Designing Radiation-Tolerant Power-Supplies for the RTAX-S/SL/DSP FPGA

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Introduction

System engineers who design products that need to be Radiation-Tolerant (such as Satellites, Gyroscopes, Rocket-Launchers, all Deep-Space missions, etc) are faced with some unique challenges.

Few Specialized Vendors

Radiation-Tolerant semiconductor products are available from very few vendors than commercial through military grade components. As a further restriction, most semiconductor manufacturers only offer a few types of products (relays, for example). System engineers often have to select different types of components from different vendors (for example, a Field Programmable Gate Array (FPGA) from Microsemi®, a Power-Supply from Vendor#2, a Regulator from Vendor#3, etc).

Functional and Radiation Test Specifications

Every semiconductor manufacturer does electrical tests, including radiation-tolerance testing slightly differently and therefore each component's specifications are slightly different (behaviorally, electrically, and radiation-tolerance wise).

As a result, the system engineers designing a system also have an additional burden and risk. They need to select various types of components-all tested and specified at different test levels and standards from the other components they selected-with the goal that they must or should work together.

Microsemi manufactures and provides many Radiation-Tolerant components that
work-together, so the system engineer can confidently select components from one semiconductor vendor which will all work together.

This application note describes how the engineers design a Microsemi Radiation-Tolerant FPGA confidently. This FPGA helps in performing the following:

1. Calculate required power of the RTAX-S FPGA[1]
2. Select an appropriate Radiation-Tolerant regulator that can supply the required power and meet all the unique power-requirements of the FPGA, using either of the below given:
   – Radiation-Tolerant Linear-Regulator (Microsemi) or
   – Radiation-Tolerant Switching regulator (Microsemi)
3. Select an appropriate Radiation-Tolerant Power-Supply (Microsemi)

1. *All references to RTAX-S FPGA Family include the RTAX-S Family, and RTAX-SL (RTAX-S Family in a Low-Power version), and RTAX-DSP (RTAX-S with internal hardcoder DSP (Digital Signal Processing) blocks).*

RTAX-S Basic Information on the RTAX-S Device

RTAX-S Topology

The RTAX-S FPGA consists of digital logic gates (referred to as cells), embedded Static-RAM blocks, embedded clock-networks, and many Input/Output (I/O) buffers connected to pins on the mechanical package.

RTAX-S Power-Supply Pin Descriptions

The RTAX-S FPGA has various power-pins. This is a summary of the power-supply voltages pins and what circuits they supply power to inside the FPGA.

VCC

The VCC is the supply voltage to the FPGA's core. There is only one VCC voltage- 1.5 V (nominal).

ICC

The ICC current into the VCC pins is the total of the static current and the dynamic current. The static current value is a constant and is given in the datasheet for each device. The dynamic current is based on the number of logic cells (~logic gates) used, their switching frequency, etc. (defined in the Power Equation, which can be found in the RTAX-S/DSP datasheet[2]).

The ICC current is one of the top two most significant power-consuming rails.

VCCIBx

The VCCIBx pins are the supply voltages to the FPGA's I/O banks (where x= 0,1,..7). There are eight separate I/O banks, and each I/O bank has its own VCCI voltage rail (which are named VCCIB0, VCCIB1, VCCIB2, VCCIB3, VCCIB4, VCCIB5, VCCIB6, and VCCIB7). Each VCCI bank can be independently powered by any of the following voltages: 1.5 V, 2.5 V, or 3.3 V.

ICCBx

The ICCBx current into the VCCIBx pins, is the total of the static current and the dynamic current. The static current value is a constant and is given in the RTAX-S/DSP datasheet. The dynamic current is based on the number of I/O pins, I/O standards used, their switching frequency, etc. (defined in the Power Equation, which can be found in the RTAX-S/DSP datasheet).

The ICCBx currents are one of the most significant power-consuming rails.

VCCDA

The VCCDA is the supply voltage to the FPGA's I/O differential amplifier, the JTAG pins, and the special probe interface pins.

There is one VCCDA voltage. The VCCDA must be 2.5 V or 3.3 V (nominal)

ICCDA

The ICCDA current into the VCCDA pins. The ICCDA current is typically a small current value (compared to ICC and ICCBx).

VPUMP

The VPUMP is the external pump supply voltage. There is one VPUMP voltage. This can be tied to +3.3 V or ground.

In normal device operation, when using the internal charge pump, VPUMP can directly be tied or through a 1K resistor to GND.

ICCPUMP

The ICCPUMP current is typically a small current value (compared to ICC and ICCBx).

2. *The RTAX-S/SL and RTAX-DSP datasheet is located at: www.microsemi.com/soc/documents/RTAXS_DS.pdf.*

RTAX-S Power-Consumption Components

The Power-Consumption of the RTAX-S FPGA is the sum of two types of power components: static power and dynamic power.

- Static power-consumption is a constant value for each device in the RTAX-S FPGA family and is a sum of the individual static power values for each power-rail of the FPGA. The static power-consumption value is provided in the datasheet for each device. Low power version of the RTAX-S/DSP FPGA's are available, which have lower standby-current, that is up to 80% less than the standard RTAX-S FPGA.
- Dynamic power-consumption values are a function of the design that is implemented in the FPGA. This value is highly design-dependent. This value is based on the number of logic cells (~logic gates) used and their switching frequency, number of I/O pins and their switching frequency, I/O standards used, the load on the I/O pins, temperature, voltage, etc.

Since the power-consumption of the RTAX-S FPGA is highly dependent on the digital design that is implemented inside of it, the power-consumption needs to be calculated for each individual design that is implemented inside the FPGA.

Dynamic power is the major part in the total power-consumption of a typical RTAX-S FPGA.

Calculating Required Power of the Radiation-Tolerant RTAX-S FPGA

The power-consumption of a RTAX-S FPGA is highly dependent on the design that is inside the FPGA. In this section the RTAX-S FPGA power is calculated.

Determine Design Requirements

The FPGA designer estimates the required resources and use them to calculate the FPGA's power- consumption.

This includes an example of the entire power-supply design process that defines a sample design called DesignExample#1. This design example represents high logic utilization and a relatively high-speed clock to determine the maximum power-consumption of the RTAX250SL-CG624. The details of the RTAX-S FPGA used are listed below.

Part Number	Microsemi RTAX250SL-CG624
Main Clock Frequency	125 MHz
Logic	80% utilized (1126 R-cells, 2253 C-cells) 80%of Logic running at 125 MHz
I/O	100% of I/O used; 50% of I/O used as Inputs (93 Inputs) 50% of I/O used as Outputs (93 Outputs) I/O Standards set to 3.3 V LVTTL, with max 8mA current output Inputs run at 125 MHz Outputs running at 12.5 MHz (Default ratio is 1/10 of main frequency)

Select a Power-Calculation Tool

The power-consumption required by an RTAX-S family FPGA can be calculated by any of the following methods shown in Table 1.

Table 1 • **Power-Calculation Tool**

Power Estimation Method #	Power Estimation Tool	Advantages	Disadvantages
1	MS-Excel Power-Calculator tool[1]	This is the most popular initial power-estimation tool, since it can be used at the beginning of a project, when the FPGA engineer is often asked to give the FPGA's required Power-Supply Voltages and Currents to the power-supply design engineer. The FPGA design need not to be completed or even started.	The power-consumption values may not the most accurate (may be too pessimistic).
2	SmartPower[2] without value-change dump (VCD)	• Accuracy depends on how accurately the FPGA design engineer describes and enters the operating environment into the SmartPower tool. • FPGA design engineer need not to write test-benches to model system real-world behavior.	• Design must be complete (design, synthesis, and layout complete). • Medium accuracy
3	SmartPower with VCD	Most Accurate: Simulation file can be used to describe real-world behavior and power VCD format, as specified in the IEEE 1364 standard, generated by the simulation runs. Support for this format allows to generate switching activity information from ModelSim[3] or other simulators.	• Requires writing Simulation test-benches so that they model the systems actual run time behavior. • Design must be complete (design, synthesis, and layout complete).

1. A Microsoft-Excel Power-Calculation estimation tool that contains the power-consumption equations of the RTAX-S FPGA, is available for download (free) from: www.microsemi.com/soc/documents/AX_RTAXSPowerCalculator.zip

2. SmartPower is a software tool that is included in the Microsemi Libero software development tool.

3. ModelSim is the name of a hardware description language (HDL) software simulation tool. ModelSim is a trademark of Mentor Graphics.

Calculate FPGA Power Required for Design Example#1

Use Method#1 to calculate the RTAX-S FPGA's power-consumption using the Microsoft Excel Power-Calculator spreadsheet tool.

Design-Example#1's values listed above were entered into the MS-Excel Power-Calculator tool. The results of the total power and current values output from this tool are listed below. This represents the maximum power required by the RTAX250SL-CG624 FPGA when it is running Design Example#1:

Power Rail	Current	Power
VCCA(1.5 V Power-Rail)	ICCA=248 ma	372 mw
VCCI (3.3 V Power-Rail)	ICCI=231 ma	762 mw
Total Power-Consumption	–	1.13 Watt

Check that FPGA Power (DesignExample#1) Does Not Exceed the Thermal Power-Dissipation Limit

In this section, calculate the maximum power that the CG624 package can thermally dissipate. Check if the design that is implemented in the RTAX-S FPGA (use DesignExample#1) is less than the maximum power that the package can dissipate.

Note: In the space environment there is no air, so the FPGA must be conduction-cooled. In a spacecraft, there are thermal cooling systems. In this example, the spacecraft cooling system would cool a cooling plate that is thermally conducting and transferring heat from CG624 mechanical package. While calculating the maximum power dissipation, it is required to use the equation that is based on thermal cooling from the case of the FPGA to the junction of the FPGA.

Use the following definitions to describe the environment:

- T_board=50°C: This is the PC-board cooling-plate temperature
- Theta_Case_to_Board, the thermal resistance of thermal paste is 0.58C/Watt
- Theta_JC, the thermal resistance for RTAX250SL in CG624 is 4.6C/Watt

$$MaximumPowerAllowed = \frac{MaximumFPGAJunctiontemp(C) - MaximumPCBoardtemp(C)}{ThetaJC + ThetaCasetoBoard}$$

EQ 1

$$MaximumPowerAllowed = \frac{125C - 50C}{(4.6C)/(Watt) + (0.58C)/(Watt)}$$

EQ 2

$$MaximumPowerAllowed = 14.47 Watts$$

EQ 3

Since the maximum power dissipation of the FPGA from DesignExample#1 (consumes 1.14 Watt) is less than the maximum power allowed that the CG624 can dissipate (14.47 Watts) in the environment described above. The CG624 package can dissipate the entire power of DesignExample#1.

Power-Supply Solutions to Power the RTAX-S FPGA

This section describes the available Radiation-Tolerant power-supplies: Switching Radiation-Tolerant voltage regulator devices and Linear Radiation-Tolerant voltage regulator devices. Either can be selected to supply the RTAX-S voltages and currents determined for DesignExample#1.

Here is a quick comparison of some of the major differences between a Switching Voltage Regulator and a Linear Voltage Regulator:

Table 2 • **Comparison Between a Switching Voltage Regulator and a Linear Voltage Regulator**

Regulator Type	Lowest Output Noise (RFI)	Highest Efficiency	Fast Response Time	Output Voltage Can be Lower than Input Voltage (Buck Regulator)	Output Voltage Can be Higher than Input Voltage (Boost Regulator)	Smallest Board Space	Lowest Price
Linear Regulator	X		X	X		X	X, at low power-levels
Switching Regulator		X		X	X		X, at high power-levels

Solution#1: Using Point-Of-Load Switching Regulators

Microsemi offers various Radiation-Tolerant switching regulators. These switching-regulators are highly efficient (up to 95%), more than linear regulators. A summary table from the Microsemi datasheet on website is shown below and is located at: www.microsemi.com/en/sites/default/files/LDS-0117.pdf.

Microsemi TECHNICAL DATA SHEET

6 Lake Street, Lawrence, MA 01841
1-800-446-1158 / (978) 620-2600 / Fax: (978) 689-0803
Website: http: //www.microsemi.com

SINGLE and QUAD 3 Amp & 4 Amp
POL REGULATORS

Table 3 – MODEL NUMBER FUNCTIONALITY CHART

MODEL NUMBER	NOTES	PACKAGE TYPE			OUTPUT TYPE			OTHER FUNCTIONALLTY					FORMER P/N
		MO-078	SIP	Flat Pack	Adj	Fixed Note C	Remote Sense Note C	Enable Pin	Parallelable Note A	Output Volt Range	Package Body	Internal Compen-sation	
MHP8565A$&	3 Amp Series	✓			✓			✓		1.21–4V		✓	SAT8565A-3$T-ADJ
MHP8565P$&	3 Amp Series	✓			✓			NO	✓	1.21–4V	Ground	✓	SAT8565P-3$T-ADJ
MHP8564A$&	4 Amp Series		✓		✓			✓	Note D	1.21–4V		✓	SAT8564A-4$F-ADJ
MHP8564F$&	4 Amp Series		✓			✓		✓	Note D	1.21–4V		✓	SAT8564F-4$F-x.y
MHP8564R$&	4 Amp Series		✓				✓	✓	Note D	1.21–4V		✓	SAT8564R-4$F-x.y
MHP8564S$&	4 Amp Series		✓		✓			✓	✓	1.21–4V		NO	SAT8564S-4$F-ADJ
MHP8566A$&	Quad 4 Amp			✓	✓			✓	✓	0–4V		✓	SAT8566A-15$F-ADJ

Replace "$" with letter to denote required screening level
C = COTS
H = CLASS H
K = CLASS K
Replace "&" with lead lend option
= No lead bend
-1 = SMT lead bend
-2 = lead bend down
-3 = lead bend up

NOTE A: Parallelable devices have a synchronizing pin so that units can be driven out of phase from each other for the purpose of input and output Voltage Bus ripple reduction. Other functions necessary for Paralleling are also available

NOTE C: Fixed and remote sense part numbers must be appendaged with fixed value of output Voltage. Example: MHP8564F$&-1.8 for a 1.8V fixed output.

NOTE D: Sync PIN is available. Other functions necessary for Paralleling are not available.

Products in shaded areas of the main chart are under development

Figure 1 **• Model Number Functionality Chart**

RTAX-S VCCA Regulator Selection

To supply the RTAX-S core with 1.5 V at the estimated 248 milliamp current requirement, select the MHP8565. According to the MHP8565 datasheet, at this output current, it is 87% efficient. The required input current will be I_in = (1.5 V * 248 mA) / (75% * 5 V) = 93 milliamps. In this circuit, the MHP8565 will be running at 3.1% (93 mA/3A=3.1%) of its maximum output current capability.

RTAX-S VCCI Regulator Selection

To supply the RTAX-S I/O's with 3.3 V at the estimated 231 milliamps current requirement, select the MHP8565. According to the MHP8565 datasheet, at this output current, it is 87% efficient. The required input current will be I_in=(3.3 V * 231mA) / (87% * 5 V) = 175 milliamps. In this circuit, the MHP8565 will be running at 5.8% (175mA/3A=5.8%) of its maximum output current capability.

Note: As in the Rad-Tolerant switching regulator table above, the MHP8566 contains four separate switching regulators inside one package. Use the MHP8566 to supply the RTAX-S VCCA voltage of 1.5 V and RTAX-S VCCI voltage of 3.3 V. The MHP8566 has two additional output voltage regulator outputs that could either supply two additional voltages to other devices in the system or to increase the amount of output current to the VCCI or VCCA rails in the systems that use larger gate count RTAX-S devices that require more current.

Power-Supply Selection

To supply 5 V at the combined current requirements of 268 milliamps (93 milliamps + 175 milliamps=268 milliamps) to the two voltage regulators just chosen, select Microsemi SA50.

Note: The SA50 version for 120 volt inputs has an efficiency as high as 86% and the 28 volt input has an efficiency as high as 83%.

In this circuit, the SA50 main output will be running at 6.7% (268 milliamps/4Amps=6.7%) of its maximum output current capability.

The pictorial view is shown in Figure 2.

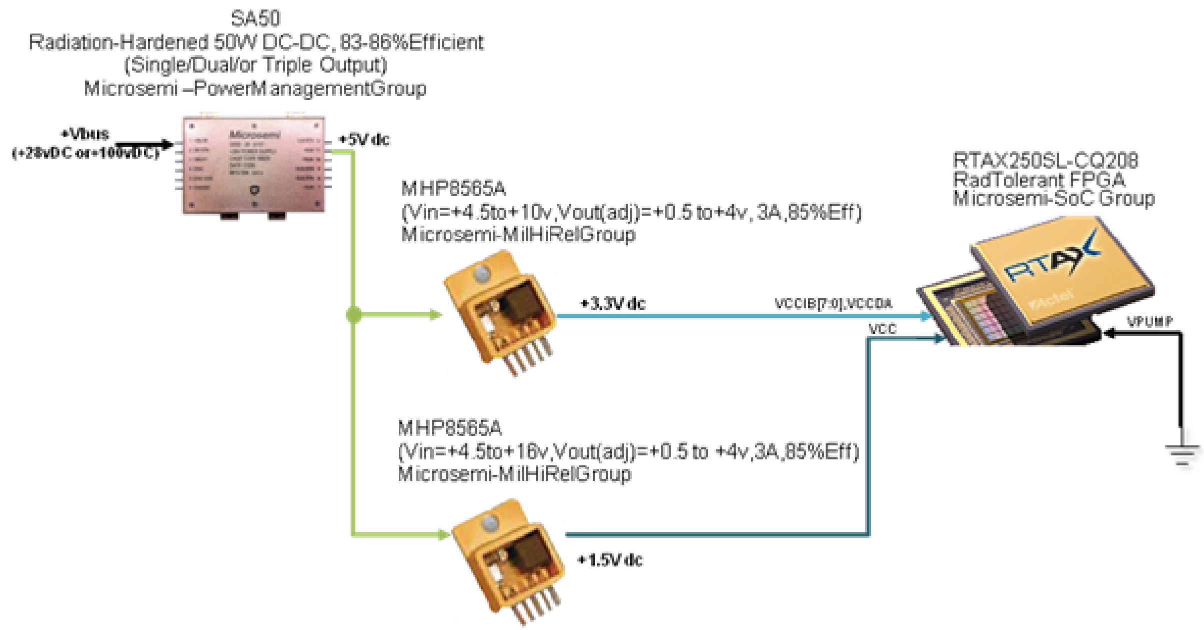

Figure 2 • **Power-Supply Selection**

The schematic view is shown in Figure 3.

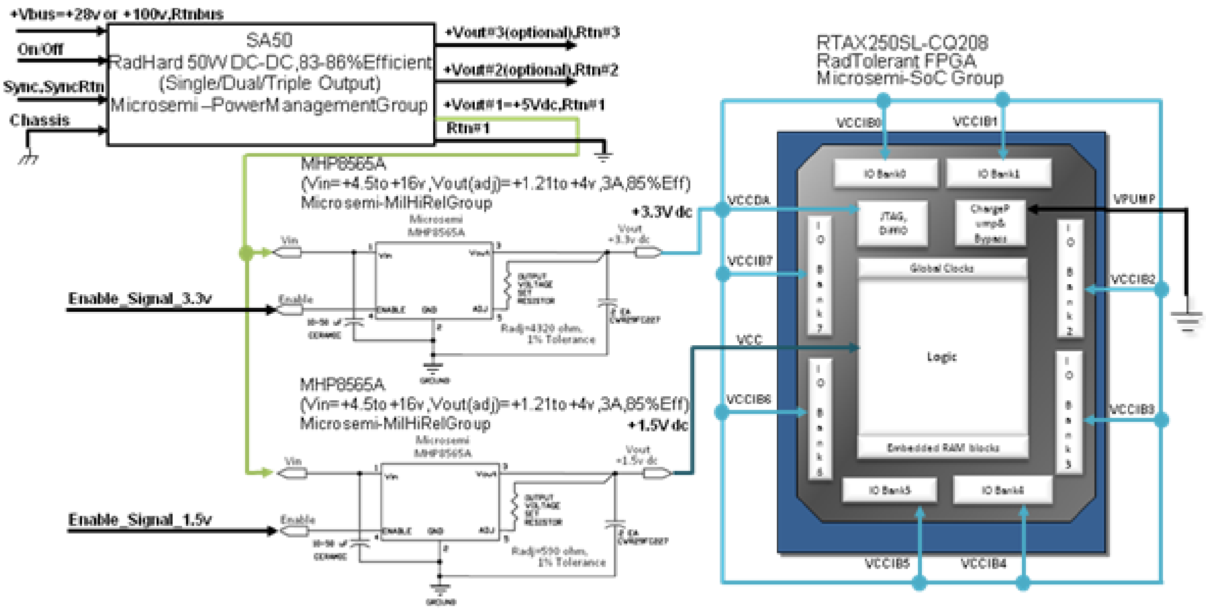

Figure 3 • **Power-Supply Selection**

In addition to selecting a power-supply or local voltage regulator that has the output current capability to power the RTAX-S FPGA, the FPGA designer and Power-Supply designer both need to be aware of all the special considerations and meet these.

The following checklist can be used to verify if all special consideration items are met.

Table 3 • **Checklist for Solution#1: (Power-Supply-Chain using Switching Regulators)**

Power-Supply-Chain, Requirements	Meets This Requirement	
	Yes/No	**Detail**
VCCA Regulator Output-Current: The RT switching regulator has the output current capability to supply the current required by the RTAX-S FPGA on the VCCA rail.	Yes	248 mA required 1250 mA available
VCCI Regulator Output-Current: The RT switching regulator has the output current capability to supply the current required by the RTAX-S FPGA on the VCCI rail.	Yes	231 mA required 3000 mA available
Power-Supply Output-Current: The RT Power-Supply has the output current capability to supply the current required on the 5 V rail to the two RT Switching Regulators.	Yes	268 mA required 4000 mA available
VCCI/VCCA Voltage Sequence Control: The RT Switching-Regulators have enabled signals so the power-down sequence of the FPGA's VCCA can be controlled before VCCDA to avoid current spike on ICCA on power-down. (This behavior is described in documents CN1003, AC344, and other documents). *Note: Use these same signals to control the FPGA's power-up sequence.*	Yes	1 Enable input to the 1.5 V regulator 1 Enable input to the 3.3 V regulator

Table 3 • **Checklist for Solution#1: (Power-Supply-Chain using Switching Regulators) (continued)**

Power-Supply-Chain, Requirements	Meets This Requirement	
	Yes/No	**Detail**
ICCA Power-Down Current Spike: The RT Switching-Regulator can supply the ICCA current spike requirement of the RTAX-S FPGA on power-down if VCCA is powered-down after VCCDA. This is the scenario if sequencing the power-supply rails is not selected as described in CN1003 and AC344 documents.	Yes	3000 mA required (per AC344, Table 3) 3000 mA available
Radiation-Induced Voltage Spike on VCCA vs RTAX-S Datasheet Transient-Spec. If the RT Switching-Regulator is hit with Radiation, the Single-Event Transient Output voltage spike/glitches output on to the VCCA power rail from the regulator will be within the acceptable VCCA specifications as listed in the RTAX-S Datasheet Table 2-2, Footnote #1. MHP8565A= 58(SET) *Note: The MHP8565A datasheet states that the test results show no significant output transients through a test limit LET of 58 MeV/(mg/cm2).*	Yes	58 (SET)
Radiation-Induced Voltage Spike on VCCA and VCCI vs RTAX-S Transient Test Whitepaper Table 3. If the RT Switching-Regulator is hit with Radiation, the Single-Event Transient Output voltage transient that could appear on the VCCA and VCCI power rails will still be within the tested limits as listed in Table 3 of Power Supply Transients on RTAX-S and RTSX-SU Devices. MHP8565A= 58(SET) *Note: The MHP8565A Datasheet states that the test results show no significant output transients through a test limit LET of 58 MeV/(mg/cm2).*	Yes	58 (SET)
TID Level for the Power-Supply-Chain and RTAX-S System The effective TID rate of the power-supply-chain and RTAX-S system is listed in the far right column. This is the lowest TID value of all of the individual component rating, which are listed below. SA50= 100 kRad(Si)@Dose Rate=0.01Rad/s(ELDRS) MHP8565A= 300 kRad(Si) @Dose Rate=107.5Rad/s RTAX250SL= 300 kRad(Si) @Dose Rate=33-50Rad/s	Yes	100 kRad(Si)
SEE Level for the Power-Supply-Chain and RTAX-S System The effective SEE rates of the power-supply-chain and RTAX-S system are listed in the far right column. These are the lowest SEE values of all of the individual component rating, which are listed below. The SEE values of components are listed below and the lowest limiting value is underlined. (Units below are in MeV/mg/cm2). SA50 "H"grade=80(SEU), 80(SEL), 80(SEB), 80(SEGR),80(SET) MHP8565A=58(SEU), 58(SEL), 58(SET)	–	37(SEU) 58(SEL) 80(SEB) 54(SEGR) 58(SET)

Solution#2: Using Point-Of-Load Linear Regulators

Microsemi offers various Radiation-Tolerant Linear Regulators and the efficiency of the linear regulator depends on the input and output voltages involved. The summary table is on page 4 in the catalog is shown below and is located at:

www.microsemi.com/en/sites/default/files/datasheets/Microsemi_Hybrid_Products.pdf

Table 4 • **Checklist for Solution#1: (Power-Supply-Chain using SWITCHING Regulators)**

Part	Description	Critical Parameters	Packages
8601	Pos., Linear, 3A, Fixed & Adj	VIDO=0.300 V (3A), (5A), Rad-Hard to 300Krad+	5 Pin MO-078
8605R	Pos., Linear, 5A, Fixed w/Remote Sense	VLDO=0.300 V (3A), 0.400 V (5A) Rad-Hard to 300Krad+	5- Pin MO-078, 8-Pin SMT
117	Pos., Linear, Adj., 1.25A, Vin=40 V	Rad-Hard to 300Krad	D2
127	Dual, 1A, Pos. & Neg.Linear regulator	Rad-Hard to 300 Krad	8-Pin, TO-254

Use of the MHL8701/8705 SET-free regulator is recommended. The MHL8701/8705 is a SET-free Linear Regulator version of the previous MHL8601/8605.

RTAX-S VCCA Regulator Selection

To supply the RTAX-S Core with 1.5 V at the estimated 248 milliamps current requirement, select the MHL8705. At an output current of 248 milliamps, the input current will also be approximately 248 milliamps. In this circuit, the MHL8705 will be running at 5.0% (248mA/5.0Amp= 5.0%) of its maximum output current capability.

RTAX-S VCCI Regulator Selection

To supply the RTAX-S I/O with 3.3 V at the estimated 231 milliamps current requirement, select the MHL8701. The input current will also be approximately 231 milliamps. In this circuit, the MHL8701 will be running at 7.7% (231mA/3.0 Amp= 7.7%) of its maximum output current capability.

Power-Supply Selection

To supply 5 V at the combined current requirements of 479 milliamps (248 milliamps + 231 milliamp=479 milliamps), to supply power to the selected two voltage regulators, select Microsemi SA50.

Note: The SA50 version for 120 V inputs has an efficiency as high as 86% and the 28 V input has an efficiency as high as 83%.

In this circuit, the SA50 main output will be running at 12.0% (479 milliamps/4Amps= 12.0%) of its maximum output current capability.

The pictorial view is shown in Figure 4 on page 11.

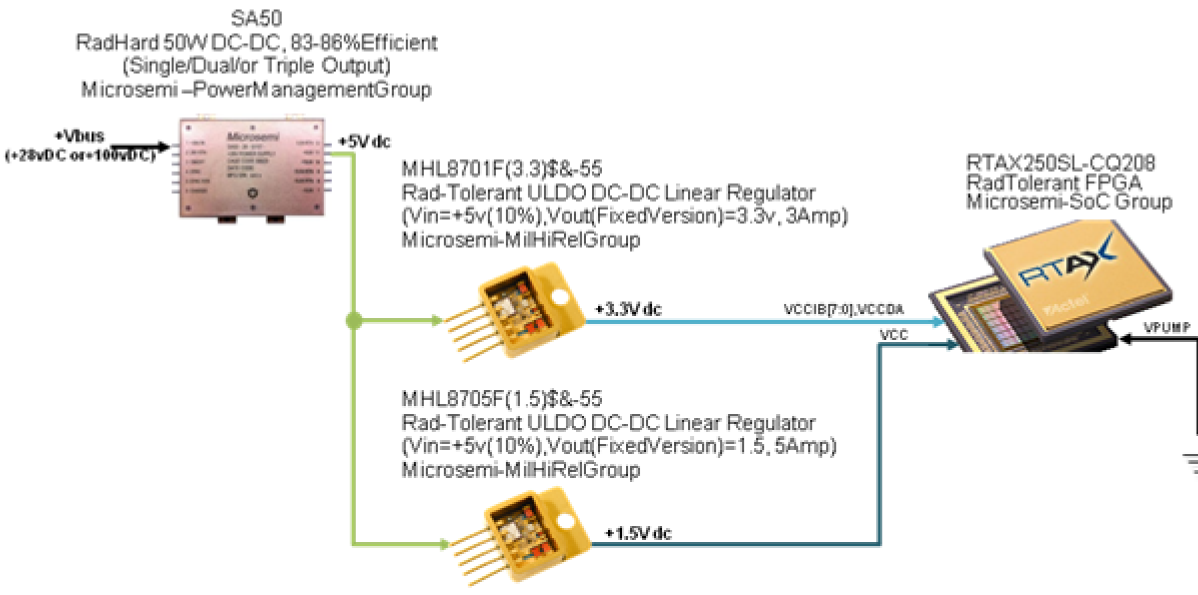

Figure 4 • **SX-A Device Selection Dialog Box**

The schematic view is shown in Figure 5.

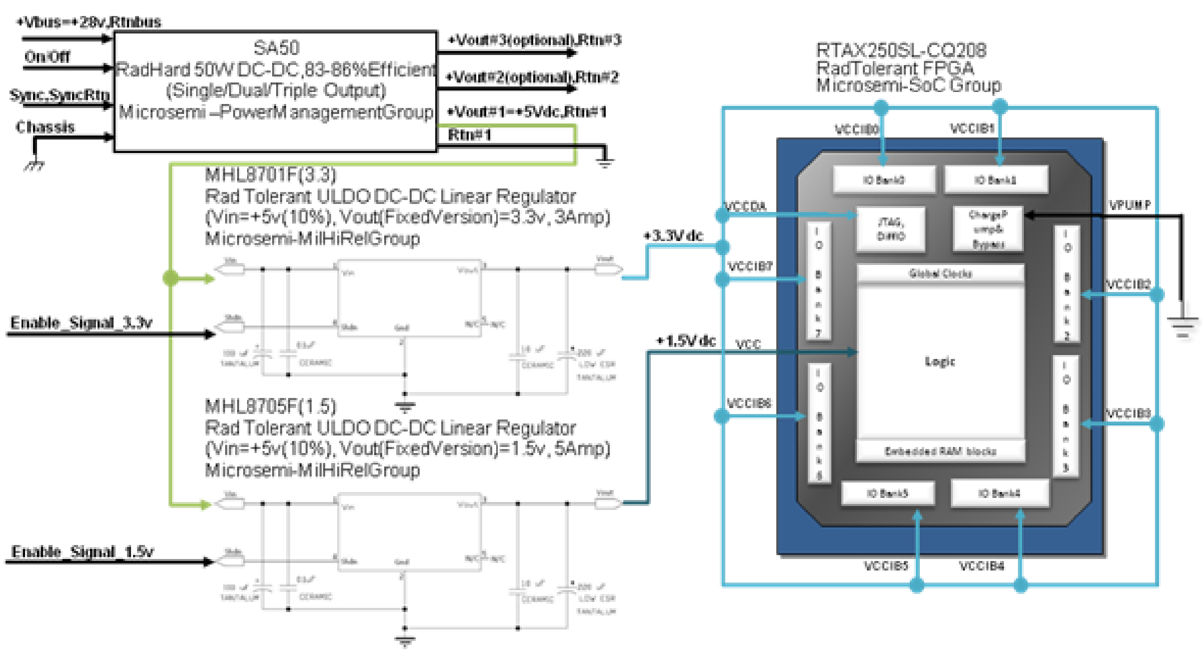

Figure 5 • **SX-A Device Selection Dialog Box**

Power-Supply-Chain Checklist

In addition to selecting a power-supply or local voltage regulator that has the output current capability to power the RTAX-S FPGA, the FPGA designer and Power-Supply designer both need to be aware of all the special considerations and meet these.

The following checklist can be used to verify if all the special considerations are being met.

Table 5 • **Checklist for Solution#2: (Power-Supply-Chain using Linear Regulators)**

	Meets this Requirement	
Power-Supply-Chain, Requirements	**Yes/No**	**Details**
VCCA Regulator Output-Current: The RT Linear Regulator has the output current capability to supply the current required by the RTAX-S FPGA on the VCCA rail.	Yes	248 mA required 5000 mA available
VCCI Regulator Output-Current: The RT Linear Regulator has the output current capability to supply the current required by the RTAX-S FPGA on the VCCI rail.	Yes	231 mA required 3000 mA available
Power-Supply Output-Current: The RT Power-Supply has the output current capability to supply the current required on the 5 V rail to the two RT Linear Regulators.	Yes	479 mA required (approx) 4000 mA available
VCCI/VCCA Voltage Sequence Control: The RT Linear-Regulators have enable signals so the power-down sequence of the FPGA's VCCA can be controlled before VCCDA, to avoid current spike on ICCA on power-down. (This behavior is described in documents CN1003 and AC344). Note: *Use these same signals to control the FPGA's power-up sequence.*	Yes	1 Enable input to the 1.5 V regulator 1 Enable input to the 3.3 V regulator
ICCA Power-Down Current Spike: The RT Linear-Regulator, can supply the ICCA current spike requirement of the RTAX-S FPGA on power-down, if VCCA is powered-down after VCCDA (this is the scenario if sequencing the power-supply rails is not selected as described in documents CN1003 and AC344).	Yes	3000 mA required (per AC344,Table3) 5000 mA available (MHL8705 has out rated at 5A)
Radiation-Induced Voltage Spike on VCCA vs RTAX-S Datasheet Transient-Spec If the RT Linear-Regulator is hit with Radiation, the Single-Event Transient Output voltage spike/glitches output onto the VCCA power rail from the regulator will be within the acceptable VCCA specifications as listed in the RTAX-S- Datasheet Table 2-2, Footnote #1. MHL8701= To Be Tested As a placeholder, use the MHL8601/8605 as a reference, which has a SET LET=58. Note: *The MHL8701/8705 is similar to the MHL8601/8605 but the MHL8701/8705 has been designed with the additional SET mitigation circuits, so its SET results should be better. The MHL8701/8705 is being tested. (The MHL8601/8606 already has a SET LET>=58 MeV*cm2/mg (Xe).*	Being tested now	58 (SET), based on MHL8601/8605

Table 5 • **Checklist for Solution#2: (Power-Supply-Chain using Linear Regulators) (continued)**

Power-Supply-Chain, Requirements	Meets this Requirement	
	Yes/No	**Details**
Radiation-Induced Voltage Spike on VCCA and VCCI vs RTAX-S Transient Test Whitepaper Table3 If the RT Linear-Regulator is hit with Radiation, the Single-Event Transient Output voltage transient that could appear on the VCCA and VCCI power rails will still be within the tested limits as listed in Table 3 of Power Supply Transients on RTAX-S and RTSX-SU Devices. MHL8701= To Be Tested As a placeholder, use the MHL8601/8605 asa reference, which has a SET LET=58. *Note: The MHL8701/8705 is similar to the MHL8601/8605 but the MHL8701/8705 has been designed with additional SET mitigation circuits, so its SET results should be better. The MHL8701/8705 is being tested. The MHL8601/8606 already has a SET LET>=58 MeV*cm2/mg (Xe).*	Being tested Now	58 (SET), based on MHL8601/8605
TID Level for the Power-Supply-Chain and RTAX-S System The effective TID rate of the power-supply-chain and RTAX-S system is listed in the far right column. This is the lowest TID value of all of the individual component rating, which are listed below. SA50= 100 kRad(Si)@Dose Rate=0.01 Rad/s(ELDRS) MHL8701= 300 kRad(Si)@Dose Rate= 129 Rad/s (The 8701/8705 uses the 8601/8605 RTAX250SL= 300 kRad(Si)@DoseRate= 33-50 Rad/s	Yes	100 kRad(Si)
SEE Level for the Power-Supply-Chain and RTAX-S System The effective SEE rates of the power-supply-chain and RTAX-S system are listed in the far right column. These are the lowest SEE values of all of the individual component rating, which are listed below. The SEE values of components are listed below, and the lowest limiting value is underlined. (All Units below are in MeV/mg/cm2). SA50 "H"grade=80(SEU), 80(SEL), 80(SEB), 80(SEGR), 80(SET) MHL8701=To Be Tested	–	37(SEU) 80(SEL) 80(SEB) 54(SEGR) 80(SET) *Note: MHL8701 is not used as a limiting factor here, since it is still being tested*

Summary

This application note described how to select an appropriate Radiation-Tolerant Power-Supply and Radiation-Tolerant Linear or Switching regulator, to power the Microsemi 'RTAX250SL-CG624' FPGA. In addition, a valuable checklist was used to help summarize that the power-supply meets all the special requirements of the RTAX-S FPGA.

This same process can be applied when using any of the RTAX-S device, including all gate counts, mechanical packages, and environmental grade varieties. The larger gate count version may require choosing the regulator part number from the selector tables that have higher current output capability.

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