Kenwood Program Structure

1. All command sequences are terminated with 0xff being the last byte. So far I have seen 0x00, 0x02, 0x03, 0x05, 0x07 and 0x08 as a structure header. The following information will describe the data sent by a Kenwood TM-231 when buttons are depressed on the front panel. The Kenwood microphone on these series of radios provides serial data using the Down pin 3 for serial in, Up pin 4 for clock and the PTT pin 2 for serial out when pin 6 is pulled high. These structures can be combined to perform several operations at once.
    a. 0x00 Frequency / Tone / Step.
    b. 0x02 Current configuration such as power, tone, etc….
    c. 0x03 Ring / Priority notification structure.
    d. 0x05 Squelch open / close structure.
    e. 0x07 Current memory channel or function number.
    f. 0x08 Function button information structure.
2. Structure Header byte 0x00 has a total of eight words that are eight bits each. The following information will break down how these fields are used and when.
    a. Bits zero through three are set to a one when a given field is not to be displayed or has no relevance. The format fields for bits zero through three are Frequency/Tone/Step.
    b. Bits zero through three in bytes one, two and seven are set to a one when tone frequency or the step frequency configuration bits are set in structure 0x02. Setting these bits to a one prevents information from being displayed on the front panel.
        i. Example of 88.5 tone 0x00 0x4f 0x4f 0x6f 0x48 0x48 0x55 0x8f
        ii. Example of 107.2 tone 0x00 0x4f 0x4f 0x61 0x40 0x47 0x52 0x8f
        iii. Example of 123.0 tone 0x00 0x4f 0x4f 0x61 0x42 0x43 0x50 0x8f
    c. Also bits zero through three in byte three are set to a one when the step frequency configuration bit is set.
        i. Example of 12.5 step 0x00 0x4f 0x4f 0x6f 0x41 0x42 0x55 0x8f
        ii. Example of 20.0 step 0x00 0x4f 0x4f 0x6f 0x42 0x40 0x5f 0x8f
    d. The Hundred Hertz field is only used when the step has been set to something as 12.5 MHz step. Below are a few examples of a frequency format.
        i. Example of 147.350 0x00 0x41 0x44 0x67 0x43 0x45 0x50 0x8f
        ii. Example of 147.362.5 0x00 0x41 0x44 0x67 0x43 0x46 0x52 0x85

	Bit 7	*Bit 6*	*Bit 5*	*Bit 4*	*Bit 3*	*Bit 2*	*Bit 1*	*Bit 0*
00	0	0	0	0	0	0	0	0
01	0	1	0	0	100 MHZ/1/1	100 MHz/1/1	100 MHz/1/1	100 MHz/1/1
02	0	1	0	0	10 MHz/1/1	10 MHz/1/1	10 MHz/1/1	10 MHz/1/1
03	0	1	1	0	1 MHz/Tone/1	1 MHz/Tone/1	1 MHz/Tone/1	1 MHz/Tone/1
04	0	1	0	0	100 KHz/Tone/Step	100 KHz/Tone/Step	100 KHz/Tone/Step	100 KHz/Tone/Step
05	0	1	0	0	10 KHz/Tone/Step	10 KHz/Tone/Step	10 KHz/Tone/Step	10 KHz/Tone/Step
06	0	1	0	1	1 KHz/Tone/Step	1 KHz/Tone/Step	1 KHz/Tone/Step	1 KHz/Tone/Step
07	1	0	0	0	100 Hz/1/1	100 Hz/1/1	100 Hz/1/1	100 Hz/1/1
	Bit 7	*Bit 6*	*Bit 5*	*Bit 4*	*Bit 3*	*Bit 2*	*Bit 1*	*Bit 0*

3. This will define structure header 0x02 which has a total of seven words that are eight bits each.
    a. The display will show REV and the frequency returned will be the reverse frequency when bit three of word one is set. The example below shows structure 0x00 and structure 0x02 combined.
        i. Example reverse of 147.362.5 with a positive offset.

0x00 0x41 0x44 0x67 0x49 0x46 0x52 0x85 0x02 0x45 0x40 0x40 0x40 0x40 0x40 0x80

        ii. Also take note that structure 0x00 was sent prior to structure 0x02. The terminating byte 0xff was not sent between structures.
    b. Bits zero and one of word one will define frequency offset operation. These two bits are never set at the same time together.
        i. Bit zero defines a positive offset
        ii. Bit one defines a simplex operation
        iii. If neither bit is set then use a negative offset.
    c. Bits two and three in word two are used together to form the type of encoding or decoding to use.
        i. If bit two and three are not set then there is no encode or decode of a PL tone.
        ii. Bit two turns on the PL tone encoding.
        iii. When bit two and three are set. This turns on the tone encode and decode of a PL tone.
            1. Example of tone encode 0x02 0x40 0x44 0x40 0x40 0x40 0x80
            2. Example of tone decode 0x02 0x40 0x4c 0x40 0x40 0x40 0x80
            3. Example of tones off 0x02 0x40 0x40 0x40 0x40 0x40 0x80
    d. Priority Alert functions is active when bit one of word two is set.
    e. Call function has been activated when bit zero of word two is set.
    f. If bit zero of word three is set, then change step frequency is active.
    g. If bit one of word three is set, then change PL tone frequency is active.
    h. If set then Beep Mode is off.
    i. Bit three of word three indicates that we are in memory mode. Also bit four of word one in structure 0x07 is cleared to indicate the memory channel that is active. If this bit is clear then the radio is in VFO mode of operation.
    j. Bit three of word four indicates the memory channel will be excluded from memory scans.
    k. Bit zero and bit one of word five indicates tone alert is active or has been activated.
    l. Bit two and bit three indicates the power level for TX. If neither are set then the power level is high.

	Bit 7	*Bit 6*	*Bit 5*	*Bit 4*	*Bit 3*	*Bit 2*	*Bit 1*	*Bit 0*
00	0	0	0	0	0	0	1	0
01	0	1	0	0	Reverse	0	Simplex	+ Offset
02	0	1	0	0	Tone Decode	Tone Encode	AL Function	Call
03	0	1	0	0	Memory	Beep Off	Set Tone	Step
04	0	1	0	0	Memory Lock	0	0	0
05	0	1	0	0	Power Medium	Power Low	Blink Tone Alert	Tone Alert
06	1	0	0	0	0	0	0	0
	Bit 7	*Bit 6*	*Bit 5*	*Bit 4*	*Bit 3*	*Bit 2*	*Bit 1*	*Bit 0*

4. This will define structure header 0x07 which has a total of three words that are eight bits each.
    a. This defines which function number or memory channel that is in use. This information is only displayed if bit four of word one is cleared. This bit is only cleared if Memory mode is enabled or the function button has been pressed.
    b. If either bit in the following structures are currently set then bit four of word one will be clear. Bit three of word four in structure two is set or bit zero of word one in structure eight is set.
    c. Bit zero through bit three of word one will be equal to a one if the memory number or the function number is less than 10. This seems to inform the display that it has nothing to display in the given slot.
    d. If the function number is greater than 10 then bit zero through bit three will be equal to the ten digit.

	Bit 7	*Bit 6*	*Bit 5*	*Bit 4*	*Bit 3*	*Bit 2*	*Bit 1*	*Bit 0*
00	0	0	0	0	0	1	1	1
01	0	1	0	Display F/M Off	1/0	1/0	F/M 10 Number	F/M 10 Number
02	1	0	0	0	F/M Number	F/M Number	F/M Number	F/M Number
	Bit 7	*Bit 6*	*Bit 5*	*Bit 4*	*Bit 3*	*Bit 2*	*Bit 1*	*Bit 0*

5. This will define structure header 0x08 which has a total of two words that are eight bits each.
    a. Bit zero of word one will set any time the function button is pressed. It also will clear bit four of word one in structure 0x07. This bit overrides the memory mode bit in structure 0x02 for which number is to be displayed in structure 0x07.
    b. If the function button is held for longer than one second, then bit one of word one will also set along with bit zero.

	Bit 7	*Bit 6*	*Bit 5*	*Bit 4*	*Bit 3*	*Bit 2*	*Bit 1*	*Bit 0*
00	0	0	0	0	1	0	0	0
01	1	0	0	0	0	0	Function 1 Sec	Function Button
	Bit 7	*Bit 6*	*Bit 5*	*Bit 4*	*Bit 3*	*Bit 2*	*Bit 1*	*Bit 0*

6. This will define structure header 0x05 which has a total of two words that are eight bits each.
    a. If bit five of word one is set then the squelch is open and bits zero through three define the signal strength of the incoming signal.
    b. If bit five of word one is clear then the squelch is closed.

	Bit 7	*Bit 6*	*Bit 5*	*Bit 4*	*Bit 3*	*Bit 2*	*Bit 1*	*Bit 0*
00	0	0	0	0	0	1	0	1
01	1	0	1	Squelch Open	RX Level	RX Level	RX Level	RX Level
	Bit 7	*Bit 6*	*Bit 5*	*Bit 4*	*Bit 3*	*Bit 2*	*Bit 1*	*Bit 0*

7. This will define structure header 0x3 which has two words of eight bits. This structure is used as a alarm structure. This structure will be sent any time a priority channel has activity. It will also be sent when the Tone Alert function is active and any channel becomes active.
    a. The priority alert bit is set any time memory channel zero has activity on it

	Bit 7	*Bit 6*	*Bit 5*	*Bit 4*	*Bit 3*	*Bit 2*	*Bit 1*	*Bit 0*
00	0	0	0	0	0	0	1	1
01	1	0	0	0	0	0	Priority Alert	0
	Bit 7	*Bit 6*	*Bit 5*	*Bit 4*	*Bit 3*	*Bit 2*	*Bit 1*	*Bit 0*

8. This will show some example data that I have examined during this study.

05 A0 FF
02 42 40 48 48 4B 80 07 4F 82 03 80 05 B7 FF
00 41 44 66 45 45 50 8F 02 42 40 48 48 4B 80 07 4F 82 08 80 05 A0 FF
00 41 44 66 46 43 50 8F 02 40 40 40 40 48 80 07 5F 82 08 80 FF
00 41 44 66 46 42 55 8F 02 40 40 40 40 48 80 07 5F 82 08 80 FF
00 41 44 66 46 42 50 8F 02 40 40 40 40 48 80 07 5F 82 08 80 FF
00 41 44 66 46 41 55 8F 02 40 40 40 40 48 80 07 5F 82 08 80 FF
00 41 44 66 46 41 50 8F 02 40 40 40 40 48 80 07 5F 82 08 80 FF
00 41 44 66 46 40 55 8F 02 40 40 40 40 48 80 07 5F 82 08 80 FF
00 41 44 66 46 40 50 8F 02 40 40 40 40 48 80 07 5F 82 08 80 FF
00 41 44 66 45 49 55 8F 02 42 40 40 40 48 80 07 5F 82 08 80 FF
00 41 44 66 45 49 50 8F 02 42 40 40 40 48 80 07 5F 82 08 80 FF
00 41 44 66 45 48 55 8F 02 42 40 40 40 48 80 07 5F 82 08 80 FF
00 41 44 66 45 48 50 8F 02 42 40 40 40 48 80 07 5F 82 08 80 FF
00 41 44 67 43 45 50 8F 02 41 41 40 40 48 80 08 80 FF
00 41 44 66 45 48 50 8F 02 42 40 40 40 48 80 07 5F 82 08 80 FF
00 41 44 66 45 48 50 8F 02 42 40 40 40 44 80 07 5F 82 08 80 FF
00 41 44 66 45 48 50 8F 02 42 40 40 40 40 80 07 5F 82 08 80 FF
05 B7 FF
05 A0 FF
05 B7 FF
05 A0 FF
00 41 44 66 45 45 50 8F 02 42 40 48 48 40 80 07 4F 82 08 80 FF
00 41 44 65 45 45 50 8F 02 40 40 48 40 40 80 07 4F 81 08 80 FF

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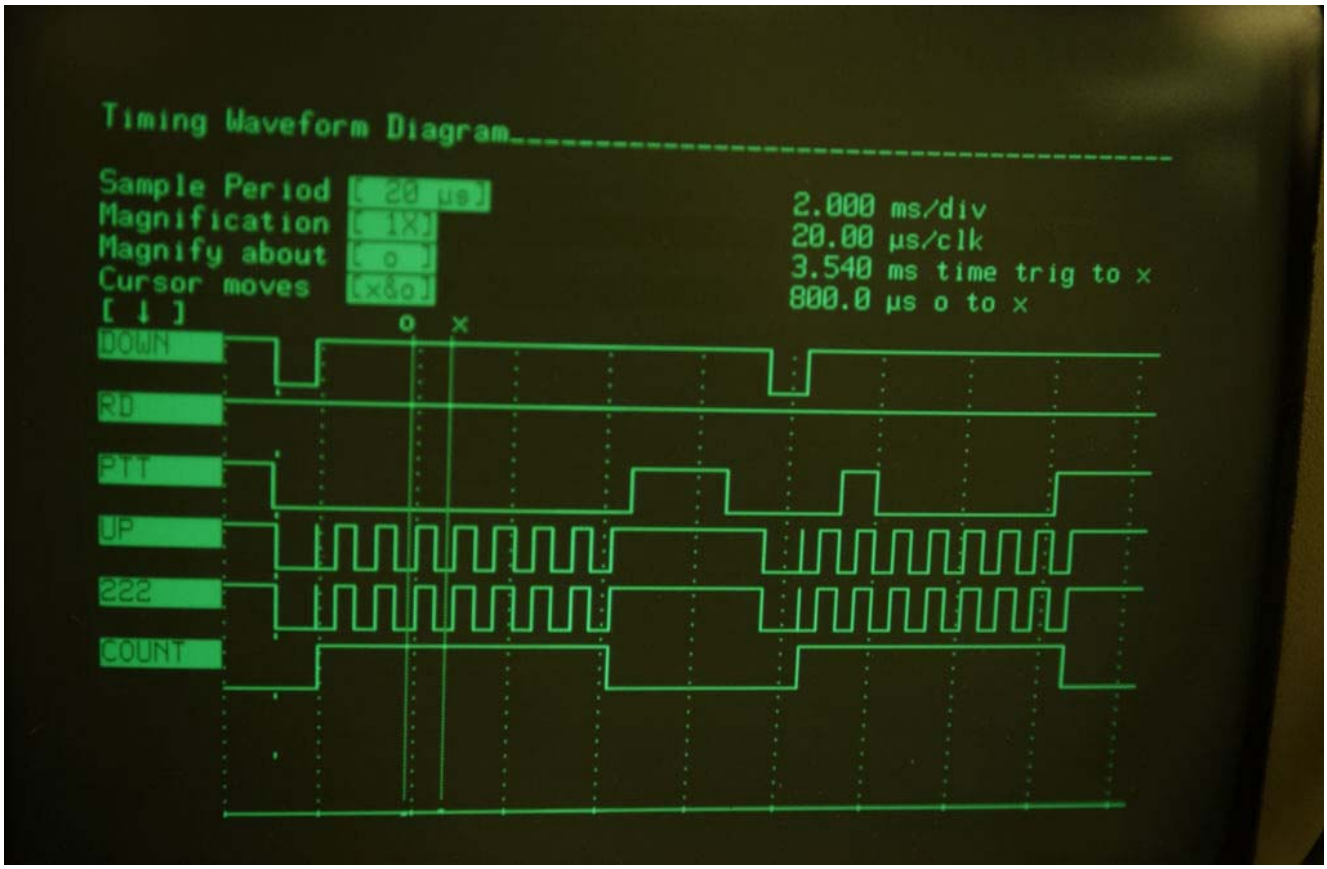

The snap shot above is the start of a zero structure as previously defined. It shows the first two bytes being passed and the acknowledge to start the sequence. Ignore the bottom two signals 222 and count in these photos. The data is clocked at a 1200 bit rate.