Norsat International Inc.

NORSAT'S CUSTOMIZATION ADVANTAGE:

BUC Customization and Certifications

THE CHALLENGE:

Norsat offers a range of industry-leading RF Block Upconverters (BUC) and Solid-State Power Amplifiers (SSPA) with some of the best SWAP and environmental tolerances available. However, sometimes an off the shelf BUC does not meet the demanding environmental, EMC/EMI, RF and mechanical requirements of a specific application or project. For example, airborne applications often require the BUCs to operate and survive extreme temperatures while maintaining RF performance and reliability. Airborne and COTM applications often have very demanding vibration and acceleration requirements. Most military and airborne applications require stringent EMC/EMI requirements.

THE NORSAT SOLUTION:

The answer is to customize an off-the-shelf BUC or SSPA to meet the specific environmental, EMC/EMI, RF and mechanical requirements required for the application. Norsat's products are designed to meet the requirements of RTCA DO-160, MIL STD 461, MIL STD 1275, MIL STD 704 and MIL STD 810 and Norsat has experience tailoring our products to meet these demanding requirements. Norsat has developed options including EMI/EMC filtering, surge protection and vibration mounts to ensure the BUCs meet the project or application requirements. Norsat has tested select BUCs to these standards and has performed an analysis of the other BUCs to ensure they meet the requirements. As Norsat is the designer and manufacturer of these products, Norsat has detailed and intimate knowledge of the product and can modify the designs to meet almost any situation.

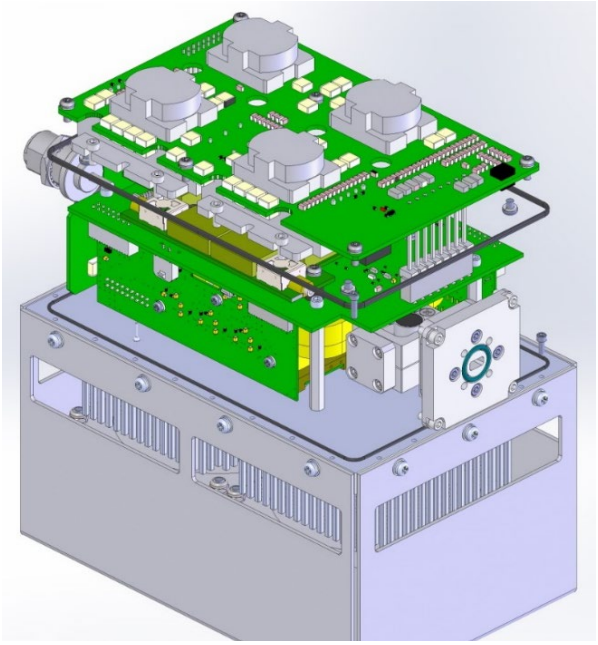
ATOM CUSTOMIZATIONS:

Norsat has solutions for or can customize the following aspects of the ATOM products:

1) Electrical
2) Mechanical
3) Thermal Management
4) Vibration
5) Certifications

ELECTRICAL

Norsat designed the ATOM BUC and SSPA product line to be small, lightweight and efficient. The ATOM design is based on a stacked design where the power amplifier power modules are mounted on the baseplate. A waveguide combining assembly is stacked directly above the power modules. Above this are pre-drivers, synthesizer, M&C assembly and power supply. The baseplate can either be fitted with radiators/heatsinks and forced air cooling or be used directly on a cold plate.



Example of a Ka band BUC

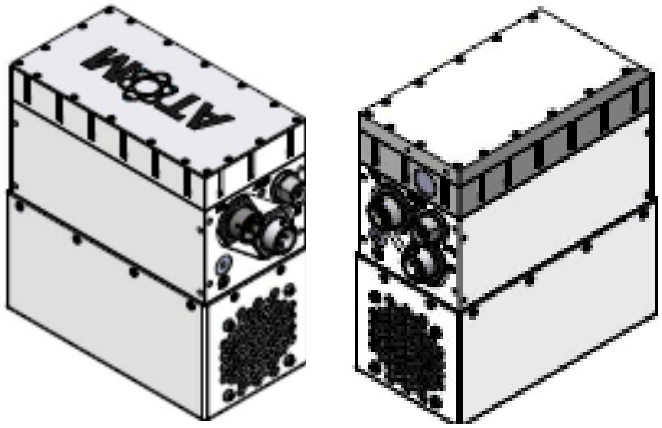
Norsat designed all aspects of the ATOM product line including mechanical, electrical (RF, synthesizer, M&C, power supply) and the internal software so can readily customize the ATOM product to meet specific requirements. Often a customized product requires changes to several aspects including mechanical, software and electrical.

RF Performance
Norsat uses wideband MMICs in its power modules rather than narrow band FETS, This allows a single SSPA design to cover a large bandwidth. For example, the KU SSPAs can cover 12.75- 16.5 GHz while the Ka band SSAPA can support 27.5-31 GHz. Optimization of the SSPA is required during assembly to ensure each SSPA meets the RF performance in the output range.

Input/output frequency plans
Norsat has programmable single and dual conversion synthesizer designs that can be used to meet a customer's unique input/output frequency plan. While the SSPA can support a wide frequency range, the synthesizer is normally programmed to provide multiple bands with the maximum bandwidth of about 1 GHz. Since the synthesizers are programable the IF input range can be tailored to non-standard ranges as can the RF output. Tuning of the SSPA during assembly ensures optimum performance in the chosen RF output range.

Input Voltage Protection
A standard option for some ATOM products is MIL-STD-704 and MIL-STD-1275 compliance. This option requires a specially designed interface PCBA that includes additional filtering. Higher power BUCs require additional filtering assemblies to be compliant with the MIL-STD-1275 voltage surges and spikes. In some cases, this extra filtering makes the BUC larger as the filters tend to be large and require proper thermal management to deal with the high current especially at the lower voltage thresholds required by MIL-STD-1275 and DO-160. Customization of the interface board to include additional ESD and lightning protection can be done.

EMC/EMI
A standard option for the Norsat ATOM products is MIL-STD-461 and RTCA DO-160 EMC/EMI specification compliance. Typically, this requires additional EMC/EMI filtering and an isolated DC-DC power supply. The additional filter assembly and isolated power supply require the housing to be larger.



25W BUC with and without EMC/EMI Filter

Fast switching
While communications systems do not usually require fast on/off switching of the power amplifier, radar applications do and the wide range of frequencies available to the ATOM products means that they can be used for some radar applications. The Ku band ATOM products have been tested up to 10 kHz switching. Capacitor banks are used to manage the current fluctuations between the on/off states. Fast switching is a standard option on some ATOM products.

Matched delays
The delay through a BUC or SSPA is not normally a concern as most BUCs are used individually and not combined . SSPAs even from the same manufacturing run will usually have different delays and hence different phase shifts. If SSPAs are to be used in a waveguide combining assembly, it is important that all BUCs are in phase and hence the delay through the SSPA RF path is the same for all SSPAs. Norsat can ensure SSPAs have a constant and/or specified delay through careful builds and testing and using integrated delay adjustments.

Internal/external and auto-sense frequency reference
Norsat BUCs can be outfitted to accept external references, have an internal reference or to autodetect an external reference and use an internal reference if not present. The Ku band is based around a 10 MHz reference. The Ka band products can be customized to accept references up to 100 MHz.

M&C Functions
Norsat can modify the M&C functionality to implement customer specific alarms and features. For example, the Norsat hardware mute capability is extremely flexible with different logic configurations. The Norsat BUC and SSPA do not include separate BIT functionality, but constantly monitors the hardware for alarms.

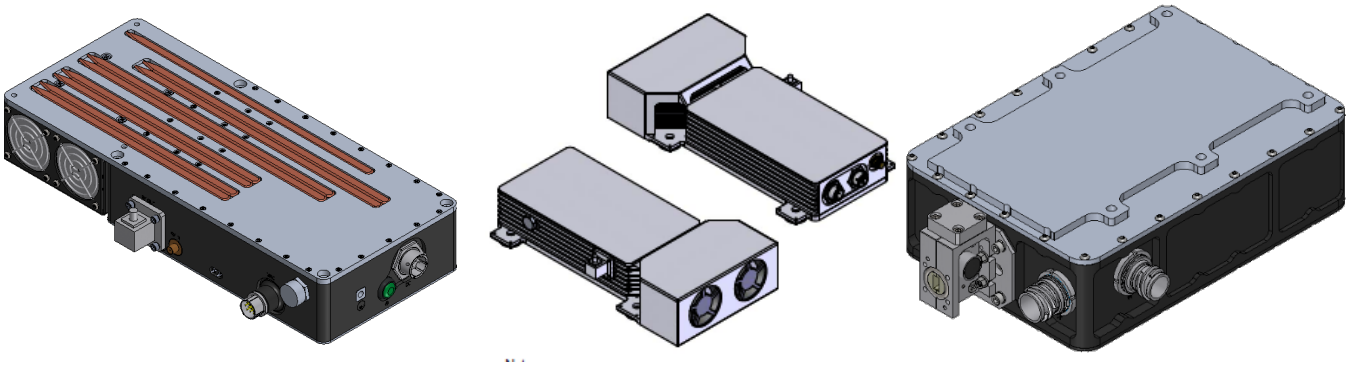
MECHANICAL:

The Norsat ATOM products have some of the best Size, Weight and Power (SWAP) characteristics in the industry. Despite their small size, sometimes they are the wrong shape to fit, mounting orientation is inconvenient or there are special requirements that require a mechanical customization. Some of the mechanical modifications that can be made are:

a) Size – low profile, different shapes
b) Orientation – mounting considerations
c) Weight – weight reductions
d) Finish – paint, anodized, special coatings

e) Connectors – type and location
f) Splitting functionality – separating upconverter and SSPA
g) Thermal – heatsinks, baseplate designs, airflow requirements

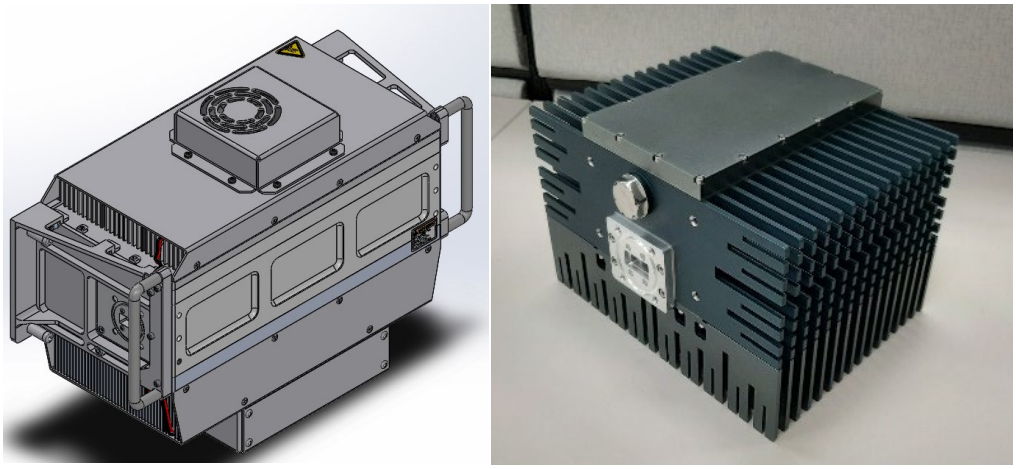
Sometimes electrical, EMC/EMI, vibration and thermal requirements lead to mechanical changes. Conversely, mechanical changes to ensure the BUC fits in a specific location may impact thermal or other requirements. Norsat will work with the customer to design a custom BUC/SSPA enclosure to meet the all the project requirements including electrical, mechanical, vibration and thermal.



Examples of Custom Mechanical enclosures

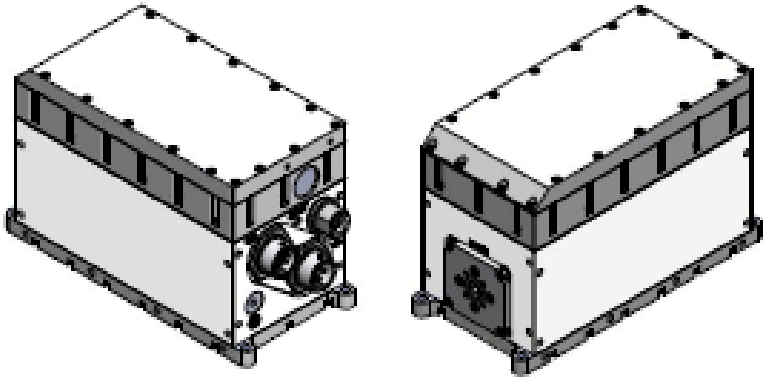
THERMAL MANAGEMENT:

Norsat's ATOM series BUCs and SSPAs can be configured with integrated fans or as a baseplate cooled unit without fans. The fan variant has an operating temperature range of -40 to +60 degrees Celsius. The ATOM units monitor the internal temperature of key components and will shut down before damage occurs. In special situations this temperature range can be increased to +70 degrees Celsius, however extended operation at maximum power is not recommended. This option is made for certain short term emergency operations. Normal fan operation works well to 3000m. For unpressurized airborne applications, the standard fans are insufficient. Norsat can design solutions for high altitude operation involving special high speed fans and specialized heatsink solutions.



Examples of Custom Thermal Management Solutions (High Altitude Fans, High Temperature Fan-less)

Often ATOM BUCs and SSPAs are used in airborne applications where a cold plate or heat exchanger is available. The Norsat baseplate cooled option is designed for these applications. The major heat dissipators within the BUC/SSPA are the power amplifier components and the power supply. The power supply is better than 93% efficient so less than 7% of the dissipated heat is from the power supply. The power amplifier components are attached to the baseplate of the BUC/SSPA using thermal interface materials. Heat from the baseplate can be dissipated by either the integrated fans or via a heat exchanger.



Example of Baseplate cooled ATOMBKA025 BUC with EMI Filter module

The baseplate temperature must be maintained at 70 degrees Celsius or less for optimal performance and to maintain the BUC MTBF. Short term operation above 70 degrees Celsius is allowable to meet emergency scenarios but is not recommended for long term operation. Modification of the internal thermal shutdown thresholds is required for operation with baseplate above 70 degrees Celsius.

The following table provides some guidance on the thermal power dissipation for the various ATOM products. The table is organized by product family and then by operating point as the thermal power to be dissipated depends on the operating output power. Typically, the BUC will not be operated above Plinear or P1dB. The thermal dissipation is much less at lower RF output powers. The first two columns provide the total thermal power for the fan cooled and baseplate cooled BUC. The main difference being the baseplate cooled does not have fans. The next two columns provide the thermal power dissipated directly through the baseplate and thermal power dissipated through the body of the BUC. For example, the baseplate cooled version of the ATOM 40W GAN BUC, ATOMBKUG040 operating at Plinear dissipates about 81W through the baseplate and about 11 watts through the body of the BUC. This thermal power is dissipated via radiation, conduction via airflow and indirectly through the baseplate.

ATOM Ku Band GaAs								
	Operating at P1dB				Operating at Psat			
	Thermal Power Dissipated (Fan Cooled) (W)	Thermal Power Dissipated Baseplate Cooled (W)	Thermal Power Dissipated via Baseplate (W)	Thermal Power Dissipated through Body (W)	Thermal Power Dissipated (Fan Cooled) (W)	Thermal Power Dissipated Baseplate Cooled (W)	Thermal Power Dissipated via Baseplate (W)	Thermal Power Dissipated through Body (W)
ATOMBKU020	150	140	124	17	185	175	156	20
ATOMBKU040	200	190	169	22	255	245	219	26
ATOMBKU080	440	421	380	41	510	491	444	48

ATOM Ku Band GAN								
	Operating at Plinear				Operating at Psat			
	Thermal Power Dissipated (Fan Cooled) (W)	Thermal Power Dissipated Baseplate Cooled (W)	Thermal Power Dissipated via Baseplate (W)	Thermal Power Dissipated through Body (W)	Thermal Power Dissipated (Fan Cooled) (W)	Thermal Power Dissipated Baseplate Cooled (W)	Thermal Power Dissipated via Baseplate (W)	Thermal Power Dissipated through Body (W)
ATOMBKUG020	75	67	57	10	85	77	65	12
ATOMBKUG040	100	92	81	11	155	147	128	19
ATOMBKUG080	180	172	155	17	290	282	251	31

ATOM Ka Band GAN								
	Operating at Plinear				Operating at Psat			
	Thermal Power Dissipated (Fan Cooled) (W)	Thermal Power Dissipated Baseplate Cooled (W)	Thermal Power Dissipated via Baseplate (W)	Thermal Power Dissipated through Body (W)	Thermal Power Dissipated (Fan Cooled) (W)	Thermal Power Dissipated Baseplate Cooled (W)	Thermal Power Dissipated via Baseplate (W)	Thermal Power Dissipated through Body (W)
ATOMBKA025	128	119	105	13	260	251	226	25
ATOMBKA050	255	237	215	22	530	512	466	46

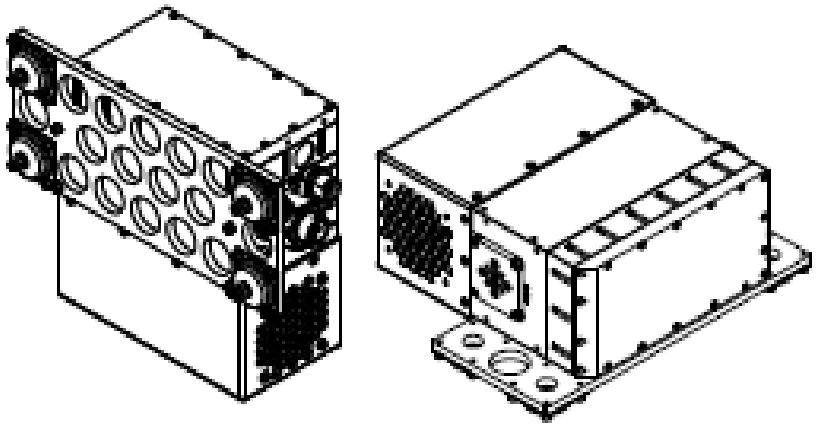
Every application is unique and Norsat can customize the ATOM products to meet these unique requirements. Using thermal modelling and testing, Norsat can design custom baseplates to meet specific customer requirements.

VIBRATION AND SHOCK:

Vibration and Shock on airborne, maritime and COTM terminals can be extreme and there are many different requirements depending on such things as:

a) Type of vehicle (aircraft, ship, land vehicle)
b) Type of vehicle (rotary wing, propeller, jet, wheeled, tracked)
c) Location on airplane/vehicle
d) Application
e) Operation vs survival

The vibration and shock requirements often use profiles specified in standards such DO-160, MIL STD 810, MIL STD 167, MIL STD 904. In many cases some tailoring of requirements is also done. To meet these stringent vibration and shock profiles the BUC will usually need an external vibration/shock dampening assembly. The following diagram shows a sample vibration assembly.



Example of External Vibration Isolation Assembly

Norsat will work with the customer's specific vibration and shock requirements to develop a solution. The solution must also consider size and interface requirements. While Norsat has several designs to use as a base, each requirement is unique and requires some customization. If the terminal the BUC is mounted to is already vibration/shock mounted a separate vibration/shock mount for the BUC may not be required. Thermal dissipation through an external vibration mount is challenging so a fan cooled variant is often used. Norsat has a vibration/shock table and can verify the BUC/external vibration assembly performance. Typically, Norsat uses a combination of phase noise and BER testing to verify performance.

CERTIFICATIONS:

The Norsat ATOM products have many standard options and Norsat can customize them to meet almost any requirement. Verification testing either inhouse or at certified 3rd party laboratories is often required and can be done. Sometimes less formal verification of a BUC or SSPA is sufficient if the system will be formally tested. Many products customizations and options have been verified and these designs can be used on similar products without significant NRE. These products are compliant by design, but not formally verified. The following tables summarize the compliance of the Norsat BUC products to various standards:

Key:

C – Product is compliant and tested.

D – Product is compliant by design, but not formally tested

N – Product can be compliant. Some NRE is required.

Input Voltage Characteristics

Standard	Description	ATOMBKU020	ATOMBKU040	ATOMBKU080	ATOMBKUG020	ATOMBKUG040	ATOMBKUG080	ATOMBKA025	ATOMBKA050
MIL STD 1275D	Characteristics of 28V DC Electrical Systems in Military Vehicles	D	D	N	D	D	C	C	N
MIL STD 704A	Characteristics and Utilization of Electric Power, Aircraft	N	N	N	D	D	C	N	N

Note: BUC/SSPA must be outfitted with the Surge protection option, Option P

MIL STD 461 – Requirements for Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

Test	Description	ATOMBKU020	ATOMBKU040	ATOMBKU080	ATOMBKUG020	ATOMBKUG040	ATOMBKUG080	ATOMBKA025	ATOMBKA050
CE101	Conducted Emissions, audio frequency currents, power leads	D	D	C	D	D	C	D	N
CE102	Conducted Emissions, radio frequency potential power leads	D	D	C	D	D	C	C	N
CS101	Conducted Susceptibility, Power leads	D	D	C	D	D	C	N	N
CS114	Conducted Susceptibility, Bulk Cable Injection	D	D	C	D	D	C	C	N
CS115	Conducted Susceptibility, Bulk Cable Injection impulse excitation	D	D	C	D	D	C	N	N
CS116	Conducted Susceptibility, Damped Sinusoidal Transients, cables and power leads	N	N	N	D	D	C	D	N
CS118	Personnel Borne Electrostatic Discharge	D	D	D	D	D	C	C	D
RE102	Radiated Emissions , electric field	D	D	D	D	D	C	C	N
RS103	Radiated Susceptibility, electric field	D	D	C	D	D	C	C	N

The above matrix provides guidance on EMC/EMI compliance. Not all products were tested to same revision application (air, ground or maritime) or level. Testing was done according to MIL-STD-461 (E,F,G). Typically, the testing was done to one of Surface Ship, Airborne, or Ground. Some testing may be tailored for specific applications. Please contact Norsat for guidance on specific applications.

The BUC/SSPA must be outfitted with the EMC/EMI filter, Option F.

RTCA-DO-160 – Environmental Conditions and Test Procedures for Airborne Equipment

Section	Description	ATOMBKU020	ATOMBKU040	ATOMBKU080	ATOMBKUG020	ATOMBKUG040	ATOMBKUG080	ATOMBKA025	ATOMBKA050
Section 4	Altitude - Category D2	D	D	C	N	N	N	N	N
Section 4	Temperature - Category D2	D	D	C	N	N	N	N	N
Section 5	Temperature Variation Category B	D	D	C	N	N	N	N	N
Section 6	Humidity - Category B	N	N	C	N	N	N	N	N
Section 7	Operational Shock - Category B	D	D	C	N	N	N	N	N
Section 7	Crash Safety - Category B	D	D	C	N	N	N	N	N
Section 8	Vibration - Category S	D	C	C	N	N	N	N	N
Section 10	Waterproofness - Category Y	D	D	C	N	N	N	N	N
Section 15	Magnetic Effect - Category A	D	D	C	N	N	N	N	N
Section 21	Conducted Emissions - Category L	D	D	C	N	N	N	N	N
Section 21	Radiated Emissions - Category L	D	D	C	N	N	N	N	N
Section 22	Lightning Category A3J3L3	N	N	C	N	N	N	N	N
Section 25	ESD - Category A	D	D	C	N	N	N	N	N
Section 26	Flammability Category C	D	D	C	N	N	N	N	N

The above matrix provides guidance on RTCA DO-160 compliance. RTCA DO 160 provides different standards of testing based on application and location of equipment. Not all products were tested to same standards. Please contact Norsat for guidance on specific applications

MIL STD 810 – Environmental Engineering Considerations and Laboratory Tests

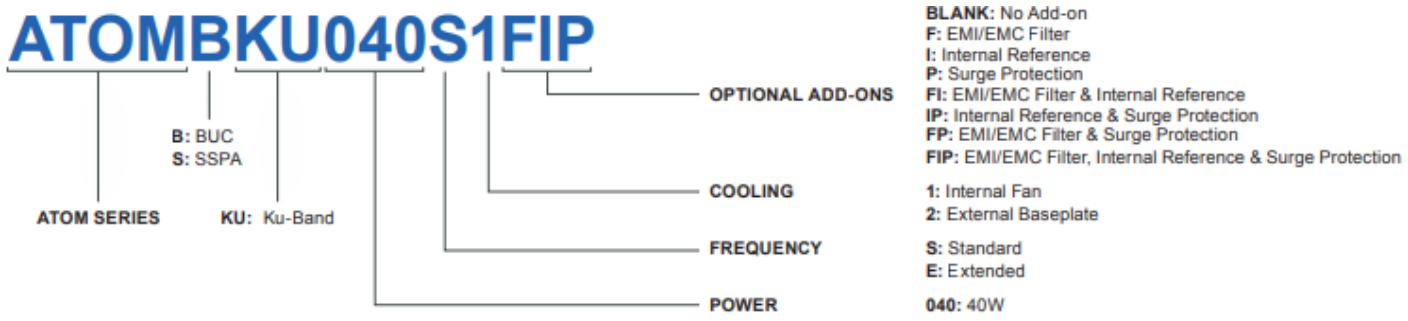
	Description / Procedure	ATOMBKU020	ATOMBKU040	ATOMBKU080	ATOMBKUG020	ATOMBKUG040	ATOMBKUG080	ATOMBKA025	ATOMBKA050
Method 501.4	High Temperature Procedure I – Storage (+80 deg C) Procedure II – Operation (+60 deg C)	 D D	 D D	 D D	 D D	 D D	 D D	 C D	 D D
Method 502.4	Low Temperature Procedure I – Storage (-50 deg C) Procedure II – Operation (-40 deg C)	 D D	 D D	 D D	 D D	 D D	 D D	 C C	 D D
Method 506.4	Rain Procedure 1 - Blowing Rain	 D	 D	 D	 D	 D	 D	 C	 D
Method 507.4	Humidity Procedure 1 – Induced	 D	 D	 D	 D	 D	 D	 C	 D
Method 509.4	Salt Fog	D	D	D	D	D	D	C	D
Method 510.4	Sand and Dust Procedure I - Blowing Dust Procedure II - Blowing Sand	 D D	 D D	 D D	 D D	 D D	 D D	 C C	 D D
Method 513.6*	Acceleration Procedure I - Structural Test Procedure II - Operational Test Procedure III - Crash Hazard Acceleration Test	 D D D	 D D D	 C N C	 N N N	 N N N	 N N N	 N N N	 N N N
Method 514.5*	Vibration Procedure I - General Vibration Procedure II - Loose Cargo Vibration	 D D	 D D	 N C	 N N	 N N	 N N	 N N	 N N

*Depends on profile and or unit configuration (baseplate versus fan cooled)

MIL-STD 810 is a method of testing and the performance standard is usually tailored for a specific application.

CHOOSING BUC OPTIONS:

As noted above, the Norsat ATOM products can be customized with a variety of options and accessories. The following table describes some of the standard options:



Series	ATOM Option
Model	B- BUC S – SSPA
Band	Ku – Band Ka – Ka Band
Technology	Missing/Blank – GaAs G – GaN
Output Power	For GaAs technology, Output Power is defined as P1dB. For GAN technology, Output power is defined as Psat
Sub-Band	Ku-Band S – Standard Ku Band, 14-14.5 GHz E – Extended Ku Band, 13.75-14.5 GHz L - Low Ku Band, 12.75-13.25 GHz Ka Band M – Military, 30-31 GHz C – Commercial, 29-30 GHz D – Dual Band, Commercial and Military
Cooling	1 – Internal Fan. This is standard configuration and fans will ensure BUC meets its operational performance over the full operational temperature range 2 - External Baseplate. This configuration does not include fans and is often used where customer has a cold plate assembly that can provide cooling. Baseplate temperature must be kept < 70 deg C for proper operation.
Optional Add-Ons	Blank – No add-ons F - EMI/EMC Filter. This Add-on is required to meet MIL-STD-461 includes an additional filter assembly. Unit size is larger to accommodate the additional filter. I – Internal Reference This add-on includes integrates a high stability 10 MHz reference. This can be configured as an auto-switch where an external 10 MHz is used if available otherwise the internal reference is used. Can also be configured to always use internal reference, P – Surge Protection. This add-on replaces the interface PACA assembly with an interface PCBA with surge, spike, and polarity protection. This add allows the unit to meet MIL STD 1275D, MIL STD 1275E and MIL STD 704 IP – Internal Reference and Surge Protection FP – EMC/EMI Filter and Surge Protection FIP EMI/EMC Filter, Internal Reference and Surge Protection

THE NORSAT ADVANTAGE

Norsat has the experience and tools required to customize the standard BUCs and SSPAs to meet the very demanding airborne, maritime and COTM thermal and mechanical requirements. Norsat works with the client to understand the requirements and uses simulation tools and test to develop and verify a design that meets the clients' requirements.

ABOUT NORSAT

Norsat International Inc., founded in 1977, is a leading provider of innovative communication solutions that enable the transmission of data, audio, and video for remote and challenging applications. Norsat's products and services include customizable satellite components, portable satellite terminals, maritime solutions, and satellite networks. The company's products and services are used extensively by telecommunications services providers, emergency services and homeland security agencies, military organizations, health care providers and Fortune 1000 companies.

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