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MAX modules

TCXO-to-crystal migration guide

Application note

Abstract

This document provides options and guidelines for migrating TCXO-based MAX modules to crystal-based MAX modules. The application note also explains the potential impact on GNSS performance and other possible hardware/firmware concerns.

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1. Introduction

This application note describes the migration procedure from TCXO-based MAX modules to crystal-based MAX variants.

The main difference between TCXO and crystal variants is basically the type of oscillator used. The small difference in the internal oscillator leads to some considerations described in this document. For example, the frequency tolerance of crystals is wider than that of TCXOs. This means that the receiver must search over a wider range of frequencies, which will extend the time-to-first-fix especially in weak signal conditions.

In addition, the crystal's frequency is highly sensitive to temperature-variant environments. Therefore, the operating temperature, as well as heat dissipating systems on the board need to be taken into consideration.

Nevertheless, with proper adjustments and design guidelines, crystal-based GNSS receivers can achieve very similar performance to a TCXO-based solution and are thus worth considering as an alternative for many applications.

This document focuses on TCXO-based MAX-M8Q, MAX-8Q, and MAX-7Q modules.

☞ This document is still under development. New or additional information (e.g. test data) might be added in the future.

2. Generic guidelines

Generally, every migration requires different considerations for each dedicated product. However, there are a few parameters that are generic to all MAX modules. One is the presence of a good LNA in the RF front-end, and the second is the effect of the temperature and how to mitigate it. For crystal-based MAX modules, RTC is also one of the generic aspects needing special attention.

2.1 RF design

Performance of crystal-based designs strongly depends on the GNSS signal power levels. Under strong signal reception, crystal-based modules can perform as well as their equivalent TCXO versions. Therefore, for designs without an external LNA or using a passive antenna, it is mandatory to include an external LNA before the crystal-based MAX module, especially in applications under difficult GNSS visibility or poor reception. If, in addition, strong out-of-band jammers are close to the GNSS antenna (for example, a cellular antenna), an additional SAW filter in front of the LNA might be needed.

Applications with an active antenna or a present external LNA are exempt from RF front-end redesign.

Refer to the relevant hardware integration manual for more guidelines on passive antenna designs and recommended LNA/SAW components: MAX-8Q and MAX-M8Q: MAX-8 / MAX-M8 Hardware Integration Manual [1], MAX-7Q: MAX-7, NEO-7 Hardware Integration Manual [2].

2.2 Temperature

The frequency drift of the crystal is very dependent on the ambient temperature. Although the receiver can correct such an offset, it is recommended to avoid quick temperature changes. As a brief explanation, a GNSS receiver can track satellite signals up to a certain high dynamic value, which is defined as Delta frequency / Delta time (Δf/Δt). As a result, temperature change in a very short time at the crystal will end in a very high dynamic, in the worst scenario losing phase lock.

If it is possible that the receiver is placed under these conditions, it is highly recommended to isolate the module thermally by minimizing thermal conduction over the PCB, and to place the module far from fans or other components with quick body temperature change that can increase the board and ambient temperature. Adding elements for heat dissipation between the receiver and other elements as well as increasing the surface contact area of the board around stabilizes the temperature.

The effect of the temperature on the crystal can be seen in the Figure 1 below. It shows the crystal frequency drifting smoothly over full operation temperature range (-40 to +85 °C) for all u-blox crystal-based receivers (NEO-M8M is used as an example here).

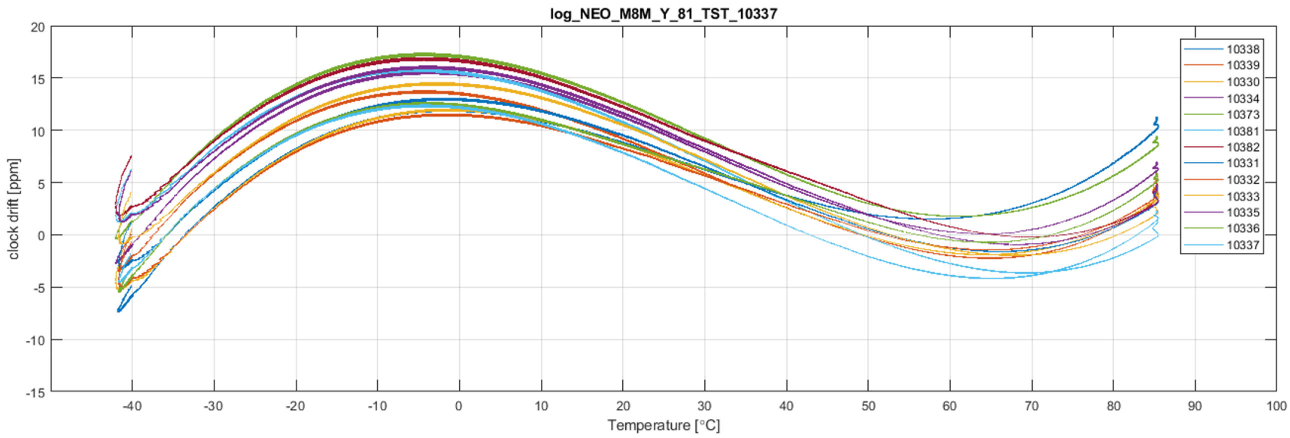


Figure 1: Temperature effect on crystal

2.3 Real-time clock (RTC)

The MAX-M8C, MAX-8C, and MAX-7C are optimized variants for cost-sensitive applications. One of the reasons is the absence of the RTC (32 KHz oscillator) compared to the TCXO-based variants. The MAX-M8C and MAX-8C modules compensate for it by using the crystal signal as RTC. For that, the crystal needs to be powered during the hardware and software backup modes, resulting in higher current consumption compared to TCXO versions, which already have an RTC in the module. This back up current difference for each product can be seen in section 3.2, section 4.2, and section 5.2, and it is relevant for battery-powered devices.

Using the crystal as an RTC feature is called "single-crystal", and by default it is enabled in all MAX crystal modules. For MAX-8C and MAX-M8C, it can be permanently disabled by sending the following command:

B5 62 41 09 00 01 01 92 81 E6 39 93 2B EE 30 31.

☞ Once the disable command is sent, it cannot be reversed.

It is not possible to disable the single-crystal feature in the crystal-based MAX-7C.

For more information about the single-crystal feature, its advantages and how to disable it, see MAX-8M / MAX-M8 Hardware integration manual [1] and MAX-7 / NEO-7 Hardware integration manual [2].

3. MAX-M8Q

This section provides details on the migration from MAX-M8Q to MAX-M8C.

3.1 MAX-M8 (Q/C) comparison

The table below summarizes the specifications to be considered during the migration.

Field	Parameter	MAX-M8Q	MAX-M8C
HW	Oscillator	TCXO	Crystal
	RTC	Yes	Yes, but with a higher backup current
	Interface config.	Same	Same
	Pinout	Same	Same
RF design	Front-end	With passive antenna, an external LNA is recommended.	With passive antenna, an external LNA is **mandatory.**
	Out of band immunity	Same	Same
Temp.	Storage temp. °(C)	Max +85	Max +105
	Thermal isolation [1]	Optional	Recommended
Power Req.	Supply (Vcc & Vio) (V)	[2.7 - 3.6]	[1.65 - 3.6]
	Supply current (mA)	Same	Same
	SW backup current (mA)	0.030	0.105 [2]
	HW backup current (mA)	0.015	0.100 [2]
Sensitivity	Dynamic Tracking (dBm)	-167	-164
	TTFF (sec) [3]	Same	Same
SW	Firmware	ROM SPG 3.01	ROM SPG 3.01
	OTP config.	-	single crystal enabled by default

Table 1: MAX-M8Q to MAX-M8C migration comparison (default mode: GPS & GLONASS including QZSS, SBAS)

3.2 Power requirements

Crystal-based MAX-M8C allows a wider voltage supply range. This is because of the lower voltage required by the crystal. Nevertheless, the products have overlapping operational voltage ranges and the same current consumption in normal operation.

The table below shows the expected current drawn of MAX-M8C and MAX-M8Q. More information is available in the MAX-M8 Data Sheet [3].

Section 2.3 explains why the crystal-based MAX-M8C has higher hardware and software backup current compared to TCXO-based MAX-M8Q.

[1] Mainly for applications where the GNSS module is under thermal activity on the board.
[2] Higher current consumption due to single-crystal feature enabled by default.
[3] Cold and hot start under good GNSS visibility and using power levels of -130 dBm.

Parameter	Symbol	Conditions	Module	Typ. GPS & GLONASS	Typ. GPS / QZSS /SBAS	Units
Average supply current [4]	Icc Acquisition mA [5]	VCC_IO = VCC = 3 V	MAX-M8C	26	20	mA
			MAX-M8Q	26	20	mA
	Icc Tracking (Continuous mode)	VCC_IO = VCC = 3 V	MAX-M8C	23	17	mA
			MAX-M8Q	23	18	mA
	Icc Tracking (Power save mode / 1 Hz)	VCC_IO = VCC = 3 V	MAX-M8C	5.4	4.9	mA
			MAX-M8Q	6.2	5.7	mA
Backup battery current [6]	I_BCKP	HW backup mode, VCC_IO = VCC = 0 V	MAX-M8C using the 26 MHz XTO in single crystal operation	100		µA
			MAX-M8C single crystal operation disabled (No RTC)	15		µA
			MAX-M8Q	15		µA
SW backup current	I_SWBCKP	SW backup mode, VCC_IO = VCC = 3 V	MAX-M8C using the 26 MHz XTO in single crystal operation	105		µA
			MAX-M8C single crystal operation disabled (No RTC)	30		µA
			MAX-M8Q	30		µA

Table 2: MAX-M8Q to MAX-M8C power requirements

3.3 Performance

3.3.1 Startup sensitivity and TTFF

Crystal-based GNSS receivers are characterized as having a longer time to synchronize with GNSS signals. The effect is more visible when the signals are weak and the GNSS visibility is poor.

Such behavior can be seen in Figure 2, where the times to fix of crystal-based MAX-M8C become longer than those of TCXO-based MAX-M8Q as the GNSS signal power drops.

[4] Simulated constellation of 8 satellites is used. All signals are at -130 dBm. VCC= 3 V.
[5] Average current from startup until the first fix.
[6] Use this figure to determine the required battery capacity.

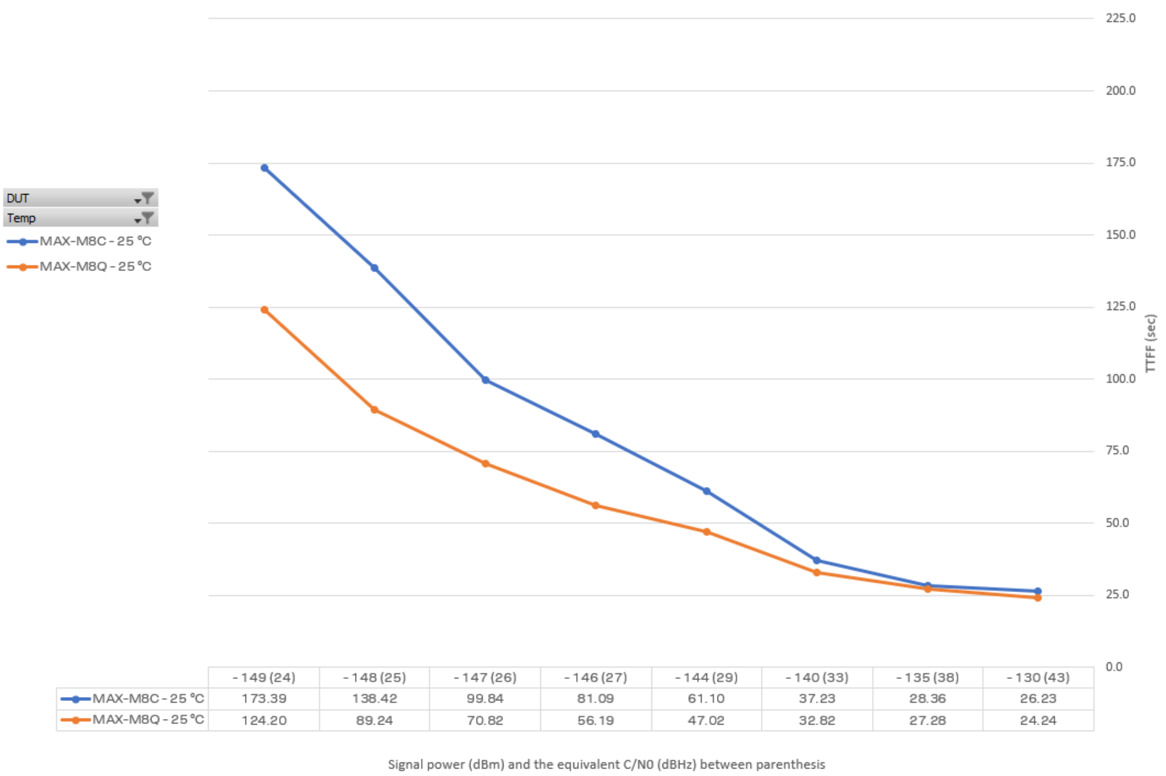


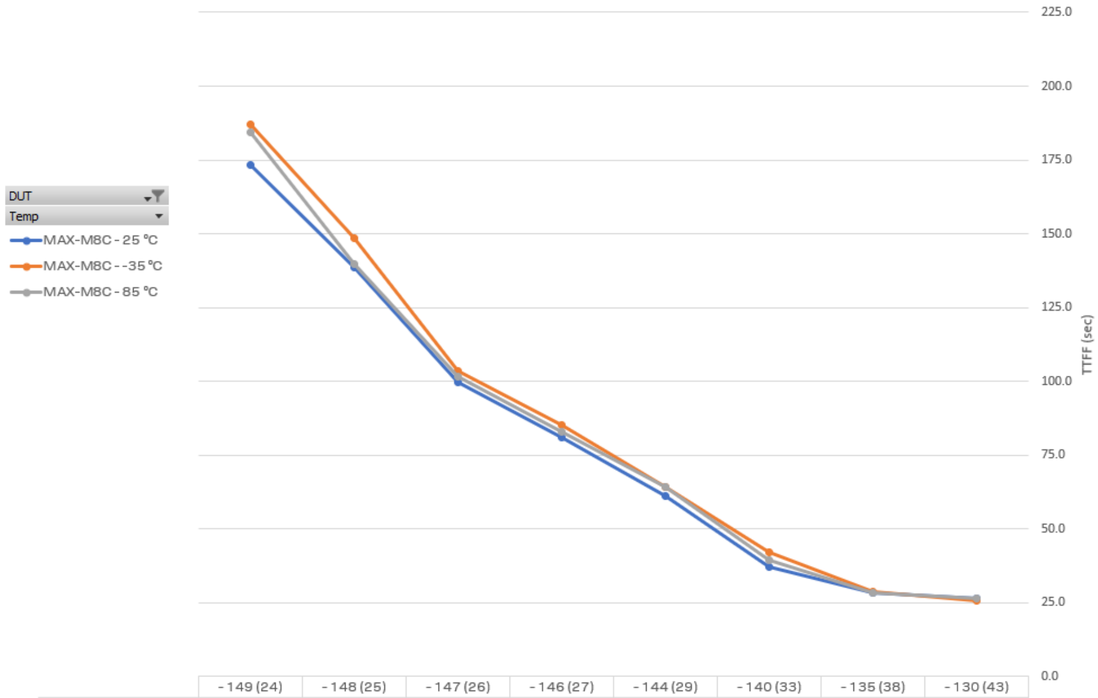
Figure 2: TTFF vs. signal power for MAX-M8Q and MAX-M8C during cold starts[7]

In general, a strong signal will give the shortest time to first fix. At room temperature (+25 °C), the TTFF differences between the MAX-M8Q (orange line in Figure 2) and the MAX-M8C (blue line) grow as the GNSS signal levels drop. Figure 2 shows that under a strong signal's environment (signals with active antenna), the TTFF is very similar for both TCXO and crystal-based MAX products.

The GNSS signal power levels above 43 dBHz (-130 dBm) are considered as strong signals. The cold start results in Figure 2 show that the TTFF numbers of MAX-M8Q and MAX-M8C are still very close to each other even at weaker signal condition of 33 dBHz (-140 dBm). Such Carrier-to-Noise ratio (C/N0) levels should be achievable with good open-sky visibility (best to have the satellite at the Zenith) using an active antenna.

If we compare TTFF at different operating temperatures, a small degradation is visible under very cold environments for crystal-based MAX-M8C, as shown in Figure 3. As an example, a receiver which starts at -35 °C will gradually increase the crystal temperature due to both components' proximity (self-heating), which results in an increase of the clock drift during the acquisition of the GNSS signals. Again, the consequences associated are not relevant when GNSS signals are strong enough, as can be seen in the figure below.

[7] Results obtained on our test sites using a good LNA in front and an attenuator to decrease power level.

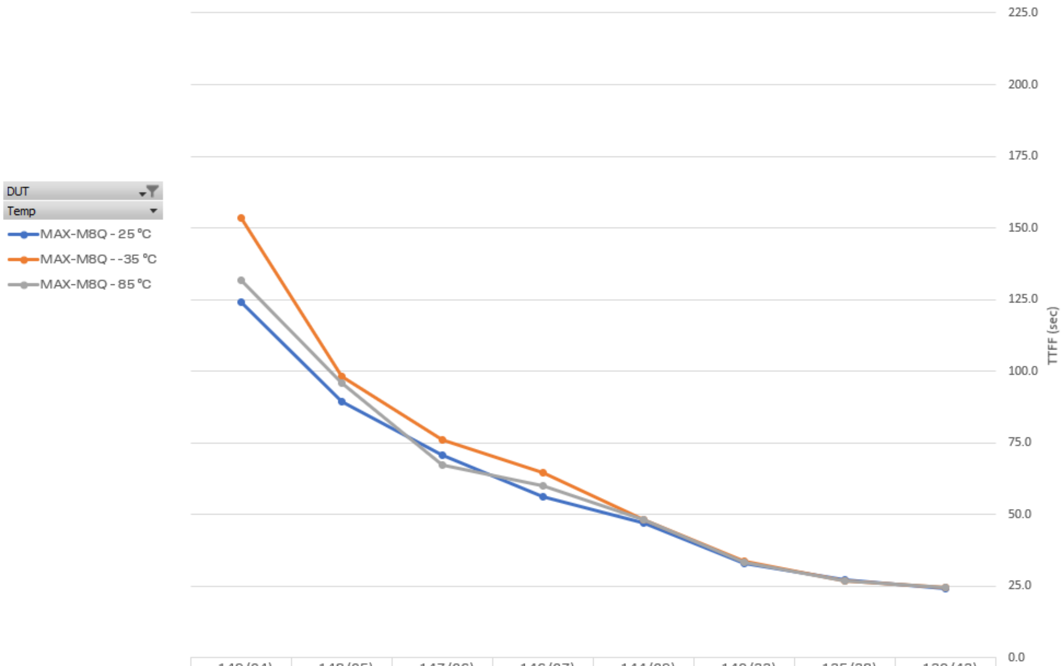


	- 149 (24)	- 148 (25)	- 147 (26)	- 146 (27)	- 144 (29)	- 140 (33)	- 135 (38)	- 130 (43)
MAX-M8C - 25 °C	173.39	138.42	99.84	81.09	61.10	37.23	28.36	26.23
MAX-M8C - -35 °C	187.12	148.39	103.31	85.01	64.33	41.91	28.55	25.76
MAX-M8C - 85 °C	184.39	139.65	101.54	82.76	64.25	39.21	28.19	26.23

Signal power (dBm) and the equivalent C/N0 (dBHz) between parenthesis

Figure 3: TTFF vs. signal power for MAX-M8C during cold starts at +25, -35, and +85 °C

For TCXO-based MAX-M8Q, the temperature dependency of the TTFF is also visible, as shown in Figure 4. TTFFs of MAX-M8Q stay faster than those of MAX-M8C in all temperature ranges.



	- 149 (24)	- 148 (25)	- 147 (26)	- 146 (27)	- 144 (29)	- 140 (33)	- 135 (38)	- 130 (43)
MAX-M8Q - 25 °C	124.20	89.24	70.82	56.19	47.02	32.82	27.28	24.24
MAX-M8Q - -35 °C	153.64	98.06	76.07	64.74	48.30	33.84	26.86	24.56
MAX-M8Q - 85 °C	131.81	96.03	67.34	59.81	48.03	33.22	26.61	24.40

Signal power (dBm) and the equivalent C/N0 (dBHz) between parenthesis

Figure 4: TTFF vs. signal power for MAX-M8Q during cold starts at +25, -35, and +85 °C

As a summary, the longer TTFFs due to the crystal's wider drift and extreme operating temperature can be easily mitigated by using a good GNSS antenna or LNA. Under such good GNSS signal conditions, we can predict a signal power level above -144 dBm, where both TCXO and crystal variants show similar TTFF values. As mentioned in section 2.1, an external LNA is mandatory when using a passive antenna with a crystal-based MAX-M8C.

4. MAX-8Q

This section provides details on the migration from MAX-8Q to MAX-8C.

4.1 MAX-8 (Q/C) comparison

The table below summarizes the specifications to be considered during the migration.

Field	Parameter	MAX-8Q	MAX-8C
HW	**Oscillator**	TCXO	Crystal
	RTC	Yes	Yes, but with a higher backup current
	Interface config.	Same	Same
	Pinout	Same	Same
RF design	**Front-end**	With passive antenna, an external LNA is recommended.	With passive antenna, an external LNA is **mandatory.**
	Out of band immunity	Same	Same
Temp.	**Storage temp. °(C)**	Max +85	Max +105
	Thermal isolation[8]	Optional	Recommended
Power Req.	**Supply (Vcc & Vio) (V)**	[2.7 - 3.6]	[1.65 - 3.6]
	Supply current (mA)	17	16
	SW backup current (mA)	0.020	0.105
	HW backup current (mA)	0.015	0.100
Sensitivity	**Dynamic tracking (dBm)**	-166	-164
	TTFF (sec)[9]	29	30
	Cold start sensitivity (dBm)	-148	-147
	Hot start sensitivity (dBm)	-157	-156
SW	**Firmware**	ROM SPG 3.01	ROM SPG 3.01
	OTP config.	-	single crystal enabled by default

Table 3: MAX-8Q to MAX-8C migration comparison (default mode: GPS, QZSS and SBAS)

4.2 Power requirements

Table 4 shows the expected current drawn of MAX-8C and MAX-8Q. More information is available in the MAX-8 Data Sheet [4].

Section 2.3 explains why the crystal-based MAX-8C has a higher hardware and software backup current compared to TCXO-based MAX-8Q.

[8] Mainly for applications where the GNSS module is under thermal activity on the board.
[9] Cold and hot start under good GNSS visibility and using power levels of -130 dBm.

Parameter	Symbol	Conditions	Module	Typ. GPS / QZSS /SBAS	Typ. GLONASS	Units
Average supply current [10]	Icc Acquisition[11]	VCC_IO = VCC = 3 V	MAX-8C	18	17	mA
			MAX-8Q	19	18	mA
	Icc Tracking (Continuous mode)	VCC_IO = VCC = 3 V	MAX-8C	16	16	mA
			MAX-8Q	17	17	mA
	Icc Tracking (Power Save mode / 1 Hz)	VCC_IO = VCC = 3 V	MAX-8C	5.4	4.9	mA
			MAX-8Q	6.2	5.7	mA
Backup battery current [12]	I_BCKP	HW backup mode, VCC_IO = VCC = 0 V	MAX-8C using the 26 MHz XTO in single crystal operation	100		µA
			MAX-8C single crystal operation disabled (No RTC)	15		µA
			MAX-8Q	15		µA
SW Backup current	I_SWBCKP	SW backup mode, VCC_IO = VCC = 3 V	MAX-8C using the 26 MHz XTO in single crystal operation	105		µA
			MAX-8C single crystal operation disabled (No RTC)	30		µA
			MAX-8Q	30		µA

Table 4: MAX-8Q to MAX-8C power requirements

MAX-8C (GPS or GLONASS only) uses the same crystal as multi-GNSS MAX-M8C variant, thus has similar behavior in terms of cold start TTFF at different temperatures. For performance of crystal-based MAX-8C, refer to MAX-M8Q and MAX-M8C test results presented in section 3.3.

[10] Simulated GNSS constellation is used. All signals are at -130 dBm. VCC= 3 V.
[11] Average current from startup until the first fix.
[12] Use this figure to determine the required battery capacity.

5. MAX-7Q

This section provides details on the migration from MAX-7Q to MAX-7C, or on upgrading MAX-7Q to MAX-8C or MAX-M8C for an improved GNSS performance of u-blox 8 and M8 platforms.

5.1 MAX-7(Q/C) comparison

Field	Parameter	MAX-7Q	MAX-7C
HW	Oscillator	TCXO	Crystal
	RTC	Yes	Yes, but with a higher backup current
	Interface config.	Same	Same
	Pinout	Same	Same
RF design	Front-end	With passive antenna, an external LNA is recommended.	With passive antenna, an external LNA is **mandatory.**
	Out of band immunity	Same	Same
Temp.	Storage temp. °(C)	Max +85	Max +105
	Thermal isolation [13]	Optional	Recommended
Power Req.	Supply (Vcc & Vio) (V)	[2.7 - 3.6]	[1.65 - 3.6]
	Supply current (mA)	17.5	16.5
	SW backup current (mA)	0.020	0.305
	HW backup current (mA)	0.015	0.300
Sensitivity	Dynamic Tracking (dBm)	-161	-160
	TTFF (sec) [14]	29	30
	Cold start sensitivity (dBm)	-148	-147
	Hot start sensitivity (dBm)	-156	-155
SW	Firmware	ROM 1.00	ROM 1.00
	OTP config.	-	-

Table 5: MAX-7Q to MAX-7C migration comparison (default mode: GPS, QZSS and SBAS)

5.2 Power requirements

In terms of power consumption, the migration to the crystal version MAX-7C would imply around 1 mA less current in all modes and a very significant increase in the hardware and software backup modes as shown in Table 6. More information is available in the MAX-7 Data Sheet [5].

Parameter	Symbol	Module	Typ.	Units	Condition
Average supply current [15, 16]	Icc Acquisition [17]	MAX-7C	21	mA	Estimated at 3 V
		MAX-7Q	22	mA	
	Icc Tracking (Continuous mode)	MAX-7C	16.5	mA	
		MAX-7Q	17.5	mA	
	Icc Tracking (Power Save mode / 1 Hz)	MAX-7C	4.5	mA	
		MAX-7Q	5.0	mA	
Backup battery current	I_BCKP	MAX-7C	300	µA	V_BCKP = 3.0 V, VCC = 0 V
		MAX-7Q	15	µA	
SW backup current	I_SWBCKP	MAX-7C	305	µA	VCC = 3.0 V
		MAX-7Q	20	µA	

Table 6: MAX-7Q to MAX-7C power requirements

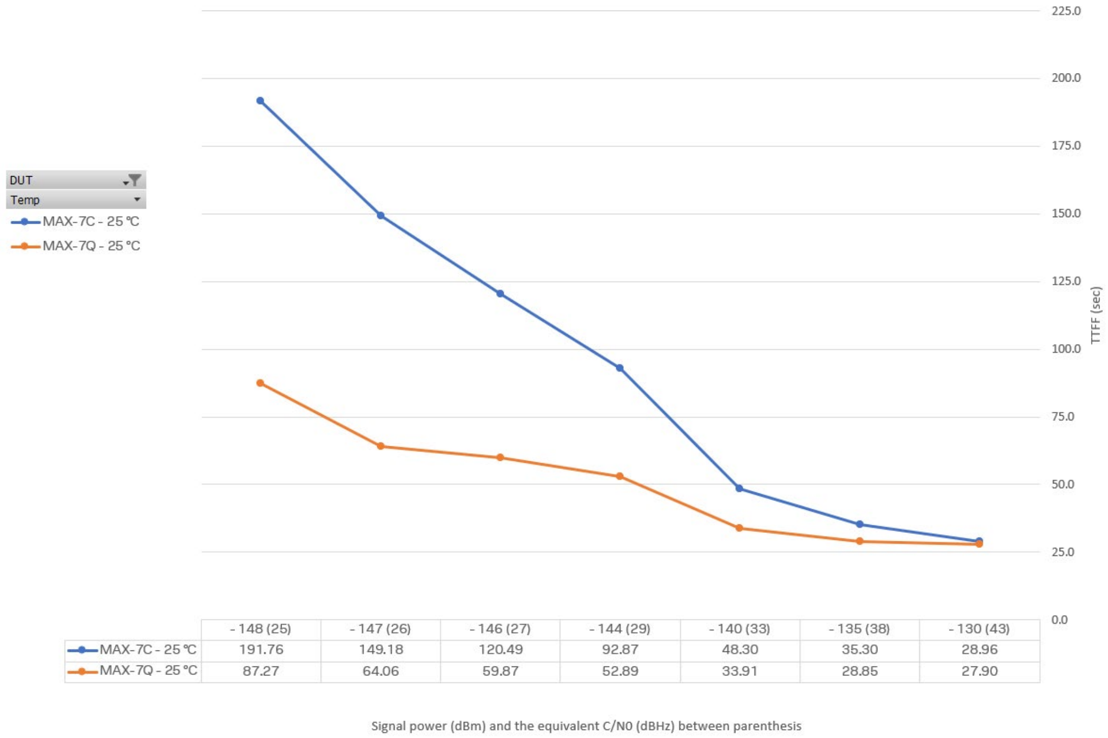
[13] Mainly for applications where the GNSS module is under thermal activity on the board.
[14] Cold and hot start under good GNSS visibility and using power levels of -130 dBm.
[15] Use this figure to determine required battery capacity.
[16] Simulated GNSS constellation using power levels of -130 dBm. Voltage supply= 3.0 V.
[17] Average current from startup until the first fix.

The higher current values in the backup modes seen in the MAX-7C are caused by keeping the crystal alive during off times, with the aim of providing faster warm and hot starts. This single-crystal feature cannot be disabled in u-blox 7 generation. Refer to section 2.3 for more information about the single-crystal feature.

☞ The new generation MAX-8C and MAX-M8C crystal modules have three times lower hardware and software backup current in the single-crystal mode, and have the option of disabling the single-crystal feature. If the application has other means of providing a time reference and/or the low current consumption is a key factor, refer to the section 5.4 for information on upgrading MAX-7 design to the u-blox 8 and M8-based MAX-8C or MAX-M8C solution.

5.3 Performance

5.3.1 Startup sensitivity and TTFF



	- 148 (25)	- 147 (26)	- 146 (27)	- 144 (29)	- 140 (33)	- 135 (38)	- 130 (43)
MAX-7C - 25 °C	191.76	149.18	120.49	92.87	48.30	35.30	28.96
MAX-7Q - 25 °C	87.27	64.06	59.87	52.89	33.91	28.85	27.90

Figure 5: TTFF vs. signal power for MAX-7Q and MAX-7C during cold starts[18]

The MAX-7Q and MAX-7C show a significant difference in TTFF at weak signals. Even at very strong signals, there is a minor difference between TCXO and crystal-based variants. The single GNSS operation (fewer satellites) may contribute to the longer TTFF times of MAX-7C.

Overall, when switching from the MAX-7Q to the MAX-7C, an active antenna or an LNA can limit the degradation of the TTFF performance somewhat.

5.4 Upgrading MAX-7Q to MAX-8C/M8C

Before taking the decision to migrate from MAX-7Q to the crystal-based MAX-7C version, u-blox recommends considering an upgrade to the newer generation MAX-8C or MAX-M8C.

[18] Results obtained on our test sites using a good LNA in front and an attenuator to decrease power level.

☞ Similar to MAX-7Q, MAX-8C is also a single-GNSS module supporting GPS only or GLONASS-only operation. MAX-M8C supports multi-GNSS operation.

Refer to MAX-8 / MAX-M8 Hardware Integration Manual [1] and GNSS FW3.01 Release notes [6] for more hardware (including antenna) and software-related guidelines during the migration of MAX-7Q to MAX-8C or MAX-M8C.

The upgrade to MAX-8C allows the customer to take advantage of the improved SPG 3.01 firmware (better tracking sensitivity) compared to ROM 1.00 used in the MAX-7 modules. More performance improvements can be achieved by migrating from MAX-7Q to multi-GNSS MAX-M8C, thanks to the higher numbers of available satellites, which will significantly improve the TTFFs, sensitivity, and performance, especially in dynamic and difficult environments. The performance benefits of MAX-8C and MAX-M8C are shown in Table 5 and Figure 6.

It is highly advisable that customers consider a migration design review with the u-blox technical support team to ensure the compatibility of key functionalities.

5.4.1 MAX-7Q vs. MAX-8C/M8C comparison

Field	Parameter	MAX-7Q	MAX-8C	MAX-M8C
HW	**Oscillator**	TCXO	Crystal	Crystal
	RTC	Yes	Yes, but with a higher backup current	Yes, but with a higher backup current
	Interface config.	Same	Same	Same
	Pinout	Same	Same	Same
	GNSS	Single GNSS (GPS or GLO)	Single GNSS (GPS or GLO)	Multi-GNSS (up to 3 concurrent GNSS)
RF design	**Front-end**	With passive antenna, an external LNA is recommended.	With passive antenna, an external LNA is **mandatory.**	With passive antenna, an external LNA is **mandatory.**
	Out of band immunity	Same	Same	Same
Temp.	**Storage temp. °(C)**	Max +85	Max +105	Max +105
	Thermal isolation [19]	Optional	Recommended	Recommended
Power req.	**Supply (Vcc & Vio) (V)**	[2.7 - 3.6]	[1.65 - 3.6]	[1.65 - 3.6]
	Supply current (mA)	17.5	18	23
	SW backup current (mA)	0.020	0.105	0.105
	HW backup current (mA)	0.015	0.100	0.100
Sensitivity	**Dynamic Tracking (dBm)**	-161	-164	-164
	TTFF (sec) [20]	29	30	26
	Coldstarts sensitivity (dBm)	-148	-147	-148
	Hotstarts sensitivity (dBm)	-156	-156	-157
SW	**Firmware**	ROM 1.00	ROM SPG 3.01	ROM SPG 3.01
	OTP config.	-	single crystal enabled by default	single crystal enabled by default

Table 7: MAX-7Q to MAX-8C, MAX-M8C migration comparison (default configuration)

[19] Mainly for applications where the GNSS module is under thermal activity on the board.
[20] Cold and hot start under good GNSS visibility and using power levels of -130 dBm.

5.4.2 Power requirements

The table below shows that the MAX-8C and MAX-M8C modules have very similar power requirements as the MAX-7Q module.

Parameter	Symbol	Module	Min	Typ.	Max	Units	Condition
Power supply voltage	VCC, VCC_IO	MAX-7Q	2.7	3.0	3.6	V	
		MAX-8C	1.65	3.0	3.6	V	
		MAX-M8C	1.65	3.0	3.6	V	
Backup battery voltage	V_BCKP	All	1.4		3.6	V	
Average supply current [21, 22]	Icc Acquisition[23]	MAX-7Q		22		mA	Estimated at 3 V
		MAX-8C		18		mA	
		MAX-M8C		19		mA	
	Icc Tracking (Continuous mode)	MAX-7Q		17.5		mA	
		MAX-8C		16		mA	
		MAX-M8C		17		mA	
	Icc Tracking (Power Save mode / 1 Hz)	MAX-7Q		5.0		mA	
		MAX-8C		5.4		mA	
		MAX-M8C		6.2		mA	
Backup battery current	I_BCKP	MAX-7Q		15		µA	V_BCKP = 3.0 V, VCC = 0 V
		MAX-8C/M8C using the 26 MHz XTO in single crystal operation		100		µA	
		MAX-8C/M8C single crystal operation disabled (No RTC)		15		µA	
SW backup current	I_SWBCKP	MAX-7Q		20		µA	VCC = 3.0 V
		MAX-8C/M8C using the 26 MHz XTO in single crystal operation		105		µA	
		MAX-8C/M8C single crystal operation disabled (No RTC)		30		µA	

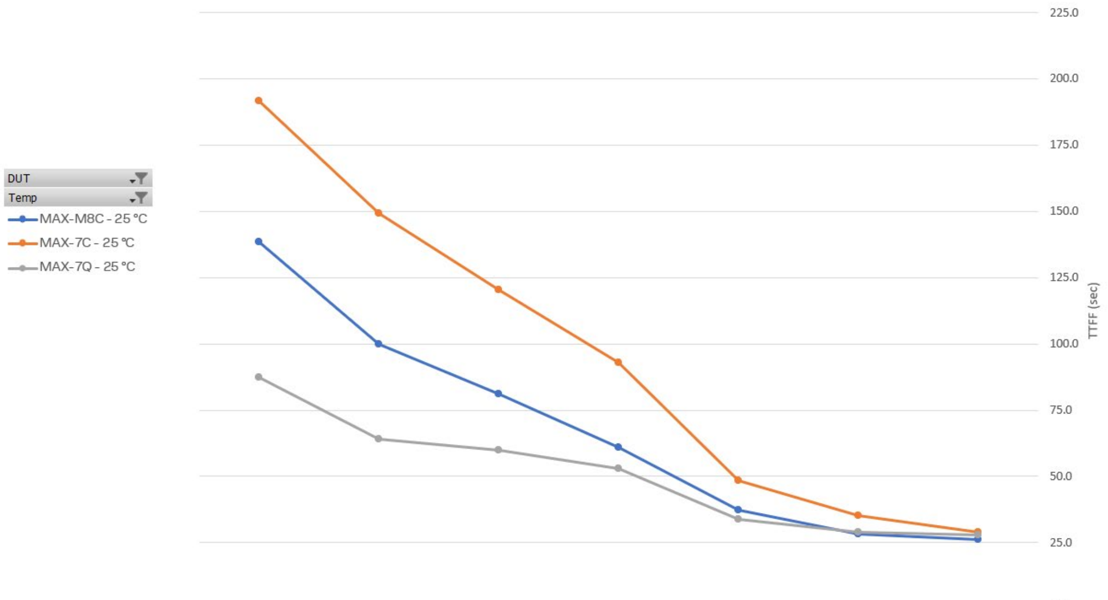
Table 8: MAX-7Q to MAX-8C and MAX-M8C power requirements

5.4.3 Performance

5.4.4 Startup sensitivity and TTFF

Because of the higher number of tracking satellites in multi-GNSS MAX-M8C, TTFF values with strong signals at room temperature are even lower than the TCXO-based single-GNSS MAX-7Q, as shown in Figure 6. By comparing the MAX-M8C (blue line) and the MAX-7C (orange line), it is clearly visible that the MAX-M8C brings the TTFF of crystal version closer to that of the TTFF of TCXO-based MAX-7Q (grey line). The cold start performance of the MAX-M8C clearly shows better performance than the MAX-7C, even at strong signals. Due to the limitation to the single-GNSS operation mode, MAX-8C would not achieve the same performance as the MAX-M8C, but would be closer to the blue curve of MAX-M8C than to the orange curve of MAX-7C.

[21] Use this figure to determine the required battery capacity.
[22] Simulated GNSS constellation using power levels of -130 dBm. Voltage supply= 3.0 V.
[23] Average current from startup until the first fix.



	- 148 (25)	- 147 (26)	- 146 (27)	- 144 (29)	- 140 (33)	- 135 (38)	- 130 (43)
MAX-M8C - 25 °C	138.42	99.84	81.09	61.10	37.23	28.36	26.23
MAX-7C - 25 °C	191.76	149.18	120.49	92.87	48.30	35.30	28.96
MAX-7Q - 25 °C	87.27	64.06	59.87	52.89	33.91	28.85	27.90

Signal power (dBm) and the equivalent C/N0 (dBHz) between parenthesis

Figure 6: TTFF vs. signal power for MAX-M8C, MAX-7Q and MAX-7C during cold starts[24]

The cold startup behavior of MAX-M8C at different temperatures (-35, +25 and +85 °C) presented in Figure 3 shows that the crystal-based MAX-M8C has only a small dependency on the temperature.

Migration from MAX-7Q to MAX-M8C provides improved startup performance at strong signals. MAX-8C and MAX-M8C are good migration alternatives for the TCXO-based MAX-7Q module.

6. Conclusion

For customers with active antennas or an external LNA in their current designs, there should be no issue when switching from TCXO-based MAX-M8Q to crystal-based MAX-M8C, or from TCXO-based MAX-8Q to crystal-based MAX-8C.

For migration from TCXO-based MAX-7Q to crystal-based MAX-7C, MAX-8C or MAX-M8C, refer to section 5 for detailed comparison of the different options. Contact u-blox technical support team for guidelines for finding the best suitable crystal-based solution for your MAX-7Q design.

Large and well-designed passive patch antennas, external LNA or active antennas can work perfectly well with u-blox crystal-based MAX receivers despite the minimal performance differences between the crystal and the TCXO variants. MAX-M8C, MAX-8C and MAX-7C solutions are good for applications where operation with a weak signal is not necessary.

[24] Results obtained on our test sites using a good LNA in front and an attenuator to decrease power level.

Related documents

[1] MAX-8 / MAX-M8 Hardware integration manual, UBX-15030059
[2] MAX-7, NEO-7 Hardware integration manual, UBX-13003704
[3] MAX-M8 Data sheet, UBX-15031506
[4] MAX-8 Data sheet, UBX-16000093
[5] MAX-7 Data sheet, UBX-13004068
[6] GNSS FW3.01 Release notes, UBX-16000319

Revision history

Revision	Date	Name	Comments
R01	21-Dec-2020	imar, cbib	Initial draft

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