

IFR COM-120 Timekeeper Options Restoration

Version – 1.0

Date - 2021/05/15

Author - Kurt Swanson WB6SMC

©2021 by Kurt Swanson – this document is provided free of charge as a service to the hobby community, and may be freely distributed provided that (a) it is distributed in complete and unaltered form, and (b) that it is distributed free of charge.

Author's note – May 2021: As of this writing, the information contained in this document has been verified to work on IFR COM-120B monitors running firmware versions 4.12, 4.13, 4.15, 4.18 and 4.19. Most "hobby grade" programmers do not support the DS1286 chip, but several folks have reported good results using several different models/revisions of Chinese Wellon programmers, which are reasonably priced. Before buying any programmer, be sure that it specifically supports these parts.

Summary:

This document is intended to provide insight into and solutions for the issues created when the battery contained within the IFR COM-120 service monitor RTC fails, causing the loss of data stored within the RAM area of this chip - a Dallas DS1286 Timekeeper IC. This failure manifests as several changes to operation, most notably the loss of all software options. A failed Timekeeper battery will not, however, prevent a unit from booting up and (mostly) operating. When the COM-120 was supported by the manufacturer, this data could be re-created during factory service, but since factory support has ended that option no longer exists, so this document also details a crude method to restore this lost data (at least for COM-120B/C units running firmware versions 4.12 and higher, possibly others). Lastly, since hardware and software options are tightly intertwined, an option list with comments is provided to help determine which options can be restored to a specific instrument.

COM-120 Options:

Options for the COM-120 included a variety of extra features that could be ordered, some of which required additional hardware, some of which required additional hardware and software, plus others that were software only. The main operating firmware already contains the needed code for the software options, but specific bits in the Timekeeper IC must be written to enable options that involve software. Because some of the options require additional hardware, enabling an option for which hardware is missing can result in very strange operation: the bottom line here is that the programmed options must match the physical options.

Options that were included when the monitor was built are normally listed on a label attached to the rear of the unit. Note that some labels have a first character of "O" for options, while others don't, and some have leading zeros on options less than 10, while others don't. Also note that some options might not be available in firmware versions earlier than 4.18.

The options are as follows:

- 01- Internal Battery: This requires a Yuasa NP5-12A (or equivalent) to be installed. No other hardware or software changes needed.
- 02- OCXO High Stability Oscillator: The normal reference oscillator is replaced with a high stability version. No other hardware or software changes needed.
- 03- 30 KHz IF Filter: A 30 KHz bandwidth filter is installed in the optional 2nd filter socket in the receiver tray. Normally the Receiver Tray will have a label indicating this option. A bit in the Timekeeper must also be set. Filter part # is 2303-0000-006 or 2303-0000-008.
- 04- Variable Audio Generator-2: Allows the frequency of the second audio generator to be varied. Requires an additional daughter board be added to the Digital Tray (normally a label indicating this will be attached to the top of the Digital Tray), plus a bit in the Timekeeper must also be set.
- 05- Generate Amplifier: Provides higher level RF output for the Aux RF Output jack to facilitate filter and duplexer alignment. Requires an additional amplifier module. A bit in the Timekeeper must also be set.
- 06- Unassigned.
- 07- Data Generator/Bit Error Rate (BER) Meter: Allows data integrity testing through an end to end path. No additional hardware needed, but a bit must be set in the Timekeeper.
- 08- Single Sideband Receive Demod and 3 KHz IF Filter: Allows listening to SSB transmissions. This requires a 3 KHz filter and a demod daughter card to be installed in the receiver tray. Normally an additional label will be added to the top of the receiver tray indicating this option. Bits must also be set in the Timekeeper. Filter part # is 2303-0000-007.
- 09- RCC Signaling Formats: Adds functionality for encoding mobile telephone (not cellular) and tone remote signaling sequences. No additional hardware needed, but a bit must be set in the Timekeeper.
- 10- Unassigned.
- 11- Audio/Digital Signaling Formats (CCIR,CCIRH,CCIRH4,EEA,EIA,NATEL,...): Allows encoding and decoding analog and digital signaling, primarily paging. Labeled POCSAG Paging on the Option screen. No additional hardware needed, but a bit must be set in the Timekeeper.
- 12- Spectrum Analyzer Tracking Generator: Provides an internal RF generator which “tracks” the spectrum analyzer receiver to facilitate testing of RF filters and duplexers. No additional hardware needed, but a bit must be set in the Timekeeper.
- 13- GPIB: Provides a GPIB port on the rear panel to facilitate remote control operation. Requires a GPIB connector to be added to the rear panel, but most (if not all) COM-120s seem to include this. A bit must also be set in the Timekeeper.

- 14- Clearchannel LTR Trunking: Allows testing of LTR trunked radio units. No additional hardware needed, but a bit must be set in the Timekeeper.
 - 15- AMPS Cellular Testing: Allows testing of the now obsolete AMPS analog cellular telephone equipment. Requires Option 3, plus bits must be set in the Timekeeper.
 - 16- EDACS Trunking: Allows testing of EDACS trunked radio units. No additional hardware needed, but a bit must be set in the Timekeeper.
 - 17- MPT-1327 Trunking: Allows testing of MPT-1327 trunked radio units. No additional hardware needed, but a bit must be set in the Timekeeper.
 - 18- Unassigned.
 - 19- Unassigned.
 - 20- 7.5 KHz IF Filter: A 7.5 KHz bandwidth filter is installed in the receiver tray to allow testing of narrow band FM communications equipment. Normally the receiver tray will have a label on top indicating this option. Bits in the Timekeeper must also be set. Filter part # is 2303-0000-017.
 - 21- Autocell NT: Automated Cellular Base Station Testing for Northern Telecom cell sites. As of this time, nothing else is known of this option.
- New Counter: Option displayed on the Options screen indicating that the later revision digital tray is installed, which appears to have started with late COM-120A units: always present in B and C models. A bit must be set in the Timekeeper: 1 for late model units, 0 for early model units that have had late firmware installed.
- 10Hz Modulator: Option displayed on the Options screen indicating that the enhanced generator board is installed, which appears to have started somewhere in the middle of the COM-120B production timeframe. A bit must be set in the Timekeeper: 1 for late model units, 0 for early model units that have had late firmware installed.

The Dallas DS1286 Timekeeper IC:

Combining a static RAM, a real time clock and crystal, plus an internal back-up battery, the Dallas DS1286 provided a compact, inexpensive solution to several challenges faced by designers of computer based equipment. Unfortunately, this convenience came with a cost: the internal battery was only rated to last for 10 years, after which the IC would need replacement. Since 10 years was considered to be the maximum economic lifetime for most equipment, this limitation was often considered acceptable. The COM-120 fits this model perfectly: virtually all units have been (or will likely soon be) phased out by the original owners, and are now in the hands of hobbyists. Most instruments are also now more than 20 years old, and are old enough that the Timekeeper battery has already died, or is about to do so. Today, the DS1286 has not been manufactured for more than 10 years, so all "real" Dallas Maxim chips are basically at end of life or beyond. Replacement options include cutting into the existing Timekeeper

and installing an external battery, or using a part sourced from China that was not made by the original manufacturer. Since these parts continue to be labelled with the Dallas name, they must be considered to be counterfeit, but many folks have reported successful use. There are also boards made by third parties that combine a DS1284 IC with a discrete crystal and battery, but the DS1284 is also obsolete, making availability of these boards spotty as well. While there are clearly professionals capable of reloading some or all of the lost information into these parts, this document was written to help today's second and third owners who desire an inexpensive "DIY" solution to recreate the data stored in the Timekeeper RAM.

In addition to the clock functions, the designers of the COM-120 took advantage of the available battery-backed RAM in the Timekeeper, using about 2/3 of the space to store information that needed to remain when the unit was powered down, but that could change in operation such as calibration data, run time, etc. while the other 1/3 is used to store information that should not change, such as the options list, serial number, and IF filter bandwidth data. A typical dump of a working RAM is shown in Figure 1, including comments about specific memory locations.

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	04	00
1	00	00	10	00	10	20	00	00	00	07	00	00	00	00	00	2A
2	68	70	50	42	F3	6F	8E	CF	0E	00	01	00	04	0A	95	90
3	28	00	00	FD	3F	01	00	DC	05	EE	02	30	75	00	00	00

Handwritten annotations in Figure 1:

- Runtime**: Brackets over addresses 8 (0E) and 9 (00).
- Checksum**: Points to address 15 (95).
- S/N**: Points to address 16 (90).
- Options**: Brackets over addresses 3 (FD), 4 (3F), and 5 (01).
- IFBW1**: Points to address 8 (DC).
- IFBW2**: Points to address 9 (05).
- IFBW3**: Brackets over addresses 10 (EE) and 11 (02).
- S/N** (second): Points to address 1 (28).

Figure 1 – Sample DS1286 Timekeeper RAM Contents

Fields that require more than 1 byte are stored in reverse byte order, which is known as "little endian" format. Note that since the instrument is capable of rewriting the first 2/3 of the RAM automatically, that area is not completely mapped here. Also note that this entire map was derived from a very late production COM-120B running firmware V4.18: normal software engineering practice would be to have the RAM map consistent over several revisions, but other firmware versions might have a totally different mapping. Likewise, some of the options listed here may not exist in earlier firmware versions.

It should also be noted that this mapping and procedure was determined with no input whatsoever from the original manufacturer, designers, or documentation, so while every effort has been made to ensure accuracy, this data may contain errors. Bottom line – you use this information at your own risk.

Recreating the DS1286 Timekeeper RAM Image:

At this point in time, virtually all of the original Timekeeper batteries will have failed, so most COM-120 units currently need or will need to have the RAM image recreated. There are at least three different ways to do this:

1. Means clearly exist to program the entire contents through the RS-232 port on the rear of the instrument. This is the way the factory programmed these units initially, but details of this method remain unknown to most or all of the hobbyist community.
2. IFR provided for field reloading of options through the use of a factory provided “secret code” that was encrypted to match a specific serial number. Unfortunately, when the Timekeeper battery fails, the serial number stored in the Timekeeper is lost along with the options, so IFR released the procedure to reprogram the serial number through the rear panel RS-232 connector, which allows the secret code to now be entered through the front panel. This works fine if one has the secret code, and if the originally supplied options meet the current owner’s needs. Support for these units has officially ended, so it is unlikely that the code is still available if the owner does not already have it. Likewise, the ability to purchase additional options is also long gone.
3. The Timekeeper RAM contents can be hand coded. This is tricky and tedious, but does not require knowledge of the secret code, and also allows a different mix of options to be installed. This is the technique that will be detailed here.

The following information is intended for use by tech savvy individuals, and is specific to the Late COM-120B running firmware Version 4.18. It is likely that it will be at least somewhat applicable to other versions of the COM-120 running other revisions of firmware, and, as of this writing, it was also successfully used to restore monitors running versions 4.12, 4.13, 4.15 and 4.19, but no other combinations have been tested. You use this information at your own risk.

In addition to a COM-120 running a compatible firmware version, the following will be needed:

1. A good DS1286 Timekeeper IC and socket
2. A programmer that will program a DS1286. Many “hobby” grade programmers do not include this type of memory chip in their libraries, so do research before buying a unit.
3. A HEX calculator. These functions are sometimes included in standalone calculators, or can be found on line or as downloadable applications.
4. Soldering skills and tools.
5. An understanding of hexadecimal arithmetic and data manipulation techniques.

If you are the least bit unsure of your skills or tools, think carefully before undertaking this effort – this equipment is fragile, and one false move in either the hardware or software arena could result in unrecoverable damage. If you have any doubts, consider having someone else do this work for you – a dead COM-120 is a bit large to use as a paperweight or even as a doorstop. Once again, you use this information at your own risk.

The examples provided use the information displayed in Figure 1, so if you are not sure that you understand a particular step, verify that you can obtain the same results as the example before trying your own parameters.

Step 1: When Dallas originally supplied a new DS1286 chip, all memory bits were written high. Modern counterfeit chips seem to come with the bits written at random, plus “repaired” ICs that now have external batteries also are likely to have random data in all locations. Regardless, since not all bits are used by the COM-120, it is suggested that the new or repaired 1286 be initially written to all zeros. The memory dumps used in this document all started with a zeroed out RAM, so step 1 is to program all 50 user bytes in the RAM to “00.”

Step 2: If not yet done, remove the defective Timekeeper from the processor board, and install a socket in its location. Install the zeroed out replacement Timekeeper into the board, insert the board back into the COM-120, and attempt to boot the system up. The unit may hang during self test, or may display a message that the Timekeeper is bad, but pressing “SETUP” repeatedly should eventually get you to the Setup screen. Select “RESTORE DEFAULTS” and press ENTER, which will load the calibration data from the front panel EEPROM, etc. into the Timekeeper.

Step 3: Program the date and time, and verify that the clock is running. Power down the unit and remove the timekeeper IC. Note that several “repaired” DS1286 chips had clocks that refused to restart, but began working after the part had been allowed to sit for a month or more with all power (including the internal battery) disconnected.

Step 4: Read the chip with the programmer – the data should now look something like Figure 2. Note that each COM-120 is likely to have different actual calibration values.

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	04	00
1	00	00	10	00	10	20	00	00	00	07	00	00	00	00	00	2A
2	68	70	50	42	F3	6F	8E	CF	04	00	00	00	04	0A	B7	00
3	00	00	00	00	00	00	00	DC	05	B8	0B	30	75	00	00	00

Figure 2 – Sample Timekeeper Contents after “Restore Defaults”

Step 5: Determine the necessary IF filter bandwidths, and make any changes needed to the values stored in locations 37h – 3Ch. Remember the values are stored in reverse byte order. Note that the default values that were likely reloaded by the instrument in step 2 are: 15 KHz for filter 1, 30 KHz for

filter 2, and 300 KHz for filter 3. The value for filter 2 will need to be changed if the instrument is equipped with option 8 (SSB - 3.0 KHz) or option 20 (Narrow band FM – 7.5 KHz). The value to enter is determined as follows: Start with the filter bandwidth expressed in Hertz, and divide by 10. Convert this number from decimal to hex, and store it in reverse byte order (little endian) at locations 39h and 3Ah. The example shown in Figure 1 has option 20, so the value for filter 2 was changed to represent 7.5 KHz. Hex values for common filters are: 012Ch for 3.0 KHz, 02EEh for 7.5 KHz, 05DCh for 15 KHz, 0BB8h for 30 KHz, and 7530h for 300 KHz.

Step 6: Determine the options needed. Remember that options requiring specific hardware must only be enabled if the correct hardware is present. The options are enabled by setting bits in locations 33h, 34h and 35h as shown in Figure 3. Note that the values from Figure 1 are used in this example, and are for a COM-120B that has all optional hardware except SSB. Your option mix will likely be different. Enter your resulting values in locations 33h, 34h, and 35h.

ADDRESS 33h							
FD							
F					D		
1	1	1	1		1	1	0 1
Tracking Generator	POCSAG Paging	RCC Encode	BER Meter		Variable AF Gen #2	Gen Amp	SSB IF Filter #2

ADDRESS 34h							
3F							
3					F		
0	0	1	1		1	1	1 1
Undefined	Undefined	New Counter	10 Hz Modulator		EDACS Trunking	AMPS Cellular	LTR Trunking IEEE 488

ADDRESS 35h							
01							
0					1		
0	0	0	0		0	0	0 1
Undefined	Undefined	Undefined	Undefined		Undefined	Undefined	Undefined MPT 1327 Trunking

Figure 3 – Timekeeper Option Map

Step 7: Set the serial number (locations 2Fh and 30h). It appears that this serial number might only be used in conjunction with the front panel loaded “secret encrypted” option code entry, so unless the user has access to the code, this area could likely be left blank, however this was not tried. For the example shown in Figure 1, a fictional serial number was created: 200010384. To get the value needed for the Timekeeper, first drop the prefix and leading zeros, which leaves 10384. Convert that decimal value into hex, which yields 2890h. Store this value in reverse byte order in locations 2Fh and 30h. See Figure 1.

Step 8: Set the checksum byte (location 2Eh). Do this after steps 1 – 7 are complete. If any changes are made to the values entered in steps 5 – 7, this step must be repeated. The COM-120 tests the integrity of the memory locations filled in steps 5 – 7 by adding up the hex values stored in locations 2Eh – 3Ch and verifying that the last byte of the sum is zero, so the value entered in location 2Eh is the value needed to make this happen. This value will be the 2’s complement of the lowest byte of the sum of the values in locations 2Fh – 3Ch. Most hex calculators can calculate this number, but it can also be done by hand, as shown in Figure 4. This example uses the values from Figure 1. Verify this carefully, because if it is incorrect, the firmware will consider the memory corrupt, and no options will be enabled.

Finding the Two's Complement:

46Bh	Add up all the hex numbers in memory locations 2F – 3C
6Bh	Drop all but the lowest byte
0 1 1 0 1 0 1 1	Convert the number to binary
1 0 0 1 0 1 0 0	Complement each bit
1 0 0 1 0 1 0 1	Add 1
95h	Convert to hex - this is the 2's complement

Figure 4 – Two’s Complement Calculation

Step 9: Set the runtime. This step is optional, but can be performed if desired. Essentially, the loss of data in the Timekeeper results in the runtime value being reset to zero. If the actual runtime (or an estimate) is known, it can be entered in the locations starting at 28h as follows:

- The runtime is stored in minutes, but displayed in hours and minutes on the instrument’s display. Determine the value to be entered. For this example, 1092 hours and 30 minutes was chosen.
- Convert the value into minutes. For this example, 65550 minutes was the result.
- Change the number from step b to hex: 65550d → 01000Eh.
- Enter this hex value, in reverse byte order, starting at location 28h. See Figure 1.

Step 10: Program this image into the DS1286 Timekeeper.

Step 11: Install the Timekeeper into the COM-120, and power the unit on. Selecting the Setup screen, verify that the programmed options are now showing. If no options are shown, it is likely the checksum is incorrect.

Step 12: Verify that the runtime and receiver filter options are as expected.

Step 13: Perform a calibration on the instrument, paying particular attention to the counter and modulation functions that are possibly affected by the option bit programming – if things don't work right, try flipping the appropriate option bit.

Step 14: Enjoy the enhanced functionality of your COM-120: See Figure 5.



Figure 5 – Option Screen for the Example Shown in Figure 1