combine data connectivity with user mobility. They are becoming very popular in a number of vertical markets, including healthcare, retail, manufacturing, warehousing, and academia.

The industries have profited from the productivity gains of using hand-held terminals and notebook computers to transmit real-time information to centralized hosts for processing. Today, wireless LANs are becoming more widely recognized as a general-purpose connectivity alternative for a broad range of applications. This technology will penetrate the health sector in the near future. In patient monitoring applications, the most important feature is reliability so that contact is maintained with patients at all times. Bandwidth, flexibility, expandability, ease of implementation and cost are important, but secondary considerations. Some of these are interrelated such as the installation must have sufficient bandwidth to support patient monitoring needs in order to be reliable.

II SPREAD SPECTRUM TECHNOLOGIES

Spread Spectrum modulation techniques are defined as being those techniques in which the bandwidth of the transmitted signal is much greater than the bandwidth of the original message, and the bandwidth of the transmitted signal is determined by the message to be transmitted and by an additional signal known as the Spreading Code. Spread spectrum technology was first used during the World War II by the military, who experimented with spread spectrum because it offered low interference and much-needed security. There are two methods for performing the spreading: frequency hopping and direct sequencing. This paper uses frequency hopping spread spectrum for wireless LAN because of the following reasons.

- Frequency hopping is one of the variants of spread spectrum technique which enables coexistence of multiple networks (or other devices) in the same area.
- Federal Communication Commission (FCC) recognizes Frequency Hopping as one of the techniques withstanding “fairness” requirements for unlicensed operation in the ISM bands.
- Frequency Hopping is resistant to multipath fading through the inherent frequency diversity mechanism.

A. Frequency hopping spread spectrum (FHSS)

Frequency hopping is a radio transmission technique where the signal is divided into multiple parts and then sent across the air in random pattern of jumping or “hopping,” frequencies. When transmitting data, these “multiple parts” are data packets. The hopping pattern can be from several times per second to several thousand times per second.

Frequency hopping is the easiest spread spectrum modulation to use. Any radio with a digitally controlled frequency synthesizer can, theoretically, be converted to a frequency hopping radio. This conversion requires the addition of a pseudo noise (PN) code generator to select the frequencies for transmission or reception. Most hopping systems use uniform frequency hopping over a band of frequencies. This is not absolutely necessary, if both the transmitter and receiver of the system know in advance what frequencies are to be skipped. Thus a frequency hopper in two meters could be made that skipped over commonly used repeater frequency pairs. A frequency hopped system can use analog or digital carrier modulation and can be designed using conventional narrow band radio techniques. De-hopping in the receiver is done by a synchronized pseudo noise code generator that drives the receiver's local oscillator frequency synthesizer. FHSS splits the available frequency band into a series of small sub channels. A transmitter hops from sub channel to sub channel, transmitting short bursts of data on each channel for a predefined period, referred to as dwell time (the amount of time spent on each hop). The hopping sequence is obviously synchronized between transmitter and receiver to enable communications to occur. FCC regulations define the size of the frequency band, the number of channels that can be used, and the dwell time and power level of the transmitter. In the frequency hopping spread spectrum a narrowband signal move or hops from one frequency to another using a pseudorandom sequence to control hopping. This results in a signal’s lingering at a predefined frequency for a short period of time, which limits the possibility of interference from another signal source generating radiated power at a specific hop frequency. The basic frequency hopping system is shown in Fig. 1[9].

The FHSS subsystem produces a spreading effect of pseudo randomly hopping the RF carrier frequency over the available RF frequencies $f_1 \ldots f_N$ where N could be several thousand or more. If Δf is the frequency separation between adjacent discrete frequencies and N is the number of available RF frequency choices, that is, channels, then the processing gain of an FHSS system is

$$Gp = \frac{\text{RF bandwidth}}{\text{message bandwidth}} = \frac{N.\Delta f}{\Delta f} = N$$

(1)

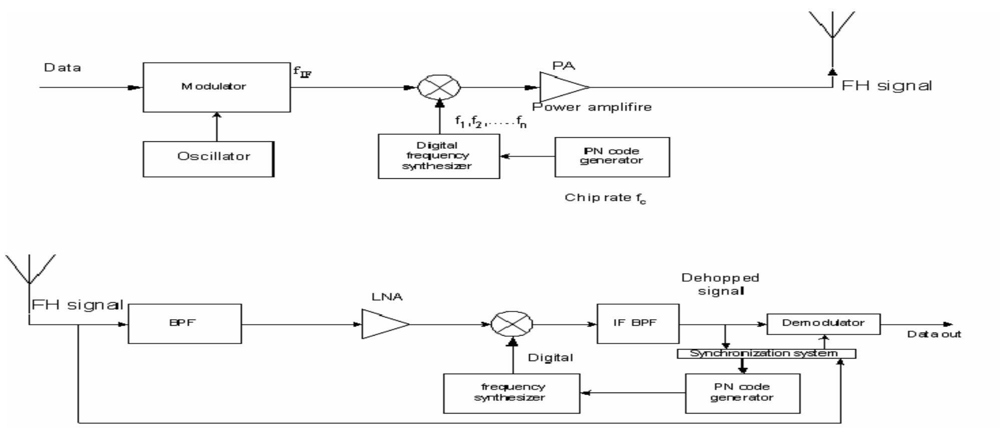

Fig. 1: General form of frequency-hopping system: (a) transmitter and (b) receiver

The transmitted hopped frequencies are generated by a digital frequency synthesizer, which is controlled by serial or parallel "words", each containing *m* binary digits. These *m*-bit words produce one of $M= 2^m$ frequencies for each separate word or symbol combination of the digits. The number of radio frequencies available for a frequency hopper is frequently $M = 2^m$ where m=2, 3….. although not all of these are necessarily used in a particular application. The instantaneous change of transmitted discrete RF frequencies is attained at the chip rate f_c, frequently specified in chips/second (c/s), kilochips/ (kc/s) or megachips/second (Mc/s). The baseband data rate is f_b (kb/s). Frequency hopping spread spectrum systems are categorized into

- Slow frequency hopping (SFH)
- Fast frequency hopping (FFH)
- Intermediate (rate) frequency hopping (IFH)

B. Slow frequency hopping (SFH)

In an SFH spread system the hop rate f_H (chip rate) is less than the baseband message bit rate f_b. Thus two or more (in several implementations, more than 1000) baseband bits are transmitted at the same frequency before hopping to the next RF frequency. The hop duration, T_H, is related to the bit duration T_b by

$T_H = kT_b$ for k =1, 2, 3…..

and (2)

$f_c = f_H = 1/T_H$

C. Fast frequency hopping (FFH)

In an FFH spread spectrum system the frequency chipping rate, f_c, (chipping rate is the same as hopping rate) is greater than the baseband data rate f_b. In this case one message bit T_b is transmitted by two or more frequency hopped RF signals. The hope duration or chip duration (T_H=T_c), is defined by

$$T_c = T_H = \frac{1}{k} T_b \quad \text{for} \quad k = 1, 2, 3\ldots..$$

and (3)

$$f_c = f_H = 1/T_c$$

III PRINCIPLE OF FHSS

An interfering signal would appear within the channel between the transmitter and thus the receiver [8].Frequency Hopping Spread Spectrum could also be a selection spectrum technique that uses a special frequency to transmit data quite 83 MHz Frequency agility depends on the facility to switch the frequency transmission of a sudden within the utilization of frequency (RF) bands. Divides the available 83.5 MHz spectrum (in most countries) into 79 discrete 1MHz channels. The IEEE 802.11 standard specifies data rates of 1 Mbps and a few of Mbps. so as for a frequency hopping system to be 802.11 compliant, it must operate within the two .4 GHz ISM band, and operate between 2.402 and 2.480 GHz [8]. FHSS is usually utilized in wireless LANs like 1EEE 802.11x [3].

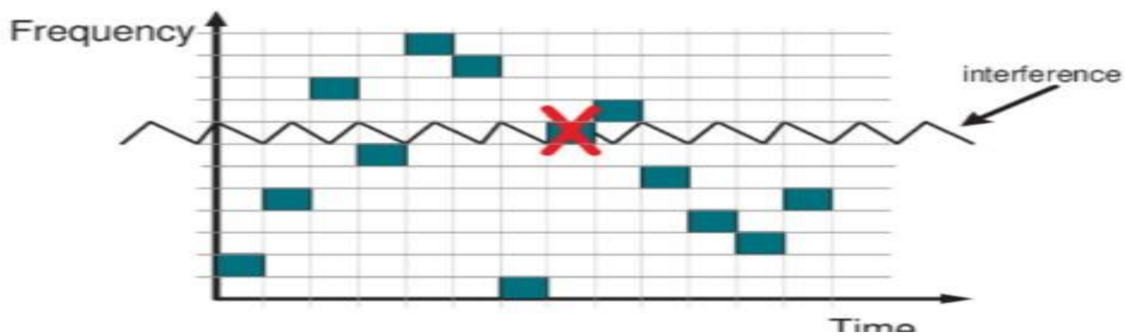

Fig. 4Frequency Hopping method's resistance to Interference [18]

In the example below, the sequences are:

2.449 GHz, 2.452 GHz, 2.448 GHz, 2.450 GHz,
2.451 GHz

After emit radio bearer information at 2.451 GHz, the radio will repeat the hop sequence (the order jump), then start again from the frequency of two .449 GHz. the method repeated sequence leap is going to be continued until the entire information received [18]. In FHSS, the frequencies to be used inside the bouncing succession could even be chosen by the client. inside the unlicensed band, any gathering of 26 frequencies or more (out of the 79 accessible) is legitimate.To "tune in", a listener should know the amount of frequencies selected within the system, the particular frequencies, the hopping sequence, also because the dwell time. The FHSS modulation acts as a layer 1 encryption process. FHSS systems, the transmitter and therefore the receiver hop from one frequency to a different in prearranged synchronized patterns. The hops occur frequently with little or no nonce spent on anybody frequency. This reduces the likelihood of interference [20] with other devices and enables several overlapping FHSS systems to be operational at an equivalent time

IV SIMULATION MODEL

Take building a single-user system model as an example. The simulation tool is MATLAB. Firstly, the information takes care of into the BFSK Modulator subsystem for baseband balance. FH Sequence Generator subsystem produces FH succession, which controls the Frequency Synthesizer subsystem to encourage intermittent Frequency bouncing complex outstanding transporter signals.

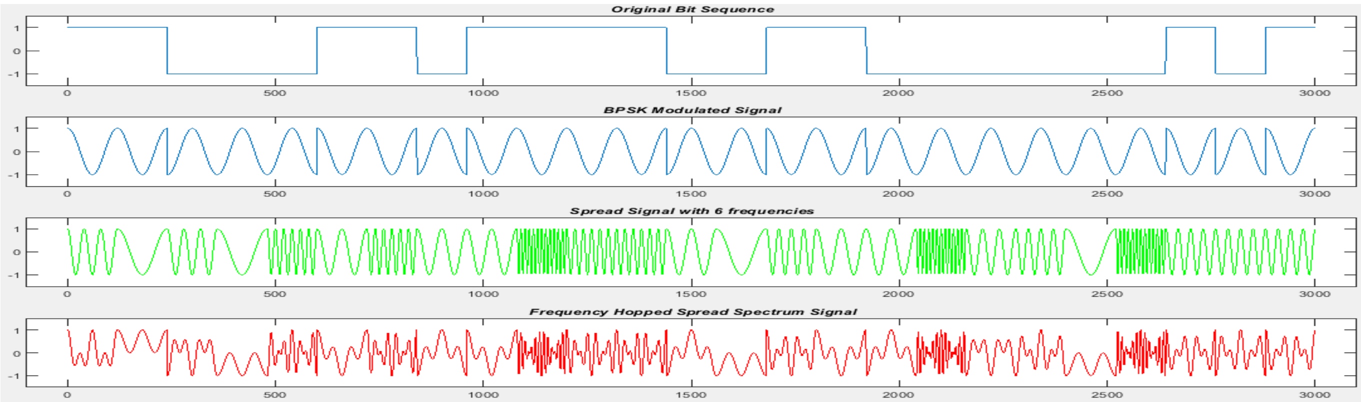

Fig.5Frequency Hopping with BFSK Digital Modulation

In the FH Modulator subsystem, the output complex exponential carrier signals of the Frequency Synthesizer subsystem and thus the output complex exponential signals of the BFSK Modulator subsystem are mixed together to urge a true wave. The frequency mixed signal is shipped to the Channel. At the receiver, all users receive multi-user mixed signals in noise. The frequency hopping signals first pass the FH Demodulator subsystem for de-hopping, then undergo the BFSK Demodulator subsystem for noncoherent BFSK demodulation [5] [6]. Demodulation of frequency hopping spread spectrum (FHSS) [11] signal is accomplished through detection and separation, parameter estimation like hop timing and hopped frequency, de-hopping and baseband demodulation [13]. First, a Digital Modulator has been wouldn't to convert the PN sequence [14] to BFSK [20], then the output has been changed to FHSS [4] [5]. FHSS we've used 6 frequencies, as is shown in figure 4. Figure 5 shows the spectrum through FFT which can be used for later analysis. Xiaopeng Tana et al. used the interference suppression algorithm of FFT overlap transformation to suppress narrowband interference [20].

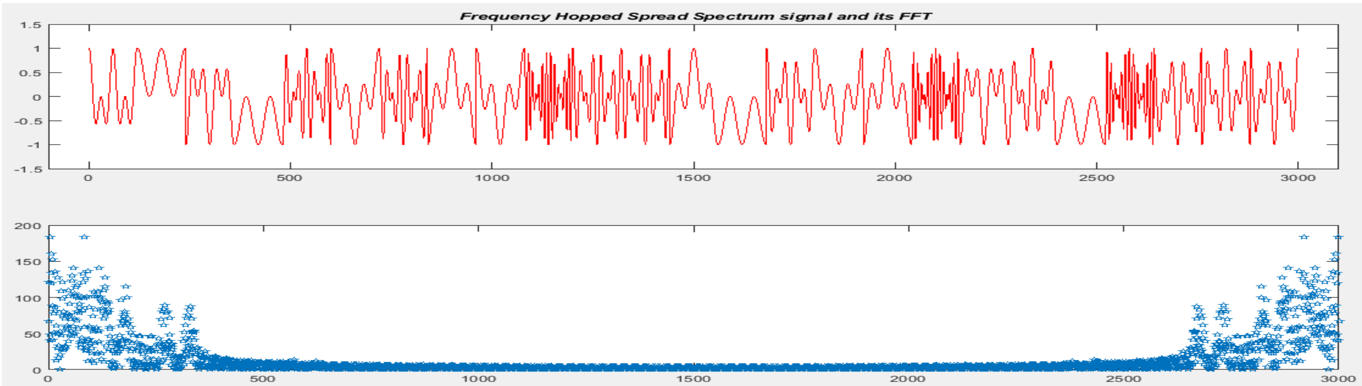

Fig. 6Hops and their FFT

The general transmission capacity needed for Frequency jumping is a lot more extensive [20] than that needed to send an identical data utilizing only one transporter Frequency [15]. Notwithstanding, on the grounds that transmission happens just on marginally segment of this transfer speed at some random time, the immediate impedance data transmission is really an identical [20]. While giving no additional assurance against wideband warm commotion, the Frequency bouncing methodology lessens the corruption brought about by narrowband obstruction sources. one among the difficulties of Frequency jumping frameworks is to synchronize the transmitter and beneficiary [2]. One methodology is to have an assurance that the transmitter will utilize all the channels during an intense and quick time of some time. The beneficiary would then be able to discover the transmitter by picking an irregular channel and tuning in for legitimate information subsequently channel.The transmitter and receiver can use fixed tables of frequency-hopping patterns, so as that when synchronized they go to take care of communication by following the indexing table.

V DISCUSSIONS AND CONCLUSIONS

FHSS [15] signals are highly immune to narrowband interference because the signal hops to a special waveband. Signals are difficult to intercept if the frequency-hopping pattern isn't known. Jamming is additionally difficult if the pattern is unknown; a malicious individual may only jam the signal for one hopping period if the spreading sequence is unknown. FHSS transmissions can share a waveband with many sorts of conventional transmissions with minimal mutual interference. Ahmed Jedda et al. [9] study on the side-effects of using the FHSS technique in Bluetooth and involves more publishing of comparable results to assist to know more distributed algorithms running over Bluetooth networks.

FHSS signals add minimal interference to narrowband communications, and thus the opposite way around. Adaptive frequency-hopping spread spectrum (AFH) [17] as utilized in Bluetooth improves resistance to frequency interference by avoiding crowded frequencies within the hopping sequence. this type of adaptive transmission is simpler to implement with FHSS than with noise. We'll control the frequency hopping sequences according to the design of frequency hopping sequences table [17]. So, on confirm the integrity and reliability of transmission in complex environments, Frequency-Hopping Spread Spectrum (FHSS) is suggesting. The characteristics of

FHSS are good concealment, strong ability of resistance to multipath and narrowband interference, high transmission rate, big system capacity, high spectrum efficiency, etc. [17]. Frequency hopping are often superimposed on other modulations or waveforms to strengthen the system performance.

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