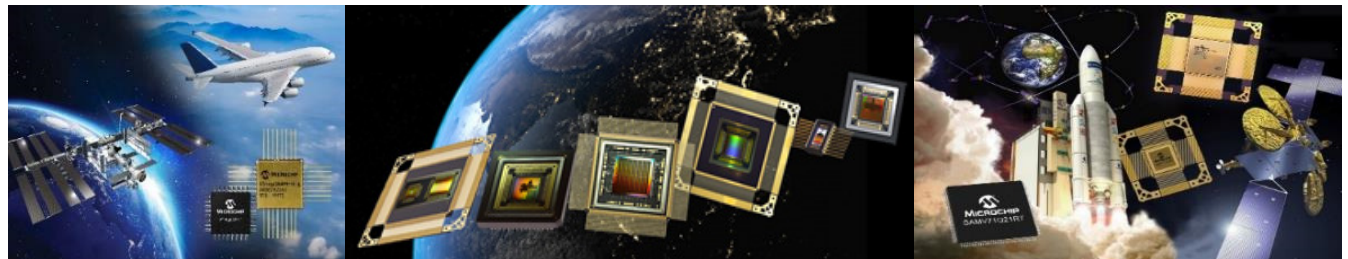


ADG Products Line Space Products Presentation



A Leading Provider of Smart, Connected and Secure Embedded Control Solutions



Eric Tinlot – Markus Seel – Tadhg O'Brien
MCHP Aerospace

October 2020



SMART | CONNECTED | SECURE

ADG Products & TSS Overview

- **ADG Products Line, Microchip France**
- **Processors & Microcontrollers**
 - Rad Tolerant
 - Rad Hard by Design
- **TSS & Power/Clock Devices**



ADG Products Line

Microchip France

Combined Portfolio: End Markets

MCUs

Analog

Mixed Signal

Interface

Memory

Power
Management

Switches &
Controllers

High-Rel
Discrete

Enterprise
Storage

FPGA

Industrial
28%

Automotive
15%

Consumer
13%

Communications
14%

Computing
18%

A&D
12%



Microchip

COMBINED CAPABILITIES

Microsemi

Combined Portfolio: Aerospace & Defense

Combined Products Portfolio for Aerospace & Defense Total System Solution (TSS)

ADG*

ADG
Products
Line

Industrial
28%

Automotive
15%

Consumer
13%

Communications
14%

Computing
18%

A&D
12%



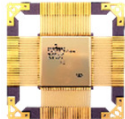
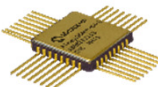
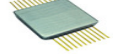
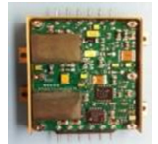
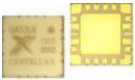
Microchip

COMBINED CAPABILITIES

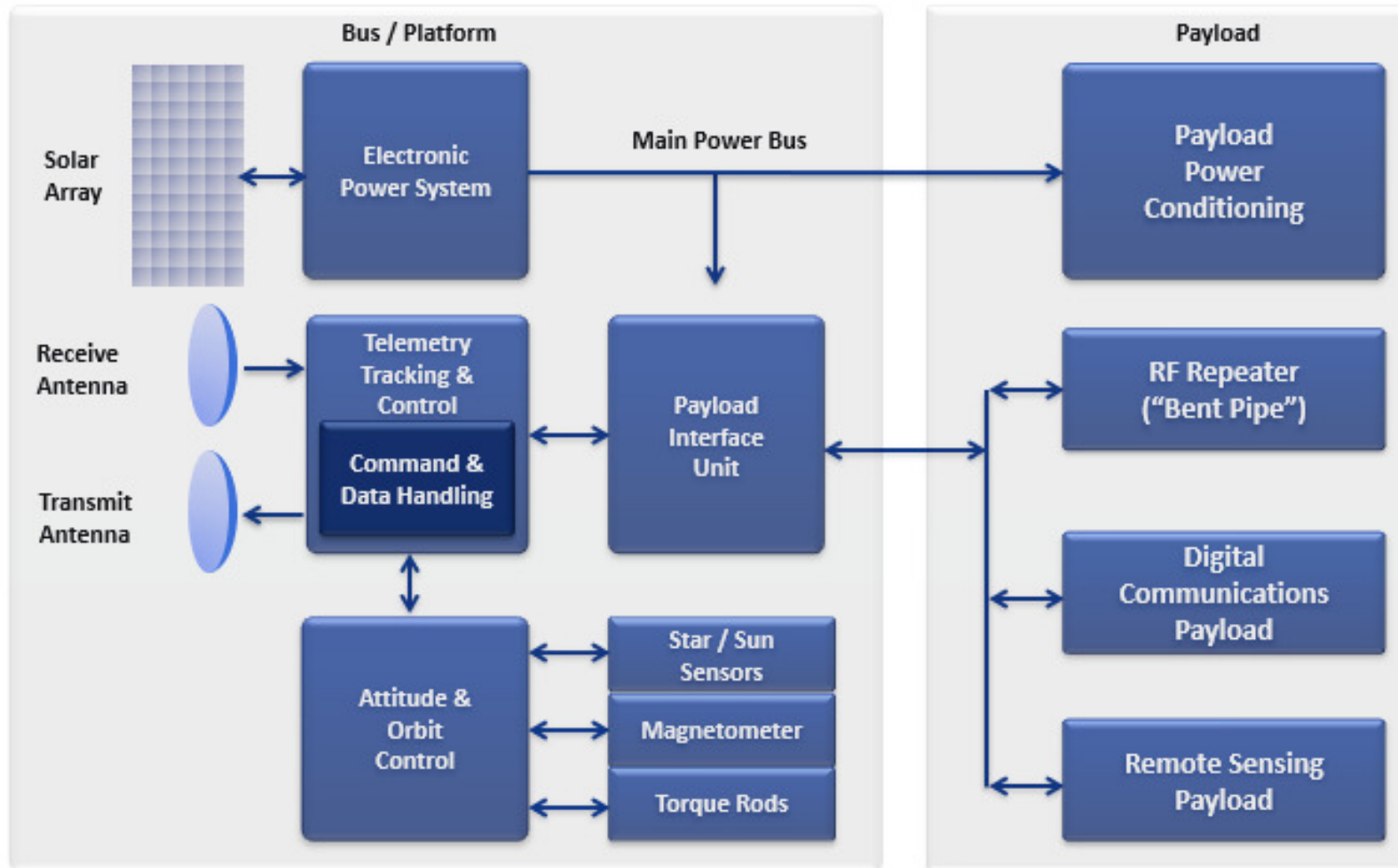
Microsemi

Delivering A Comprehensive Space Portfolio

ADG

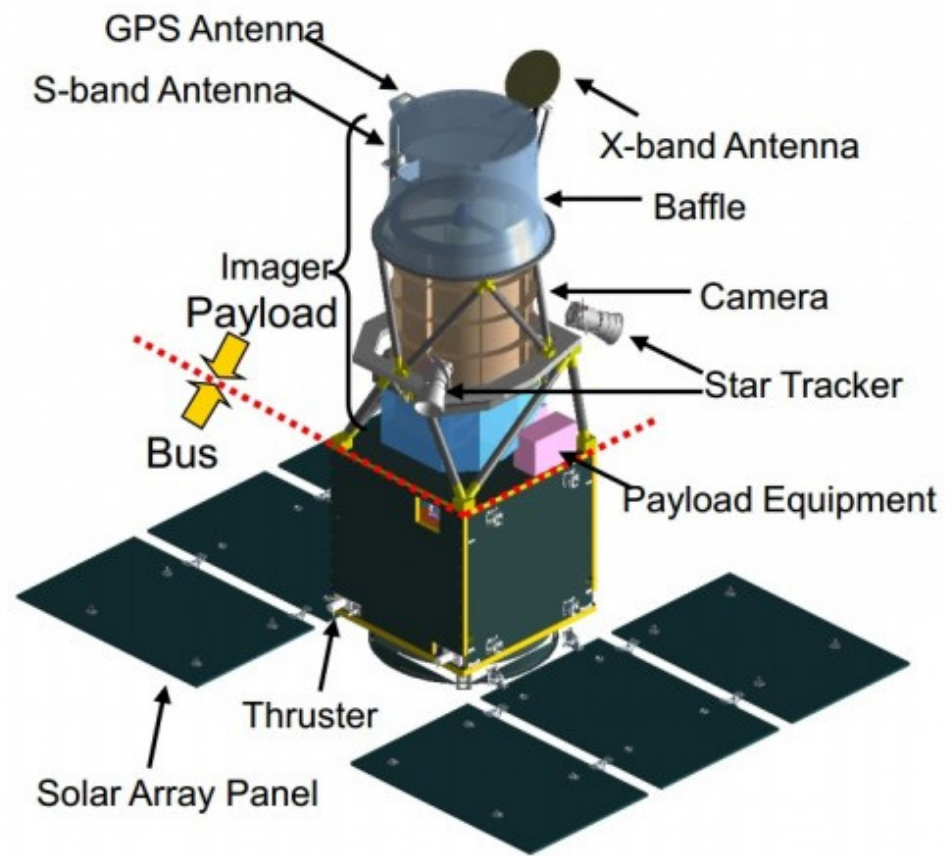
Rad-Tolerant & RHBD MCU/MPU, Com & Mem	COTS to Rad Tolerant, Rad Hard by Design, QML/ESCC 8-bit & 32-bit AVR, arm, SPARC V8 MCU and MPU Memories, SpaceWire Router, Ethernet & CAN devices	    
Radiation Tolerant FPGAs	High Performance, High Density, Low Power TID up to 300 Krad, SEL Immune RTG4 FPGAs up to 300 MHz and 150K LE RTProASIC3, RTAX and RTSX-SU QML Qualified	   
Rad-Hard Mixed Signals Integrated Circuits	Telemetry and Motor Control Space System Managers Extensive Custom IC Capability Power supply protection	   
Space Qualified Oscillators	Ovenized Quartz Oscillators Hybrid Voltage Controlled and Temperature Compensated Crystal Oscillators Cesium Clocks	   
Rad-Hard Power Solutions	Rad-hard JANS Diodes, Bi-Polar Small Signal Transistors Rad-hard Isolated DC-DC Converter Modules Custom Power Supplies 2 W to > 5 KW Point of Load Hybrid Solutions Electromechanical Relays	   
Space Screening for RF Products	Surface Acoustic Wave (SAW) Filters Packaged and Chip Si Diodes Si Bipolar Transistors & GaAs pHEMT MMICs	     

Satellite Architecture Overview



The BUS is how it flies and the PAYLOAD is why it flies

Bus and Payload of an Imager Satellite



The BUS is how it flies and the PAYLOAD is why it flies

Microcontrollers for Space

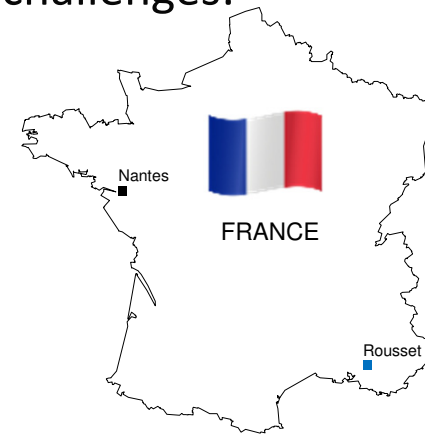
Targeted Applications

- Platform & Payload data storage
- Platform Data Handling
- Remote Terminal Units (RTUs)
- Propulsion system control
- Sensor bus control
- Robotics applications
- Mechanisms and motor control
- Power control
- OBC for nano-satellites
- Thermal control
- Simple instrumentation (particle detector, radiation monitor, etc)
- Angular sensor
- Sun sensor
- ...

Microchip Technology France

Aerospace & Defense Product line

- **Committed to High Reliability and Long-Term Supply**
 - Delivering aerospace ICs for more than 30 years
 - Strong flight heritage in space and avionic applications
 - Leverage from automotive solutions for “new space” challenges: volumes, costs and time to market
- **Major Products Focus**
 - ASICs
 - Processors and microcontrollers
 - Communication interfaces and memories
- **Long term cooperation with European agencies:**
 - ESA, CNES, DGA, DLR....
- **Internal Qualified Supply Chain**
 - DLA/ESCC: Wafer lot to qualified parts (France)
 - DLA: Assembly line (Thailand)



Use of COTS in Aerospace & Defense

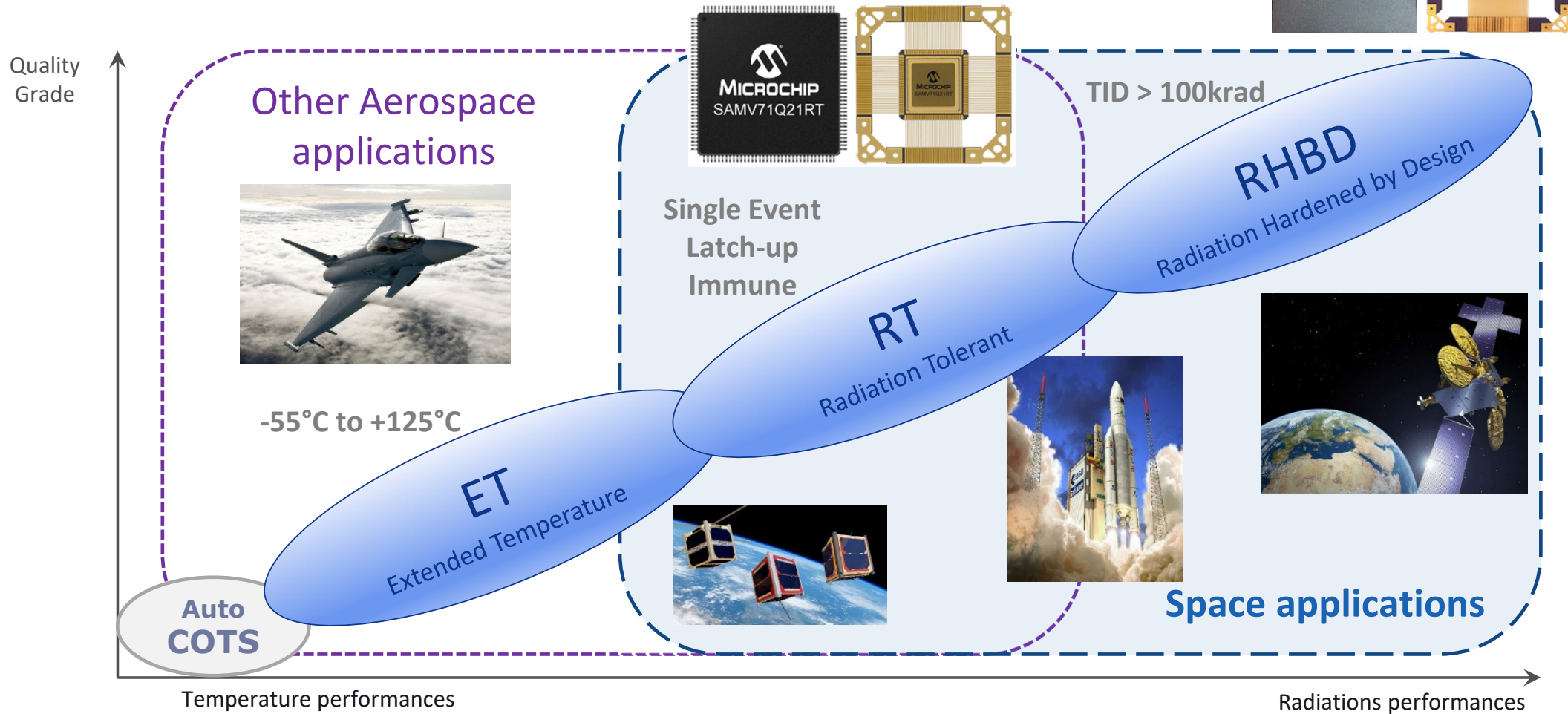
Advantages

- Easy access and costs effective (volume)
- AECQ100 Automotive qualified parts
- Reliability linked to high volumes & high nb of users
- Wide access to State of art technologies and architectures
- Access to free ecosystem and benefit from community

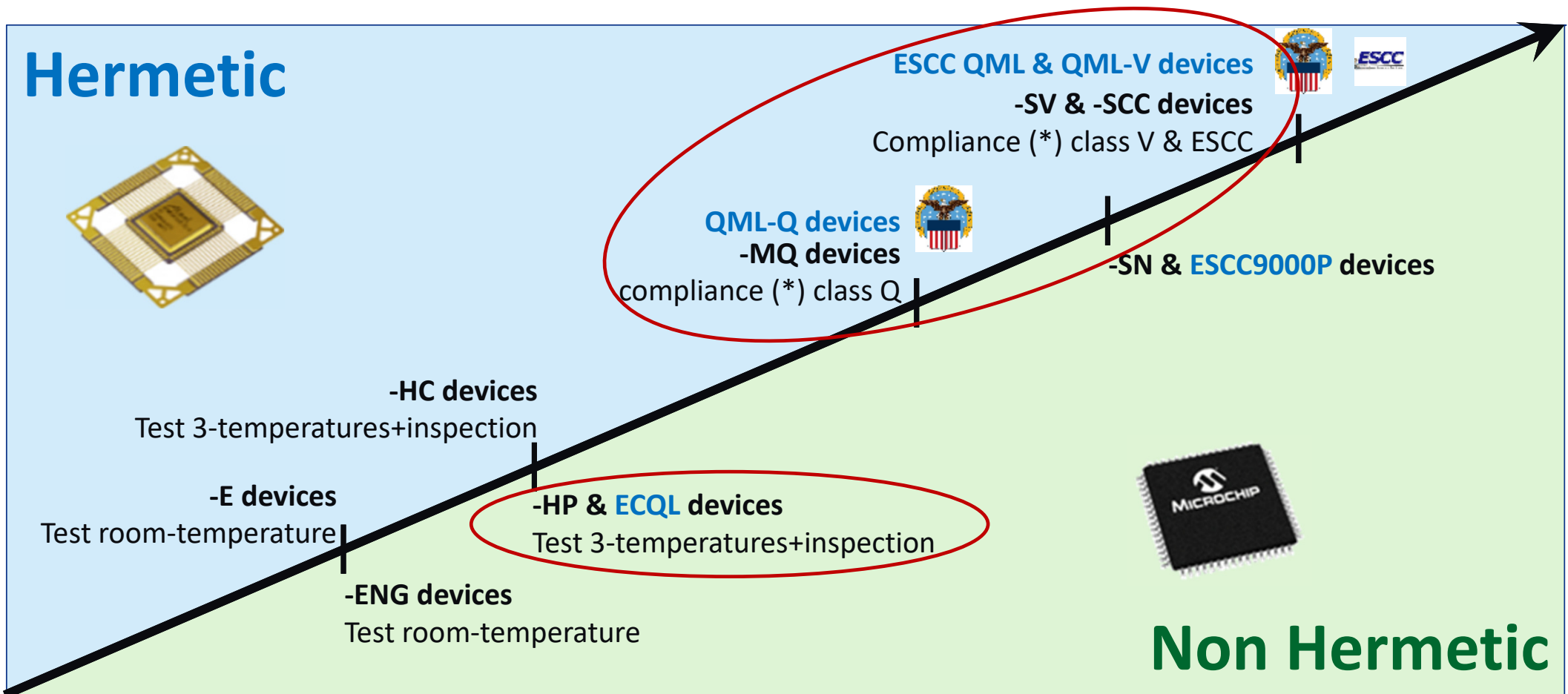
Drawbacks

- No traceability, No SLDC, High silicon lots discrepancy
- Limited access to qualification and supply chain data
=> PPAP only for “specific” auto customers / volumes
- Products turnover, versioning and obsolescence (EOL)
- Weak or Unknown radiations performances. Not always lucky.
- Product knowledge and costs for radiations testing/screening
- No FM support from silicon provider, no guarantee and RMA

Scalable Solutions for Aerospace



RHBD & RT Proposed Quality Flows



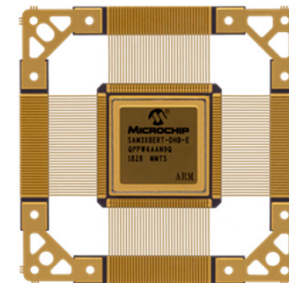
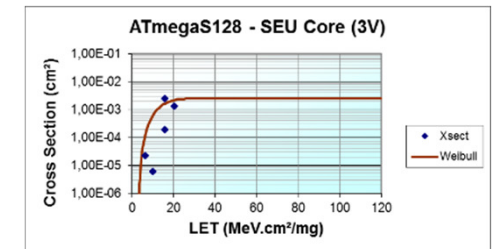
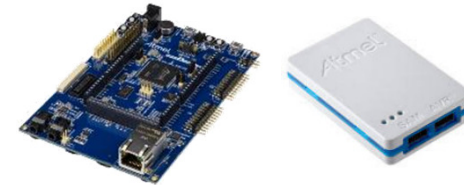
(*) compliance = Qualification testing, screening testing, and TCI/QCI inspections meet MIL-PRF 38535 or ESCC9000 requirements

Processors & Microcontrollers

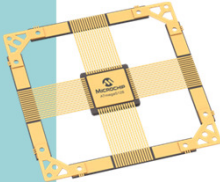
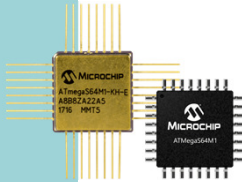
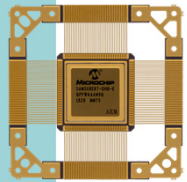
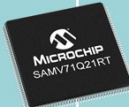
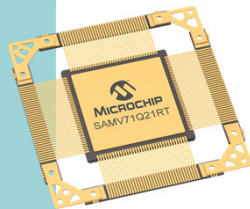
Rad Tolerant

COTS to Radiation Tolerant Devices

- **Start from industrial/automotive products**
 - Same mask set
 - Same functionality
 - Same development tools
 - Easy access via commercial eval kit
 - Free tool chain & libraries
 - Same pin out as commercial device
- **Hardening of critical parameters**
 - Process tuning for no Single Event Latch-up up to $62 \text{ MeV.cm}^2/\text{mg}$ @ T_{max}
 - Total Ionizing Dose above 20 krad (Space)
 - Radiation report including SEU full characterization
 - Embedded Flash & SRAM robustness, Limited SEFI occurrence
- **Scalable solution, 2 proposed quality flows**
 - Space Grade Ceramic SV/MQ, MOQ min 5 units
 - Hirel Plastic HP, MOQ min 200 units

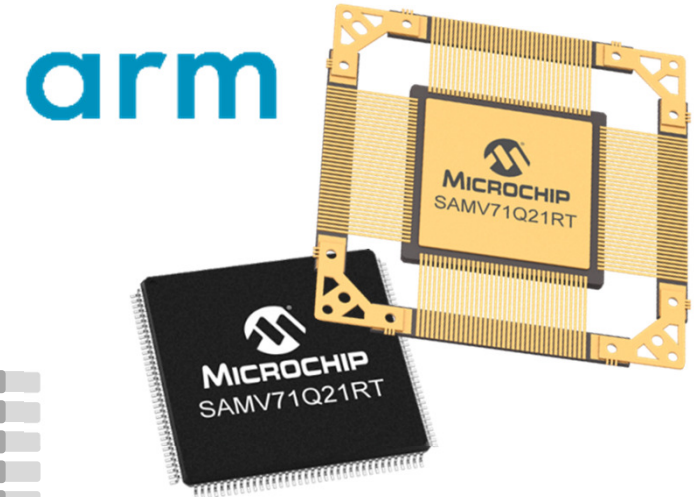


Radiation Tolerant Microcontrollers

Products	Summary / Highlights	Flight Models
ATmegaS128 	 8-bit Rad Tolerant AVR MCU (10 MIPS) / -55°C to +125°C 10-bit ADC / 6x PWM UART / TWI / SPI 128KB Flash / 4KB SRAM  	Since 2017 
ATmegaS64M1 	8-bit Rad Tolerant AVR MCU (10 MIPS) / -55°C to +125°C 10-bit ADC DAC / Power Stage Controller / Motor Control UART / SPI / CAN 64KB Flash / 4KB SRAM	Since 2018 
SAM3X8ERT 	32-bit Rad Tolerant Arm Cortex-M3 MCU (100 DMIPS) / -40°C to +105°C Dual CAN / Ethernet 10 & 100 / UART / TWI / SPI 12-bit ADC DAC / PWM / Timers Dual-bank Flash 2x 256 KB / Dual-bank SRAM 64 KB + 32 KB / Ext Mem Cont. 	Since 2020 
SAMV71Q21RT 	32-bit Rad Tolerant Arm Cortex-M7 MCU (600 DMIPS) / -55°C to +125°C TCM / MPU / ECC / FPU / DSP Dual CAN-FD / Ethernet 10 & 100 / UART / TWI / SPI / QSPI 12-bit ADC DAC / 16-bit PWM / 16-bit Timers Flash 2 MB / Multiport SRAM 384 KB / Ext Mem Cont. 	Since 2018 

SAMV71Q21RT Rad Tolerant

Samples & Flight models available



2MB Flash

ECC

384 KB SRAM

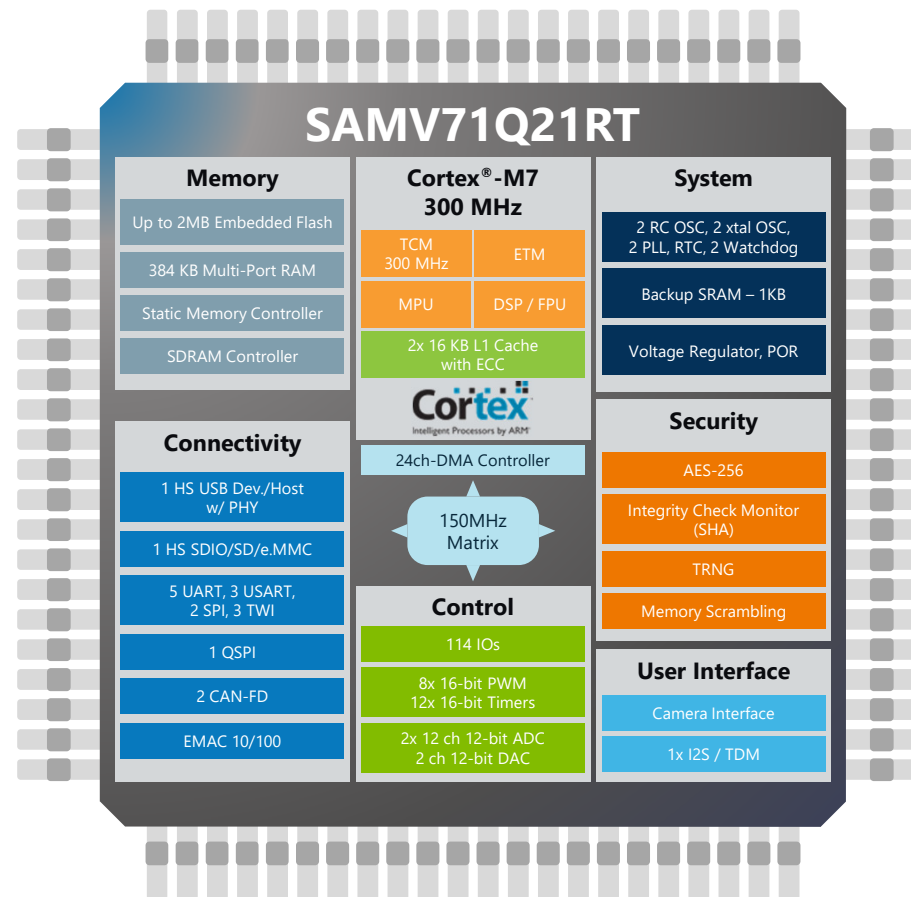
TCM up to 128KB
Caches R/W 16KB

ECC

Ext. Memory

144-pins package

-55°C / +125°C



600 DMIPS

TCM / MPU / ICM*
FPU / DSP

Dual CAN FD

Ethernet 10/100

Crypto AES

*Integrity Check Monitor  MICROCHIP

Arm® Cortex®-M7 SoC

Benefits from Same HW/SW Ecosystem

Xplained board

Ordering Code: ATSAMV71-XULT



SW Tools suite



Microchip J32 Probe

Ordering Code: DV164232



Atmel ICE programmer and debugger

Ordering code P/N: ATATMEL-ICE

Ready to use software, example projects

Already ported OS for M7 SoC (V71)



A&D BSP/SW ongoing projects with :



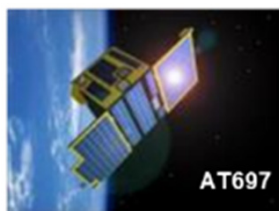
Processors & Microcontrollers

Rad Hard by Design

Processors : An Unrivalled Flight Heritage



Colombus
2008



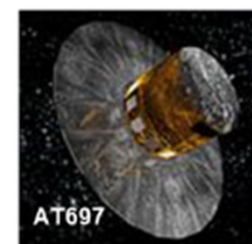
Proba2
2009



JUNO (Nasa)
2011



SPOT6
2012



Gaia
2013



Alphasat
2013



SVOM/Eclair
2013



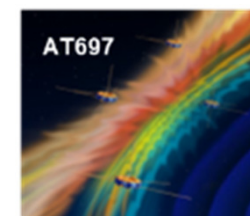
SWARM
2013



Sentinels
2013



SMAP (Nasa)
2014



MMS (Nasa)
2014



Exomars
2016



Solar Obiter
2017

More than 5,000 flight models
delivered worldwide

Bepi-Colombo
2018



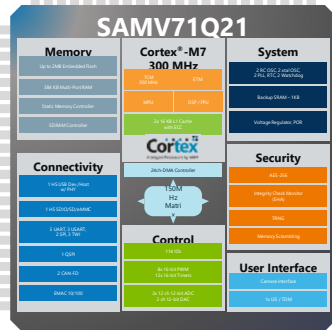
Arm® Cortex®-M7 SoC

Scalable Solution

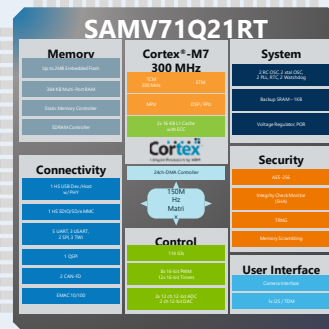
Qualification
Level

Other aerospace applications

Auto COTS

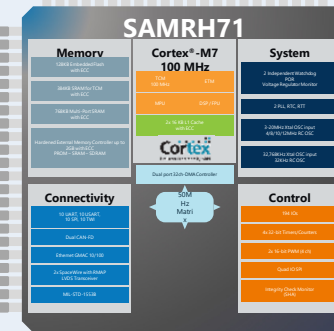


RT

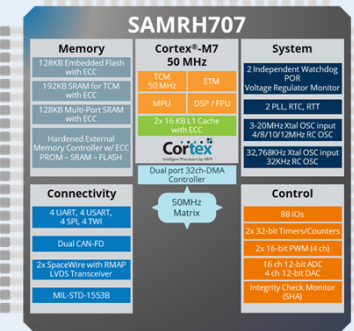


SAMV71Q21RT
600 DMIPS
Latch-up Immune

RHBD



SAMRH71
 >200 DMIPS
TID > 100 krad



SAMRHXXX
>100 DMIPS
TID > 100 krad

1553



SpaceWire

Space applications

Temperature performances

Radiations performances

SAMRH71 Rad Hard SoC

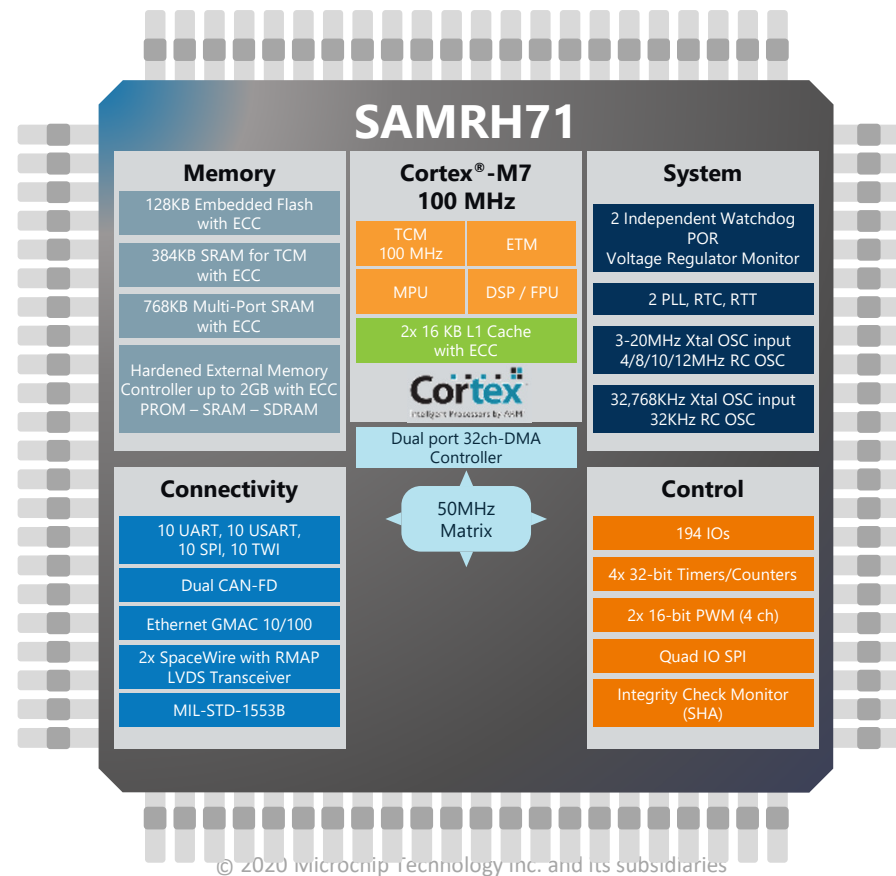
ES Available
MQ Available
SV Q420

128KB Flash **ECC**
1MB SRAM **ECC**
(384KB TCM) **ECC**
Int/Ext Mem **ECC**

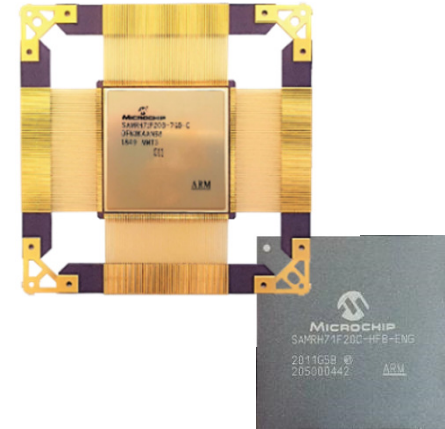
CQFP256
BGA625 (ES Q420)

-55°C / +125°C

- SEL immune up to 62Mev.cm²/mg
- TID >100Krad, Flash limited to 20Krad
- SEU LET >20Mev.cm²/mg, Xsection <10⁻⁹ cm²/word



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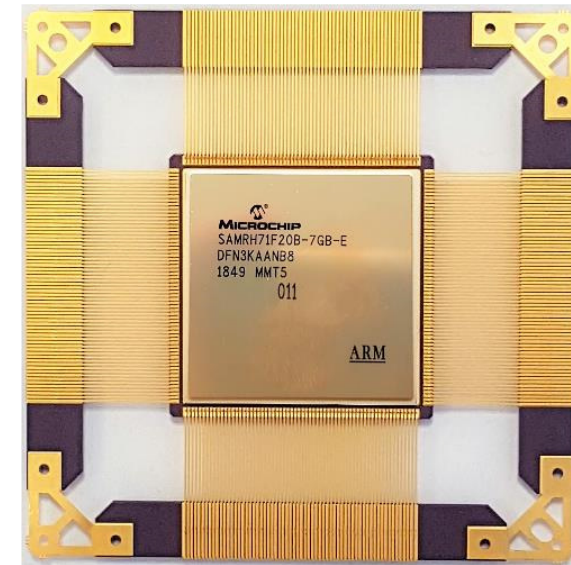
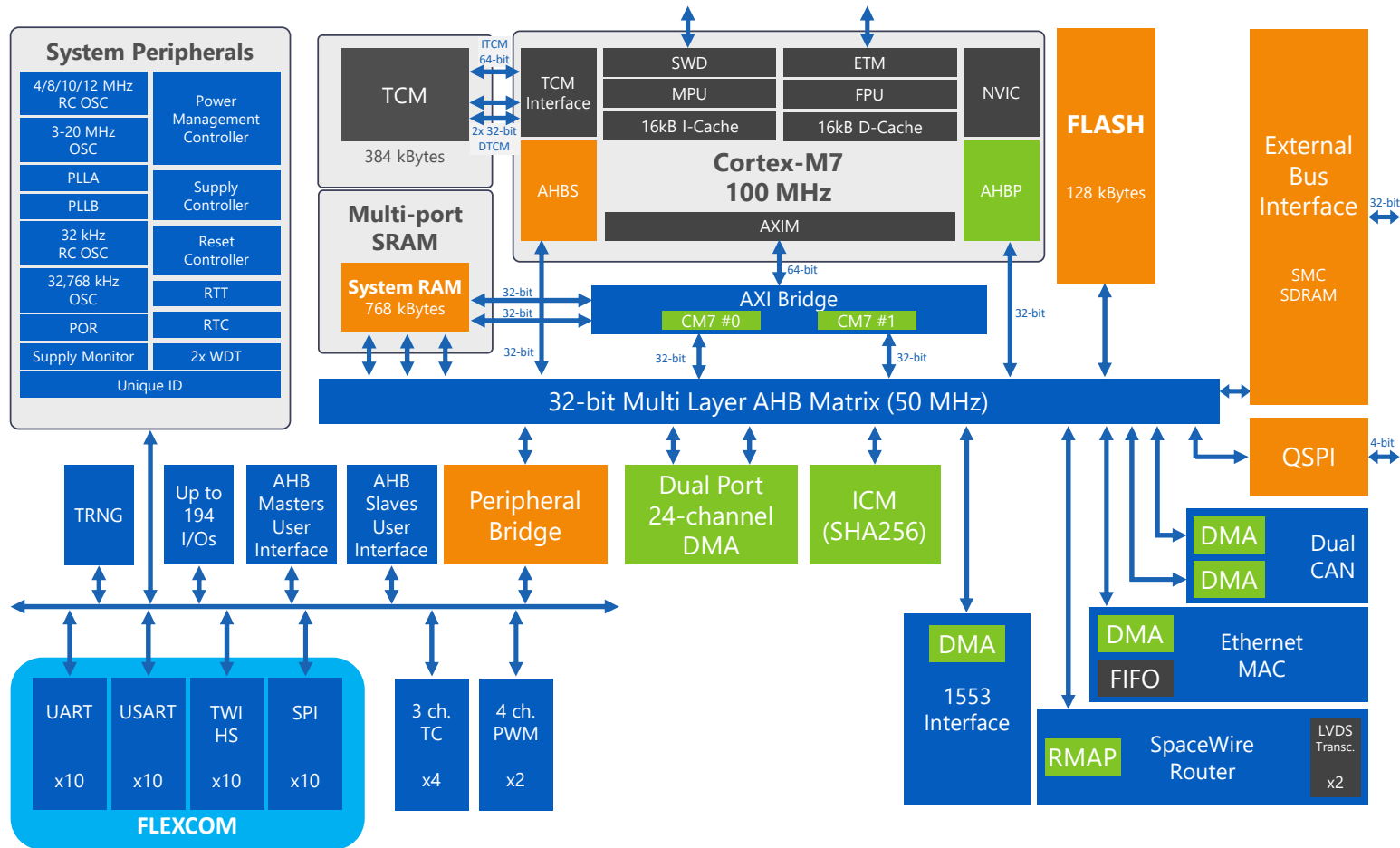
>200 DMIPS
TCM / MPU / ICM
FPU / DSP
Dual CAN FD
Ethernet TSN 10/100
SpaceWire 200Mb x2
1553 M/S

*Integrity Check Monitor



SAMRH71

SoC architecture



Legend:
 AHB Masters (green)
 AHB Slaves (orange)

SAMRH71

SAMRH71F20-EK Evaluation Kit

- **SAMRH71F20-EK Hardware**

- SAMRH71F20C-7GB-E
- Power supply cable
- USB cable

- **SAMRH71 Tools**

- MPLAB X IDE support
- 3rd party support on-going



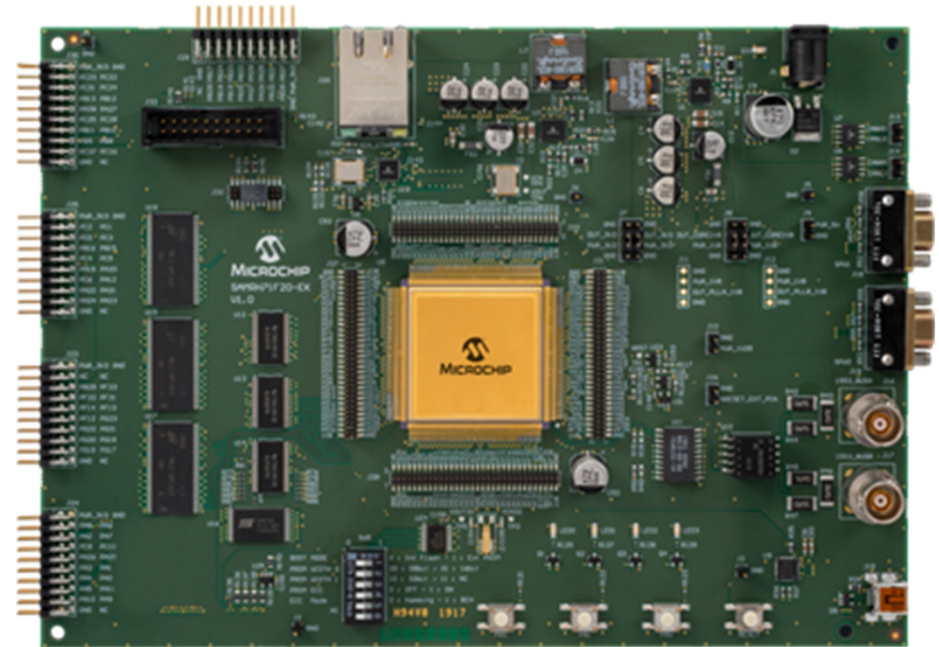
- **SAMRH71 Embedded Software (Full set of drivers examples)**

- MPLAB HARMONY 3 (Software Package)
- 3rd party support on-going



- **SAMRH71 Documentation**

- Datasheet
- Evaluation Kit User Manual
- Application Notes (Getting Started, ICM management,...)
- IBIS model
- Available from
 - <https://www.microchip.com/wwwproducts/en/SAMRH71>
 - <https://www.microchip.com/DevelopmentTools/ProductDetails/PartNO/SAMRH71F20-EK>



SAMRH71 Evaluation Kit
([SAMRH71F20-EK](#))



Atmel ICE programmer and debugger
([ATATMEL-ICE](#))

SAMRH707 Rad Hard Microcontroller



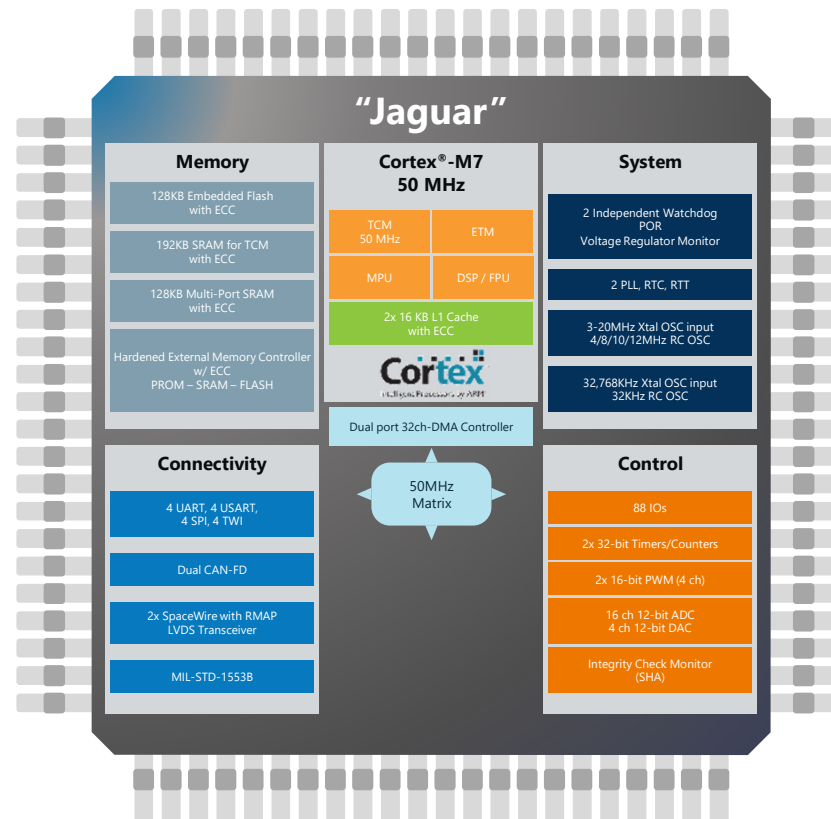
Sampling early 2021
FM end 2021

- SEL immune up to 62Mev.cm²/mg
- TID >100Krad, Flash limited to 20Krad
- SEU LET >20Mev.cm²/mg, Xsection <10⁻⁹ cm²/word

128KB Flash ECC
320KB SRAM ECC
(192KB TCM) ECC
Int/Ext Mem ECC

- CQFP 164
- CGA 484
- BGA 484

-55°C / +125°C

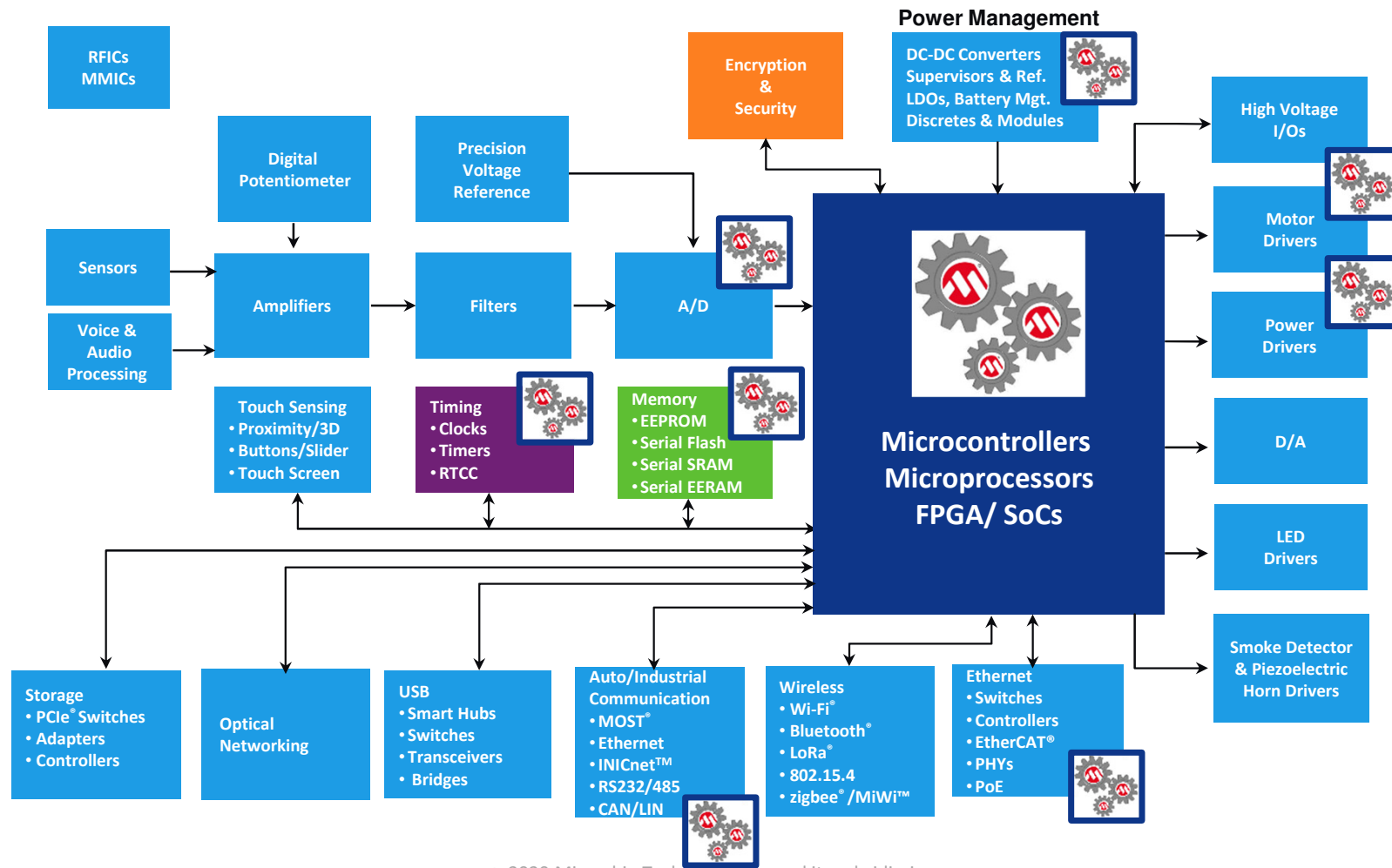


>100 DMIPS
TCM / MPU / ICM
FPU / DSP
Dual CAN FD
SpaceWire 200Mb x2
1553 M/S
Analog integration
ADC & DAC 12 bits

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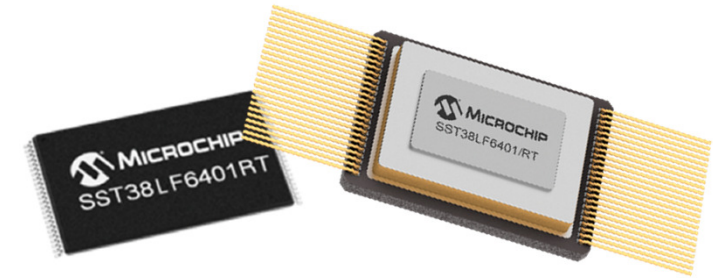
*Integrity Check Monitor MICROCHIP

A&D Total System Solutions



SRAM & NVM Memories

- SRAM



Products	SMD	Rad	Type	Available
AT65609	Yes	RH	SRAM 1 Mbit, QFP32	FM since 2002
AT60142H	Yes	RH	SRAM 4 Mbit w physical bit separation, QFP36	FM since 2005
AT68166H	Yes	RH	SRAM 16 Mbit, 4 x AT60142 MCP, QFP68	FM since 2006

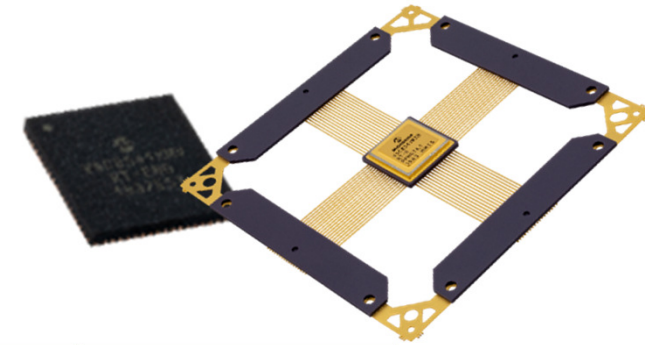
- NVM

Products	Rad	Type	Available
AT69170	RH	Serial EEPROM 4 Mbit, QFP18	FM since 2016
AT17LV010-10DP	RT	Serial EEPROM 1 Mbit	FM available
AT28C010-12DK	RT	Parallel EEPROM 1 Mbit	FM available
SST38LF6401RT	RT	64 Mbit // Rad Tolerant Flash Memory	Sampling H220

Communication and ADC

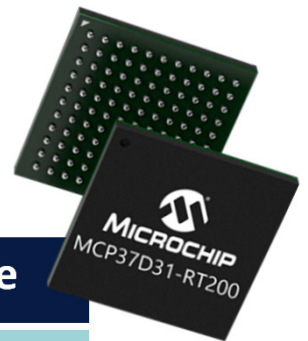
- Communication Interfaces

Products	Rad	Type	Available
AT7910	RH	Spacewire Router	FM
VSC8540/41RT	RT	100Mb/1Gbit Ethernet Transceiver, RMII/RGMII	Sample Available



- Analog to Digital Conversion

Products	Rad	Type	Available
MCP37D31-RT200	RT	200MSPS, 16bit, Pipeline ADC	FM



Timing & Clocks solutions

Anchor devices companions



- **SAMRH71**

- <http://www.microchip.com/wwwappnotes/appnotes.aspx?appnote=en1002211>

- **RTG4**

- https://www.vectron.com/products/space/AN3216_RTG4_App_Note.pdf

- **VSC841RT**

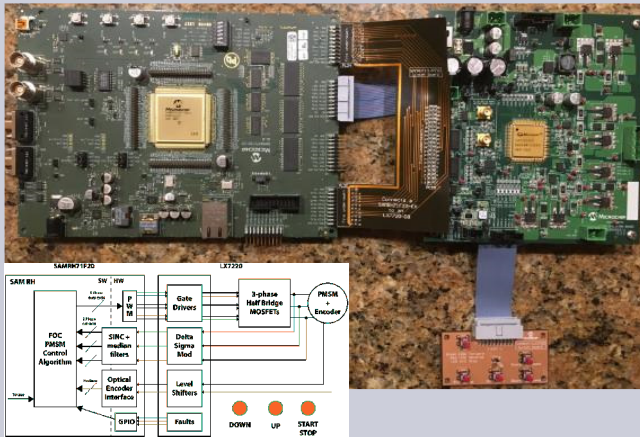
- <http://www.microchip.com/wwwappnotes/appnotes.aspx?appnote=en1002207>

- **RT MCUs**

- <https://www.microchip.com/wwwappnotes/appnotes.aspx?appnote=en1003706>
- <https://www.microchip.com/wwwappnotes/appnotes.aspx?appnote=en1003705>
- <https://www.microchip.com/wwwappnotes/appnotes.aspx?appnote=en1003704>
- <https://www.microchip.com/wwwappnotes/appnotes.aspx?appnote=en1003703>

A&D TSS - HW/SW available

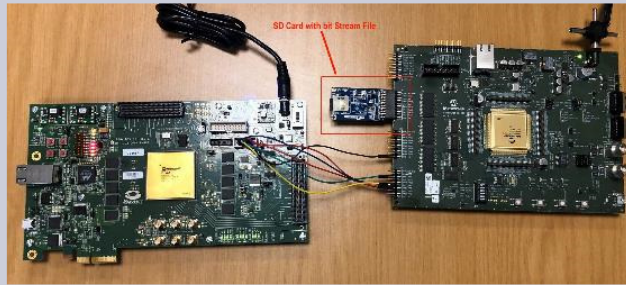
Motor Control



SAMRH71 + LX7720

https://github.com/Microchip-MPLAB-Harmony/motor_control/tree/master/apps/pmsm_foc_encoder_lx7720_sam_rh71_ek

FPGA Reconfiguration



SAMRH71 + RTG4/PolarFire

https://github.com/MicrochipTech/adg_fpga_reconfiguration

CAN



SAMRH71 + SAMV71RT + ATMEGAS64M1

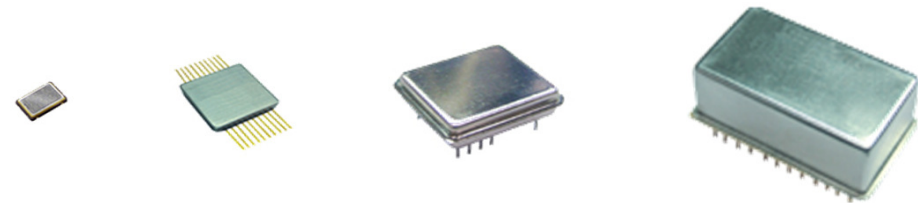
https://github.com/MicrochipTech/adg_can_motor_control



Frequency Control Space Products



A Leading Provider of Smart, Connected and Secure Embedded Control Solutions

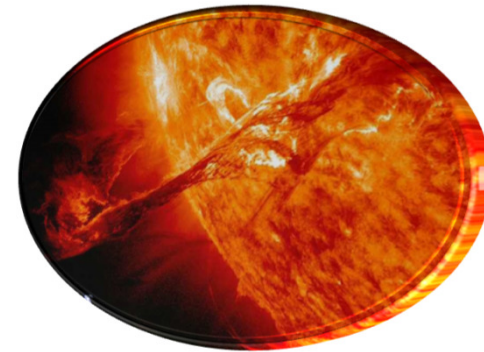


Microchip Proprietary and Confidential

Extensive Space Heritage

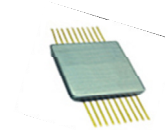
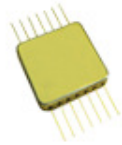
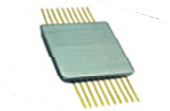
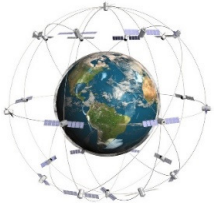
- **Vectron products onboard:**

- First successful US space mission in 1958
- First Lunar Landing in 1969
- Furthest manmade object from Earth – Voyager 1
 - 13 billion miles away
 - 42 years of operation
 - Interstellar space
- Spacecraft on surface of Moon, Venus, Mars, and Titan
- Spacecraft intentionally impacted Mercury, Jupiter, Saturn and Sun
- Flyby's of every planet in our solar system
- Geosynchronous and Low Earth Orbit Space Craft
- Hubble Telescope



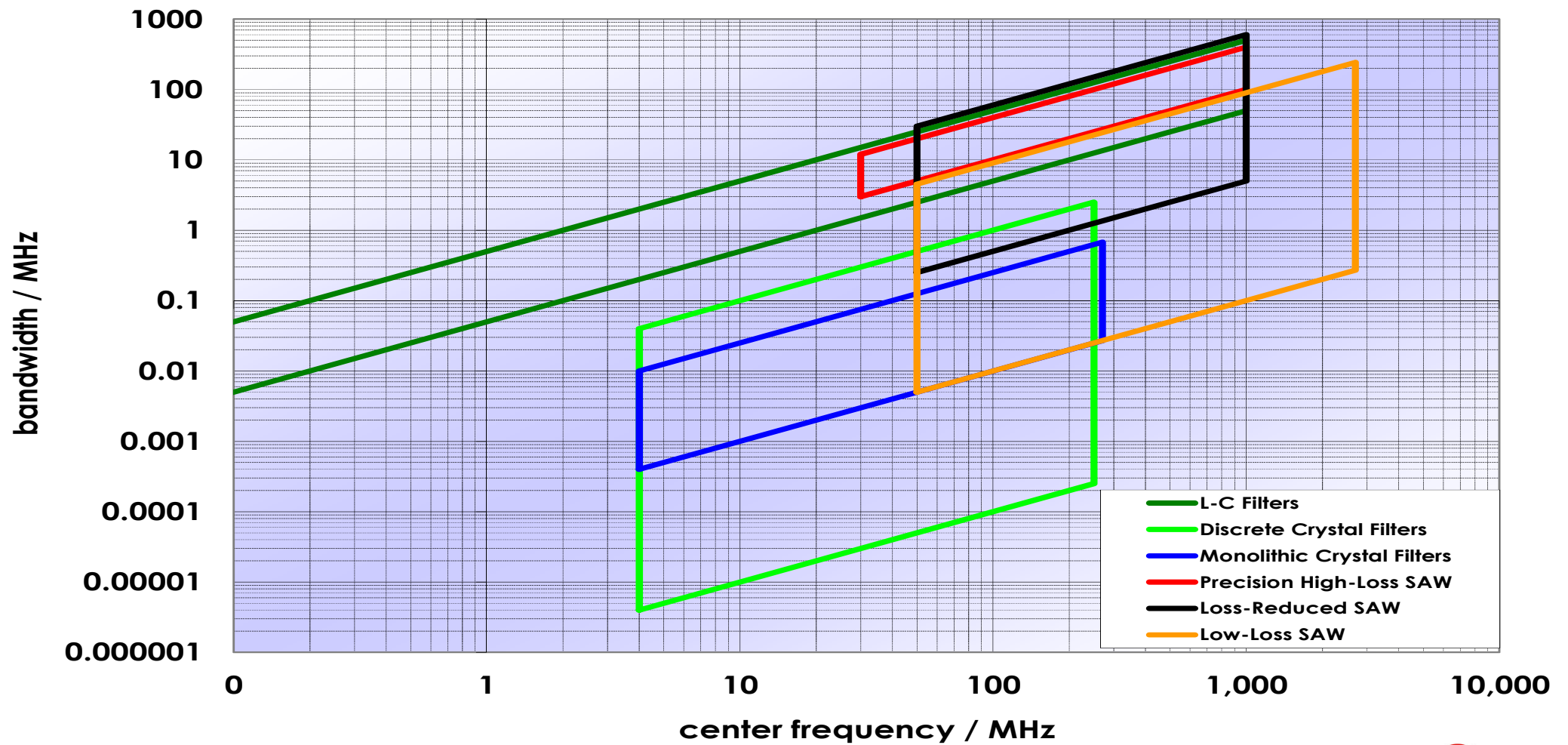
1960s	Apollo	Gemini	Pioneer	Intelsat
1970s	GPS	Viking	Nimbus	Voyager
1980s	Galileo	Milstar	Magellan	Space Shuttle
1990s	Centaur	Cassini-Huygens	Hubble Telescope	International Space Station
2000s	Mars Spirit	Mars Odyssey	New Horizons	Global Star II
2010s	Orion	GPS III	Galileo	Atlas IV launch vehicle

Broadest Space Portfolio



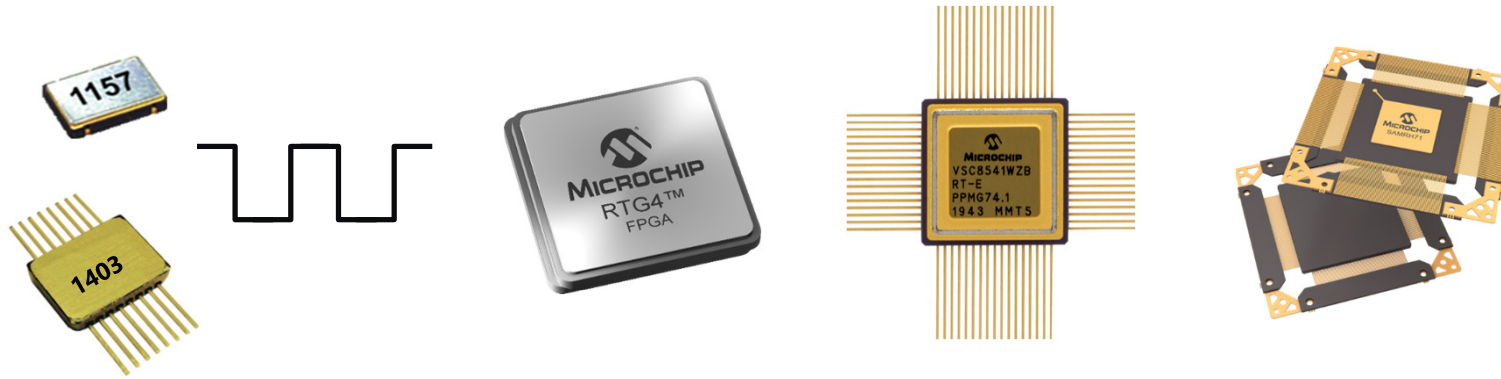
	Single Ended Clocks	Differential Clocks	TCXOs	VCXO	VCSO	Mid Stability OCXO	CSAC	High Stability OCXO
Outputs	CMOS, TTL, SINE	LVDS, LVPECL	CMOS, SINE, LVDS	CMOS, Sine, LVDS, LVPECL	SINE, LVPECL	CMOS, SINE, LVDS	CMOS, 1PPS	TTL, SINE
Max Frequency (MHz)	500	700	200	700	3000	120	10	50
Maximum Operating Temperature Range (°C)	-55 to 125	-55 to 125	-55 to 105	-40 to 85	-40 to 85	-40 to 85	-10 to 70	-40 to 65
Best Temperature Stability (ppm)	50	50	0.5	50 (APR)	20 (APR)	0.1	0.0005	0.0003
Smallest Size Offered (mm ²)	7 x 5	12.7 x 9	19.5 x 19.5	14 x 9	16 x 16	24 x 26	40 x 35	34 x 34
Max TID (krad)	300	300	100	100	300	300	20	100

Frequency Ranges - Filter Technologies



Microchip Reference Clock Timing Solutions

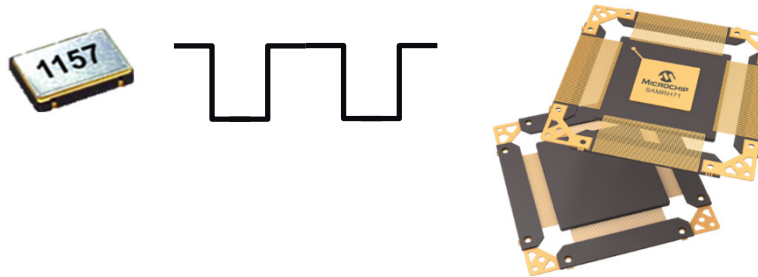
- Vectron Space XOs fully characterized frequency sources for Microchip RH/RT products



Microchip Part Number	Product Type	Timing Application Note
ATmegaS128	Rad Tolerant Microprocessor	AN3568
ATmegaS64M1	Rad Tolerant Microprocessor	AN3567
PolarFireRT	Rad Hard FPGA	In Process
RTG4	Rad Hard FPGA	AN3216
SAM3X8ERT	Rad Tolerant Microprocessor	AN3659
SAMRH71FA20	Rad Hard Microprocessor	AN3520
SAMV71Q2RT	Rad Tolerant Microprocessor	AN3660
VSC854(x)RT	Rad Tolerant Ethernet Phy	AN3503

SAMRH71FA20 Reference Clocks

- Vectron Space XOs only clocks fully characterized for SAMRH71FA20 Rad Hard Microprocessor



MCU Model	Reliability Level	Main Clock Frequency (MHz)	Oscillator Model Number
SAM71RHF20C-7GB-E	Prototype (-E)	10	1157D10M00000BX
SAM71RHF20C-7GB-MQ	QML-Q	10	1157B10M00000BE
SAM71RHF20C-7GB-SV	QML-V	10	1157R10M00000BS
SAM71RHF20C-7GB-E	Prototype (-E)	12	1157D12M00000BX
SAM71RHF20C-7GB-MQ	QML-Q	12	1157B12M00000BE
SAM71RHF20C-7GB-SV	QML-V	12	1157R12M00000BS
SAM71RHF20C-7GB-E	Prototype (-E)	20	1157D20M00000BX
SAM71RHF20C-7GB-MQ	QML-Q	20	1157B20M00000BE
SAM71RHF20C-7GB-SV	QML-V	20	1157R20M00000BS

- REF Clock App Notes in Process for: Polar Fire RT

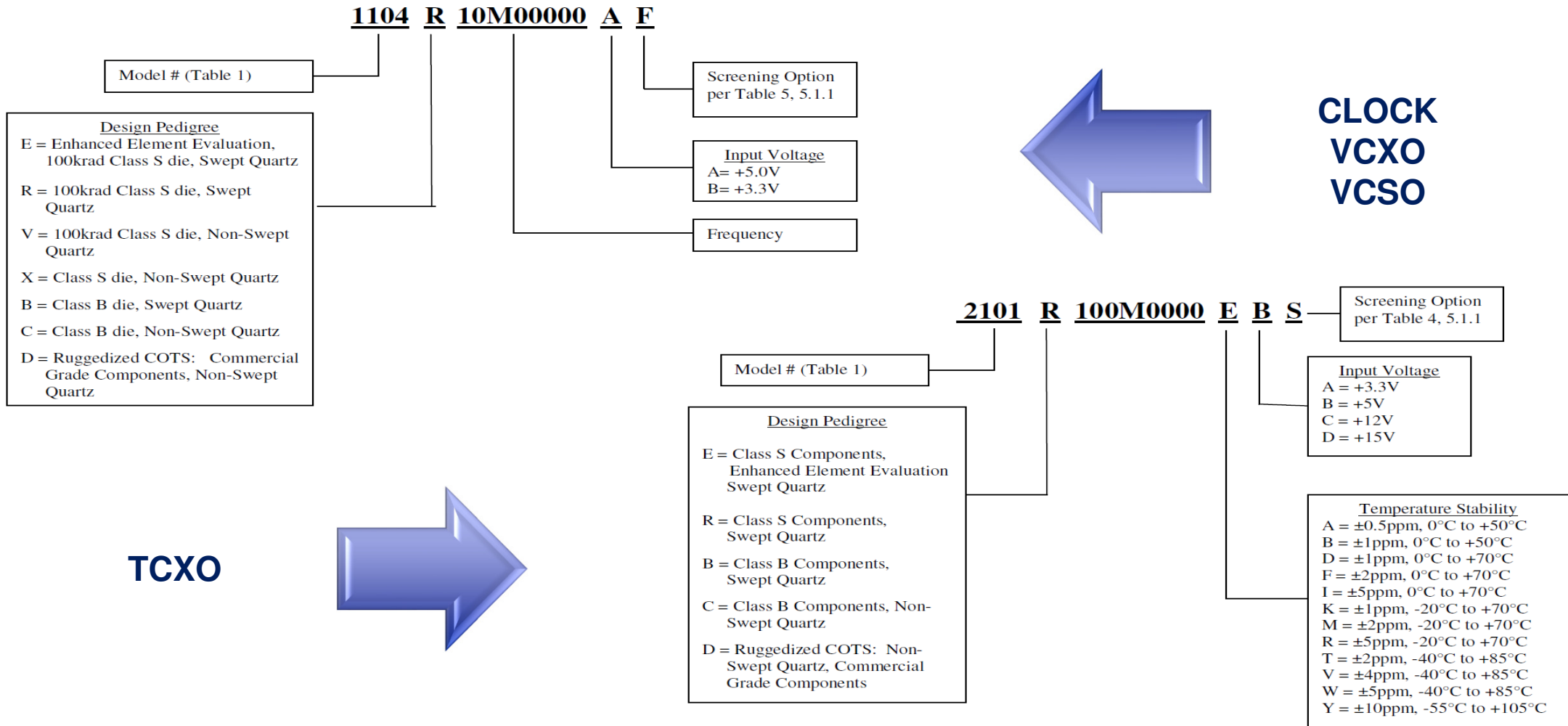
Single Ended Clock Options

- ± 50 ppm, -55 to 125 °C
- ± 15 ppm @25 °C
- CMOS, TTL, Sinewave
- Up to 500 MHz
- Up to 300 krad TID
- No BiCMOS leads to better SEL/SET



Specification	Model Number	Lead Form Version	Output Logic	Number of RF outputs	Frequency Range MHz	Radiation Tolerance			Package	Dimensions
						TID kRad	SET MeV-cm ² /mg	SEL MeV-cm ² /mg		mm
OS-68338	1101	1121	CMOS	1	0.35 to 100	100	40	120	12 Lead Flatpack	16.5x16.5x3.5
	1102	1122	CMOS	1	0.35 to 100	100	40	120	14 Lead Flatpack	20.3x15.2x3.5
	1103	1119	CMOS	1	0.35 to 100	100	40	120	16 Lead Flatpack	12.7x9.6x3
	1104	1120	CMOS	1	0.35 to 100	100	40	120	20 Lead Flatpack	16.5x16.5x3.8
	1105		CMOS	1	0.35 to 100	100	40	120	14 Pin DIP	22.8x13.7x5.1
	1107		TTL	1	0.35 to 100	100	40	120	12 Lead Flatpack	16.5x16.5x3.5
	1108		TTL	1	0.35 to 100	100	40	120	14 Lead Flatpack	20.3x15.2x3.5
	1109		TTL	1	0.35 to 100	100	40	120	16 Lead Flatpack	12.7x9.6x3
	1110		TTL	1	0.35 to 100	100	40	120	20 Lead Flatpack	16.5x16.5x3.8
	1111		TTL	1	0.35 to 100	100	40	120	14 Pin DIP	22.8x13.7x5.1
	1115		CMOS	1	0.35 to 100	100	40	120	4 Pin 1/2 DIP	12.7x12.7x5.08
	1116		CMOS	1	0.35 to 100	100	40	120	4 J-Lead SMT	14.0x8.9x4.8
	1117		TTL	1	0.35 to 100	100	40	120	4 J-Lead SMT	14.0x8.9x4.8
	1157		CMOS	1	1.5 to 100	100	40	120	4 Pad LCC	7x5x2
	1167	1177/1187	CMOS	1	1.5 to 100	100	40	120	4 Lead Ceramic DIP	7x5x2
	1179	1189/1199	CMOS	1	1.5 to 100	100	40	120	4 Lead Ceramic DIP	9x7x3
DOC204900	1403	1419	CMOS	1	12 to 160	100	90	90	16 Lead Flatpack	12.7x9.6x3
	1404	1420	CMOS	1	12 to 160	100	90	90	20 Lead Flatpack	16.5x16.5x3.8
DOC206379	1504	1520	CMOS	1	12 to 100	300	93	93	20 Lead Flatpack	16.5x16.5x3.8
DOC207975	1704	1720	SINE	1	10 to 200	300	N/A	N/A	20 Lead Flatpack	16.5x16.5x3.8
	1719	1721	SINE	1	200 to 500	300	N/A	N/A	16 Lead Flatpack	25.4x25.4x3.8
MIL-PRF-55310	M55310/16S		TTL	1	.375 to 80	100	40	120	14 Pin DIP	22.8x13.7x5.1

Hi-Rel Standard Part Number Breakdown



Clock/VCXO/VCSO Screening Options (REVISED)

OPN. NO.	OPERATION LISTING	REQUIREMENTS AND CONDITIONS	Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option S	Option X
	SCREENING	MIL Class Similarity (MIL-PRF-55310, Class S/B or MIL-PRF-38534, Class K)	K	B-	S-	K+	B	S (Rev E)		S (Rev F)	EM
			100%	100%	100%	100%	100%	100%	100%	100%	100%
1	Non-Destruct Bond Pull	MIL-STD-883, Meth 2023	X	NR	X	X	NR	X	NR	X	NR
2	Internal Visual	MIL-STD-883, Meth 2017 Class K, Meth 2032 Class K	X	X	X	X	X	X	X	X	X
3	Stabilization (Vacuum) Bake	MIL-STD-883, Meth 1008, Cond C, 150°C	X 48 hrs.	X 24 hrs.	X 48 hrs.	X 48 hrs.	X 24 hrs.	X 48 hrs.	X 24 hrs.	X 48 hrs.	X 24 hrs.
4	Thermal Shock	MIL-STD-883, Meth 1011, Cond A	NR	NR	X	NR	NR	X	NR	X	NR
5	Temperature Cycle	MIL-STD-883, Meth 1010, Cond. B (except Option S), 10 cycles min.	X	X	X	X	X	X	X	X Cond. C	NR
6	Constant Acceleration	MIL-STD-883, Meth 2001, Cond A, Y1 plane only, 5000 g's	X	X	X	X	X	X	X	X	NR
7	Particle Impact Noise Detection	MIL-STD-883, Meth 2020, Cond B (except Option S)	X	X	X	X	X	X	NR	X Cond. A	X
8	Electrical Testing, Pre Burn-In	Perform tests in Table 3. Nominal Vcc, nominal temperature	X	X	X	X	X	X	X	X	X
9	1 st Burn-In	MIL-STD-883, Meth 1015, Condition B	X 160 hrs.	X 160 hrs.	X 240 hrs.	X 160 hrs.	X 160 hrs.	X 240 hrs.	X 160 hrs.	X 240 hrs.	NR
10	Electrical Testing, Intermediate	Perform tests in Table 3. Nominal Vcc, nominal temperature	X	NR	NR	X	NR	NR	NR	NR	NR
11	2 nd Burn-In	MIL-STD-883, Meth 1015, Condition B	X 160 hrs.	NR	NR	X 160 hrs.	NR	NR	NR	NR	NR
12	Freq-Temp Slew Test	Operating temp. range, frequency plotted at 1.0°C steps	AR	AR	AR	AR	AR	AR	NR	AR	NR
13	Electrical Testing, Post Burn-In (Group A)	Perform tests in Table 3. Nominal Vcc & extremes, nominal temperature & extremes	X	X	X	X	X	X	X nom. Vcc	X	NR
14	Seal: Fine Leak Seal: Gross Leak	MIL-STD-202, Meth 112, Cond C (5 x 10 ⁻⁸ atm cc/sec max) MIL-STD-202, Meth 112, Cond D	X	X	X	X	X	X	X	NR	X
15	Seal: Fine Leak Seal: Gross Leak	MIL-STD-883, Meth 1014, Cond A2 or B1 MIL-STD-883, Meth 1014, Cond B2 or B3	NR	NR	NR	NR	NR	NR	NR	X	NR
16	Radiographic Inspection	MIL-STD-883, Meth 2012	X	AR	AR	X	AR	X	NR	X	NR
17	Solderability	MIL-STD-883, Meth 2003	1/	1/	1/	1/	1/	1/	1/	1/	NR
18	External Visual & Mechanical	MIL-STD-883, Meth 2009	X 2/	X 2/	X 2/	X 2/	X 2/	X 2/	X 2/	X 2/	X 2/
19	Aging, 30 Day 3/ (M55310 Group B)	MIL-PRF-55310, para. 4.8.35.1	NR	NR	NR	X	13 pcs.	X	NR	X	NR
20	Group C Inspection (optional)	See Para 5.2 herein for details of supplier recommended Group C Inspection options	5.2(g)	5.2(e)	5.2(e)	5.2(g)	5.2(e)	5.2(e)	5.2(e)	5.2(f)	NR

Change Orders in process to include Random Vibration



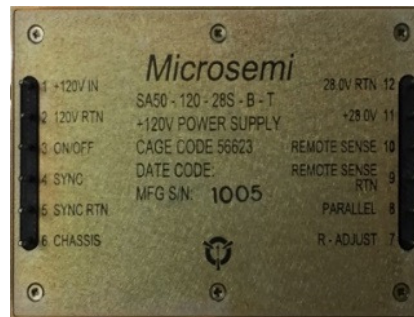
Links

- <https://www.vectron.com/products/space/space.htm>
- <http://ww1.microchip.com/downloads/en/Appnotes/AN3216-Reference-Clocks-for-RTG4-SerDes-REFCLK-Inputs-and-Interface-Circuits-DS00003216A.pdf>[http://ww1.microchip.com/downloads/en/Appnotes/Reference_Clocks_for_VSC854\(x\)RT Ethernet Transceiver AN 00003503B.pdf](http://ww1.microchip.com/downloads/en/Appnotes/Reference_Clocks_for_VSC854(x)RT_Ethernet_Transceiver_AN_00003503B.pdf)
- <http://ww1.microchip.com/downloads/en/Appnotes/AN3520-Crystal-Oscillators-for-SAMRH71F20-Rad-Hard-Microcontroller-Main-Clock-Input-DS00003520A.pdf>
- https://www.vectron.com/products/brochures/Vectron_Space_Brochure.pdf
- <https://www.microsemi.com/product-directory/embedded-clocks-frequency-references/5207-space-csac>

Standard SA50 Family

DC-DC Power Converters

Switch frequency	200/240Khz
Sync frequency	500/600Khz
POWER	5 to 50W
Operating temp	-55 to 85 °C
Storage temp	-55 to 125 °C
V input range	20 to 40V (SA50-28) 86 to 158V (SA50-120)
Shock	1500 g- P K,0 0.5ms,1/2 sine
Acceleration	50 gs
Random Vibe	24,06 grms
Isolation	100MΩ at 200V
Inhibit function	Yes
Over Volt. protection	Yes
TID	100 to 300Krad Per MIL-STD-883 M1019
ELDRS	<10mrads, to 100Krad Per MIL-STD-883 M1019
SEE	LET 89.5 Mev.cm ² /mg (hardened)
Export classification	EAR99



Target Application	Key Differentiation
- Power conditioning unit (PCU) - Electronic Power Converter (EPC) - Power distribution unit (PDU) - System power bus converter (DC-DC) - Power Processing Unit (PPU) - Ion propulsion thrusters	- Highest output power and efficiency - Robust SMT construction - Hundreds of successful space missions - Greatest customization flexibility without added schedule risk - Shortest lead times 30+years of flight hours with 0 failure - Worst-case analysis on hundreds of space programs

Standard module Model No.	Output voltages	Output current	Efficiency Nominal	Line regulation	Load regulation	Ripple
SA50-28-3.3S	3.3 V	1 to 10 A	81%	± 10 mV	± 50 mV	50 mV
SA50-28-5S	5 V	1 to 10 A	82%	± 10 mV	± 50 mV	50 mV
SA50-28-12S	12 V	0.4 to 4 A	82%	± 50 mV	± 120 mV	120 mV
SA50-28-15S	15 V	0.3 to 3.4 A	83%	± 30 mV	± 150 mV	150 mV
SA50-28-28S	28 V	0.2 to 2 A	83%	± 56 mV	± 280 mV	280 mV
SA50-28-3.3-12T	3.3, ±12 V	1 to 10 A	80%	± 10 mV	± 50 mV	50 mV
SA50-28-3.3-15T	3.3, ±15 V	1 to 10 A	80%	± 10 mV	± 50 mV	50 mV
SA50-28-5-12T	5, ±12 V	0.4 to 4 A	81%	± 10 mV	± 50 mV	50 mV
SA50-28-5-15T	5, ±15 V	0.4 to 4 A	81%	± 10 mV	± 50 mV	50 mV
SA50-120-3.3S	3.3 V	1 to 10 A	81%	± 10 mV	± 50 mV	50 mV
SA50-120-5S	5 V	1 to 10 A	82%	± 10 mV	± 50 mV	50 mV
SA50-120-12S	12 V	0.4 to 4 A	82%	± 50 mV	± 120 mV	120 mV
SA50-120-15S	15 V	0.3 to 3.4 A	83%	± 30 mV	± 150 mV	150 mV
SA50-120-28S	28 V	0.2 to 2 A	83%	± 56 mV	± 280 mV	280 mV
SA50-120-3.3-12T	3.3, ±12 V	1 to 10 A	80%	± 10 mV	± 50 mV	50 mV
SA50-120-3.3-15T	3.3, ±15 V	1 to 10 A	80%	± 10 mV	± 50 mV	50 mV
SA50-120-5-12T	5, ±12 V	0.4 to 4 A	81%	± 10 mV	± 50 mV	50 mV
SA50-120-5-15T	5, ±15 V	0.4 to 4 A	81%	± 10 mV	± 50 mV	50 mV

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MHP50601A

3 – 7 Vin, 6 A, Synchronous Hybrid Point-of-Load DC-DC Converter

Device Features

- VIN = 3 V to 7 V (7.5V in Absolute Max)
- Internal reference (0.8 V)
- Adjustable frequency 300 kHz to 500kHz
- Parallel operation 180° out of Φ with sync pin
- Internal VREF 1.5% variation over temp and radiation
- Ultra-fast transient response to lower output impedance
- Integrated design (Cin, Cout, and Lswitch)
- Internal or optional external compensation and soft-start
- External enable or Under-voltage Lockout
- 96% peak efficiency

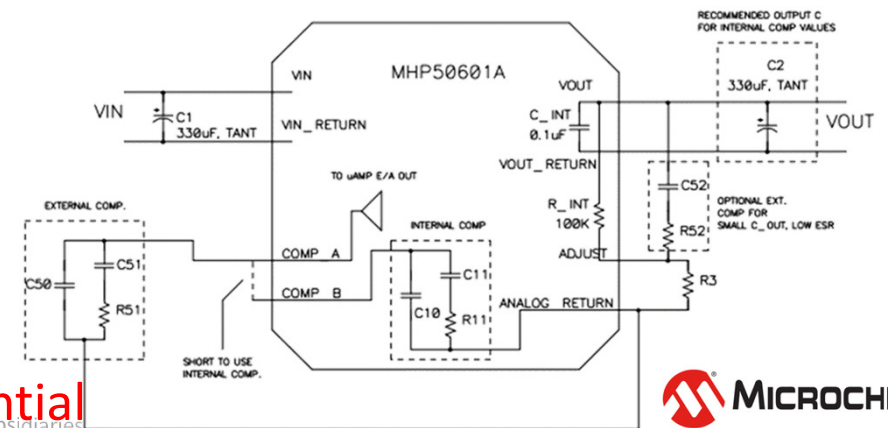
Best in Class Benefits for System Performance

- **Voltage Input** = 3 V to 6.3 V with 7V in Absolute Max – Improved derating margin for 5V input
- **Efficiency** - 95% peak – Highest efficiency solution at optimal typical current loading
- **SEFI/SET onset** > LET = 65 MeV - Best in class SEE radiation performance without external filtering
- **Highest output voltage accuracy** - Internal VREF 1.5% variation over temp and radiation coupled with ultra-fast transient response with smaller output capacitances
- **Smallest switching solution** on the market across both hybrid and discrete IC solutions

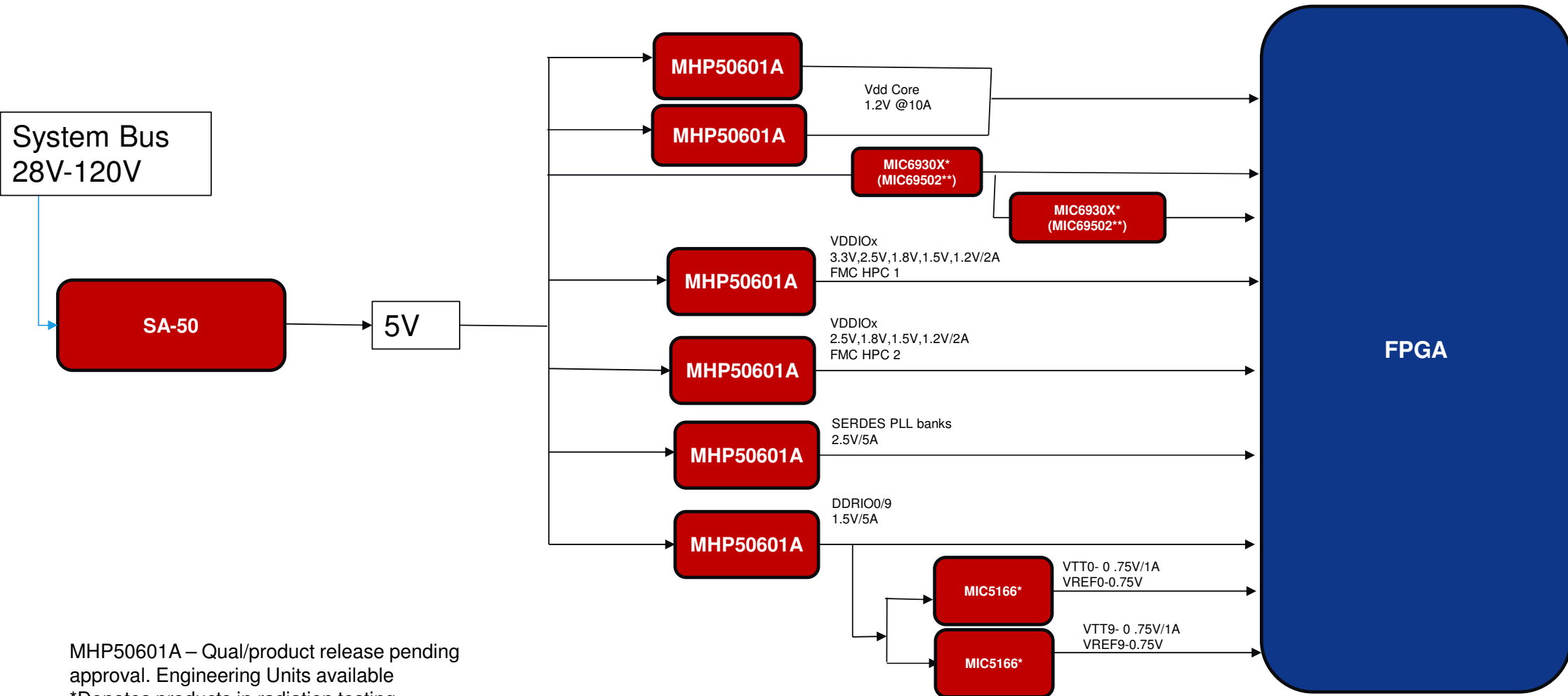
Radiation Performance

- TID = 100 krad(Si), radiation hardness assured
- SEL/SEB/SEGR immune to LET 75 MeV at 125 °C
- SEFI/SET onset > LET = 65 MeV

Application Circuit



FPGA Power for Space



MHP50601A – Qual/product release pending approval. Engineering Units available
 *Denotes products in radiation testing
 ** Denotes product in internal review

Rad Hard Power Discretes

Bipolar Junction Transistor / Diodes & Rectifiers

- **Rad Hard Bipolar Junction Transistor**

- Higher transductance than MOSFETs, not requiring separate gate drivers
- Current amplifiers capable of very high current densities
- Broad offering of QPL qualified BJT:
 - Voltages from 10 V to 760 V
 - Rated current from 0,01 A to 50 A
 - Power ratings from 0,15 W to 300 W
 - Up to 200 °C maximum junction temperature
- <https://www.microsemi.com/product-directory/transistors/3274-bjt-bipolar-junction-transistor#parametric-search>

- **Space-Grade Diodes and Rectifiers, Zeners, TVS**

- Pioneer in creating Rectifier Diodes since 1960
- First supplier to offer JANS qualified diodes for space applications in 1983
- Qualified to MIL-PRF-19500, and has more DLA slash sheets qualifications than any other space manufacturer
- Broad offering:
 - Schottky diodes
 - Ultrafast Rectifiers (trr < 100 ns)
 - Fast Rectifiers (trr 100 – 500 ns)
 - Standard Rectifiers (trr > 500 ns)
- <https://www.microsemi.com/product-directory/radiation-tolerant-devices/5217-space-grade-diodes-and-rectifiers#parametric-search>

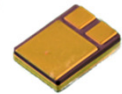
M6 Rad Hard MOSFET Part Numbers



TO-254

Sampling Now

Bvdss (V)	ID1 (A)	Similar JEDEC Number	MIL-PRF-19500/SS	Industry Equivalent	M6 Base p/n	Package	I2MOS Samples Available (Y/N) (Earlier I2MOS Fab Process)	Quantity of Samples Available (Earlier I2MOS)
100	22	2N7587U3	746	IRHNJ67130	MRH10N22U3	SMD0.5	Y	< 20
150	19	2N7589U3	746	IRHNJ67134	MRH15N19U3	SMD0.5	Y	> 100
200	16	2N7591U3	746	IRHNJ67230	MRH20N16U3	SMD0.5	Y	> 100
250	12.4	2N7593U3	746	IRHNJ67234	MRH25N12U3	SMD0.5	Y	> 100



SMD0.5

N- Ch, Sz 3



SMD 2

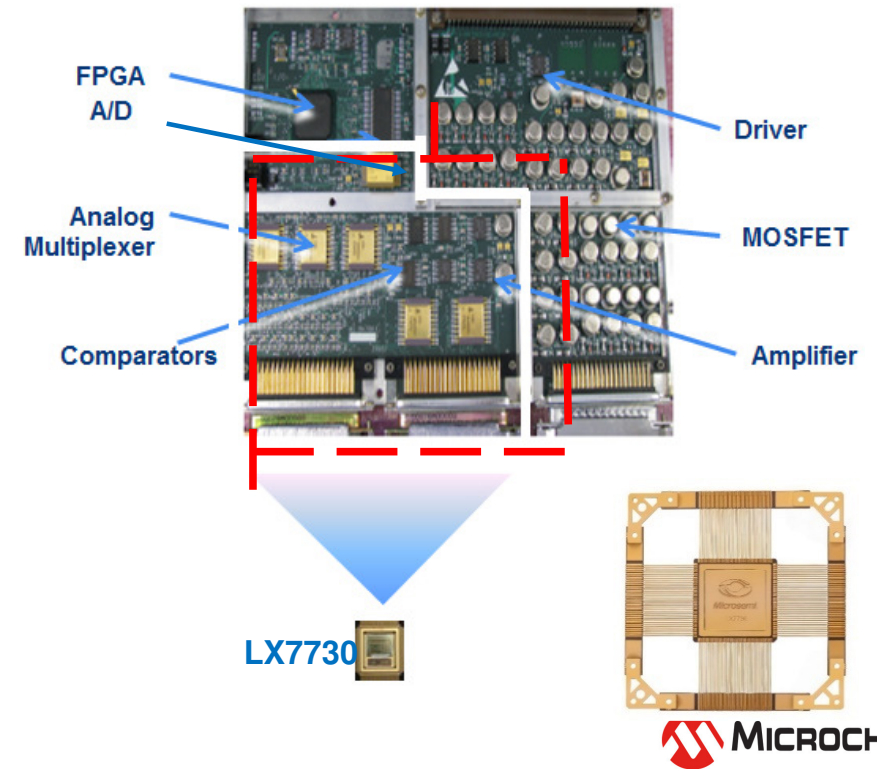
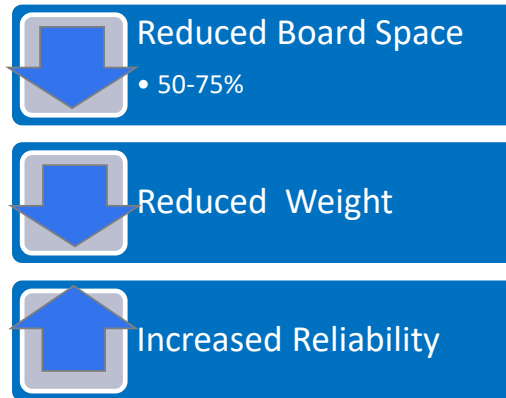
N- Ch, Sz 6

Bvdss (V)	ID1 (A)	Similar JEDEC Number	MIL-PRF-19500/SS	Industry Equivalent	M6 Base p/n	Proposed Part Numbers	Package
100	0.011	2N7580T1	753	IRHMS67160	MRH10N45T1	JANR2N7587T1	TO-254
100	0.01	2N7579U2	760	IRHNA67160	MRH10N56U2	JANSR2N7587U2	SMD-2
150	45	2N7582T1	753	IRHMS67164	MRH15N45T1	JANSR2N7582T1	TO-254
150	56	2N7581U2	760	IRHNA67164	MRH15N56U2	JANSR2N7581U2	SMD-2
200	45	2N7584T1	753	IRHMS67260	MRH20N45T1	JANSR2N7584T1	TO-254
200	56	2N7583U2	760	IRHNA67260	MRH20N56U2	JANSR2N7583U2	SMD-2
250	45	2N7586T1	753	IRHMS67264	MRH25N45T1	JANSR2N7586T1	TO-254
250	50	2N7585U2	760	IRHNA67264	MRH25N56U2	JANSR2N7585U2	SMD-2

Space System Managers LX7730 and LX7720

- The Space System Manager (SSM) are special purpose analog mixed signal ICs that can be used with a microcontroller or an FPGA
- The SSM ICs add power and mixed signal capability to supplement the digital functionality and flexibility of the uC/FPGA

- LX7730 Telemetry controller
- LX7720 Motor controller with position sensing



64 Analog Input Telemetry Controller

- 64 channel analog input multiplexer
 - **$\pm 20\text{V}$ cold sparing on all 64 inputs**
- 13ksps 12-bit ADC with 1% voltage reference
- 3% precision adjustable current source
- 8 bi-level analog inputs and logic outputs
- 8 additional bi-level inputs from the multiplexer for input channel threshold monitoring
- 10-bit DAC
- Parallel interface or dual SPI interfaces
- 132-pin CQFP, 24 mm x 24 mm
- 208 plastic QFP in sub-QML screening sampling this quarter

- 100 krad TID, 50 krad ELDRS
- SEL immune up to 87 MeV.cm²/mg and 125°C (fluence of 108 particles/cm²)
- QML SMD 5962-1721901 (Q and V flows)
- **Flight heritage since 2019**



LX7720 Power Driver with Rotation and Position Sensing

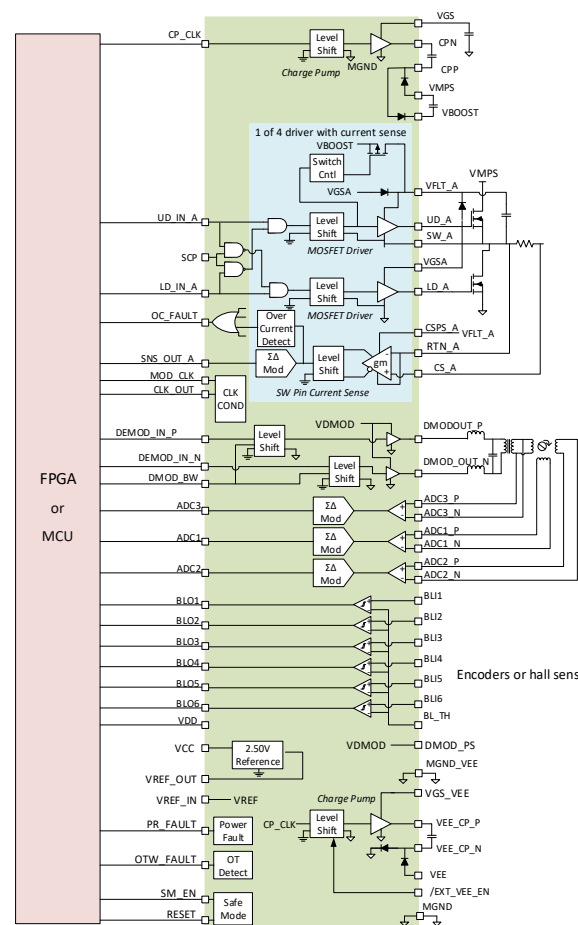
Features

- 4 half-bridge N-channel MOSFET drivers
 - Independent high side and low side MOSFET timing
- 4 floating differential current sensors for motor winding currents
- PWM driver for resolver or LVDT primary winding driver
- 3 differential sense inputs for resolver/LVDT measurement
 - Primary voltage measurement for ratiometric sensor processing
- 6 threshold adjustable bi-level logic inputs
 - Interfaces hall effect sensors and/or optical encoder for rotation sensing
- Fault detection and automatic fault protections
- 132-pin CQFP, 24 mm x 24 mm
- 208 plastic QFP in sub-QML available CQ2 2020

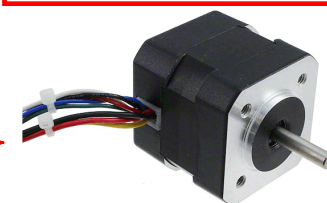


Radiation Tolerance and Approvals

- 100 krad TID, 50 krad ELDRS, SEL immune up to 60 MeV.cm²/mq and 125°C (fluence of 107 particles/cm²)
- Q flow production now, V production July 2020
- Seeking QML SMD Q & V



4 half-bridge motor winding drivers



Analog rotation sensor manager



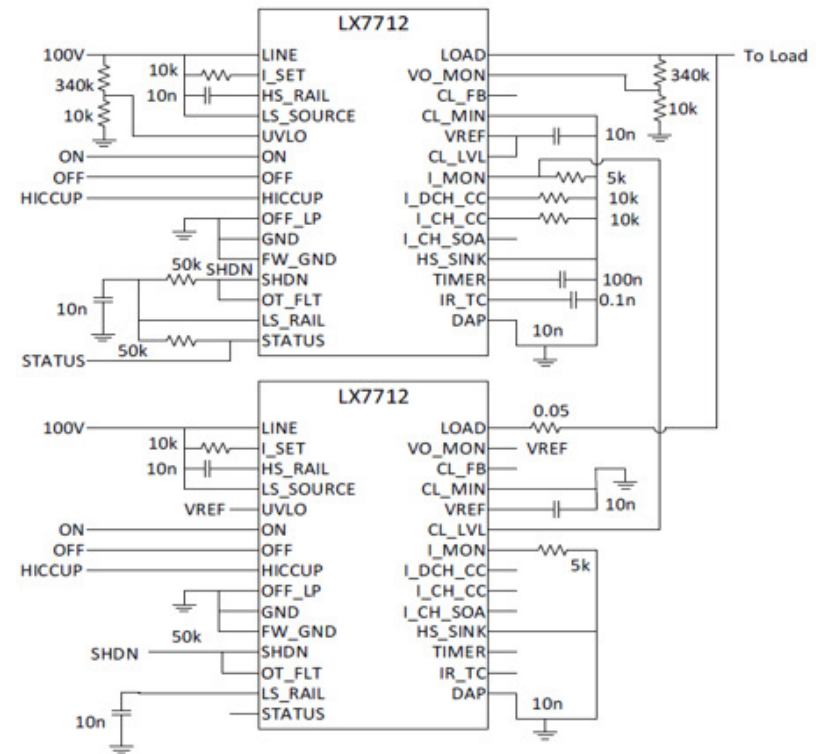
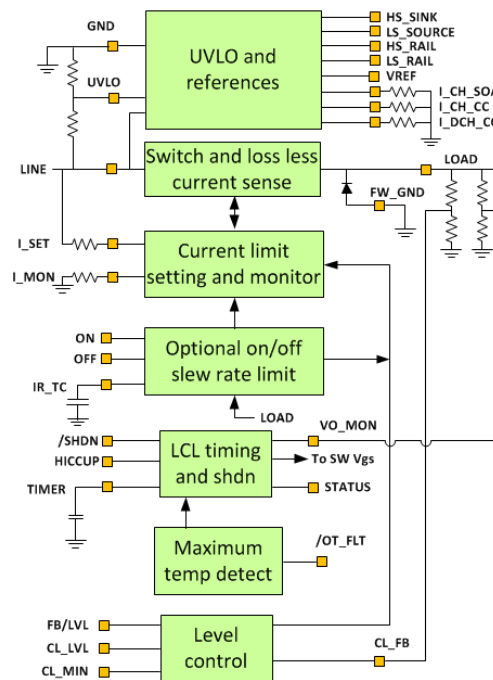
Digital rotation sensors interface



LX7712 Programmable Current Limiting Power Switch

Features

- Internal 5A PMOS switch and diode
- 120V rated
- LCL or FCL configurable
- ON, OFF, and STATUS pins
- Programmable UVLO and STATUS
- Parallel-able for higher currents
- Current limit and monitor
- Current slew rate limit
- Chip temp monitor
- 48-lead hermetic HTF flatpack package
– 19 mm x19 mm
- Radiation tolerant: 100krad TID, 50 krad ELDRS, SEL free–87Mev-cm²/mg
- ESA Standards
ECSS-E-HB-20-20A
ECSS-E-ST-20-20C



Sampling Now

Evaluation boards available

Power Relays DC/AC Up to 30 A

SPST, SPDT, DPDT Up to 30 A power switching

Over 60 years of expertise manufacturing space application relays

Relays built according to MIL-STD-Approved materials-Class ISO 5 environment-Milipore

1PDT, **25 Amp**, non-Latching
BR250 series, M6106 qualified



2PDT, **10 Amp**, non-Latching
BR246 series, M83536 qualified



4PDT, **10 Amp**, non-Latching
BR230 series, M83536 qualified



2PDT, **5 Amp**, non-Latching
BR13 series, design to meet M39016



4PDT, **5, 7.5, or 10 Amp**, non-Latching
BR15 series, design to meet M39016

2PDT, **2 Amp**, non-Latching
BR26 series, design to meet M39016

2PDT, **10 Amp**, Latching
BR247 series, M83536 qualified

4PDT, **10 Amp**, Latching
BR231 series, M83536 qualified

4PDT, **5, 7.5, or 10 Amp**, Latching
BR23 series, design to meet M39016

2PDT, **2 Amp**, Latching
BR17 series, design to meet M39016



General Specification

Coil voltages	From 6V-120V DC or AC
Insulation resistance	Up to 10GW
Dielectric	Up to 1500 Vac
Vibration	Up to 30 Gs
Life cycles	50K to 100K
Shock	Up to 200Gs 6 ms
Temperature range	-65°C to +150°C
PIN config	Solder hook, straight plug-in
Mounting	As customer design requires
Contact bounce	2ms max @ 2 Amps
Contact resistance	20 mW @ 2 Amps
Operate/Release time	4 ms to 15 ms Max
Duty cycle	Continuous
Radiation	TID & SEE immune

**NASA-IEEE-INST-002 Level I,
II, II qualification testing and
custom solutions available**

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Thank You