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TELEX COMMUNICATIONS, INC.
8601 East Cornhusker Highway, Lincoln, NE 68505

ORDER No. 2415AB/AC

High-Gain WLAN Antenna
MODEL HGY-15

INSTRUCTION SHEET

General Description

This antenna is a totally enclosed 16 element Yagi antenna for the 2400 to 2483 MHz frequency band. It is designed to be used as a bridge antenna between two networks, or for point to point communications.

It has a typical VSWR of 1.5:1 and is less than 2:1 over the entire frequency band. The gain is 13.5 dBi and the half-power beamwidth is 30 degrees. This antenna is normally mounted on a 1.25" OD mast and is vertically polarized.

SPECIFICATIONS

Electrical:

Frequency Range	2400-2483 MHz
VSWR	Less than 2:1, typically 1.5:1
Nominal Impedance	50 ohms
Gain	13.5 dBi (11.3 dBd)
Front-to-Back Ratio	greater than 20 dB
Half-power Beamwidth	30 degrees
Polarization	Vertical

Mechanical:

Size	18" long
Mounting method	clamps to vertical mast, 1.125" - 1.25" OD
Cable length	36"
Cable Type	RG-58A/U, 50 ohm low-loss, white
Connector	2415AB: Reverse TNC (polarized) 2415AC: Reverse SMA (polarized)

Mounting

Attach the antenna to the mast using the U-bolts, washers, and nuts provided. Minimum recommended height above ground is five (5) feet. If mounted indoors, all antennas should be at the same height. For outside use, heights greater than 20 feet will give greater range. Point the antenna toward the other WLAN antenna. The accuracy of the orientation should be within plus or minus 15 degrees to achieve maximum gain.

This is especially important if the pathlength is over one mile! If you will be using this antenna to connect to several terminals, aim the antenna in the general direction of the group. If the paths are not obstructed or not over 1 mile, this arrangement should work well. If your path is obstructed by buildings, high fences, or hills, mush less performance can be expected. Once you have selected a direction, tighten the U-bolts securely.

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Process Gain

Appendix A

The following is a communication sent from Harris to Greg Czumak of the FCC:

To: Greg Czumak, FCC , fax 301-344-2050, 301-725-1585x230

From: Carl Andren, Harris Semiconductor, Systems Engineering Group
407-724-7535, candren@harris.com, fax 407-729-4853

We are in the early stages of development of chips to increase the data rate in the 2.4 GHz ISM band beyond that contemplated by the IEEE 802.11 standards committee. This committee has applied the FCC part 15 rules to specify wireless local area networks to transmit 1 and 2 MBps using spread spectrum. We designed a set of chips that will implement the DSSS part of this specification. The chips we developed so far are capable of double rate clocking that will achieve 4 MBps but this effectively allows only one channel in the band. We have many customers clamoring for even higher data rates while not filling the band altogether. Our response is to invent better modulation schemes that use the band like the FCC intended in terms of radiated power, spectrum shape and number of channels. These modulations have the same spectrum shape as standard DSSS signal, but carry more information. Before we invest significant resources into these developments, we need to know if there is any chance the FCC would reject radios based on these principles. Our basic thrust is to make sure the waveform has low power spectral density with a uniform spectrum that has a high degree of randomness.

The standard 802.11 waveform is DSSS with an 11 chip BPSK spreading code which is a Barker word. To apply data modulation, the standard applies BPSK or QPSK modulation at 1 MSps to phase modulate the spread symbols. The demodulator processes this waveform in a time invariant matched filter correlator that basically integrates .energy over the 11 chips and therefore bandwidth compresses the signal by a factor of 11. This rejects 91 % of a CW jammer's energy.

We would like to extend this basic technique by first making the spreading QPSK which will not change the spectrum shape. Secondly, we want to select one of 8 'orthogonal' I spreading codes and one of 8 'orthogonal' Q spreading codes to encode 6 more bits into each symbol (3 bits for I and 3 bits for Q). This will impart even more randomness to the spreading process and make the waveform less likely to interfere with other signals. This waveform has 6 bits from the M-ary orthogonal keying (MOK) of the spreading function and 2 bits from BPSK modulating each of the spread sequences for a total of 8 bits per symbol. We

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would also up the symbol rate moderately (to 1.375 MSps) to get a data rate of 11 MBps. The spread rate of this waveform is 15.125 MCps and it can be constrained to a bandwidth of about 22 MHz. This would allow us to use up to 3 spread channels in the ISM band at the same location.

An alternative is to do basically the same as above but change the numbers to 16 chips per symbol, allowing 8 bits for MOK modulating the I and Q sequences and 2 bits for BPSK modulating each of them. This gives a total of 10 bits per symbol. This also keeps the symbol rate to 1 MSps while increasing the chip rate to 16 MCps (about the same as above).

The receivers for the above modulations require a straight BPSK modulated spread preamble to insure proper carrier phase alignment, followed by the more complex waveform. We envision a bank of serial correlators for the I and Q sequences where each correlator integrates the correlation energy of its symbol type over the length of a symbol. Thus, by the same argument as above, 91 % of the CW jammer energy is rejected in each correlator. This waveform will naturally require more Es/N0 than BPSK, but its Eb/N0 performance will be somewhat better. We believe that with the appropriate interpretation of the requirements, it will pass the 10 dB CW jammer test.

One possible addition to the basic waveform is a PN cover sequence which further randomizes the spreading. This cover sequence may help in multipath rejection and will give a modest amount of waveform security. There are several methods of 'orthogonalizing' waveforms such as using Walsh sequences. These are generally applied to binary length sequences, so the 11 chip case will not be purely 'orthogonal', but we expect that it will have very nearly the same performance.

In summary, we would like for you to look over this technique and let us know if it will be acceptable to the FCC. Wireless local area networks using these higher data rates will better match the capability of the wired networks like Ethernet. This can be a significant boost for this industry and allow us to better compete in the world marketplace. This technique would be significantly easier to implement than any of the others we investigated. It would therefore allow US industries access to low cost chips to implement the next generation of wireless communications.

Appendix B

The following is the reply from Greg Czumak of the FCC to Appendix A

Carl:

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This is in response to your fax dated 091896 and your e-mail dated 110196. We agree to interpret the (S/N)o used in the CW Jamming Margin test (see our Public Notice dated July 12, 1995) as the symbol signal to noise ratio, Es/NO, rather than the bit signal to noise ratio, Eb/NO. When the test report is submitted, it should include the curves (or equations) used to determine the actual required Es/NO value for the specific system's modulation scheme and minimally acceptable symbol error rate. If equations do not exist to calculate this value, then our acceptance of the actual value used will be based on our evaluation of its validity.

I hope that this has been responsive to your inquiry. If you have any further questions, please do not hesitate to call/fax/e-mail me.

Greg

Appendix C

The following was communicated to Greg Czumak and a verbal response was received agreeing to the basic concept.

To: Greg Czumak, FCC , fax 301-344-2050, 301-725-1585x230

From: Carl Andren, Harris Semiconductor, Systems Engineering Group 407-724-7535, candren@harris.com, fax 407-729-4853

Greg, I hate to be a pest, but our engineer in charge of the project has come up with a scheme that differs from what I described earlier and yet should still pass the CW jamming test. Please look over this paper and give a reply as to whether or not you agree that this technique meets the requirements of the part 15.247 rules.

We previously communicated with you about modulation techniques that would allow us to offer higher data rates in the 2.4 GHz ISM band. We are now looking into a technique that uses 8 I chips and 8 Q chips per symbol and modulation that is a combination of BPSK and M-Ary Orthogonal Keying (MOK) modulation. The chipping sequences are chosen from orthogonal sets of 8. By applying the spreading modulation independently to I and Q components of the carrier, we can have 8 choices for I and 8 choices for Q which gives 3 bits each for a total of 6 bits per symbol. Then, by BPSK modulating each of these spreading modulations, we can get 2 more bits per symbol for a total of 8 bits per symbol. This will impart even more randomness to the spreading process than straight DSSS and make the waveform less likely to interfere with other signals. We would also set the symbol rate to 1.375 MSps to get a net data rate of 11 MBps,

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keeping the 11 MCps spreading rate consistent with the upcoming IEEE 802.11 standard. Our simulations have shown that this modulation will pass the CW Jamming Margin test (Public Notice dated July 12, 1995) and will have the same or better spectrum properties as straight DSSS modulation. It will have a high modulation efficiency with better Eb/N0 performance than BPSK due the properties of the MOK modulation. There could also be a mode where we turn one of the orthogonal channels off to cut the data rate in half and get better range.

The reason that the modem designer wants to use this waveform versus the one previously discussed is that it will have the same occupied bandwidth as the IEEE 802.11 standard and achieve higher rates. It could also readily be combined in hardware with the lower rate modulations of 802.11. The main concern is that it will have a bandwidth ratio of less than 10 even though it has 16 chips per symbol.

Our market studies have shown that there is a perception that the next step in data rates has to be at least 10 MBps. If this waveform is acceptable to the FCC, we would then also propose it to the IEEE as the high rate modulation for the IEEE 802.11 committee to adopt for extensions of the 802.11 standard.

In summary, we would like for you to look over this description and let us know if it will be acceptable to the FCC.