TM8000 mobile radios

TN-855-AN
TM8000 and TB7100 Data Modem Facilities

Application Note version 2.1
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Abbreviations and Definitions

Abbreviation	Description
0x	Denotes a Hexadecimal number
ASCII	American Standard Code for Information Interchange
Baud Rate	Symbols per second
BER	Bit Error Rate, A measure of received errors
bps	Bits per second, a measure of data rate
CCDI	Computer Controlled Data Interface, Tait Proprietary
CTS	Clear to Send, a means of hardware flow control
DCE	Data Connecting equipment, The radio Modem.
DSP	Digital Signal Processor
DTE	Data Terminating Equipment, Usually equipment connected to the radio modem
FEC	Forward Error Correction. A means of detecting received data errors
FFSK	Fast Frequency Shift Keying modulation scheme
GPS	Global Positioning System
PLC	Programmable Logic Controller
RF	Radio Frequency
RTS	Ready to Send, a means of hardware flow control
SCADA	Supervisory Control And Data Acquisition
SFE	Software Feature Enabler, A software mechanism for enabling a feature
SINAD	Signal induced Noise and Distortion, a measure of noise within audio
THSD	Tait High Speed Data, A high speed data modem and protocol
VCXO	Voltage Controlled Crystal Oscillator
Xon / Xoff	Characters used to define software flow control
UART	Universal Asynchronous Receiver Transmitter

Contents

1 Introduction

This application note introduces the data facilities that Tait provides with the TM8000 conventional series of mobiles and the TB7100 conventional base station equipment. It covers the internal software modems provided with the TM8000 and TB7100 ranges and the protocols used to drive them.
This application note is intended for System Integrators.

As a standard feature, TM8000 mobiles and the TB7100 Base station come supplied with an internal Digital Signal Processor (DSP) 1200-baud FFSK modem.

As an option, a Software Feature Enabler key (SFE) can be purchased for the TM8000 to provide a high-speed 12000bps or 19200bps modem. This high-speed option is known as Tait High Speed Data (THSD). As the TB7100 is supplied with THSD enabled from the factory, a SFE does not need to be purchased. The 19200bps (19k2bps) option can only be used on wideband channels (25kHz).

These modems have a number of configurable parameters, which are configured using the TM8000 and TB71000 programming applications. The 1200 baud standard option uses the proven Fast Frequency Shift Keying (FFSK) modulation scheme, which performs well at low signal levels and through most repeaters.

The THSD option uses a four-level Gaussian frequency shift keying modulation scheme, which occupies most of the available audio bandwidth and requires a synchronised stream of data.

This document provides information about the workings of both modems and their use in a system. It is not meant to provide complete and detailed instructions on setting up products for data use as separate documents are available for this.

2 Tait High Speed Data Modem

2.1 Overview

A DTE connects to the radio modem via a serial connection and will send and receive serial data in a standard asynchronous fashion. The radio then processes this data and sends it over-air using a synchronous protocol, sending data in a continuous bit stream until there is no more data available to be sent.

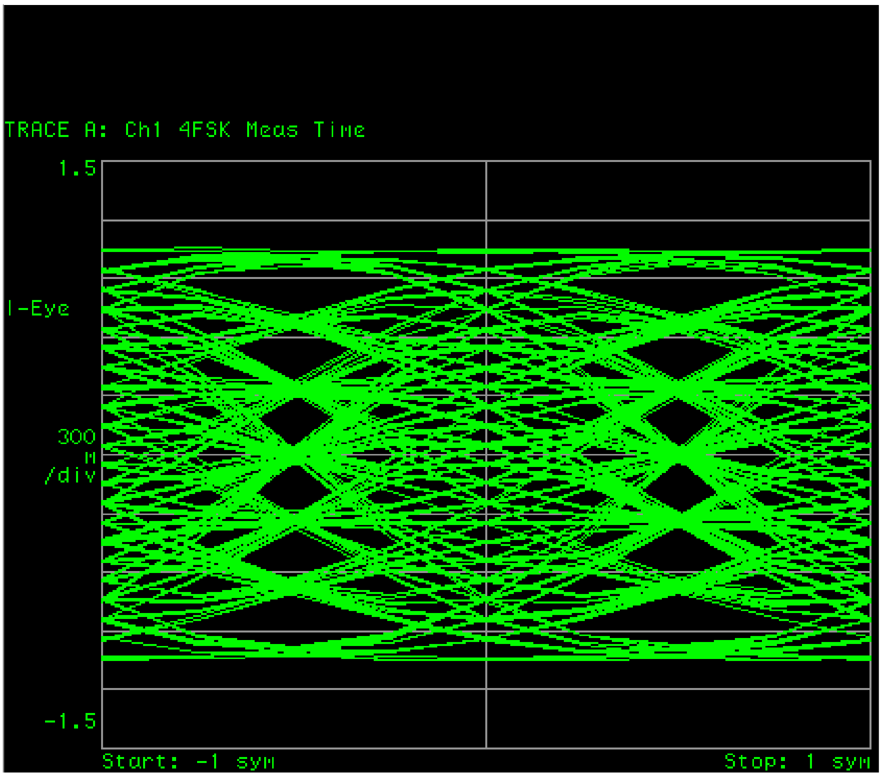
The radio enters THSD mode either via a Computer Controlled Data Interface (CCDI) command, when programmed to do so at powerup or via a programmed input line.

When a radio is in THSD mode, the radio keys up the transmitter as soon as it detects data from the DTE. It then formats the data according to the configuration (layer-1 or layer-2, Forward Error Correction (FEC) or no FEC) and after the programmed lead-in delay, passes that data to the modem to be encoded for over-air transmission.

The receiving radio decodes the modulated data and passes it on to the control-software. Here the data gets processed according to the configuration (layer-1 or layer-2, FEC or no FEC) and user data is then passed on to the connected DTE. When the sending radio has no more data to send, it automatically keys down the transmitter.

2.2 Modulation Scheme

The THSD modem uses a CP-4GFSK modulation scheme.



Like C4FM, this is a four-level FSK scheme, but can achieve higher data rates while maintaining compliance with ETS300-113 ACP. This scheme is a form of minimum shift keying, and hence is a subset of MSK.

A good explanation of CPFSK can be found in chapters 6.5 to 6.10 of "Communication Systems 4th Edition" by Simon Haykin.

2.3 Over–Air Protocols

Layer 1

Layer 1 mode requires a good understanding of transmission timing. The nominal terminal port speed (asynchronous) must be at least 20% higher than the over-air data speed (synchronous). Depending on the amount of data and the programmed lead-in delay, it may also be important to enable terminal flow control. Refer to "Flow Control" on page 14.

If at any stage the transmitting radio runs out of data to transmit, idle characters are inserted. Idle characters may also be appended to fill the last THSD frame.

As the data has no format, the receiving radio cannot strip out the inserted idle characters, as it cannot distinguish between valid data and idle data. It is up to the DTE to handle detection and the removal of the idle characters.

Layer 1 with FEC

Protocols using forward error correction (FEC) provide better over-air data integrity than protocols without FEC . Data is packetised into lots of 12 bytes and a 9-byte calculated parity is added to each packet to form one FEC code word. The receiving radio receives a code word and uses the data and parity information to correct any detected errors. Again, idle characters may be inserted into and/or appended to the data stream and passed on to the receiving terminal. Usually the last code word contains idle data to fill up the 12 byte data block.

Layer-2

Layer-2 adds a header containing a start-of-data sequence and a data-length byte. This header is pre-pended to a block of data of the given data length.

When the receiving radio detects the start-of-data sequence it examines the length and then passes the indicated number of bytes to the terminal. It then ignores all incoming data until the next valid start-of-data sequence is detected. So in essence, layer-2 is a data filter that strips out non-user data.

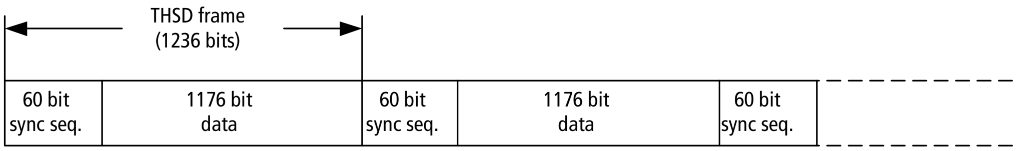
The transmitting radio packetises only data that it already holds in its input buffer from the terminal. If the buffer runs empty, idle data is sent, which the receiving radio removes and does not pass on to the terminal. As a result, a slower terminal speed is no longer an issue as it is with fully transparent mode. However, if data arrives at the sending radio too slowly, the radio may decide that there is no more data and key down the transmitter. As soon as it detects new data the transmitter is keyed up again and data transmission commences after the lead-in delay.

Layer-2 with FEC

This combines the above two features: FEC provides a high level of data integrity and layer-2 filters out non-user data at the receiving radio. Layer-2 uses the first of the 12 data bytes as a length byte (1 to 11 data bytes).

2.4 THSD Over-Air Data Format

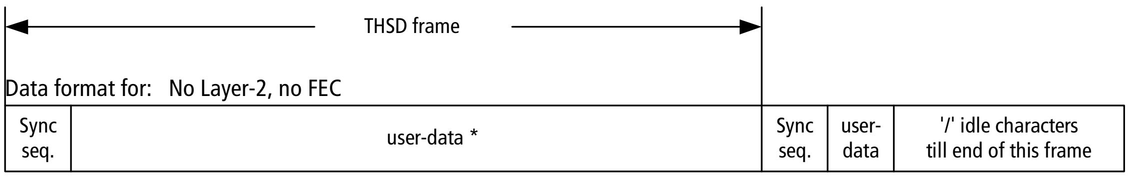
Basic Modem Data Structure



Frame time:

- 64.4ms at 19k2 (wide-band)
- 103ms at 12k (narrow-band)

Data Format

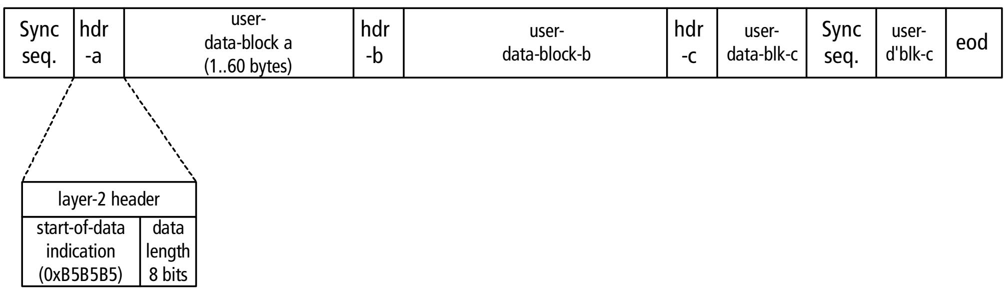


Effective mode user-data rate: 95%

Note user-data may contain idle characters if sending terminal does not provide data in time. To prevent idle data insertion

- the terminal speed should be 20% higher than the modem speed, or sufficient lead-in delay should be programmed to fill the buffer before transmission (data amount less than 127 bytes and no flow control)
- there should not be a long gap in the data packet. A data packet is defined by the terminal application.

Data Format for Layer-2, no FEC

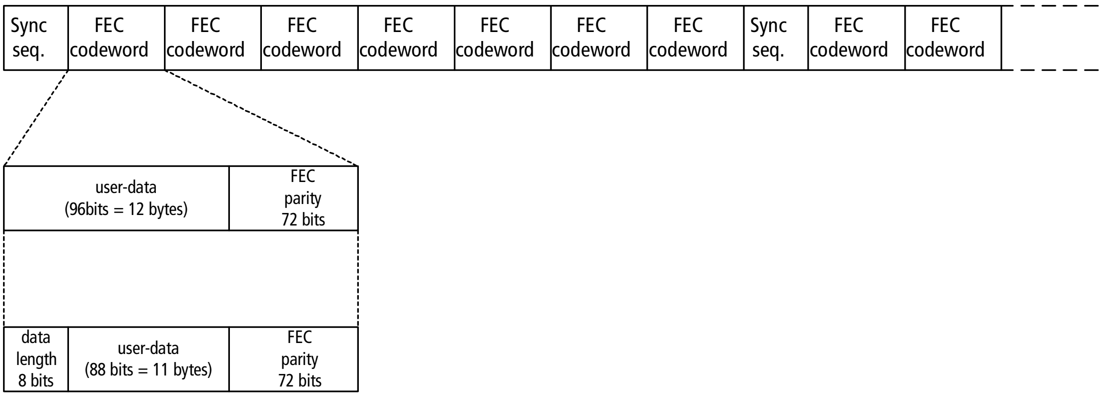


The eod (End Of Data) indication merely provides a lead-out delay to ensure that the data is completely sent before the transmitter is turned off.

Effective modem user data rate: 6.3% (1 byte block) to 88% (60 byte block).

The data block size depends on data availability in the radio, which in turn depends on the lead-in delay, terminal speed and modem speed

Data Format with FEC



A THSD frame holds seven, 168-bit codewords.

Format without layer-2:

- Effective modem user-data rate: 54.4%. In case there are insufficient data bytes, the user-data block is filled with idle characters

Format with layer-2:

- Effective modem user-data rate: 49.8%. The user-data block can contain 1 to 11 bytes

2.5 Scrambling

In The THSD implementation, data is scrambled before it is packed and sent over-air. This introduces a controlled randomness to aid decode performance.

2.6 Synchronisation

Synchronisation (sync) sequences are added into the data stream. The sync sequence that occurs every 588 symbols is the same as the start sync sequence.

Synchronisation allows the receiving radio to synchronise its symbol clock with the incoming data. This reduces the possibility of data errors when the transmitting and receiving radios are not exactly on the same frequency due to frequency drift or ageing.

The sync sequence is inverted if the modem is in FEC mode which tells the receiving radio to expect data packets with FEC data added.

2.7 Rate Changer

The rate changer has the ability to detect changes within the VCXO frequency when receiving a signal, and can adjust the DSP accordingly so that a constant 48K sample rate is achieved.

This effectively tracks the VCXO frequency to offset the effects of ageing, temperature and "Birdie" channels, providing a reliable data decode.

3 FFSK Modem

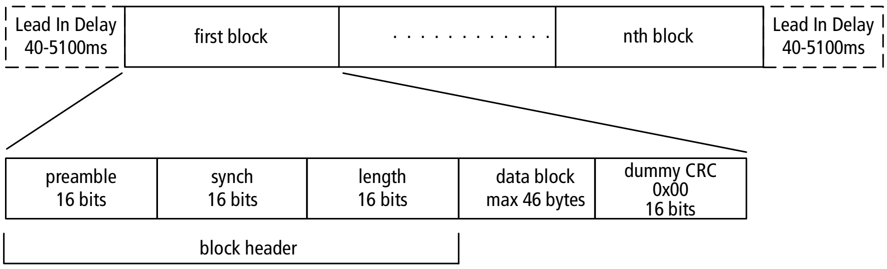
3.1 Overview

A 1200 baud modem is also provided as standard for data transfer. The modulation scheme for the 1200-baud modem is FFSK. Data is represented by one cycle of 1200 Hz (logic 1) or 1.5 cycles of 1800 Hz (logic 0), and is transmitted at rates of 1200 bps.

It is important to note that while the FFSK format is widely used, it is unlikely that a third party FFSK modem is compatible with the Tait 1200 baud FFSK implementation. This is mainly due to the proprietary way in which the data is packed and sent over-air.

Data is presented to the modem in the same fashion for THSD as it is for FFSK. Refer to "DTE Considerations" on page 5.

3.2 Over-Air Protocol



Note The structure of all blocks is the same.

Lead In Delay

The time for which the transmitter is keyed up, without modulation applied, as a lead in to a data transmission. It is programmable in the range 20 to 5100 (TM8100) or 1200 ms (TM8200). Refer to "Lead Out Delay" on page 12.

Preamble Field

Bit reversals to allow the receiver demodulator to acquire bit synchronisation. The preamble consists of 16 bits of constant value 0xAAAA.

Sync Field

Synchronisation sequence of 16 bits of constant value 0x3B28.

Length Field

The length, in bytes, of the data fields in the current block. Range 1 to 46 (0x01 to 0x2E).

Data Block

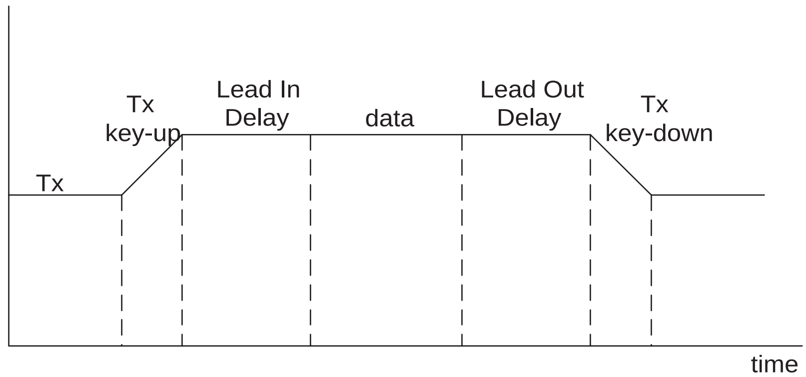
The payload data (1 to 46 bytes).

Dummy CRC

This field is present only to preserve the message structure used in earlier versions of the CCDI. It has the constant value 0x00.

Lead Out Delay

The time for which the transmitter remains keyed up with no modulation, after the data transmission has been sent. It is programmable in the range 0 to 250 ms.



4 DTE Considerations

4.1 Physical Connections

TM8000

As the serial ports available on the TM8000 are 3V3 CMOS levels and the majority of DTE equipment is RS-232, it is strongly recommended that a TMAA01-02 RS-232 options board is fitted to the TM8000 to connect to the DTE.

This option board fits in the options space of a TM8000 and provides a standard 9-way D-range socket, with RS-232 levels, at the rear of the radio. The front microphone serial port can also be used with the radios programming lead, which is useful for testing purposes.

The radio programming software, connected via the front microphone serial port, is used to configure the serial ports, baud rates, and flow control.

TB7100

A 9-way D-range socket is available at the rear of the TB7100 which provides Standard RS-232 levels. Transmit data from this port is sent to the transmitter module and receive data is sourced from the receiver module and sent to the DTE. This provides limitations for software flow control and some CCDI commands which send a response.

Important Note that this connector does not provide a full serial connection to each of the transmit and receive modules.
This port is labelled “Aux” within the TB7100 programming application. Although there are two other options, “Mic” and “Internal options”, these should not be used. There is no physical connection to the Internal Options port, and the Mic port can only connect to a single receiver or transmitter module in turn, depending on the position of the “Tx/Rx” switch.

4.2 Baud Rate

There are a number of serial baud rates available between the DTE and the radio modem, from 1200 to 28800bps

Important The raw over-air baud rate is fixed at a different rate depending on which modem is chosen e.g. 1200 bps for the FFSK modem, 12kbps for THSD on a narrow band channel and 19k2bps for THSD on a wideband channel.
The baud rate for the serial port can be set to a different value than the over-air baud rate.

There are some points to consider when choosing a serial port baud rate;

- Is the baud rate faster than the effective over-air rate, so the modem does not have to wait for more data, adding delays?
- Is the baud rate a lot faster than the effective over-air rate, and is a lot of information being sent? In this case there may be the possibility of overflowing the serial port buffer, losing data. Flow control should be considered.

4.3 Flow Control

Flow control provides a mechanism to stop serial data being sent from the DTE:

- During the Lead In Delay period
- When the serial port buffer is full.

The DTE also has the ability to use flow control to stop data coming from the Modem (DCE).

Support for flow control is slightly different for each product:

TM8000

The TM8000 provides two forms of flow control:

- Hardware: Ready to Send (RTS) / Clear to Send (CTS)
- Software Xon/Xoff.

The programming software is used to configure the flow control.

For hardware flow control, General Purpose Input Output (GPIO) lines must be assigned. Although CTS/RTS can be assigned to a number of different I/Os, it is recommended you use the TMAA01-02 RS-232 options board which provides CTS/RTS at RS-232 levels.

The assignment of the correct I/Os is detailed in the fitting instructions which come with the TMAA01-02.

For software flow control, the Xon /Xoff characters can be configured. Default characters are 0x11 for Xon and 0x13 for Xoff.

It is important that the Xon/Xoff characters do not appear in the "user" data.

TB7100

Important The TB7100 does not support software flow control

Hardware flow control is available, however the TB7100 needs to be configured.

- 0 ohm resistor links are added to the TB7100 Systems Interface to assign CTS/RTS to an appropriate I/O (not a factory default).
- The receiver and transmitter TB7100 modules need to be programmed to assign the CTS/RTS lines to the I/Os chosen above

4.4 Serial Port Buffer

For the TM8000 and the TB7100, a 512 byte buffer is provided for data received from the DTE and a 128 byte buffer is available for data received over-air and sent to the DTE.

4.5 Uart Write Delay

A programmable option for both the TM8000 and the TB7100 is to enable a UART write delay (programmable 0 – 500ms).

In some case small "gaps" can appear in the serial data send from the DCE to the DTE. These gaps can occur when the data is converted from the over air format into an asynchronous format suitable for sending to the DTE.

Over-air protocol overheads including FECs, Syncs and headers can contribute to these small gaps.

In many case these gaps in the received serial data do not cause a problem, however some DTEs require serial data to be received in a constant stream without gaps between the received serial data.

The UART write delay can provide a type of data buffer by delaying the time that the received data is sent out the serial port, thereby providing a constant stream of serial data to the DTE. (depending on the size of the gaps)

4.6 Serial Port Protocol

Overview

Data is sent to the serial port with a start bit, eight data bits and a stop bit. No parity is used.

The Tait Proprietary CCDI (Computer Controlled Data Interface), protocol is used for serial data. It has the two modes, command mode and transparent mode. The TM8000 and TB7100 can be programmed to start up in either mode.

Transparent mode is the more common mode for operation in data systems. Often the DTE provides a higher level protocol which uses transparent mode for the transfer of this higher protocol.

Command Mode

In this mode, CCDI commands can be used to “drive” the radio and receive information on the state of the radio. An example of a CCDI command is “g0223D2” which tells the radio to go to channel 23. The radio then responds with a prompt “.” to indicate it is ready to receive another command.

The format of a CCDI command is ASCII text with:

- a one letter identifier, e.g. “g” for go to channel
- the number of characters to follow, e.g. “02”
- the channel to go to e.g. “23”
- and finally a two digit checksum e.g. “D2”.

A CCDI protocol manual is available which gives a full list of commands.

Examples of what you can do in command mode are:

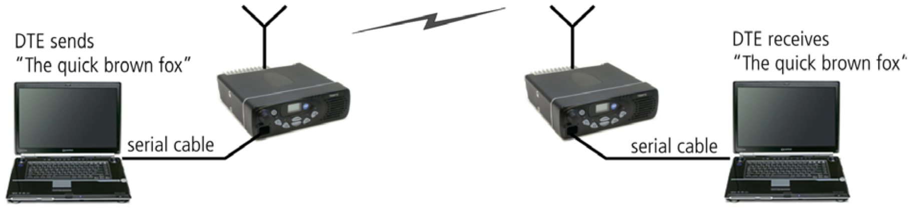
- change channels (TM8000 only)
- send a short data message to another radio (1200 Baud FFSK only)
- receive progress messages e.g. channel busy
- change into transparent mode (TM8000 only)

As the TB7100 does not provide a complete serial connection to both the receive and transmitter modules, the TB7100 has very limited support for command mode.

If a DTE sends a CCDI command to the TB7100, no responses (including CCDI prompts “.”) are possible.

Transparent Mode

In transparent mode, any data sent to the serial port is picked up, processed, and sent over-air. At the receiving radio, the data is demodulated, processed, and then sent to the serial port.



Serial data in transparent mode is free format and it does not have to be sent in a certain sequence or be of a certain length.

No prompt is received from the radio modem indicating that it is ready for more data. If flow control is used, then this can be used to indicate when the radio is ready/not ready for more data.

This mode provides a very simple interface to an end user, as any data sent to the serial port of the radio appears at the other end, and the link in between can be thought of as "transparent".

Characters sent or received do not have to be a ASCII representation, any Hexadecimal characters can be sent from 0x00 to 0xFF – providing the characters are not used as a software Xon / Xoff character.

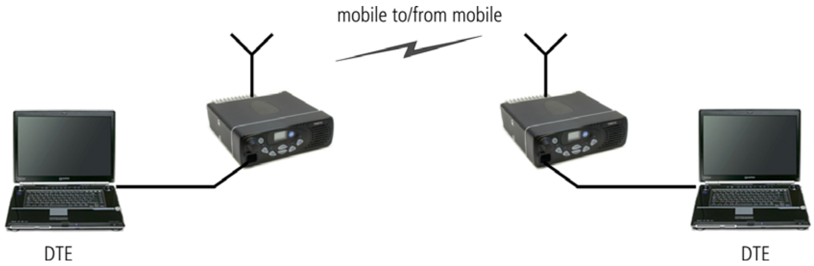
Transparent mode can use either 1200 baud FFSK or the THSD modem.

Important The term Transparent mode is used throughout this document to describe both over-air protocols and serial port protocols.
The term "Transparent Mode" has been used for some time in Tait terminology, however it is somewhat of a misnomer. In all cases over-air data is not sent in a fully transparent fashion as the data is always assembled into a "packet" or packets before being set over-air.
The concept of a "transparent" mode is from a DTEs perspective. Any data that a DTE sends to the modem should appear at the other end as if the modem and the RF link are "transparent".

5 System Considerations

5.1 Configurations

Mobile to / from Mobile



In this configuration the DTE is connected to the TM8000 via the serial port, data is sent from DTE to DTE via the TM8000 radio modems.

- Point to Point or Point to Multipoint
- Semi Duplex
- Suitable for FFSK or THSD

Mobile to / from Base Station (RS-232 out)

Using a TB7100 base in this configuration has the advantages of a higher duty cycle, higher transmit power and the possibility of duplex transmission, (although the TM8000 is semi-duplex so two would be required).

This configuration provides the most direct route for the data, and is the recommended configuration - if it is practical to bring the RS-232 data back from the site to a location where the DTE sits (often a PC running an application).

- Point to Point or point to multipoint (many TM8000s)
- Semi Duplex (full if two TM8000s used)
- Recommended configuration
- Suitable for FFSK or THSD

Data Repeater (serial loop)

In this configuration, data is sent from the DTE to TM8000 to the TB7100. The data is then decoded by the TB7100 receive module and sent to the serial port where it is “looped” back to the transmitter module.

The transmitter module then picks up the data and re-transmits it on a different frequency.

- Point to Point or Point to Multipoint
- Semi duplex
- Additional delays are added as the TB7100 re-broadcasts the data
- Suitable for FFSK or THSD

Important With this configuration, it is likely that the sending DTE sees data “Echoed” shortly after it has stopped sending data. After the DTE finishes sending data, due to delays as the data is re-broadcast by the TB7100, the TM8000 connected to the DTE starts receiving data that is being re-broadcast. This data is then sent back to the DTE. It is important to take this echo into consideration.
If a higher level protocol is used by the DTE then it is likely that this echo is ignored.

Data Repeater (Talk Through voice and data)

In this configuration, the TB7100 acts as a talk though repeater. When the receive gate of the receive module opens, the transmit module starts transmitting and audio is passed from the receive module to the transmit module. This configuration is:

- **NOT** suitable for THSD
- Possibility of voice and FFSK data
- Semi Duplex
- Point to Point or Point to Multipoint

5.2 Throughput

Important The over-air data rates that have been mentioned in this document are "raw" data rates. Once the data is packetised and processed (and for THSD if an FEC is added), the data rate available to the user is an "effective" data rate. This is often considerably less than the raw data rate.

For example, using the THSD 12Kbps modem to send 80 bytes of data, with no FEC and a Lead In Delay of 10ms, provides an "effective" over-air rate of approximately 7kbps.

The following table shows an approximate indication of throughput for the THSD and FFSK modems, at specific user data values (20 bytes and 80 bytes). This is intended to give the user an approximate measure to go by.

As can be seen from the table, the more data sent, the greater the effective throughput is. The numbers in the table show that, when FEC is enabled, the effective throughput is reduced for the same amount of user data.

Test	LID (ms)	FEC	A	B	C	D	E	F	Tx Time	Lag	bps (system)	bps (over-air)
1200bps	20	N/A	20	166.2	136	429	334.4	503	293	342.7	318.1	546.1
12kbps	20	No	20	10.3	11.0	69.3	64.9	75.3	58.3	73.2	2124.8	2744.4
1200bps	20	N/A	80	665.4	135.8	989	334.4	1109.4	853.2	342.7	576.9	750.1
12kbps	10	No	80	41.5	10.5	102.4	61.7	113	91.9	70	5663.7	6964.1
12kbps	10	Yes	80	41.4	10.6	159	54.8	158.7	148.4	63.1	4032.8	4312.7

LID	Lead In Delay (Lead Out Delay set to 0)
FEC	Forward Error Correction (applicable to THSD modem only
A	number of characters sent to the transmitter
B	time that the last bit of data was received by the transmitter
C	time transmitter keyed up
D	time transmitter keyed down
E	time that first bit of data was output from the receiver's serial port
F	time that last bit of data was output from the receiver's serial port
Tx Time	time from Tx key up to Tx key down
Lag	time from the start of the first bit being sent to the radio to the first byte being output from the receiver's serial port
bps (system)	effective bits per second (bps) from the first bit being sent to the last bit being received
bps (over-air)	effective over-air bits per second (bps) from key up to key down

Note DTE to DCE baud rate was 1200 baud for 1200bps test and 19k2bps for the 12kbps test.

5.3 Turnaround times

A common application is "polling" a DTE connected to a modem for information. This information could be SCADA or GPS information.

To provide an indication of the time taken for this process, a comparison was performed using different modems and configurations, first sending out 4 bytes of information as a "poll" request and then sending back 18 bytes as a poll response.

18 bytes for a poll response was chosen as this would be enough information for a compressed GPS report, however in practice the poll and poll response could be any length, this table is for an indication only.

The configuration used for test was:

DTE <–> TB7100 <–> over-air <–> TM8000 <–> DTE.

In practice using a TM8000 instead of a TB7100 should provide the same result.

Test	LID (ms)	FEC	A (ms)	B (ms)	C (ms)	D (ms)	E (ms)
1200bps	20	N/A	0	91	106	215	316
12kbps	10	No	0	42	44	98	101
12kbps	10	Yes	0	52	54	115	127
19k2bps	10	No	0	38	40	87	89
19k2bps	10	Yes	0	44	47	99	106

LID Lead In Delay (Lead Out Delay set to 0)
FEC Forward error correction (applicable to THSD modem only)
A Four Bytes sent to the TB7100 serial port
B Time first byte arrived at the TM8000 serial port
C Time last byte arrived at the TM8000 Serial port (and poll response sent)
D Time first byte of poll response arrived at the TB7100 serial port
E Time last byte of poll response arrived at the TB7100 serail port

Note A Lead In Delay of 20ms for FFSK is unachievable if CTCSS is also to be used on the system. A Lead In Delay of 300ms should be used to provide enough time for the CTCSS to be decoded.

5.4 Voice and Data systems

THSD

When a TB7100 or a TM8000 is in THSD transparent mode, it is not in a suitable state to enable demodulating / modulating voice. Therefore to enable voice communication, the TM8000 or the TB7100 must be changed back to voice mode. For the TM8000, this can be achieved using CCDI or an I/O line.

On the TB7100 it is not possible to change the Base Station from THSD mode to voice mode using CCDI. Separate GPIO lines can be used to toggle the receive and transmit modules into and out of THSD mode, however these are not set up as default and need to be configured. It may be also impractical to toggle these lines if the TB7100 is located remotely.

FFSK

When the TM8000 and the TB7100 are in FFSK mode, they do have the ability to also be used for voice communications. There is a useful TM8000 programmable option to mute the speaker while FFSK transmissions are received, preventing users hearing the FFSK bursts.

A balance needs to be obtained between how often data is sent on the channel versus how often the channel is available for voice communication. If practical, it is a better idea to separate voice and data channels to prevent one interfering with the other.

5.5 Bit error rates (BER)

The following table gives a comparison of Bit Error Rates (BER) in four different situations:

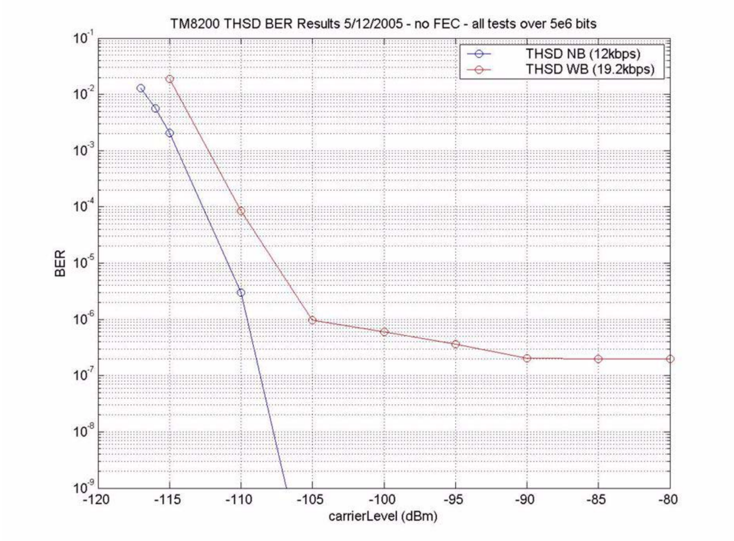
- the 1200 baud FFSK modem on a wide and narrow channel spacing, and
- the high speed data modem (THSD) with and without error correction (FEC).

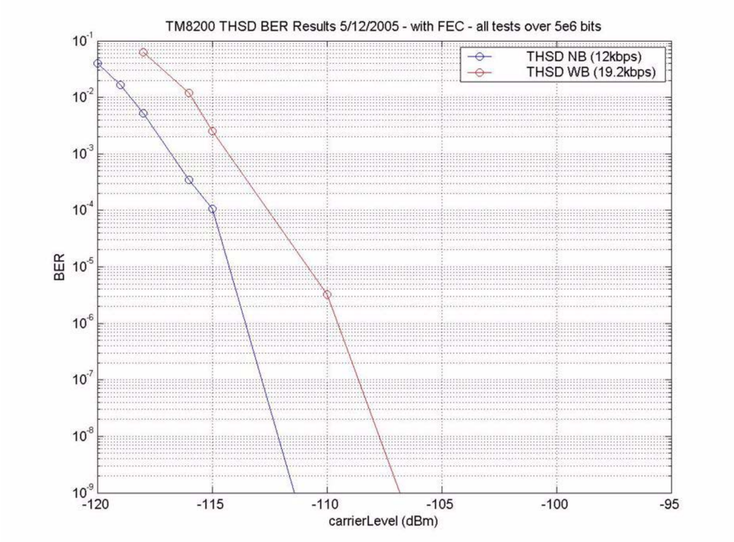
The BERs were measured according to the approval specification of Maximum Usable Sensitivity. This is the RF signal level at which the modems achieve a BER of 1 x 10-2.

It can be seen that the FFSK modem produces a more satisfactory BER than the high speed modem and that the BER for the high speed modem is improved using FEC.

Modem	Sensitivity
1200bps FFSK modem, Wide Band	-122.0dBm
1200bps FFSK modem, Narrow Band	-122.6dBm
Narrow Band THSD no FEC	-115.7dBm
Narrow Band THSD with FEC	-118.1dBm

These measurements were performed on radio that has an Rx sensitivity of -121.99dBm for 12dB SINAD. For a clear picture of THSD bit error rates, two graphs are provided below, which compare the BER of the THSD 12kbps and 19k2 modems, with and without FEC.





It is important to note that the BER results were measured using a standard specification TM8000.

A “Trigger Base” TM8000 receiver (including a TB7100 receiver module) has a lower receive sensitivity due to the more stringent receiver performance specifications it has to meet, therefore BER results are likely to be less (approximately 3dB less) for Trigger base configurations.

5.6 Retries

Neither modem performs retries of missed or incorrect packets. If this functionality is required, this should be handled by the DTE using a higher level protocol.

5.7 Error Checking and Correction

The 1200 baud FFSK modem does not provide any true form of error checking or correction. This is left up to the third party application. There is however, a TM8000 radio programming option called “Check Packet Length”, that provides limited error checking for incoming data packets.

The trade-off with using this option is that an entire packet has to be received before the length can be checked, which adds delays. Without this option, data is sent out the serial port as soon as it is received, which can speed up the over-air rate considerably.

The THSD modem provides an rugged FEC (Forward Error Correction) option. This uses a Reed-Solomon algorithm and enables the modem to work at lower signal levels than without FEC.

Note It is important to note that the effective throughput of the modem drops when FEC is added. This is due to the information added to the data packet to detect and correct errors.

6 FAQS

Which modem should I use?

This really depends on the application. The FFSK modem comes as standard and has the potential to be used for voice and data on the same channel, where data use is low.

THSD comes at an extra cost, however throughputs are much greater, useful for larger amounts of data, and where transferring data quickly is important.

Should I use FEC for THSD?

Even though using FEC reduces the effective data rate, using FEC is often a good idea, especially in a mobile (as opposed to fixed) environment. FEC improves data reliability in lower signal areas.

If another higher level protocol is being used which also has some form of FEC then it may be inefficient to have two forms of FEC for the same data. In this case not using the modems FEC may be a better option.

Which Protocol should I use for THSD?

Layer 1 provides the least overhead, if the data is provided in multiples of the correct packet length. However if it is not, then idle characters "/" are passed to the DTE which can be annoying.

Layer 2 provides more overhead, however is a good compromise. No extra characters are presented to the DTE and if the received serial data does not make up a complete packet, then often a full packet is not sent.

What is the minimum packet size that I can send with different THSD protocols ?

If 1 byte was sent to the THSD modem from the DTE, Layer 1 with or without FEC would send 154.5 bytes over-air as a full THSD frame needs to be sent, 146 bytes of the user data would be filled with idle characters "/ ". The .5 byte or nibble comes from the sync sequence which is 60 bits or 7.5 bytes).

If a full THSD frame is sent, there is no difference for 1-84 bytes of user data with or without FEC.

Layer 2 would send 14.5 bytes over-air without FEC and 28.5 bytes with FEC.

So what is the optimum serial data burst to send to the THSD modem?

Assuming that the serial baud rates can provide enough data to the modem.

For Layer 1, multiples of 147 bytes without FEC and multiples of 84 bytes with FEC will completely fill the user data portion of the over-air packets.

For Layer 2, multiples of 60 without FEC and multiples of 12 with FEC, will completely fill the user data portion of the over-air packets and provide the most effective over-air rate.

What serial port baud rate should I use?

In general if THSD is being used then a serial port baud rate of 19k2 is recommended. This ensures that enough data is provided to the modem (in all configurations) to prevent it "starving".

For FFSK, as the over-air data is transferred at 1200 baud, it is not so important. A rate of 1200 baud or above is acceptable.

If a rate of above 1200 baud is used for FFSK, consideration must be given to prevent over flowing the serial port buffer, and flow control may be a good option.

Can I use my existing base station to pass THSD?

Because of the modulation scheme of THSD and because of the audio bandwidth required to pass it, it is very unlikely that a third party base station can pass THSD.

How many more vehicles can I be able to support if I change to THSD?

If you have an existing fleet (e.g. taxis) using a 1200 baud FFSK data system and you change to THSD at 12Kbps, then it is unlikely that you can support 10 times more vehicles.

There are a number of "fixed" overheads which are similar for both modems (e.g. lead in delays, transmitter key up times), especially if the amount of bytes being transferred at a time is small. As the data speed is increased, the efficiency of the system is not increased in proportion.

A good aim for the example above would be to double the number of vehicles that a system could support.

Can I address a radio individually?

In transparent mode **no** facility is provided for addressing an individual radio. Furthermore, **all** radios on the same channel in the same mode (e.g. THSD transparent) decode data that is transmitted.

Often the addressing scheme is provided by the DTE using a higher level protocol.

An FFSK SDM can be sent to an individual radio, this needs to be initiated using a CCDI command and is limited in length. This SDM can be used to "poll" a TM8000 radio with a GPS attached. The radio returns an SDM with compressed GPS data.

This is a standard programmable feature in the TM8000.

Can I use CTCSS Selcall or DCS with THSD

No, THSD uses most of the available audio bandwidth, therefore no other types of signalling can be used at the same time.

What is a high level protocol?

Often certain types of data systems for different industry segments have one or more common protocols (a set of rules for determining the format transmission of data) that DTE devices (e.g. Programmable Logic Controllers (PLC's), Data loggers) use.

Examples of some industry standard higher level protocols are MODBUS® or DNP3. Sometimes a system integrator may define their own high level protocol for communication between their devices.

7 Related Technical Notes

In additional to this application note, there are some additional technical notes which deal specifically with product configuration:

- TN1022-AN Configuring the TB7100 for Data Operation
- TN919-AN Configuring the TM8000 for Data Operation

8 Publication Information

Compliance Issues

None

CSO Instruction

CSOs please inform registered Systems Integrators that this document is available.

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