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(54) **Title:** METHOD, DEVICE AND SYSTEM FOR MODULATING COMMUNICATION SIGNALS

(57) **Abstract:** A device for adjusting a modulating scheme of a communication system having a modem. The device comprises a modulation overlay, capable of demodulating and modulating analog signals to respectively provide demodulated incoming analog signals and modulated outgoing analog signals. The demodulated incoming analog signals are recognizable by the modem.

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METHOD, DEVICE AND SYSTEM FOR MODULATING COMMUNICATION SIGNALS

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to communication systems and, more particularly, to communication systems supplemented by a device for modulating the incoming and outgoing communication signals, for the purpose of, *e.g.*, reducing interferences.

In many communication networks, such as satellite communication networks, analog signals are digitized and transmitted from transmitters using digital communication techniques, such as digital modulation and coding. A digital communication offers benefits, such as quality and compression, not available with analog communication.

In general, a digital communication network provides communication access to a large number of stations (or users) who exchange radiofrequency or microwave signals through antenna devices. To provide high speed information transfer to large number stations over the communication network, the communication signals are modulated by multiple access scheme, such as time division multiple access (TDMA), multi-frequency time division multiple access (MF-TDMA), frequency division multiple access (FDMA), code division multiple access (CDMA), polarization division multiple access (PDMA), and the like.

It is recognized that the type of multiple access modulation is one or the major characteristics of a communication network. The selection of the multiple access scheme is based on various considerations, including power efficiency, spectral efficiency, cost, complexity and the like. Once the type of modulation is selected, the hardware for providing the modulation (modems *etc.*) and the interfaces between the modulation hardware and the front-end applications are designed in accordance with the selected type of modulation.

One problem in communication networks is the reception of spurious signals. Such signals are typically originated from nearby transmitters or repeaters which interfere with the legitimate signal. For example, in satellite communication network, signals coming from adjacent satellites may interfere with the legitimate channel and signals the legitimate channel may interfere with other channels.

In the early days of satellite communications, there were few downlink earth stations and those in existence were essentially large antenna devices having a relatively narrow beamwidths. These large earth stations were distributed through wires and cables to numerous destinations. Interference between these large earth stations was, therefore, minimal.

This scenario changed with the advent of very small aperture terminal (VSAT) communications systems. VSAT systems are cost-effective systems supporting internet, voice, fax, data, LAN and many other communication formats. A VSAT network typically includes a satellite transponder, positioned in a geostationary orbit, and a large number of geographically dispersed terrestrial VSAT systems located in many different areas, including rural and metropolitan areas. Each VSAT system receives and transmits signals via the satellite to other VSAT systems in the network. The term "very small" used in the VSAT name refers to the small antenna dish that can be mounted in almost any location, such as a roof, building wall or on the ground.

However, as the antenna dish gets smaller, its characteristic beamwidth becomes larger, resulting in severe interference problems between channels of different networks or between different terminals of the same network.

To reduce interference between neighboring stations, different frequency bands are allocated to the transmitted and received signals of the terrestrial stations. These allocated frequency bands are known as uplink and downlink frequency bands, respectively.

Nonetheless, interference may be generated due to redeployment of the communication network, interweaving of several communication networks, and various phenomena, such as particular weather conditions, scattering and the like.

A known method for reducing interference is the spread spectrum modulation method. In this technique, a modulating signal which is independent of the data is used to significantly increase the bandwidth of the transmitted signal beyond the bandwidth of the data signal. The spread spectrum modulation method has been used for many years for the purpose of encrypting the transmitting data, because, once modulated, the transmitted data are noise-like ("pseudo noise") and are therefore hard to detect or demodulate by non-designated receiver without having *a-priori* information on the modulating signal knowing.

The spread spectrum transmitter uses the same or similar power level as the equivalent narrow band transmitter. Being composed of a much wider frequency range, the spread spectrum signal has a lower spectral power density (power per unit frequency) than the narrow band signal.

Thus, besides the aforementioned benefits of spread spectrum modulation in terms of security, this technique also has the advantage of reducing interference between nearby stations, because the low spectral power density of the transmitted signal makes it less likely to interfere with narrowband communications, even when both communications have overlapping frequency bands. Narrow band communications, on the other hand, causes little or no interference to spread spectrum communication because the receiver in the spread spectrum receiving station effectively integrates over a very wide bandwidth to recover the spread spectrum signal. A potentially interfering narrow band signal arriving to the spread spectrum receiving station is therefore "smeared" over the receiver's total integration range, resulting in a low signal-to-noise ratio of the narrow band signal. The spread spectrum receiving station estimates the minimal signal-to-noise ratio of the legitimate signal (the ratio of modulator bandwidth to the data bandwidths), and all signals with a signal-to-noise ratio which is below this estimate are treated as noise and discarded.

Another method commonly employed by conventional digital communication systems for reducing interference is error coding. In error coding the data signal is encoded with extra bits prior to its transmission. Suppose, for example, that a data signal composed of k-words (strings of length k) is encoded and a few bits are add to each k-word resulting in an encoded signal composed of n-words (strings of length n), where $n > k$. The size of the word space of the encoded signal (2^n) is therefore much larger than the size of the word space (2^k) of the data signal. If an encoded signal is interfered with a spurious signal, most of the errors induced by the spurious signal on the encoded signal are discarded during the decoding process at the receiving station, because the interfered signal is transformed into an invalid bit string. Due to the size difference between the word spaces of the transmitted signal and the data signal, the receiving station can recognize invalid words.

Another technique to handle the problem of interference includes the use of directional antennas with high spatial selectivity to radiation patterns which, reduce the number of rays picked up by the receiver, thus attenuating the effect of interference

from stations outside the spatial coverage of the antenna. Oftentimes, an array of several directional antennas associated with a signal processing circuit is used to obtain spatial coverage which is larger than the spatial coverage of a single spatial selective antenna. Known in the art are antenna arrays and signal processing circuits which ensure a 360° spatial coverage.

All the above solutions have to be considered at the design phase of each station of the communication network, and in some cases even in the design phase of entire communication network or a considerable portion thereof. Oftentimes, however, the peripheral conditions known to the designer during the design and initial deployment of the communication network are changed once the communication network becomes operative or a certain period thereafter. If in the operative phase of traditional communication network spurious signals interfere with the legitimate signal, several stations of the communication network have to be redesigned or redeployed in order to remedy the newly occurring problem. It is appreciated that such post deployment operation may incur major additional costs. An interference reducing technique which can be employed with minimal modifications the operative communication network, is therefore very desirable.

There is thus a widely recognized need for, and it would be highly advantageous to have a method and device for modulating communication signals, devoid of the above limitations.

SUMMARY OF THE INVENTION

It is the object of preferred embodiments of the present invention to provide a device and method for adjusting the modulating scheme of the communication system without changing the appearance and operation mode at the end user's level. The device and method of the present embodiments are particularly useful when it is required to reduce interference in an operative communication system. It is further the object of preferred embodiments of the present invention to provide a communication system.

The Inventor of the present invention has uncovered that the adjustment of the modulating scheme can be performed at reduced cost and complexity while preserving most of the components of the original system.

Thus, according to one aspect of the present invention there is provided a device for adjusting a modulating scheme of a communication system having a modem. The device comprises a modulation overlay, capable of demodulating and modulating analog signals to respectively provide demodulated incoming analog signals and modulated outgoing analog signals. The demodulated incoming analog signals are recognizable by the modem.

According to another aspect of the present invention there is provided a device for adjusting a modulating scheme of a communication system having a customer application. The device comprises a modem, capable of communicating with the customer application. The device further comprises a modulation overlay as described herein.

According to further features in preferred embodiments of the invention described below, the device further comprises a transceiver device, capable of establishing communication between the modulation overlay and an antenna device of the communication system.

According to yet another aspect of the present invention there is provided a communication system for providing communication to a customer application. The communication system comprising a modem, capable of communicating with the customer application, a modulation overlay as described herein and a transceiver device, capable of establishing communication between the modulation overlay and an antenna device.

According to further features in preferred embodiments of the invention described below, the system is a satellite communication system.

According to still further features in the described preferred embodiments the satellite communication system is a VSAT system.

According to further features in preferred embodiments of the invention described below, the system further comprising the antenna device.

According to still further features in the described preferred embodiments the modulation overlay is configured to modulate and demodulate intermediate frequency signals.

According to still further features in the described preferred embodiments the transceiver device comprises a frequency converter, designed and configured for

converting intermediate frequency signals to outgoing high-frequency signals, and incoming high-frequency signals to intermediate frequency signals.

According to still further features in the described preferred embodiments the transceiver device further comprises an amplifier, for amplifying the intermediate frequency signals.

According to still further features in the described preferred embodiments the antenna device comprises a satellite antenna. According to still further features in the described preferred embodiments the satellite antenna has a 3 dB beamwidth of at least 2.5 degrees.

According to still further features in the described preferred embodiments the system further comprises an application interface for establishing communication between the modem and the customer application.

According to still further features in the described preferred embodiments the system or device further comprises a front-end interface for establishing communication between the modulation overlay and the modem.

According to still another aspect of the present invention there is provided a method of adjusting a modulating scheme of a communication system operative to transmit and receive information signals. During transmission, the method comprises inputting outgoing analog signals from a modem and modulating the analog signals to provide modulated outgoing analog signals. During reception, the method comprises inputting modulated analog signals from a transceiver device and demodulating the modulated analog signals to provide demodulated incoming analog signals recognizable by the modem. The method therefore adjusts the modulating scheme of the communication system.

According to further features in preferred embodiments of the invention described below, the modulated outgoing analog signals are modulated by spread spectrum modulation.

According to still further features in the described preferred embodiments the modulated outgoing analog signals are modulated by error coding.

According to still further features in the described preferred embodiments the modem is designed and configured to host a multiple access scheme.

According to still further features in the described preferred embodiments the system or device further comprising a synchronizer, for synchronizing the modulation overlay to the incoming analog signals.

According to still further features in the described preferred embodiments the method further comprises synchronizing the modulation overlay to the incoming analog signals.

According to still further features in the described preferred embodiments the method further comprising further comprising generating at least one pilot signal for the synchronization.

According to still further features in the described preferred embodiments the demodulation of the analog signals is synchronized using the one pilot signal. According to still further features in the described preferred embodiments the pilot signal(s) comprises a continuous wave signal.

According to still further features in the described preferred embodiments the demodulation of the analog signals is synchronized using a residual carrier signal.

According to still further features in the described preferred embodiments the demodulation of the analog signals is synchronized a synchronization word preceding each data field transmitted by the communication system.

According to still further features in the described preferred embodiments the multiple access scheme is a TDMA scheme.

According to still further features in the described preferred embodiments the multiple access scheme is an FDMA scheme.

According to still further features in the described preferred embodiments the multiple access scheme is a MF-TDMA scheme.

According to still further features in the described preferred embodiments the multiple access scheme is a CDMA scheme.

According to still further features in the described preferred embodiments the multiple access scheme is a PDMA scheme.

The present invention successfully addresses the shortcomings of the presently known configurations by providing a communication system and a method and device for adjusting the modulating scheme of a communication system.

Implementation of the method and system of the present invention involves performing or completing selected tasks or steps manually, automatically, or a

combination thereof. Moreover, according to actual instrumentation and equipment of preferred embodiments of the method and system of the present invention, several selected steps could be implemented by hardware or by software on any operating system of any firmware or a combination thereof. For example, as hardware, selected steps of the invention could be implemented as a chip or a circuit. As software, selected steps of the invention could be implemented as a plurality of software instructions being executed by a computer using any suitable operating system. In any case, selected steps of the method and system of the invention could be described as being performed by a data processor, such as a computing platform for executing a plurality of instructions.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

In the drawings:

FIGs. 1a-c are schematic illustrations of prior art communication system;

FIG. 2 is a block diagram illustrating a device for adjusting a modulating scheme of a communication system, according to various exemplary embodiments of the present invention;

FIG. 3 is a block diagram of a communication system for providing communication to a customer application, according to various exemplary embodiments of the present invention; and

FIG. 4 is a flowchart diagram of a method for adjusting a modulating scheme of a communication system, according to various exemplary embodiments of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is of a device, system and method which can be used for radiofrequency or microwave communication. Specifically, the present invention can be used for modulating the incoming and outgoing communication signals, for the purpose of, *e.g.*, reducing interferences.

For purposes of better understanding the present invention, as illustrated in Figures 2-5 of the drawings, reference is first made to the construction and operation of a conventional (*i.e.*, prior art) communication system as illustrated in Figures 1a-c.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments or of being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

Referring now to the drawings, Figure 1a is a block diagram illustrating the prior art communication system, generally referred to herein as system **10**. An application **12** (*e.g.*, voice, video stream) is connected to an application interface **14**. Application **12** transmits data through interface **14** to a modem **16**, which receives the data, modulates it according to a suitable modulation scheme, and produces information signals having an intermediate carrier frequency.

A transceiver device **18** receives the intermediate frequency signals and converts them to a format suitable for transmission over the air. Typically, transceiver device **18** converts the frequency of the signals to higher frequency in the radiofrequency or microwave range. An antenna device **20** receives the data from device **18** and broadcasts it in the form of airborne electromagnetic waves.

Conversely, when data arrives at antenna device **20**, it is being converted by transceiver device **18** to intermediate frequency information signals recognizable by modem **16**. Modem **16** receives the data, demodulates it and sends the information to application **12** via application interface **14**.

A plurality of communication systems like system **10** above form a communication network schematically illustrated in Figure 1b. Shown in Figure 1b is

a communication systems **10a**, sending information signal **22** to a second communication system **10b**. A communication system of an adjacent channel **10c** also transmits information signals **24** to a different direction. However, a portion **26** of signal **24** is leaking into the side lobe of system **10b**. Portion **26** interferes with the legitimate information signal **22** and decreases the detection capability of system **10b**. In some cases, system **10b** falsely interprets portion **26** as a legitimate signal. Similarly, when system **10b** responds, a part of its legitimate information signal may leak into the side lobe of system **10c**.

A traditional solution for the interference problem is to modify the systems in the communication network to apply spread spectrum modulation to the exiting signals and spread spectrum demodulation to the entering signals. The transmitting system applies spread spectrum demodulation to spread the energy of the legitimate signal over a wide energy band. The designated receiving station, apply spread spectrum demodulation ("de-spreading") so as to separate legitimate signal from the interference signal. The communication systems of the adjacent channels, which do not apply spread spectrum modulation (or use different type of modulation), identify the wide band signals of the transmitting system as noise.

A block diagram of modified system **10** is illustrated in Figure 1c. As shown, modem **16** is replaced by a spread spectrum modem **28** which applies spread spectrum modulation in addition to the basic modulation and compressing.

During transmission, the application **12** transmits digital data through interface **14** to spread spectrum modem **28**, which applies spread spectrum modulation to the digital data to create wide band signals. Modem **28** further modulates the wide band data to produce intermediate frequency information analog signals which are then converted by transceiver device **18** and broadcasted by antenna **20**.

During receiving, the process is inverted. Antenna **20** receive airborne electromagnetic waves, transmits signals to transceiver device **18** which converts their frequency to intermediate frequency signals recognizable by spread spectrum modem **28**. Modem **28** digitizes the data to a format suitable for being demodulated by the spread spectrum demodulation functionality of modem **28**. If the signals are legitimate, the spread spectrum demodulation process allows modem **28** to extract the information embedded in the wide band signals. If, on the other hand, the airborne electromagnetic waves received by antenna **20** arrive from an alien channel, the spread

spectrum demodulation process destroy information encoded therein making them to appear as noise.

It is recognized that the modification to system **10** presented in Figure 1c requires the replacement of many components in the system to allow the various components to communicate with modem **28**. The modem replacement incurs major modifications to the services, interfaces and protocols of the original system are. The implementation of such modifications is rather complex and highly expensive, in particular because it is necessary to implement the modifications on all the communication systems sharing the network. Such modifications may also present discomfort and additional costs to the end users who have to become familiar with the new protocols and may even have to replace the end hardware. in their application require the presents

While reducing the present invention to practice it has been uncovered by the Inventor of the present invention that adjustment of the modulating scheme of a communication system can be performed at reduced cost and complexity while preserving most of the components of the original system. Preferred embodiments of the invention described below are particularly useful when it is required to adjust an already operative communication system for the purpose of, *e.g.*, reducing interference. As further explained below, the present embodiments successfully provide a device and method for adjusting the modulating scheme of the communication system without changing the appearance and operation mode at the end user's level.

Reference is now made to Figure 2 which is a block diagram illustrating a device **30** for adjusting a modulating scheme of a communication system, according to various exemplary embodiments of the present invention. Device **30** can be installed in an existing communication system thus serving as an add-on device therein.

Preferably, but not obligatorily, device **30** is adapted for being installed in a satellite communication system. For example, device **30** can be installed in a very small aperture terminal (VSAT) system. As further detailed hereinunder, such installation allows to modify an existing VSAT system while essentially maintaining full functionality of its outdoor and indoor units, including the antenna, transceiver, modem and application interface and the like.

Hence, device **30** comprises a modulation overlay **32**, capable of demodulating and modulating analog signals, such as, but not limited to, analog signals provided by a modem device or a transceiver device. Modulation overlay **32** demodulates signals entering the communication system and modulates signals prior to their transmission. The signals provided by modulation overlay **32** are referred to herein as demodulated incoming analog signals and modulated outgoing analog signals.

The term "modulation overlay", as used herein, refers to a device or electronic circuitry embedded in a hosting device which applies modulation and demodulation which is supplementary to other modulation schemes employed by the communication system. Preferably, the type of supplementary modulation differs from the type of the other modulations employed by the communication system. For example, supplementary modulation can be applied to signals which are already modulated by another device, such as, but not limited to, a modem device. Also contemplated, are modulation overlays which perform the same type of modulation as the other modulations, but using to a different technique. For example, spread spectrum supplementary modulation can be applied to signals which are already modulated by spread spectrum modulation, however using a different modulation function.

Modulation overlay **32** directly or indirectly (*e.g.*, via a front-end interface **36**) communicates with a modem **34** of the communication system in which device **30** is installed. Modem **34** preferably hosts a multiple access scheme, which can be any multiple access scheme known in the art, including, without limitation, a TDMA scheme, an FDMA scheme, an MF-TDMA scheme, a CDMA scheme, a PDMA scheme and the like. In various exemplary embodiments of the invention modem **34** is the original modem of the communication system. However, this need not necessarily be the case, since, for some applications, it may be desired to replace the modem of the communication system.

In various exemplary embodiments of the invention the communication between modulation overlay **32** and modem **34** is at the intermediate frequency level of the communication system. This is in sharp distinction to prior art communication systems in which the modulation is performed at the application level (see Figure 1c). In terms of the block diagram, the position of modulation overlay **32** is between the modem and the antenna device of the communication system, unlike the prior art

system in which the additional modulation is performed on digital data within the modem.

The specific intermediate frequency range to which modulation overlay **32** is configured can vary, depending on the type of communication system in which device **30** is installed. In various exemplary embodiments of the invention the intermediate frequency signals are in the UHF band which is traditionally defined from 300 MHz to 3000 MHz. This embodiment is particularly useful when device **30** is installed in VSAT system. More preferred the frequency ranges for the intermediate frequency signals include, without limitation, from about 500 MHz to about 2500 MHz, more preferably from about 800 MHz to about 2000 MHz, even more preferably from about 900 MHz to about 1800 MHz.

As used herein the term "about" refers to ± 10 %.

Thus, modulation overlay **32** preferably applies modulation to analog intermediate frequency signals exiting from modem **34** and demodulation to analog intermediate frequency signals entering modem **34**.

Device **30** may further comprise a front-end interface **36** for establishing communication between modulation overlay **32** and modem **34**. This embodiment is particularly useful when device **30** does not include modem **34** in which case front-end interface **36** facilitates data transfer between the original components of the communication system and the add-on device of the present embodiments. During transmission, interface **36** receives analog signals from modem **34** and converts them to signals recognizable by modulation overlay **32**. During reception, interface **36** receives signals from modulation overlay **32** and converts them to analog signals recognizable by modem **34**.

In various exemplary embodiments of the invention device **30** comprises a transceiver device **38** which establishes communication between modulation overlay **32** and an antenna device (not shown) of the communication system in which device **30** is installed. Transceiver device **38** preferably comprises a frequency converter **40** which converts intermediate frequency signals to outgoing high-frequency signals (on transmission), and incoming high-frequency signals to intermediate frequency signals (on reception). Transceiver device **38** can also comprise an amplifier **42** which amplifies the intermediate frequency signals to allow further processing.

The specific high-frequency range to which transceiver device **38** is configured depends on the type of communication system in which device **30** is installed. In satellite communication systems, for example, the high-frequency frequency signals are typically at the K band, which is traditionally defined from 12 GHz to 63 GHz. Thus, transceiver device **38** preferably communicates with the antenna device at a frequency range from the K band, and with modulation overlay **32** at a frequency range from the UHF band.

A preferred frequency range for the communication of transceiver device **38** with the antenna device is from about 12 GHz to about 18 GHz, more preferably from about 13 GHz to about 15 GHz, more preferably from about 13.75 GHz to about 14.5 GHz.

Modulation overlay **32** preferably modulates the analog signals received from modem **34** so as to reduce various types of communication anomalies, including, without limitation, the aforementioned interference phenomenon between adjacent channel, hostile attempts to intercept transmission, environmental interference and the like.

In various exemplary embodiments of the invention the modulation overlay **32** employs spread spectrum modulation. Any kind of spread spectrum modulation can be employed, including, without limitation, direct sequence (DS) spread spectrum modulation, frequency hopping (FH) spread spectrum modulation, hybrid DS/FH spread spectrum modulation and the like.

These spread spectrum modulations are known in the art and can be found in the literature (to this end see, *e.g.*, the pioneer work of Hedy Lamarr and George Antheil, U.S. Patent No. 2,292,387, and newer patents such as U.S. Patent Nos. 6,922,432, 6,925,110, 6,934,316, 6,934,319, 6,940,837, 6,947,469, 6,963,600, 6,975,672, 6,975,673, 6,980,531, 6,980,581, 6,980,587, 6,980,810, 6,982,707, 6,982,945, 6,983,009, 6,985,514 and 6,985,515, the contents of which are hereby incorporated by reference).

Broadly speaking, in FH spread spectrum, the carrier frequency "hops" according to a unique sequence, called the FH-sequence. in DS spread spectrum modulation the data signal is multiplied by a pseudo random function, also known as a pseudo noise (PN) function. The PN function can assumes one of two possible values which are typically –1 and 1 (polar PN function), or 0 and 1 (non-polar PN function).

The duration at which the PN function assume a given value is called a "chip period" and it is typically shorter than the period of a single data bit. In hybrid DS/FH spread spectrum modulation, one data bit is divided over frequency-hop channels, while in each frequency-hop channel a DS modulation is employed. According to a preferred embodiment of the present invention the spread spectrum modulation is employed such that, on transmission, the bandwidth of the modulated signal exiting modulation overlay **32** is about 5 - 200 times wider than the bandwidth of the analog signal entering modulation overlay **32**. For example, an analog signal having a bandwidth of from about 1 MHz to about 1.5 MHz is modulated by overlay **32** to a modulated signal having a bandwidth of from about 0.5 MHz to about 300 MHz.

In other embodiments modulation overlay **32** employs error coding. Any kind of error coding can be employed, such as, but not limited to, the techniques disclosed in U.S. Patent Nos. 4,063,038, 6,598,201, 6,360,348, 6,418,171, 6,671,852 and 6,903,665).

Signals arriving at the antenna are converted to intermediate frequency in transceiver device **38**. The modulation overlay **32** receives the analog signals and applies the demodulation procedure as further detailed hereinabove. The modem recognizes the demodulated incoming analog signals as regular, coherent analog signals for which the modem is initially designed. On the other hand, any interference arriving at the antenna, even if modulated (*e.g.*, spread), cannot become coherent at the modem's input because the interference signal is not modulated using the modulation function for which overlay **32** is designed. Similarly, non-modulated interference arriving at overlay **32** becomes incoherent during the demodulation process.

According to a preferred embodiment of the present invention modulation overlay **32** is designed and configured to apply a predetermined gain the signals so as to facilitate rejection of illegitimate signals. For example, when overlay **32** performs spread spectrum modulation and demodulation (*e.g.*, DS spread spectrum), narrow band incoming interference arriving at overlay **32** is subjected to the PN function which spreads the interference signal. The spread interference signal preferably has a low power level such that modem **34** interprets the spread interference signal as wide band low power noise and rejects it.

The present embodiments thus provide a technique which efficiently rejects interference signals. The rejection is preferably done at the modem level, which, as

stated, can be the original modem of the communication system. It will be appreciated that the use of modulation overlay **32** at the intermediate frequency level of the communication system allows using the same modem for rejecting interference signals which otherwise would not have been rejected.

Modem **34** can be any type of digital or analog modem, capable of modulating the application data to a format suitable to be converted to airborne signals. Modem **34** can apply any of the known modulation technique, including, without limitation, frequency shifted keying, quadrature phase shifted keying, quadrature amplitude modulation, and the like. Modem **34** can also perform data compression to achieve high data transfer rates. As stated, modem **34** preferably hosts a multiple access scheme. In general, the multiple access scheme allows the sharing of a single transmission channel among many users.

Multiple access transmission schemes typically have non-continuous nature. When the transmitting communication system employs non-continuous transmission, the receiving communication system may be unsynchronized with the information signals. As is appreciated by one of ordinary skill in the art, synchronization between the non-continuous transmitted signals and receiving communication system can prevent loss of information. In particular, synchronization can facilitate accurate demodulation of the legitimate signals without loosing the information encoded in the first few bits of each data field.

Thus, in various exemplary embodiments of the invention device **30** employs a synchronization scheme. In this embodiment, device **30** comprises a synchronizer **44** which recognizes the modulation scheme and facilitates the synchronization of modulation overlay **32** to the received signal. Synchronizer **44** can be a separate element in device **30** or it can be an internal element of modulation overlay **32**.

Upon reception, the first action of modulation overlay **32** is preferably to synchronize its internal sequence generator to the received signal. After the synchronization, overlay **32** performs the demodulation.

The synchronization can be done, for example, by adding a synchronization word, typically a constant preamble, at the beginning of the transmission. Based on the synchronization word, synchronizer **44** verifies, and more preferably maximizes, the correlation between the received signal and the internal sequence generator of modulation overlay **32**. Once initial synchronization is achieved, synchronizer **44**

keeps tracking the arriving signal so as to ensure that synchronization is maintained. Tracking is advantageous because the transmitter and receiver do not necessarily use the same clock.

Also contemplated, is a synchronization scheme in which a constant pilot signal is added to the transmitted data signals. In this way, all the receivers in the communication network can synchronize their clocks and the synchronization is easier. Such pilot signal can be generated by a central element in the communication network, *e.g.*, a "hub", or the like.

During reception, the pilot signals are picked up by modulation overlay **32** which uses the pilot signals for synchronizing the demodulation procedure. Synchronizer **44** receives the pilot signals and provides synchronization signal to modulation overlay **32**.

The pilot signal can be, for example, a continuous signal to allow constant synchronization by the receiving communication system. Alternatively, a narrow band pilot signal can be used.

The synchronization can also be done using a residual carrier signal on which the modulation is applied. This can be done because all the information is contained in the original modulation which is carried by the residual carrier signal. The present embodiment is particularly useful when the transmitting system transmits signal continuously. As will be appreciated by one ordinarily skilled in the art, the narrow band of the residual carrier signal facilitates its recovery even for very weak because it is being transmitted continuously.

Reference is now made o Figure 3, which is a simplified illustration of a communication system **50** for providing communication to a customer application, according to various exemplary embodiments of the present invention.

The customer application can be, for example, a desktop box, a PC, a display, a voice channel, a position tracking system and the like. System **50** comprises modem **34**, modulation overlay **32** and transceiver device **38**, which operates according to the principles described above. System **50** may further comprise an antenna device **52**, which can be, for example, a satellite communication antenna.

It was found by the Inventor of the present invention that modulation overlay **32** is capable of reducing interference in satellite communication systems having antennas of relatively wide beamwidth. The beamwidth of the antenna is defined as

the angle of sky which can be illuminated (picked up or sent out) by the antenna at a given (*e.g.*, 3 dB) suppression.

Thus, according to a preferred embodiment of the present invention antenna **52** has a substantially wide beamwidth. Typically, antenna **52** has a 3 dB beamwidth of at least 2.5°, more preferably at least 5°, even more preferably at least 7°, say about 7.5° or more. The characteristic beamwidth of the antenna depends on its effective aperture, which is, roughly, the diameter of the antenna. The effective aperture of antenna **52** is preferably smaller than 60 centimeters, more preferably smaller than 30 centimeters, *e.g.*, between about 20 centimeters and about 30 centimeters.

In various exemplary embodiments of the invention system **50** comprises a front-end interface, for establishing communication between modem **34** and modulation overlay **32**, as further detailed hereinabove. Optionally, system **50** further comprises a synchronizer as further detailed hereinabove. System **50** can further comprise an application interface **54** for establishing communication between modem **34** and the customer application.

Reference is now made to Figure 4 which is a flowchart diagram of a method for adjusting a modulating scheme of a communication system, according to various exemplary embodiments of the present invention.

It is to be understood that, unless otherwise defined, the method steps described hereinbelow can be executed either contemporaneously or sequentially in many combinations or orders of execution. Specifically, the ordering of the flowchart of Figure 4 is not to be considered as limiting. For example, two or more method steps, appearing in the following description or in the flowchart of Figure 4 in a particular order, can be executed in a different order (e.g., a reverse order) or substantially contemporaneously.

The method begins at step **60** and continues to step **62** (transmission) or step **66** (reception), depending whether the communication system transmits or receives data.

In step **62**, outgoing analog signals are inputted from a modem, as further detailed hereinabove. The method continues from step **62** to step **63** in which the analog signals are modulated to provide modulated outgoing analog signals. Optionally and preferably, the method continues to step **64** in which the pilot signal is generated as further detailed hereinabove.

In step **65**, incoming signals are inputted from a receiver device, as further detailed hereinabove. From step **65**, the method continues to step **67** in which the incoming signals are demodulated to provide demodulated incoming analog signals recognizable by the modem. Step **67** is preferably preceded by a synchronization step **66**, as further detailed hereinabove.

The method ends at step **70**.

It is expected that during the life of this patent many relevant modulation techniques will be developed and the scope of the terms modulation and demodulations is intended to include all such new technologies *a priori*.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable subcombination.

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims. All publications, patents and patent applications mentioned in this specification are herein incorporated in their entirety by reference into the specification, to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated herein by reference. In addition, citation or identification of any reference in this application shall not be construed as an admission that such reference is available as prior art to the present invention.

WHAT IS CLAIMED IS:

1. A device for adjusting a modulating scheme of a communication system having a modem, the device comprising a modulation overlay, capable of demodulating and modulating analog signals to respectively provide demodulated incoming analog signals and modulated outgoing analog signals, wherein said demodulated incoming analog signals are recognizable by the modem.

2. A device for adjusting a modulating scheme of a communication system having a customer application, the device comprising:

a modem capable of communicating with the customer application; and

a modulation overlay capable of demodulating and modulating analog signals to respectively provide demodulated incoming analog signals and modulated outgoing analog signals, wherein said demodulated incoming analog signals are recognizable by said modem.

3. The device of claim 1 or 2, further comprising a transceiver device, capable of establishing communication between said modulation overlay and an antenna device of the communication system.

4. A communication system, for providing communication to a customer application, the communication system comprising:

a modem capable of communicating with the customer application;

a modulation overlay capable of demodulating and modulating analog signals to respectively provide demodulated incoming analog signals and modulated outgoing analog signals, wherein said demodulated incoming analog signals are recognizable by said modem; and

a transceiver device, capable of establishing communication between said modulation overlay and an antenna device.

5. The system of claim 4, further comprising said antenna device.

6. The device or system of claim 3 or 4, wherein said modulation overlay is configured to modulate and demodulate intermediate frequency signals.

7. The device or system of claim 6, wherein said transceiver device comprises a frequency converter, designed and configured for converting intermediate frequency signals to outgoing high-frequency signals, and incoming high-frequency signals to intermediate frequency signals.

8. The device or system of claim 3 or 4, wherein said transceiver device further comprising an amplifier, for amplifying said analog signals.

9. The device or system of claim 3 or 4, wherein said antenna device comprises a satellite antenna.

10. The system of claim 9, wherein said satellite antenna is characterized by a 3 dB beamwidth of at least 2.5 degrees.

11. The system of claim 4, further comprising an application interface for establishing communication between said modem and the customer application.

12. The system or device of claim 1, 2 or 4, further comprising a front-end interface for establishing communication between said modulation overlay and said modem.

13. A method of adjusting a modulating scheme of a communication system operative to transmit and receive information signals, comprising:

during transmission, inputting outgoing analog signals from a modem and modulating said analog signals to provide modulated outgoing analog signals; and

during reception, inputting modulated analog signals from a transceiver device and demodulating said modulated analog signals to provide demodulated incoming analog signals recognizable by the modem;

thereby adjusting the modulating scheme communication system.

14. The device, system or method of claim 1, 2, 4 or 13, wherein said system is a satellite communication system.

15. The device, system or method of claim 14, wherein said satellite communication system is a VSAT system.

16. The device, system or method of claim 1, 2, 4 or 13, wherein said modulated outgoing analog signals are modulated by spread spectrum modulation.

17. The device, system or method of claim 1, 2, 4 or 13, wherein said modulated outgoing analog signals are modulated by error coding.

18. The device, system or method of claim 1, 2, 4 or 13, wherein said modem is designed and configured to host a multiple access scheme.

19. The system or device of claim 18, further comprising a synchronizer, for synchronizing said modulation overlay to said incoming analog signals.

20. The method of claim 18, further comprising synchronizing said modulation overlay to said incoming analog signals.

21. The method of claim 18, further comprising generating at least one pilot signal for synchronization.

22. The system, device or method of claim 18, wherein said demodulation of said analog signals is synchronized using at least one pilot signal.

23. The device, system or method of claim 21 or 22, wherein said at least one pilot signal comprise a continuous wave signal.

24. The system, device or method of claim 19 or 20, wherein said synchronization is based on a residual carrier signal.

25. The method of claim 18, further comprising generating a synchronization word preceding each data field transmitted by the communication system.

26. The system, device or method of claim 19 or 20, wherein said synchronization is based on a synchronization word preceding each data field transmitted by the communication system.

27. The device, system or method of claim 18, wherein said multiple access scheme is a TDMA scheme.

28. The device, system or method of claim 18, wherein said multiple access scheme is an FDMA scheme.

29. The device, system or method of claim 18, wherein said multiple access scheme is a MF-TDMA scheme.

30. The device, system or method of claim 18, wherein said multiple access scheme is a CDMA scheme.

31. The device, system or method of claim 18, wherein said multiple access scheme is a PDMA scheme.

32. A device for adjusting a modulating scheme of a communication system essentially as described and exemplified herein.

33. A communication system essentially as described and exemplified herein.

34. A method of adjusting a modulating scheme of a communication system essentially as described and exemplified herein.

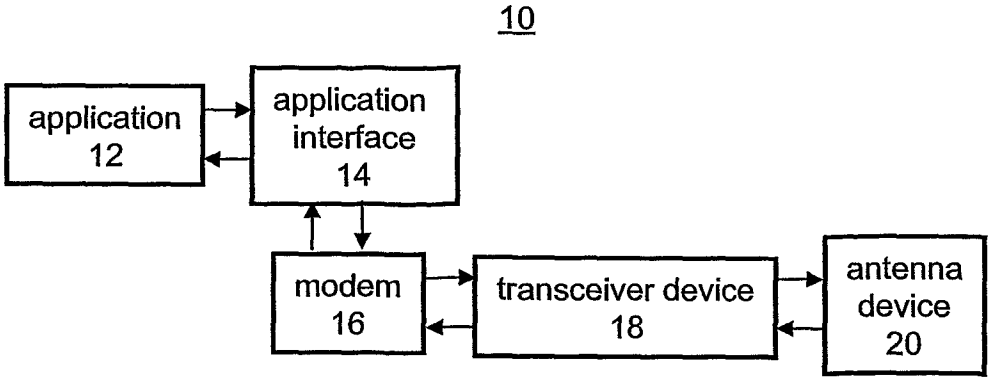
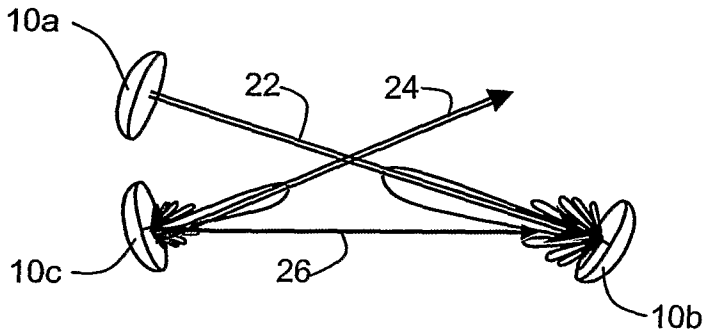


Fig. 1a (Prior Art)

Fig. 1b (Prior Art)



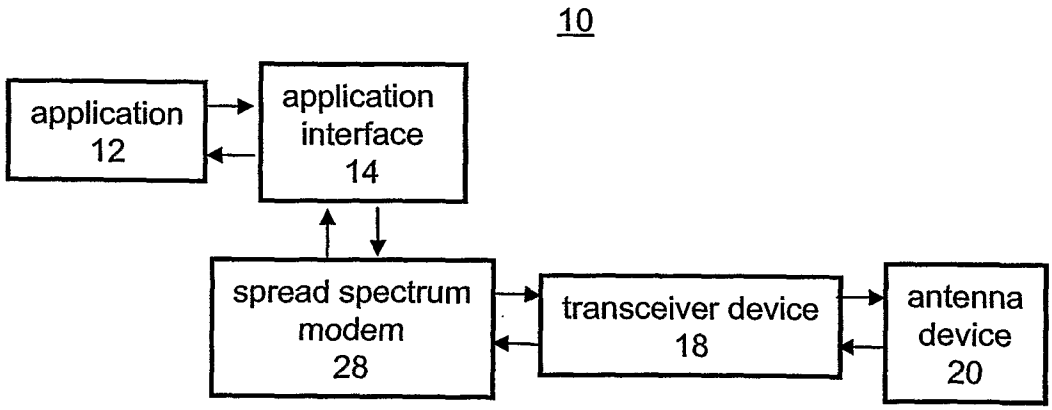


Fig. 1c (Prior Art)

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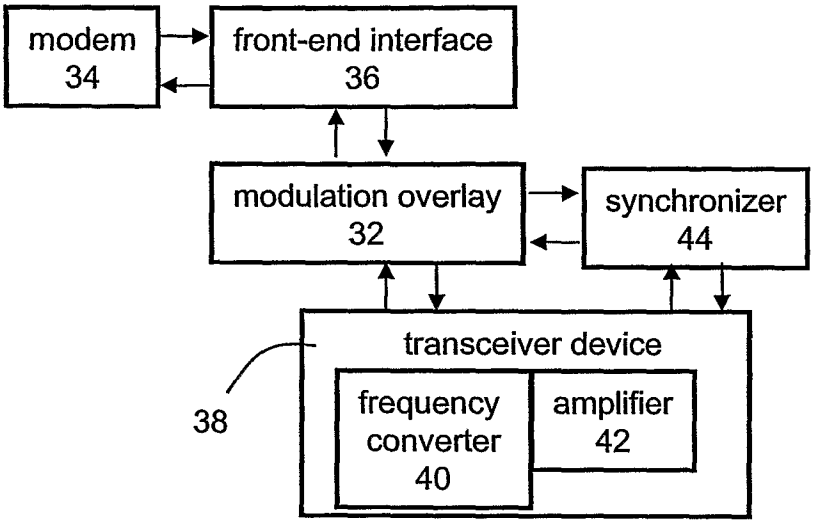

modem
34
front-end interface
36
modulation overlay
32
synchronizer
44
transceiver device
frequency
converter
40
amplifier
42
38

Fig. 2

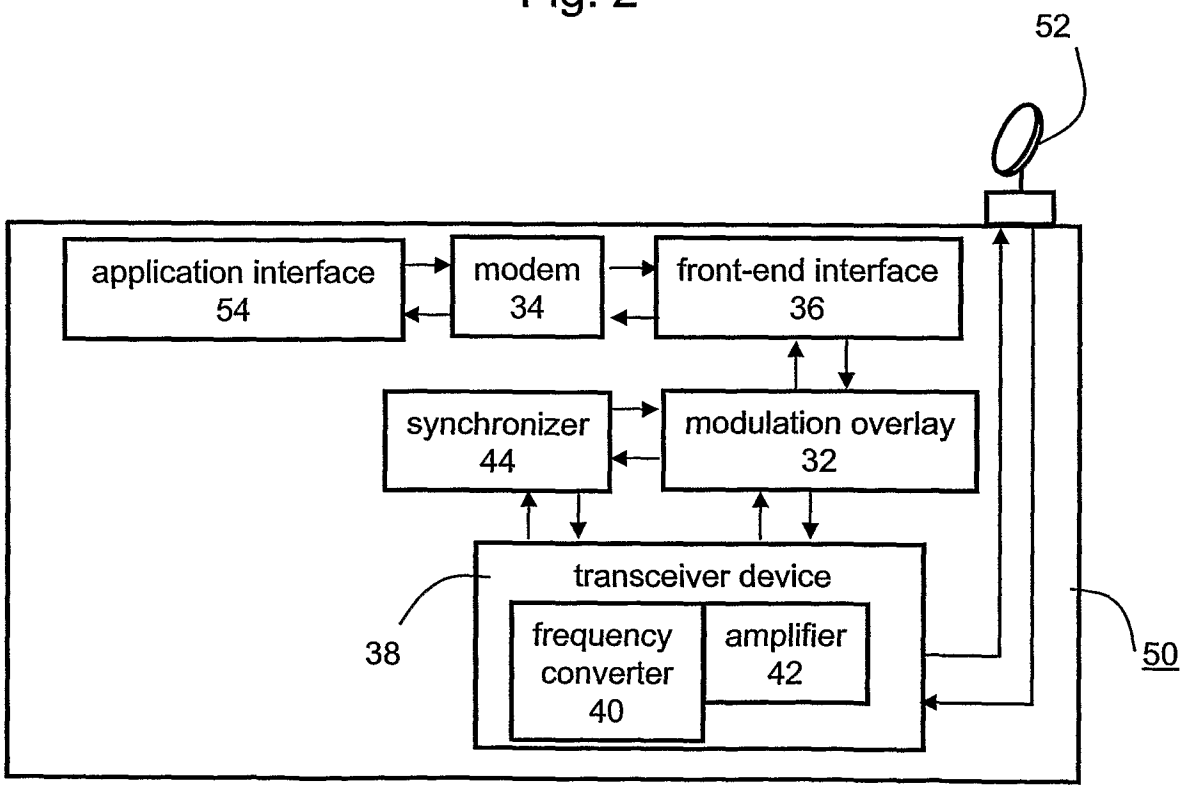

52
application interface
54
modem
34
front-end interface
36
synchronizer
44
modulation overlay
32
transceiver device
frequency
converter
40
amplifier
42
38
50

Fig. 3

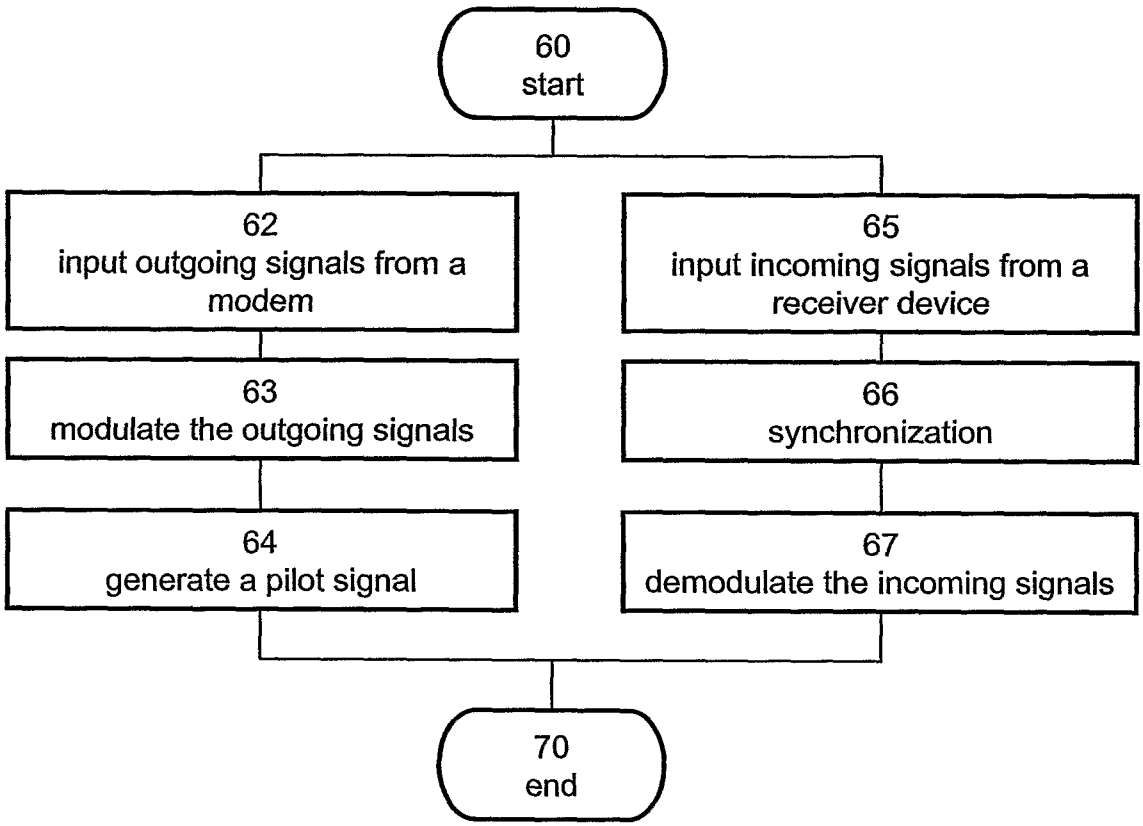

60
start
62
input outgoing signals from a modem
63
modulate the outgoing signals
64
generate a pilot signal
65
input incoming signals from a receiver device
66
synchronization
67
demodulate the incoming signals
70
end

Fig. 4