

## Crystal Oscillators for SAMRH7x Rad-Hard Microcontroller Main Clock (MAINCK) and Slow Clock (SLCK) Inputs

### INTRODUCTION

This application note lists the Vectron high-reliability oscillator model numbers that have been characterized for use as sources for the Main Clock and Slow Clock of the SAMRH7x series of rad-hard microcontrollers. These oscillators are the only recommended external frequency sources for use as the SAMRH7x Main Clock and Slow Clock. While other suppliers may offer clocks that meet the specifications, they are not approved reference designs by Microchip, and as such the user must complete his/her own qualification and analysis for fitness of use.

**Note:** This document is applicable for both SAMRH71 and SAMRH707. For the benefit of the audience, the document uses SAMRH7x instead of SAMRH71 and SAMRH707.

### RECOMMENDED OSCILLATORS

The SAMRH7x clock generator block defined in paragraph 26 of the data sheet consists of a Slow Clock and a Main Clock. The sources for these clocks can either be generated by internal RC oscillators, external crystals with on-chip oscillators, or by external crystal oscillators. This application note specifically addresses the external crystal oscillators that are recommended for use with the Main Clock (Table 1) and Slow Clock (Table 2). Three common oscillator frequencies, 10 MHz, 12 MHz, and 20 MHz are recommended for the Main Clock in the application note, though any frequency between 3 MHz and 20 MHz may be used per Table 47-14 of the SAMRH7x data sheet. Three different reliability levels of the microcontroller are available. For each of these reliability levels, the customer needs to ensure that the corresponding reliability level of the crystal oscillator is correctly specified to match the application. Nine individual oscillator model numbers are defined in Table 1 (one for each combination of frequency and reliability level).

**TABLE 1: RECOMMENDED VECTRON HIGH RELIABILITY OSCILLATOR MODELS AT THREE PRIMARY REFERENCE CLOCK FREQUENCIES**

MCU Model	Reliability Level	Main Clock Frequency	Oscillator Model Number
SAMRH71F20x-7GB-E SAMRH707F18x-DRB-E	Prototype (-E)	10 MHz	1157D10M00000BX
SAMRH71F20x-HFB-HP SAMRH707F18x-4QB-HP	Hi-Rel Plastic (-HP)	10 MHz	1157B10M00000BE
SAMRH71F20x-7GB-MQ SAMRH707F18x-DRB-MQ	QML-Q	10 MHz	1157B10M00000BE
SAMRH71F20x-7GB-SV SAMRH707F18x-DRB-SV	QML-V	10 MHz	1157R10M00000BS
SAMRH71F20x-7GB-SR SAMRH707F18x-DRB-SR			
SAMRH71F20x-7GB-E SAMRH707F18x-DRB-E	Prototype (-E)	12 MHz	1157D12M00000BX
SAMRH71F20x-HFB-HP SAMRH707F18x-4QB-HP	Hi-Rel Plastic (-HP)	12 MHz	1157B12M00000BE
SAMRH71F20x-7GB-MQ SAMRH707F18x-DRB-MQ	QML-Q	12 MHz	1157B12M00000BE
<b>Note:</b> The models chosen are the most cost-effective solutions that meet the requirements of SAMRH7x and the required reliability level. The 1157 series oscillators recommended are from the Vectron Hi-Rel Oscillator standard OS-68338. All the devices listed are 3.3V, CMOS, surface mount, 7 mm x 5 mm, ceramic leadless chip carrier oscillators.			

**TABLE 1: RECOMMENDED VECTRON HIGH RELIABILITY OSCILLATOR MODELS AT THREE PRIMARY REFERENCE CLOCK FREQUENCIES (CONTINUED)**

MCU Model	Reliability Level	Main Clock Frequency	Oscillator Model Number
SAMRH71F20x-7GB-SV SAMRH707F18x-DRB-SV	QML-V	12 MHz	1157R12M00000BS
SAMRH71F20x-7GB-SR SAMRH707F18x-DRB-SR			
SAMRH71F20x-7GB-E SAMRH707F18x-DRB-E	Prototype (-E)	20 MHz	1157D20M00000BX
SAMRH71F20x-HFB-HP SAMRH707F18x-4QB-HP	Hi-Rel Plastic (-HP)	20 MHz	1157B20M00000BE
SAMRH71F20x-7GB-MQ SAMRH707F18x-DRB-MQ	QML-Q	20 MHz	1157B20M00000BE
SAMRH71F20x-7GB-SV SAMRH707F18x-DRB-SV	QML-V	20 MHz	1157R20M00000BS
SAMRH71F20x-7GB-SR SAMRH707F18x-DRB-SR			
<b>Note:</b> The models chosen are the most cost-effective solutions that meet the requirements of SAMRH7x and the required reliability level. The 1157 series oscillators recommended are from the Vectron Hi-Rel Oscillator standard OS-68338. All the devices listed are 3.3V, CMOS, surface mount, 7 mm x 5 mm, ceramic leadless chip carrier oscillators.			

**TABLE 2: RECOMMENDED VECTRON HIGH RELIABILITY OSCILLATOR MODELS AT 32.768 KHZ FOR SLOW CLOCK**

MCU Model	Reliability Level	Slow Clock Frequency	Oscillator Model Number (Unformed Leads)	Oscillator Model Number (Formed Leads)
SAMRH71F20x-7GB-E SAMRH707F18x-DRB-E	Prototype (-E)	32.768 kHz	1103D32K76800BX	1119D32K76800BX
SAMRH71F20x-7GB-MQ SAMRH707F18x-DRB-MQ	QML-Q	32.768 kHz	1103B32K76800BE	1119B32K76800BE
SAMRH71F20x-7GB-SV SAMRH707F18x-DRB-SV	QML-V	32.768 kHz	1103R32K76800BS	1119R32K76800BS
SAMRH71F20x-7GB-SR SAMRH707F18x-DRB-SR				
SAMRH71F20x-HFB-HP SAMRH707F18x-4QB-HP	Hi-Rel Plastic (-HP)	32.768 kHz	1103C32K76800BB	1119C32K76800BB

## COMPARISON OF SAMRH7X QUALITY FLOW REQUIREMENTS VS. OS-68338 SCREENING AND PEDIGREES

Due to differences in the requirements listed in MIL-PRF-38534 (for radiation hardened electronics) and MIL-PRF-55310 (for crystal oscillators), exact matches in quality flow vs. screening levels and component pedigrees are not available. [Table 3](#) summarizes available quality flows for the SAMRH7x rad-hard microcontroller, and the recommended corresponding screening and pedigree levels for OS-68338 oscillators. Customers are encouraged to review applicable specifications for mission critical applications to ensure full compliance.

**TABLE 3: SAMRH7X QUALITY FLOW REQUIREMENTS VS. OS-68338 OSCILLATOR SCREENING AND PEDIGREES**

PHY Quality Flow	Oscillator Screening	Oscillator Component Pedigree	Description
Prototype (-E)	X	D	Engineering model hardware using high reliability design with commercial grade components and non-swept quartz.
QML-Q	E	B	Military grade hardware using high reliability design with military grade components and swept quartz.
QML-V	S	R	Space grade hardware with 100krad die, space grade components, and swept quartz.
Hi-Rel Plastic (-HP)	E	B	Military grade hardware using high reliability design with military grade components and swept quartz.

## COMPARISON OF SAMRH7X ELECTRICAL REQUIREMENTS VS. OS-68338 ELECTRICAL SPECIFICATIONS

Electrical performance requirements for the Main Clock external oscillator are partially defined in Table 47.1, Table 47.3, and Table 47.5.4 of the SAMRH7x data sheet. Additional requirements have been derived from customer use cases and radiation testing reports. These requirements are listed in [Table 4](#), along with the corresponding electrical parameter specification from OS-68338. The subsequent paragraphs provide additional details for parameters that require further explanation.

**TABLE 4: ELECTRICAL COMPLIANCE MATRIX FOR THE MAIN CLOCK EXTERNAL OSCILLATOR**

Specification	SAM71RHF20 Microcontroller Requirement	OS-68338 Oscillator Specification	Units	Notes
Operating Temperature	-55 to +125	-55 to +125	°C	—
20 Year Total Stability	Not Defined	±100	ppm	See <a href="#">Stability Requirements</a>
Supply Voltage	1.8/3.3	3.3	VDC	—
Voltage Low Logic Min.	-0.3	0	V	—
Voltage Low Logic Max.	0.7	0.363	V	—
Voltage High Logic Min.	2	2.67	V	—
Voltage High Logic Max.	4	3.63	V	—
Duty Cycle	40 to 60	45 to 55	%	—
Rise and Fall Time Max.	Not Defined	5	ns	—
Total Jitter Peak-to-Peak, Max (10k samples)	360	85	pspp	See <a href="#">Jitter Requirements</a>
Total Ionized Dose	100	100	krad	See <a href="#">Radiation Requirements</a>
Single Event Latch-Up	62.5	120	MeV*cm <sup>2</sup> /mg	—

## Stability Requirements

The SAMRH7x data sheet does not specify a frequency stability requirement for the reference oscillators. The recommended oscillators in this application note will maintain a fractional frequency error of  $\pm 100$  ppm under all conditions for a 20 year operational life. Table 5 provides details on the frequency budget. Note that while OS-68338 specification lists  $\pm 5$  ppm for first-year aging, and  $\pm 2$  ppm/year after year one, due to the logarithmic nature of the aging curves, oscillators will comply with  $\pm 31$  ppm total aging over 20 years.

**TABLE 5: FREQUENCY STABILITY OF OS-68338 OSCILLATORS**

Parameter	Specification Maximum
Initial accuracy at +23°C	$\pm 15$ ppm
Frequency Temperature Stability from +23°C reference	$\pm 50$ ppm
Frequency vs. Voltage Tolerance	$\pm 4$ ppm
20-year aging (including 100 krad TID effects)	$\pm 31$ ppm
Total cumulative frequency error for 20 year life	$\pm 100$ ppm

## Jitter Requirements

The SAMRH7x data sheet does not specify jitter requirements for an external oscillator. The limit in this application note was derived from expected use requirements for the SAMRH7x including SpaceWire, CAN and IEEE 1553.

## Radiation Requirements

The SAMRH7x has been tested to  $>100$  krad total ionizing dose (TID) and  $>62.5$  MeV-cm<sup>2</sup>/mg single-event latch-up (SEL). The OS-68338 specification was chosen as it has a similar TID and a higher SEL tolerance.

## ENCLOSURE OPTIONS

OS-68338 offers multiple enclosure options. The 1157 enclosure chosen for this application note, a surface mountable, 7 mm x 5 mm, ceramic leadless chip carrier, is the lowest cost solution in OS-68338. Other enclosures may be chosen based on mission profiles, customer assembly and manufacturing guidelines, and customer quality requirements.

## SUMMARY

The OS-68338 oscillators listed in Table 1 have been characterized and are recommended for use as the external oscillator for the Main Clock for the SAMRH7x rad-hard microprocessor. The oscillators meet all required performance parameters per the SAMRH7x data sheet and expected use cases. The oscillators are rated to similar radiation levels as the microcontroller. Multiple alternate enclosure options are available, and alternate frequencies in the range of 3 MHz to 20 MHz can be provided.

## REFERENCES

OS-68838 Oscillator Specification:

<https://www.vectron.com/products/military/xo/OS-68338.pdf>

SAMRH7x Rad-Hard Microcontroller data sheet:

<https://www.microchip.com/en-us/product/SAMRH71>

<https://www.microchip.com/en-us/product/SAMRH707>

## APPENDIX A: REVISION HISTORY

### Revision F (May 2024):

- Document title updated
- Added [Table 2](#)
- Updated table numbering
- Added some wording under [Introduction](#) and [Recommended Oscillators](#) sections
- Replaced back matter pages with latest versions
- Corrected copyright details in footer throughout document to have full range of copyright years for this app note

### Revision E (July 2022):

- Updated [Table 1](#)
- Updated [References](#)
- Updated [Table 3](#)

### Revision D (July 2022):

- Added a note to [Introduction](#)
- Updated the document by replacing SAMRH71 and SAMRH707 with SAMRH7x
- Updated the MCU part numbers in [Table 1](#)

### Revision C (July 2021):

- Updated referenced table numbers from the SAMRH71 data sheet throughout document
- Added MCU part numbers to [Table 1](#)
- Corrected Voltage Low Logic Max. to Voltage High Logic Max. (7th row) in [Table 4](#)

### Revision B (June 2020):

- Updated notes column in [Table 4](#).

### Revision A (June 2020):

- Initial release of AN3520 “Crystal Oscillators for SAMRH7x Rad-Hard Microcontroller Main Clock (MAINCK) Input”.

# AN3520

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NOTES:

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