

Optoelectronics, Inc.
OptoScan456™
Version 1.2
Serial Interface Specification

June 29, 1994

INTRODUCTION

This document describes the serial interface of the OptoScan456™, an add-in circuit board for the Realistic PRO-2006 or PRO-2005 Scanning VHF/UHF Receiver. The OptoScan456™ provides a serial computer interface, as well as built-in circuitry to decode Continuous Tone-Controlled Squelch System (CTCSS) sub-audible tones, Digitally-Coded Squelch (DCS) codes, and Dual-Tone Multi-Frequency (DTMF) digits. A Realistic PRO-2006 or PRO-2005 receiver equipped with an OptoScan456™, along with a personal computer and the appropriate application software, forms a complete computer-aided scanning system capable of receiving VHF/UHF signals in the range 25 - 519.995 MHz and 760 - 1299.995 MHz. AM, FM-narrowband, and FM-wideband modes are supported.

This document was written to assist the programmer in developing software applications for the OptoScan456™. In this document, the terms *receiver* or *OptoScan456 receiver* generally refer to a PRO-2006 or PRO-2005 receiver with an OptoScan456™ board installed.

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WHAT'S NEW

Version 1.2 of the OptoScan456™ includes several improvements over Version 1.1. The changes are summarized below:

1. Added TRANSFER NEXT FREQUENCY/MODE command and RTS interface signal to implement pipelined frequency and mode selection.
2. Added DCD interface signal to implement hardware squelch status indicator.
3. Corrected 12.5 kHz channel tuning problem.
4. Added 31-digit DTMF buffer. The READ DTMF DIGIT command now returns the next DTMF digit in the order received, or a special code to indicate that the buffer is empty.
5. Added ENABLE SPEAKER AUDIO and DISABLE SPEAKER AUDIO commands.
6. Added ENABLE 5 KHZ SEARCH WINDOW and DISABLE 5 KHZ SEARCH WINDOW commands.
7. Reports signal strength in absolute dBm as measured at the antenna connector.
8. Added access to SOUND SQUELCH indicator. This provides a means of skipping over dead carrier signals.
9. Added second status byte to READ STATUS command for tape recorder, speaker audio, 5 kHz search window, and sound squelch status.
10. Added power-up default frequency of 162.55 MHz, FM-narrowband mode (NOAA weather VHF channel 1).
11. Reversed tape recorder control signal polarity. When tape recorder is enabled, control signal is grounded. When tape recorder is disabled, control signal is open.
12. Suppresses all CI-V command responses if a RECEIVE ADDRESS of 00 is specified.
13. Ignores CI-V command if TRANSMIT ADDRESS matches OptoScan456™ address.
14. READ IDENTIFICATION command now reports Software Version 1.2 and Interface Version 1.1.

ABOUT CI-V

The serial interface on the OptoScan456™ conforms to the Icom CI-V interface standard. The CI-V interface is an asynchronous, half-duplex, TTL serial interface connected in a wire-OR (bussed) configuration. Several different devices can be connected to the bus simultaneously, and each device has its own unique address. Software developers are strongly encouraged to obtain a copy of the *Icom Communication Interface - V Reference Manual* from Icom, Inc. for detailed information on the CI-V interface protocol. The communications parameters for the serial interface are listed in Table 1 below.

Table 1. Communications Parameters.

DATA RATE	DIP switch selectable
START BITS	1
DATA BITS	8
PARITY	NONE
STOP BITS	1

One important thing to note about the CI-V interface is that, as mentioned above, it is connected in a wire-OR configuration. This means that the transmit data signal and the receive data signal are connected together. Therefore, when a command is transmitted by the computer, it is automatically echoed back as received data, followed by the response to the command, if any. For example, if an eleven-byte command is transmitted to a device on the bus, which returns a six-byte response, the computer will receive a total of seventeen bytes. This configuration allows devices on the bus to monitor their own transmissions in order to detect interface collisions. A collision occurs when two or more devices transmit simultaneously. If a collision occurs, the command must be re-transmitted.

The OptoScan456™ includes a built-in CI-V - to - RS-232C interface converter for applications in which only one receiver is connected to a computer. Its purpose is to convert the CI-V interface voltage levels to RS-232C levels compatible with most personal computers. This feature eliminates the need for an external interface converter box in many applications. The RS-232C interface is available on the 9-pin male "D"-type connector located on the rear panel. In addition, the RS-232C interface provides two optional interface signals, RTS and DCD, which can be used to significantly increase the scanning speed of the OptoScan456™. These signals and their functions are not a part of the Icom CI-V interface specification. The use of these signals is described later.

For multiple-receiver applications, such as connection of one or more OptoScan456™ receivers to one or more Icom receivers, a standard CI-V miniature phone jack is provided on the rear panel. In this configuration, an external interface converter box, such as the Optoelectronics model CX12 or the Icom model CT-17, is required to connect the receivers to an RS-232C computer interface. When the CI-V phone jack is being used, the RS-232C transmit and receive data signals on the OptoScan456™ are disabled, but the two additional interface signals, RTS and DCD, are still functional. This allows the increased scanning speed feature to be used even in multiple-receiver applications. However, special cabling is required between the OptoScan456™, the interface converter box, and the computer.

DIP SWITCH SETTINGS

There are two DIP switches located on the OptoScan456™ circuit board. SW1 (farthest from the mounting hole) selects the CI-V interface address. Sixteen different addresses are available. In order to communicate with the OptoScan456™, the computer software must specify the address selected by SW1. The CI-V address switch settings are listed in Table 2 below. All addresses are specified in hexadecimal notation. The factory default setting, address 80, is shown in bold type.

Table 2. CI-V Interface Address Dip Switch (SW1) Settings.

1	2	3	4	ADDRESS	1	2	3	4	ADDRESS
OFF	OFF	OFF	OFF	80	OFF	OFF	OFF	ON	88
ON	OFF	OFF	OFF	81	ON	OFF	OFF	ON	89
OFF	ON	OFF	OFF	82	OFF	ON	OFF	ON	8A
ON	ON	OFF	OFF	83	ON	ON	OFF	ON	8B
OFF	OFF	ON	OFF	84	OFF	OFF	ON	ON	8C
ON	OFF	ON	OFF	85	ON	OFF	ON	ON	8D
OFF	ON	ON	OFF	86	OFF	ON	ON	ON	8E
ON	ON	ON	OFF	87	ON	ON	ON	ON	8F

SW2 (closest to the mounting hole) selects the CI-V interface data rate. In order to communicate with the OptoScan456™, the data rate of the computer serial port must match the data rate selected by SW2. The CI-V data rate settings are listed in Table 3 below. The factory default setting, 9600 bps, is shown in bold type. The 9600 bps data rate is strongly recommended, as a lower data rate will impair scanning speed.

Table 3. CI-V Interface Data Rate Dip Switch (SW2) Settings.

1	2	3	4	DATA RATE	1	2	3	4	DATA RATE
OFF	OFF	OFF	OFF	75 bps	OFF	OFF	OFF	ON	9600 bps
ON	OFF	OFF	OFF	110 bps	ON	OFF	OFF	ON	19200 bps
OFF	ON	OFF	OFF	150 bps	OFF	ON	OFF	ON	38400 bps
ON	ON	OFF	OFF	300 bps	ON	ON	OFF	ON	unused
OFF	OFF	ON	OFF	600 bps	OFF	OFF	ON	ON	unused
ON	OFF	ON	OFF	1200 bps	ON	OFF	ON	ON	unused
OFF	ON	ON	OFF	2400 bps	OFF	ON	ON	ON	unused
ON	ON	ON	OFF	4800 bps	ON	ON	ON	ON	unused

CTCSS/DCS/DTMF DECODER

The OptoScan456™ contains built-in circuitry to decode Continuous Tone-Controlled Squelch System (CTCSS) sub-audible tones, Digitally-Coded Squelch (DCS) codes, and Dual-Tone Multi-Frequency (DTMF) digits. Furthermore, the CTCSS/DCS/DTMF decoder operates whether the receiver is under REMOTE control or LOCAL control. However, decoding only takes place when the squelch is open. Furthermore, CTCSS and DCS decoding only takes place when FM-narrowband mode is selected. If CTCSS or DCS decoding is to be performed while the receiver is under LOCAL control, then FM-narrowband mode must first be selected under REMOTE control, as well as from the front panel under LOCAL control. In other words, the application software must first select REMOTE control, then select FM-narrowband mode, then select LOCAL control. The operator must then select FM-narrowband mode from the front panel.

The OptoScan456™ is capable of decoding 52 CTCSS tones. The specified acquisition time of the CTCSS decoder is 600 milliseconds (0.6 seconds). At times it may be faster, or, if the incoming signal is weak or noisy, it may be slower. The specific CTCSS tones decoded by the OptoScan456™ are listed in Table 4 below.

Table 4. CTCSS tones.

60.0	100.0	151.4	192.8
67.0	103.5	156.7	196.6
69.3	107.2	159.8	199.5
71.9	110.9	162.2	203.5
74.4	114.8	165.5	206.5
77.0	118.8	167.9	210.7
79.7	120.0	171.3	218.1
82.5	123.0	173.8	225.7
85.4	127.3	177.3	229.1
88.5	131.8	179.9	233.6
91.5	136.5	183.5	241.8
94.8	141.3	186.2	250.3
97.4	146.2	189.9	254.1

The OptoScan456™ is capable of decoding 106 DCS codes. The specified acquisition time of the DCS decoder is 350 milliseconds (0.35 seconds). At times it may be faster, or, if the incoming signal is weak or noisy, it may be slower. The specific DCS codes decoded by the OptoScan456™ are listed in Table 5 below.

Table 5. DCS codes.

017	125	251	411	565
023	131	252	412	606
025	132	255	413	612
026	134	261	423	624
031	143	263	431	627
032	145	265	432	631
036	152	266	445	632
043	155	271	446	654
047	156	274	452	662
050	162	306	454	664
051	165	311	455	703
053	172	315	462	712
054	174	325	464	723
065	205	331	465	731
071	212	332	466	732
072	223	343	503	734
073	225	346	506	743
074	226	351	516	754
114	243	356	523	
115	244	364	526	
116	245	365	532	
122	246	371	546	

The OptoScan456™ is capable of decoding 16 DTMF digits. The specified maximum digit rate of the DTMF decoder is 10 digits per second. The specific DTMF digits decoded by the OptoScan456™ are listed in Table 6 below.

Table 6. DTMF digits.

1	2	3	A
4	5	6	B
7	8	9	C
*	0	#	D

PIPELINED TUNING

Perhaps the most significant feature of the OptoScan456™ is its ability to pipeline the tuning operation. This is important because it nearly doubles the maximum possible scanning speed of the PRO-2006 or PRO-2005 receiver. By making use of this feature, scanning speeds of up to 50 channels per second are possible.

In non-pipelined computer-aided scanning systems, scanning each frequency involves three main steps performed in sequence. First, the command or commands to tune the receiver to the new frequency and/or mode must be issued. The amount of time required by this step depends on the number of bytes in the command or commands and their responses, and the serial interface data rate.

The second step involves the settling time of the receiver, once the new frequency and/or mode command or commands have been received. The receiver settling time includes the time necessary for the synthesizers to slew and re-acquire lock, the time necessary for the preselector filters to settle, and the time necessary for the squelch detection circuitry to respond. The settling time of the PRO-2006 or PRO-2005 receiver with the OptoScan456™ installed is 20 milliseconds (0.02 seconds).

Third, the command to request squelch status must be issued and the response returned. The amount of time required by this step is again dependent on the length of the command and its response, and the serial interface data rate.

To increase scanning speed, the overall time required for the three steps outlined above must be reduced. Receiver settling time is generally a function of the hardware architecture. Therefore, nothing much can be done to reduce the settling time, short of a fairly major re-design of the receiver hardware. The remaining area of concern is the transit time of commands and responses on the serial interface.

One obvious way to reduce the serial interface transit time is to simply increase the data rate. However, even at 19,200 bps, the practical limit of most PC-based serial ports, the collective transit time of the necessary commands and responses is several milliseconds.

The most desirable solution is to completely eliminate the serial interface transit time from impacting the scanning speed. This can be accomplished by the use of pipelining. The basic concept of the OptoScan456™ pipelined tuning scheme is to take advantage of the otherwise wasted receiver settling time by sending the next frequency and mode to the receiver while it is still settling on the current frequency and mode. A special command, TRANSFER NEXT FREQUENCY/MODE, is provided in which the next frequency and mode are sent to the receiver, but do not take effect until commanded to do so. Therefore, the transit time of the command is totally transparent, as long as it is completed within the settling time of the receiver. This can be easily accomplished at an interface data rate of 9600 bps. In fact, there is no advantage to increasing the data rate beyond 9600 bps, since the limiting factor is the 20 millisecond receiver settling time.

To complete the operation, two hardware interface signals are added. First, the Request To Send (RTS) RS-232C interface signal is used as a hardware tuning command. Once the next frequency and mode have been sent to the receiver using the TRANSFER NEXT FREQUENCY/MODE command, the receiver is commanded to tune to the next frequency and mode by simply changing the state of the RTS signal. If it was previously negated, it is asserted. If it was previously asserted, it is negated. The receiver immediately begins settling on the next frequency and mode, which have now become the current frequency and mode.

Second, the Data Carrier Detect (DCD) RS-232C interface signal is used as a hardware squelch indicator. This eliminates the need to send a command over the serial interface to request squelch status, and wait for the response. The steps involved in implementing a fully pipelined computer-aided scanning system are summarized below:

- Step 1: Command the receiver to select REMOTE control.
- Step 2: Send the next frequency and mode to the receiver using the TRANSFER NEXT FREQUENCY/MODE command.
- Step 3: Change the state of the RTS interface signal to cause the next frequency and mode to become the current frequency and mode, and the receiver to begin settling.
- Step 4: While the receiver is still settling on the current frequency and mode, send the next frequency and mode to the receiver using the TRANSFER NEXT FREQUENCY/MODE command.
- Step 5: Wait for the receiver to finish settling. The total settling time, including sending the next frequency and mode, is 20 milliseconds (0.02 seconds).
- Step 6: Check the squelch status by reading the DCD interface signal. If the squelch is open, scanning is stopped. Otherwise, scanning continues. Optionally, the status of the CTCSS/DCS/DTMF decoder can be checked, and the appropriate action taken.
- Step 7: Continuously repeat steps 3 through 6 above.

Of course, either of the two hardware interface signals can be used without the other, but maximum scanning speed is achieved when both are used. It should be noted that the implementation of the RTS and DCD interface signals by the OptoScan456™ is not a part of the Icom CI-V interface specification, which specifies only the serial interface protocol. If more than one OptoScan456™ receiver is connected on the bus, then special hardware provisions must be made to provide RTS and DCD signals for each receiver. However, the details are beyond the scope of this specification. Alternatively, the appropriate serial interface commands can be used in place of the two hardware signals, but maximum scanning speed will be degraded.

COMMAND REFERENCE

As mentioned earlier, the OptoScan456™ conforms to the Icom CI-V interface standard. In this section, all CI-V command and response bytes are expressed in hexadecimal notation.

The OptoScan456™ recognizes twenty-three different commands. The first nine commands are standard CI-V commands compatible with receivers such as the Icom R-7100. The remaining "7F" series commands are special OptoScan456™ commands provided to access features, such as CTCSS/DCS/DTMF decoding, not generally found on other receivers. The commands, along with their corresponding responses, are summarized in Table 7 below.

Following the table is a detailed description of each of the commands, including examples illustrating their use. In the command descriptions, "ra" refers to the RECEIVE ADDRESS, and "ta" refers to the TRANSMIT ADDRESS.

The RECEIVE ADDRESS is the address of the OptoScan456™. DIP switch SW1 is used to select any address in the range 80 through 8F. Each device on the CI-V bus must have its own unique address. The OptoScan456™ will not process any command in which the RECEIVE ADDRESS does not match the address selected by SW1. However, the OptoScan456™ will process commands with a RECEIVE ADDRESS of 00, but all command responses will be suppressed. A RECEIVE ADDRESS of 00 has special meaning. It provides a means for a device on the CI-V bus to transmit a command to all other devices simultaneously. However, since several simultaneous responses would cause a collision, the responses are suppressed.

The TRANSMIT ADDRESS is the address of the device which is transmitting the command to the OptoScan456™. In most cases, this device is a personal computer executing application software, usually referred to as the CONTROLLER. The standard address for the CONTROLLER is E0, but any address can be used for the TRANSMIT ADDRESS. However, the TRANSMIT ADDRESS must be in the range 01 to EF. Also, the OptoScan456™ will not process any command in which the TRANSMIT ADDRESS matches its own address selected by SW1.

Table 7. OptoScan456™ CI-V Interface Command Summary.

COMMAND	SUB-COMMAND	DESCRIPTION
00	-	Transfer frequency, no response.
01	-	Transfer mode, no response.
02	-	Read upper/lower-edge frequency.
03	-	Read frequency.
04	-	Read mode.
05	-	Write frequency.
06	-	Write mode.
15	01	Read squelch status.
15	02	Read signal strength.
7F	01	Select LOCAL control (front panel).
7F	02	Select REMOTE control (computer interface).
7F	03	Enable tape recorder.
7F	04	Disable tape recorder.
7F	05	Read status.
7F	06	Read CTCSS tone.
7F	07	Read DCS code.
7F	08	Read DTMF digit.
7F	09	Read identification
7F	0A	Enable speaker audio.
7F	0B	Disable speaker audio.
7F	0C	Enable 5 kHz search window.
7F	0D	Disable 5 kHz search window.
7F	0E	Transfer next frequency/mode, no response.

TRANSFER FREQUENCY

Command:

FE	FE	ra	ta	00	frequency	FD
----	----	----	----	----	-----------	----

Example:

437.162500 MHz

FE	FE	80	E0	00	00	25	16	37	04	FD
----	----	----	----	----	----	----	----	----	----	----

Response:

NONE

Description:

This command selects the operating frequency of the receiver. However, no response is returned under any condition. This command is only valid when the unit is under REMOTE control.

The frequency data is in the form of five bytes, each consisting of two BCD digits. The order of the ten BCD digits is as follows: 10 Hz digit, 1 Hz digit, 1 kHz digit, 100 Hz digit, 100 kHz digit, 10 kHz digit, 10 MHz digit, 1 MHz digit, 1 GHz digit, 100 MHz digit. See the example shown above.

If the received frequency is out of range or is not an even multiple of 5 kHz or 12.5 kHz, or if the unit is under LOCAL control, the command is ignored.

TRANSFER MODE

Command:

FE	FE	ra	ta	01	md	FD
----	----	----	----	----	----	----

md

 is a BCD value representing the selected operating mode. BCD values are encoded as follows:

- 02: AM
- 05: FM-narrowband
- 06: FM-wideband

Example:

FM-narrowband

FE	FE	80	E0	01	05	FD
----	----	----	----	----	----	----

Response:

NONE

Description:

This command selects the operating mode of the receiver. However, no response is returned under any condition. This command is only valid when the unit is under REMOTE control.

The mode data is in the form of one byte, consisting of two BCD digits. See the example shown above.

If the received mode is not a valid mode select code, or if the unit is under LOCAL control, the command is ignored.

READ UPPER/LOWER-EDGE FREQUENCY

Command:

FE	FE	ra	ta	02	FD
----	----	----	----	----	----

Example:

FE	FE	80	E0	02	FD
----	----	----	----	----	----

Response:

FE	FE	ta	ra	02	lower frequency	2D	upper frequency	FD
----	----	----	----	----	-----------------	----	-----------------	----

Example:

25.000000 - 1299.995000 MHz

FE	FE	E0	80	02	00	00	00	25	00	2D	00	50	99	99	12	FD
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Description:

This command instructs the unit to send the upper and lower edge of the operating frequency range. This command is valid at any time.

The frequency data is in the form of five bytes, each consisting of two BCD digits. The order of the ten BCD digits is as follows: 10 Hz digit, 1 Hz digit, 1 kHz digit, 100 Hz digit, 100 kHz digit, 10 kHz digit, 10 MHz digit, 1 MHz digit, 1 GHz digit, 100 MHz digit. See the example shown above.

READ FREQUENCY

Command:

FE	FE	ra	ta	03	FD
----	----	----	----	----	----

Example:

FE	FE	80	E0	03	FD
----	----	----	----	----	----

Response:

FE	FE	ta	ra	03	frequency	FD
----	----	----	----	----	-----------	----

Examples:

162.550000 MHz

FE	FE	E0	80	03	00	00	55	62	01	FD
----	----	----	----	----	----	----	----	----	----	----

Error

FE	FE	E0	80	FA	FD
----	----	----	----	----	----

Description:

This command instructs the unit to send the current operating frequency. This command is only valid when the unit is under REMOTE control.

The frequency data is in the form of five bytes, each consisting of two BCD digits. The order of the ten BCD digits is as follows: 10 Hz digit, 1 Hz digit, 1 kHz digit, 100 Hz digit, 100 kHz digit, 10 kHz digit, 10 MHz digit, 1 MHz digit, 1 GHz digit, 100 MHz digit. See the example shown above.

If the unit is under LOCAL control, the command is ignored, and the error response is returned.

READ MODE

Command:

FE	FE	ra	ta	04	FD
----	----	----	----	----	----

Example:

FE	FE	80	E0	04	FD
----	----	----	----	----	----

Response:

FE	FE	ta	ra	04	md	FD
----	----	----	----	----	----	----

md

 is a BCD value representing the selected operating mode. BCD values are encoded as follows:

- 02: AM
- 05: FM-narrowband
- 06: FM-wideband

Examples:

AM

FE	FE	E0	80	04	02	FD
----	----	----	----	----	----	----

Error

FE	FE	E0	80	FA	FD
----	----	----	----	----	----

Description:

This command instructs the unit to send the current operating mode. This command is only valid when the unit is under REMOTE control.

The mode data is in the form of one byte, consisting of two BCD digits. See the example shown above.

If the unit is under LOCAL control, the command is ignored, and the error response is returned.

WRITE FREQUENCY

Command:

FE	FE	ra	ta	05	frequency	FD
----	----	----	----	----	-----------	----

Example:

162.550000 MHz

FE	FE	80	E0	05	00	00	55	62	01	FD
----	----	----	----	----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	FB or FA	FD
----	----	----	----	----------	----

Examples:

OK

FE	FE	E0	80	FB	FD
----	----	----	----	----	----

Error

FE	FE	E0	80	FA	FD
----	----	----	----	----	----

Description:

This command selects the operating frequency of the receiver. This command is only valid when the unit is under REMOTE control.

The frequency data is in the form of five bytes, each consisting of two BCD digits. The order of the ten BCD digits is as follows: 10 Hz digit, 1 Hz digit, 1 kHz digit, 100 Hz digit, 100 kHz digit, 10 kHz digit, 10 MHz digit, 1 MHz digit, 1 GHz digit, 100 MHz digit. See the example shown above.

If the received frequency is out of range or is not an even multiple of 5 kHz or 12.5 kHz, or if the unit is under LOCAL control, the command is ignored, and the error response is returned.

WRITE MODE

Command:

FE	FE	ra	ta	06	md	FD
----	----	----	----	----	----	----

md

 is a BCD value representing the selected operating mode. BCD values are encoded as follows:

- 02: AM
- 05: FM-narrowband
- 06: FM-wideband

Example:

FM-wideband

FE	FE	80	E0	06	06	FD
----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	FB or FA	FD
----	----	----	----	----------	----

Examples:

OK

FE	FE	E0	80	FB	FD
----	----	----	----	----	----

Error

FE	FE	E0	80	FA	FD
----	----	----	----	----	----

Description:

This command selects the operating mode of the receiver. This command is only valid when the unit is under REMOTE control.

The mode data is in the form of one byte, consisting of two BCD digits. See the example shown above.

If the received mode is not a valid mode select code, or if the unit is under LOCAL control, the command is ignored, and the error response is returned.

READ SQUELCH STATUS

Command:

FE	FE	ra	ta	15	01	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	15	01	FD
----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	15	01	sd	FD
----	----	----	----	----	----	----	----

Examples:

Squelch closed

FE	FE	E0	80	15	01	00	FD
----	----	----	----	----	----	----	----

Squelch open

FE	FE	E0	80	15	01	01	FD
----	----	----	----	----	----	----	----

Description:

This command instructs the unit to send the current squelch status. This command is valid at any time.

The squelch status data is in the form of one byte, consisting of two BCD digits. See the examples shown above.

READ SIGNAL STRENGTH

Command:

FE	FE	ra	ta	15	02	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	15	02	FD
----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	15	02	sd	FD
----	----	----	----	----	----	----	----

Examples:

0 dBm

FE	FE	E0	80	15	02	00	00	FD
----	----	----	----	----	----	----	----	----

- 67 dBm

FE	FE	E0	80	15	02	00	67	FD
----	----	----	----	----	----	----	----	----

- 125 dBm

FE	FE	E0	80	15	02	01	25	FD
----	----	----	----	----	----	----	----	----

Description:

This command instructs the unit to send the current signal strength. This command is valid at any time.

The signal strength data is in the form of two bytes, each consisting of two BCD digits. The signal strength is reported in units of absolute dBm as measured at the antenna connector. The reported signal strength ranges from a maximum signal of 0 dBm to a minimum signal of - 125 dBm. A minus sign is implied. See the examples shown above.

SELECT LOCAL CONTROL

Command:

FE	FE	ra	ta	7F	01	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	7F	01	FD
----	----	----	----	----	----	----

Response:

OK

FE	FE	ta	ra	FB	FD
----	----	----	----	----	----

Example:

OK

FE	FE	E0	80	FB	FD
----	----	----	----	----	----

Description:

This command selects LOCAL control. This command is valid at any time.

When the unit is under LOCAL control, the OptoScan456™ board relinquishes control of the receiver hardware to the PRO-2006 or PRO-2005 processor. However, the operating parameters are retained for use when the unit is under REMOTE control.

SELECT REMOTE CONTROL

Command:

FE	FE	ra	ta	7F	02	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	7F	02	FD
----	----	----	----	----	----	----

Response:

OK

FE	FE	ta	ra	FB	FD
----	----	----	----	----	----

Example:

OK

FE	FE	E0	80	FB	FD
----	----	----	----	----	----

Description:

This command selects REMOTE control. This command is valid at any time.

When the unit is under REMOTE control, the OptoScan456™ board shuts down the PRO-2006 or PRO-2005 processor, and takes control of the receiver hardware.

ENABLE TAPE RECORDER

Command:

FE	FE	ra	ta	7F	03	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	7F	03	FD
----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	FB or FA	FD
----	----	----	----	----------	----

Examples:

OK

FE	FE	E0	80	FB	FD
----	----	----	----	----	----

Error

FE	FE	E0	80	FA	FD
----	----	----	----	----	----

Description:

This command enables a tape recorder connected to the TAPE PAUSE output. This command is only valid when the unit is under REMOTE control.

The TAPE PAUSE output provides an NPN transistor open collector which is grounded when the tape recorder is enabled, and open when the tape recorder is disabled. The power-up default mode is tape recorder disabled.

If the unit is under LOCAL control, the command is ignored, and the error response is returned.

DISABLE TAPE RECORDER

Command:

FE	FE	ra	ta	7F	04	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	7F	04	FD
----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	FB or FA	FD
----	----	----	----	----------	----

Examples:

OK

FE	FE	E0	80	FB	FD
----	----	----	----	----	----

Error

FE	FE	E0	80	FA	FD
----	----	----	----	----	----

Description:

This command disables a tape recorder connected to the TAPE PAUSE output. This command is only valid when the unit is under REMOTE control.

The TAPE PAUSE output provides an NPN transistor open collector which is grounded when the tape recorder is enabled, and open when the tape recorder is disabled. The power-up default mode is tape recorder disabled.

If the unit is under LOCAL control, the command is ignored, and the error response is returned.

READ STATUS

Command:

FE	FE	ra	ta	7F	05	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	7F	05	FD
----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	7F	05	s1	s2	FD
----	----	----	----	----	----	----	----	----

s1 is a hexadecimal byte representing composite status information. Individual bits are encoded as follows:

- bit 0: 1 = Remote control
- bit 1: 1 = DTMF digit/s pending
- bit 2: 1 = DTMF buffer overrun
- bit 3: Unused, always 0
- bit 4: 1 = Squelch open
- bit 5: 1 = CTCSS tone active
- bit 6: 1 = DCS code active
- bit 7: Unused, always 0

s2 is a hexadecimal byte representing composite status information. Individual bits are encoded as follows:

- bit 0: 1 = Tape recorder enabled
- bit 1: 1 = Speaker audio enabled
- bit 2: 1 = 5 kHz search window enabled
- bit 3: Unused, always 0
- bit 4: 1 = Audio present
- bit 5: Reserved
- bit 6: Reserved
- bit 7: Unused, always 0

Example:

Remote mode, DTMF digit pending, squelch open, DCS code active, Audio enabled, Audio present

FE	FE	E0	80	7F	05	53	12	FD
----	----	----	----	----	----	----	----	----

Description:

This command contains all pertinent information about the receiver and CTCSS/DCS/DTMF decoder, including squelch status. Therefore, the READ SQUELCH STATUS command is optional. The following is a discussion of the use of the status bits contained in the READ STATUS command. Note that the CTCSS/DCS/DTMF decoder is only enabled when the squelch is open. Therefore, the appropriate status bits should be checked frequently while the squelch is open.

s1, bit 0: REMOTE CONTROL. This bit is set when the receiver is under REMOTE control, and cleared when the receiver is under LOCAL control. It is a good idea to check this bit periodically, in case the receiver has been turned off and
and

s1, bit 1: DTMF PENDING. This bit is set if one or more DTMF digits are waiting in the 31-digit DTMF buffer. One or more READ DTMF DIGIT commands should then be issued to read the new digits. The DTMF PENDING bit is automatically cleared when the last digit is read from the DTMF buffer. The READ DTMF DIGIT command will always return the next DTMF order received. In other words, the DTMF buffer works like a FIFO. Once the DTMF buffer is empty, the READ DTMF DIGIT command will return a "99" code to indicate that the buffer is empty. This feature eliminates the need to check the DTMF PENDING bit after each digit has been read from the buffer.

s1, bit 2: DTMF OVERRUN. This bit is set if one or more new DTMF digits are received after the DTMF buffer is full. It is an indication that one or more DTMF digits have been lost. Any digits received after the DTMF buffer becomes full are discarded. The DTMF OVERRUN bit is cleared when a READ DTMF DIGIT command is issued. The maximum supported DTMF digit rate is approximately 10 per second. Therefore, the DTMF PENDING bit should be checked at least every two to three seconds to avoid losing digits.

s1, bit 3: UNUSED. This bit will always be zero.

s1, bit 4: SQUELCH OPEN. This bit is set when the squelch is open, and cleared when the squelch is closed. This bit provides that same information as the READ SQUELCH STATUS command.

s1, bit 5: CTCSS ACTIVE. This bit is set when a valid CTCSS tone is currently being received. A READ CTCSS TONE command should then be issued to read the CTCSS tone. The READ CTCSS TONE command will always return the most recent CTCSS tone, even if the tone is no longer being received, so the command should only be issued while the CTCSS ACTIVE bit is set. Note that the CTCSS ACTIVE bit does not function the way the DTMF PENDING bit does. The CTCSS ACTIVE bit is only set while a valid CTCSS tone is being received. It does not store the previous occurrence of a CTCSS tone.

s1, bit 6: DCS ACTIVE. This bit is set when a valid DCS code is currently being received. A READ DCS CODE command should then be issued to read the DCS code. The READ DCS CODE command will always return the most recent DCS code, even if the code is no longer being received, so the command should only be issued while the DCS ACTIVE bit is set. Note that the DCS ACTIVE bit does not function the way the DTMF PENDING bit does. It is only set while a valid DCS code is being received. It does not store the previous occurrence of a DCS code.

s1, bit 7: UNUSED. This bit will always be zero.

s2, bit 0: TAPE ENABLED. This bit is set when the tape recorder is enabled, and cleared when the tape recorder is disabled. The tape recorder is enabled using the ENABLE TAPE RECORDER command. The tape recorder is disabled using the DISABLE TAPE RECORDER command.

- s2, bit 1: SPEAKER ENABLED. This bit is set if the speaker audio is enabled, and cleared if the speaker audio is disabled. The speaker audio is enabled using the ENABLE SPEAKER AUDIO command. The speaker audio is disabled using the DISABLE SPEAKER AUDIO command.
- s2, bit 2: 5 KHZ SEARCH. This bit is set if the 5 kHz search window is enabled, and cleared if the 5 kHz search window is disabled. The 5 kHz search window is enabled using the ENABLE 5 KHZ SEARCH WINDOW command. The 5 kHz search window is disabled using the DISABLE 5 KHZ SEARCH WINDOW command.
- s2, bit 3: UNUSED. This bit will always be zero.
- s2, bit 4: AUDIO PRESENT. This bit is set when audio is present on the current frequency, and cleared when no audio is present. This bit allows the programmer to make use of the SOUND SQUELCH feature of the PRO-2006/5 receiver, which provides a means to skip over dead carrier signals. However, the SOUND SQUELCH switch on the receiver front panel must be ON for this bit to function. If the SOUND SQUELCH switch is OFF, AUDIO PRESENT bit will always be set.
- the
- s2, bit 5: RESERVED. This bit is reserved for future use.
- s2, bit 6: RESERVED. This bit is reserved for future use.
- s2, bit 7: UNUSED. This bit will always be zero.

READ CTCSS TONE

Command:

FE	FE	ra	ta	7F	06	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	7F	06	FD
----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	7F	06	sd	FD
----	----	----	----	----	----	----	----

Examples:

82.5 Hz

FE	FE	E0	80	7F	06	08	25	FD
----	----	----	----	----	----	----	----	----

103.5 Hz

FE	FE	E0	80	7F	06	10	35	FD
----	----	----	----	----	----	----	----	----

Description:

This command instructs the unit to send the most recent CTCSS tone. This command is valid at any time.

The CTCSS data is in the form of two bytes, each consisting of two BCD digits. The order of the four BCD digits is as follows: 100 Hz digit, 10 Hz digit, 1 Hz digit, 0.1 Hz digit. See the examples shown above. A complete list of the CTCSS tones decoded by the OptoScan456™ is given in Table 3.

READ DCS CODE

Command:

FE	FE	ra	ta	7F	07	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	7F	07	FD
----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	7F	07	sd	FD
----	----	----	----	----	----	----	----

Examples:

023

FE	FE	E0	80	7F	07	00	23	FD
----	----	----	----	----	----	----	----	----

732

FE	FE	E0	80	7F	07	07	32	FD
----	----	----	----	----	----	----	----	----

Description:

This command instructs the unit to send the most recent DCS code. This command is valid at any time.

The DCS data is in the form of two bytes, each consisting of two BCD digits. The order of the four BCD digits is as follows: unused digit (always 0), 100's digit, 10's digit, 1's digit. See the examples shown above. A complete list of the DCS codes decoded by the OptoScan456™ is given in Table 4.

READ DTMF DIGIT

Command:

FE	FE	ra	ta	7F	08	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	7F	08	FD
----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	7F	08	sd	FD
----	----	----	----	----	----	----	----

sd

 is a BCD value representing the next DTMF digit. BCD values are encoded as follows:

00:	"0"	08:	"8"	99:	DTMF Buffer Empty
01:	"1"	09:	"9"		
02:	"2"	10:	"A"		
03:	"3"	11:	"B"		
04:	"4"	12:	"C"		
05:	"5"	13:	"D"		
06:	"6"	14:	"*"		
07:	"7"	15:	"#"		

Examples:

"3"

FE	FE	E0	80	7F	08	03	FD
----	----	----	----	----	----	----	----

"A"

FE	FE	E0	80	7F	08	10	FD
----	----	----	----	----	----	----	----

DTMF Buffer Empty

FE	FE	E0	80	7F	08	99	FD
----	----	----	----	----	----	----	----

Description:

This command instructs the unit to send the next DTMF digit waiting in the DTMF buffer. This command is valid at any time.

The DTMF data is in the form of one byte, consisting of two BCD digits. The BCD digits are encoded as shown above. Each issuance of the READ DTMF DIGIT command causes the next digit in the DTMF buffer to be sent in the order it was received, in a First-In-First-Out (FIFO) fashion. Once the DTMF buffer is empty, the READ DTMF DIGIT command returns the DTMF Buffer Empty code. See the examples shown above.

READ IDENTIFICATION

Command:

FE	FE	ra	ta	7F	09	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	7F	09	FD
----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	7F	09	id	sv	iv	FD
----	----	----	----	----	----	----	----	----	----

Example:

OptoScan456™, software version 1.2, interface version 1.1

FE	FE	E0	80	7F	09	34	35	36	12	11	FD
----	----	----	----	----	----	----	----	----	----	----	----

Description:

This command instructs the unit to send the identification information. This command is valid at any time.

The identification data is in the form of five bytes, each consisting of two BCD digits. The first six BCD digits uniquely identify the device. The next two BCD digits indicate the current software version. The last two BCD digits indicate the current interface version.

ENABLE SPEAKER AUDIO

Command:

FE	FE	ra	ta	7F	0A	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	7F	0A	FD
----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	FB or FA	FD
----	----	----	----	----------	----

Examples:

OK

FE	FE	E0	80	FB	FD
----	----	----	----	----	----

Error

FE	FE	E0	80	FA	FD
----	----	----	----	----	----

Description:

This command enables the speaker audio. This command is only valid when the unit is under REMOTE control.

The speaker audio can be enabled and disabled under software control to facilitate selective scanning. This feature allows the software to mute the speaker audio unless a certain CTCSS tone, or DCS code, or DTMF digit sequence is detected on a particular frequency. The power-up default mode is speaker audio enabled.

If the unit is under LOCAL control, the command is ignored, and the error response is returned.

DISABLE SPEAKER AUDIO

Command:

FE	FE	ra	ta	7F	0B	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	7F	0B	FD
----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	FB or FA	FD
----	----	----	----	----------	----

Examples:

OK

FE	FE	E0	80	FB	FD
----	----	----	----	----	----

Error

FE	FE	E0	80	FA	FD
----	----	----	----	----	----

Description:

This command disables the speaker audio. This command is only valid when the unit is under REMOTE control.

The speaker audio can be enabled and disabled under software control to facilitate selective scanning. This feature allows the software to mute the speaker audio unless a certain CTCSS tone, or DCS code, or DTMF digit sequence is detected on a particular frequency. The power-up default mode is speaker audio enabled.

If the unit is under LOCAL control, the command is ignored, and the error response is returned.

ENABLE 5 KHZ SEARCH WINDOW

Command:

FE	FE	ra	ta	7F	0C	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	7F	0C	FD
----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	FB or FA	FD
----	----	----	----	----------	----

Examples:

OK

FE	FE	E0	80	FB	FD
----	----	----	----	----	----

Error

FE	FE	E0	80	FA	FD
----	----	----	----	----	----

Description:

This command enables the 5 kHz search window. This command is only valid when the unit is under REMOTE control.

The 5 kHz search window can be enabled by the software when a limit search is conducted using 5 kHz channel spacing. This provides more selective squelch operation, which helps prevent the receiver from stopping 5 or 10 kHz away from the actual transmitter frequency. When 12.5 kHz or wider channel spacing is used, the 5 kHz search window should be disabled. The power-up default mode is 5 kHz search window disabled.

If the unit is under LOCAL control, the command is ignored, and the error response is returned.

DISABLE 5 KHZ SEARCH WINDOW

Command:

FE	FE	ra	ta	7F	0D	FD
----	----	----	----	----	----	----

Example:

FE	FE	80	E0	7F	0D	FD
----	----	----	----	----	----	----

Response:

FE	FE	ta	ra	FB or FA	FD
----	----	----	----	----------	----

Example:

OK

FE	FE	E0	80	FB	FD
----	----	----	----	----	----

Error

FE	FE	E0	80	FA	FD
----	----	----	----	----	----

Description:

This command disables the 5 kHz search window. This command is only valid when the unit is under REMOTE control.

The 5 kHz search window can be enabled by the software when a limit search is conducted using 5 kHz channel spacing. This provides more selective squelch operation, which helps prevent the receiver from stopping 5 or 10 kHz away from the actual transmitter frequency. When 12.5 kHz or wider channel spacing is used, the 5 kHz search window should be disabled. The power-up default mode is 5 kHz search window disabled.

If the unit is under LOCAL control, the command is ignored, and the error response is returned.

TRANSFER NEXT FREQUENCY/MODE

Command:

FE	FE	ra	ta	7F	0E	frequency	md	FD
----	----	----	----	----	----	-----------	----	----

md

 is a BCD value representing the selected operating mode. BCD values are encoded as follows:

- 02: AM
- 05: FM-narrowband
- 06: FM-wideband

Examples:

435.162500 MHz, FM-narrowband

FE	FE	80	E0	7F	0E	00	25	16	35	04	05	FD
----	----	----	----	----	----	----	----	----	----	----	----	----

99.500000 MHz, FM-wideband

FE	FE	80	E0	7F	0E	00	00	50	99	00	06	FD
----	----	----	----	----	----	----	----	----	----	----	----	----

Response:

NONE

Description:

This command selects the next operating frequency and operating mode of the receiver. However, no response is returned under any condition. This command is only valid when the unit is under REMOTE control.

The frequency data is in the form of five bytes, each consisting of two BCD digits. The order of the ten BCD digits is as follows: 10 Hz digit, 1 Hz digit, 1 kHz digit, 100 Hz digit, 100 kHz digit, 10 kHz digit, 10 MHz digit, 1 MHz digit, 1 GHz digit, 100 MHz digit. The mode data is in the form of one byte, consisting of two BCD digits. See the examples shown above.

This command allows the software to make use of the OptoScan456™ pipelined tuning feature. The next frequency and mode specified by this command are stored by the OptoScan456™. However, the receiver is not tuned to the next frequency and mode until a transition is detected on the RTS interface signal. This feature allows the next frequency and mode to be sent to the receiver while waiting for the receiver to settle on the current frequency and mode.

If the received frequency is out of range or is not an even multiple of 5 kHz or 12.5 kHz, or if the received mode is not a valid mode select code, or if the unit is under LOCAL control, the command is ignored.

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