ADAPTIVE BROADBAND™

# Technical Report
FCC ID Number E5MDS24810

Adaptive Broadband Corporation
175 Science Parkway
Rochester, NY 14620

## Table Of Contents

# 1. General Equipment Information

This device will be marketed and manufactured by Adaptive Broadband Corporation as the MDS 24810 Spread Spectrum Transceiver. It will operate as an intentional radiator in accordance with FCC Rule Part 15.247. Consequently, the device must be authorized by a grant of Certification, and will be marked with the identification number E5MDS24810. This number will be located on the rear panel label of the transceiver housing, and be preceded by the term "FCC ID:", in compliance with § 2.1045, 2.925 and 2.926.

## 1.1 Summary of RF Parameters

**Transmitter**

| | |
|---|---|
| Type: | Synthesized, 80 KHz steps |
| Frequency Range: | 2400.64-2472.24 MHz |
| Power Output: | 10 dBm to 28 dBm, variable in 1 dB steps |
| Crystal frequency: | 16 MHz |

**Receiver**

| | |
|---|---|
| Type: | Double conversion superheterodyne |
| Frequency Range: | Master: 2400.64-2472.24MHz |
| | Remote: 2400.64-2472.24MHz |
| 1st Local Oscillator Range: | 2154.64-2226.24 MHz |
| First Intermediate Frequency: | 246 MHz |
| Second Intermediate Frequency: | 10.7 MHz |
| Crystal Frequencies: | 16 MHz |

## 1.2 Construction Details

The MDS24810 Spread Spectrum Transceiver consists of a transmitter and receiver constructed on a common printed wiring board assembly, sharing many common circuits. The transceiver board is mounted within a die-cast aluminum housing. A die-cast aluminum top cover completes the enclosure assembly, providing a well-shielded enclosure.

Power, data interface and antenna connections are made via connectors on the front face of the transceiver package.

## 2. 2.1033(b)(1) Full name and address of the manufacturer:

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## 3. (2) FCC Identifier

This device will be marketed and manufactured by Adaptive Broadband Corporation as an intentional radiator in accordance with FCC Rule Part 15.247. Consequently, the device must be authorized by a grant of Certification, and will be marked with the identification number E5MDS24810. This number will be located on the rear panel label of the transceiver housing, and be preceded by the term "FCC ID:", in compliance with § 2.1045, 2.925 and 2.926.

The identification label will also have marked upon it the statement required per § 15.19 (a)(3).

In accordance with § 2.1033(b)(7), please refer to Section 11, page 12, of this report for the FCC Identification label drawing, and to the drawing in Section 11, page 12, for the exact placement of the label on the device.

## 4. (3) Installation and Operation Manual

Included as Attachment 1 of this report.

# 5. 2.1033(b)(4) Description of Device Operation

## 5.1 General Operation

The MDS 24810 Spread Spectrum Transceiver is designed to operate in the 2400-2483.5MHz unlicensed frequency band, using the frequency hopping spreading technique. The transceiver can be configured as either a master or a remote. The master has configurable parameters that allow a variety of operating options, allowing the user to optimize system performance.

The transceiver can be set up for one of 260000 hop patterns determined uniquely by the 16 bit network address and 4 bit user-selectable pattern choice. All patterns have a minimum frequency step of 80 KHz and use up to 896 channels. The pattern is determined by a series generated from a cubic polynomial. All patterns can use from 2400.64 MHz to 2472.24 MHz of the spectrum. The spectrum is broken into seven 128 channel maskable zones where any 0 to 6 zones can be masked to avoid interference. The zone mask choice is provided for maximum flexibility in minimizing interference from, and to, other Part 15 users. The system maybe operated in a simplex or half duplex configuration.

The transceiver is capable of transmitting data at either 1200, 2400, 4800, 9600, 19200, or 38400 bits per second (bps), asynchronous only. This data rate applies only to the interface between the transceiver and the external equipment connected to it; the data exchange rate between transceivers is 22.5 kbps synchronous over-the-air and cannot be changed. Data flow through the radio is transparent, but there can be up to 22 milliseconds of delay between input at the transmitter and output at the receiving radio. This is necessary to provide seamless data flow, even though the radio is changing frequencies from 6.25 to 100 times a second.

In order to receive a constant signal, all transceivers in a system must be synchronized. This is done by designating one radio the master. It is similar to the remote radios in the system, except that every 1.61 seconds it transmits a special 5 millisecond synchronization message. Each remote radio looks for this message to learn the configuration information of the network and then follows its master as it hops frequencies. There are 7 frequencies predetermined by the network address one in each zone, that the master uses to send synchronization information. It may take up to 13 seconds for a remote radio to hear the sync message from the master. If a remote that is in lock does not hear the sync message from the master for more than thirteen (13) seconds, it goes into a slow-hop "seek" mode. In this mode, the remote listens on each channel for 12.88 seconds for the master to hop by, at which time lock will be re-acquired.

To ensure that a radio does not start following the wrong master, each system has its own network address and hop pattern determined by the network address. The system address is used to identify all remote units intended to communicate with a particular master radio. The address must not be one that will be used in other systems that may be in the area in which the radio will be installed, since duplicate addresses can cause failure in, or incorrect data from, other master or remote units with the same address. The address can be any number from 1 to 65000.

## 5.2 Antenna

Adaptive Broadband Corporation does not plan to market the MDS 24810 Spread Spectrum Transceiver with a permanently attached antenna, or special antenna connector, as required under § 15.203. This is because of the following reasons:

1. The MDS 24810 Spread Spectrum Transceiver is designed specifically to provide point-to-multipoint radio links in Multiple Address System (MAS) data communications systems, in applications where frequencies assigned under Part 101 (formerly Part 94) are no longer available in the 928/952 MHz band due to frequency congestion. Users of this communications service are typically large electric utilities, oil/gas pipeline companies, water distribution agencies, railroads, and other similar users.

   Point-to-multipoint systems typically involve a number of fixed-location remote sites, each of which has a control function or functions to be performed at that site. Each location has an associated telemetry unit that provides the control or monitoring function, and requires some type of data link back to a central control point, usually a computer. In some cases, the data link is provided via dedicated telephone line, where such lines are available. The use of Part 101 (formerly Part 94) radio equipment has brought about a new generation of data equipment for use by the major utility companies; this, in turn, has allowed these companies to extend their span of control and supervision to locations previously inaccessible by leased telephone line.

2. Communication protocols for point-to-multipoint systems are invariably set up such that the central computer (called the "host") polls each remote site in turn, commanding some type of response from each remote telemetry unit (RTU). The protocol is implemented in such a way as to guarantee that the RTU does not transmit anything until commanded to do so by the host. By using this scheme, one host can control anywhere between 4 and 300 RTU sites, or more, depending the frequency of the control function required.

   When radio equipment is used to provide the data link between host and remote sites, the equipment is "transparent", in that the radio in no way alters the communication protocol; the host and RTU data equipment controls the operation of the radio equipment. A MDS 24810 "master" transceiver is used at the host site, while a "remote" unit is used at each RTU. Because of the communication prototcol, neither device will function as intended unless the normal polling routine is active, and the RTU is commanded to transmit data by the system host computer.

3. In many instances a critical control function or monitoring point, such as gas pipeline flow, electric power distribution, or vehicle traffic control, is linked via radio. The control system design is done by either by the user's engineering staff, an independent consultant, the manufacturer of the data equipment, or by Adaptive Broadband's Systems Engineering. The control equipment, consisting of the host computer and RTU, is designed specifically for the purpose and not usable in any other types of service. The radio equipment becomes an integral part of a much larger and specialized control system.

   The reliability and quality of the radio path from the master to each remote site has to be optimized so that maximum reliability of the control system is attained. This dictates the use of unidirectional Yagi or parabolic antennas at each remote site, to maximize the received signal strength from the master location. In order to allow 360° azimuth coverage from the master site, an omnidirectional gain antenna is often used. However, each radio system is different due to terrain, local obstructions, antenna height, etc. and therefore the antenna systems have to be tailored to suit the individual requirements of each system.

   Due to the custom installation often required at each radio site, the choice of antenna feed line varies from location to location, and it becomes impractical for one specific type of connector/feed line combination to be used for all applications. This includes antenna protection devices, such as surge suppressers, which are required for use in hazardous areas such as oil refineries, gas transmission plants, and the like.

   Also, with new data equipment installed, and interfaced to radio link equipment, there often is a troubleshooting period wherein system "bugs" are worked out until the system performs as intended. Therefore, it can be seen that these systems, including the radio equipment, must be properly designed and professionally installed by technically competent personnel in order to assure proper operation and compliance with the 6 dBW EIRP power limitation. These technicians are experienced in the use of radio measurement devices, and are able to ensure that the equipment is used within its ratings.

4. The MDS 24810 Spread Spectrum Transceiver is sold directly by Adaptive Broadband Corp. to either the end user, the control system manufacturer, or the subcontractor responsible for the system installation. It is marketed solely for industrial applications, and is not available to the general public, either directly or through retail outlets.

5. Adaptive Broadband recognizes that the intent of § 15.203 is to prevent excessive power levels from being transmitted in the 2400-2483.5MHz unlicensed frequency band, in order to minimize interference to other users. Adaptive Broadband believes that for the most part, intentional radiators expected to

meet Part 15 requirements have to be designed such that the casual user is prevented from easily modifying the device to increase its effective radiated power and therefore its range of coverage.

Adaptive Broadband also believes that the intent of § 15.247 is to provide a frequency band that can be utilized to provide a communications service to users not normally allowed specific frequency assignments. While this is a major step forward, it must be recognized that there are increasingly large numbers of potential, qualified users of Part 101 (formerly Part 94) radio frequencies that cannot obtain frequencies because of frequency congestion. Areas of such frequency congestion are often not in major urban areas, but at rural locations such as natural gas or oil production fields. These users have specific system requirements that must be met, regardless of operating frequency.

In the past several years Adaptive Broadband has marketed a large number of 900 MHz radio transceivers to Part 101 (formerly Part 94) users, and has built up a fairly large customer base. In so doing, the technical competence of these users, particularly the larger utility companies, has been found to be considerable. It is the opinion of Adaptive Broadband that the technical staff of prospective users of this device are not only technically competent, but are responsible, capable of exercising good engineering judgment, and can ensure that the equipment is used as intended, subject to the requirements of § 15.247.

6. Since 1993, Adaptive Broadband (formerly Microwave Data Systems) has sold a similar spread spectrum transceiver, the MDS 9310, employing a type-N antenna connector and not sold with a specific antenna, which was Certified by the Commission under FCC ID E5M5LL9310. Adaptive Broadband has sold several thousand MDS 9310s in the past 6½ years to industrial users, and has built up a sizable customer base and extensive operating history. In so doing, the technical competence of these users to plan a system and install these radios in compliance with FCC Rules has been amply demonstrated. There have been no known reports of interference to other users of the spectrum.
7. Adaptive Broadband has also sold a 2.4 GHz direct-sequence spread spectrum transceiver, the Model MDS SST1, which carries FCC ID E5M5LLSST1. This radio also employs a type-N antenna connector.
8. Since 1997, Adaptive Broadband has sold the MDS 9810, a successor to the MDS 9310, employing a type-N antenna connector and not sold with a specific antenna. This is Certified by the Commission under FCC ID E5M5LL9810. Adaptive Broadband has sold several thousand MDS 9810s in the past two years to industrial users. The technical competence of these users to plan a system and install these radios in compliance with FCC Rules has been amply demonstrated. There have been no known reports of interference to other users of the spectrum.

## 6. Description of Circuit Functions

The following is a summary of the operation of the MDS 24810 Spread Spectrum Transceiver. Refer to Figure 1, the block diagram, to follow the discussion.

### 6.1 Receiver

#### 6.1.1 Receive Front End

Connector J301 on the main PWB board conducts the RF signal from the front panel antenna connector to the antenna switch network. In the receive mode, one port of the antenna switch conducts the receive signal to the input of ceramic filter FL302.

The output of FL302 is fed to low noise amplifier U304, whose output goes to ceramic filter FL303. The output of FL303 goes to M301, a double-balanced mixer whose local oscillator injection voltage is derived from the VCO output.

#### 6.1.2 High IF

The 246 MHz High IF signal from M301 enters IF amplifier FET Q304, whose output goes to FL304, a SAW filter which provides part of the IF selectivity of the receiver. The output of FL304 is connected to Q305, which provides more IF amplification.

#### 6.1.3 Low IF

The output of Q305 feeds an FM demoduation chip, U305, which downconverts to the second IF of 10.7 MHz and provides a demodulated audio output. U305 contains several circuit sections: mixer, oscillator, IF amplifier / limiter, quadrature detector and meter drive. The oscillator section of U305 uses VCO U311, synthesizer U312, and associated components to set the second oscillator frequency at 235.3 MHz.

The 10.7 MHz output of the second mixer is fed to ceramic filters FL306 and FL307. These filter sets provide the main adjacent channel selectivity of the receiver.

The output of FL307 is fed to the limiter amplifier input pin of U305. The limiter output is fed to a quadrature detector circuit tuned by ceramic filter FL308; audio recovered from the detector appears on Pin 9 of U305.

A secondary output of the IF subsystem at Pin 7 of U305 gives a received signal strength indication (RSSI) voltage.

#### 6.1.4 Digital Signal processing

Audio processing

The unfiltered recovered audio from the IF detector passes through amplifier U201 to an A/D converter U205 and then processed by the DSP U202 to decode the digital information.

RSSI Processing

The unfiltered RSSI from the IF detector passes through a low pass filter to a monolithic internal A/D converter built within the 68HC11 micocontroller U101. A scaled version of the RSSI signal is output though the D/A converter U203 connected to the DSP U202.

### 6.2 Power Supply

The + 13.8 volt DC input appears when an external power source is connected to J103. From J1, the +13.8V is conducted to the internal transceiver circuits through F1, a 1.5 ampere board-mounted polyfuse.

CR112 is a transient voltage suppresser on the + 13.8 VDC primary power input. It protects against a reverse polarity condition. U105 is a switching regulator that provides + 6.0 volts for all transceiver circuits.

- U102 regulates the + 6.0 volts down to + 5 volts which supplies power to the line driver, D/A converter, microprocessor and all of the CMOS logic.
- U204 regulates the + 6.0 volts down to + 3.3 volts which supplies power to the DSP and A/D converter.
- Regulator U410 provides 10 volts for a 4.75 volt supply to various RX and TX components.
- Regulator U411 provides +5 volts for all RF sections.
- Regulator U412 provides -5 volts for TX amplifier bias and an RX switch.

## 6.3 Transmitter

### 6.3.1 CPFSK Modulation Process

The transmit audio is generated internal to the DSP with an FIR filter. The DSP drives a D/A converter U203 which provides a control voltage to the VCO U309 and the TCXO Y401. This process creates the CPFSK modulation.

### 6.3.2 Transmit Power Amplifier

The power amplifier chain of the transmitter section consists of U406, U407, Q401, Q403, Q404, U403, U404, and U405. U407 is a driver amplifier with an active bias network. The output of U407 feeds U406, which is a 1 W power amplifier with an active bias network. The output of U406 is filtered with FL401 to remove harmonic content from transmitted signal.

From FL401, the RF is fed through a directional coupler to the antenna switching network.

### 6.3.3 Antenna Switch

The antenna switch consists of U301.

## 6.4 Processors

### 6.4.1 Microprocessor / FLASH Memory

The microprocessor U101, controls many of the on-board functions of the transceiver. It runs a predetermined routine that controls all of its pin functions.. All programmable functions and values are stored by the microprocessor in an electrically erasable (EEPROM) IC, U104. These include operating parameters such as home channel and hop pattern, frequency, CTS delay time/mode, as well as model and factory serial numbers. The microcontroller uses the 16 MHz system clock as its clock source.

### 6.4.2 Digital Signal Processor (DSP)

The DSP controls all of the real time modem functions including FIR filtering, converting writing to A/D, reading from D/A and running the asynchronous RS-232 interface. It runs a predetermined routine that controls all of its pin functions. The routines are downloaded from the microcontrollers FLASH memory when the radio is powered up. All programmable functions and values are stored by the microprocessor in EEPROM in the microcontroller. These are also downloaded when the radio is powered up. These include operating parameters such as receive FIR coefficients, application interface baud rate. The DSP uses the 16 MHz system clock as its clock source.

## 6.5 PLL/Synthesizers

Three separate PLLs generate the High IF mixer local oscillator, low IF mixer local oscillator, and transmitter local oscillator.

The temperature compensated 16 MHz crystal oscillator (TCXO) sets the reference frequency for the phase-lock loop (PLL) circuits. The TCXO's output is run to U308, U312, and U312, the synthesizer ICs.

These three PLL synthesizers consist of two phase detectors, programmable reference dividers, programmable feedback dividers, and prescalers. Data input is serially loaded from the microcontroller U101; this data consists of binary coded numbers representing the reference and feedback (VCO RF sample) divider ratios required to produce the final transmit frequency. The reference divider is programmed only on power-up, with a power reset or with a PLL out-of-lock condition. The feedback divider value changes according to the transmit/receive frequencies sent from the microcontroller.

The phase detector output of each PLL synthesizer is fed to the VCO tuning input through an R-C loop filter to the VCOs. U307, U311, and U309 are self-contained voltage-controlled oscillator (VCO) assemblies whose output are amplified by buffer amplifiers U306, Q311, and U309 respectively.

## 6.6 RS-232 Data Interface

U106 is an RS232 line driver/receiver integrated circuit. It has an internal +5 volts to +10/–10 volt converter that allows it to provide a true RS-232 compatible output. Transient protection for the six RS-232 I/O lines is built into the RS-232 driver.

## 6.7 LED Indicators

LED indicators are provided to visually signal the state of the transceiver. U108 and U109 are inverting buffers which provide drive to the LED indicators.

| | |
|---|---|
| CR101 - RUS | Receiver unsquelched |
| CR102 - AL | Alarm indication |
| CR104 - GP | General purpose |
| CR106 - CTS | Clear-to-send |
| CR107 - TR | Transmit |
| CR108 - TXD | Transmit data |
| CR109 - RXD | Receive data |
| CR110 - DCD | Data carrier detect |

## 8. 2.1033(b)(5) Transceiver Schematic Diagram

The transceiver schematic diagrams (4 sheets) follow this page.

## 9. (6) Test Report

All testing to demonstrate compliance with Part 15 was performed by UltraTech Laboratories, Inc. It should be pointed out that this device was tested with various peripheral devices, explained as follows:

1. Antennas. The MDS 24810 is to be marketed without antenna, as previously discussed. Upon advice of the Commission, the device was tested with antennas typically used in its intended application.

2. Peripheral Equipment: Since this device does not function as intended unless connected as part of a data system, it was tested using a standard personal computer (PC) running a program designed to simulate the actual conditions of use, in order to fully exercise the device for compliance testing.

Test Reports on the MDS 24810 Spread Spectrum Transceiver are shown as Attachment 2 of this Report.

## 10. (7) Product Photographs

The required product photographs are contained within Attachment 2.

## Statement Of Certification

This is to certify that:

This technical report was prepared by me, or under my direct supervision, and to the best of my knowledge and belief, the facts set forth herein are true and correct.

by:

Jacob Z. Schanker 6/18/99

Jacob Z. Schanker, P.E.
Director of Agency Compliance
Adaptive Broadband Corporation

## List of Attachments

Attachment 1
Installation and Operation Manual

Attachment 2
Test Reports for FCC compliance
(Including Product Photographs)