Space Qualified Products Heritage and Present Capabilities

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Dover Structure

DOVER

Headquarters: Downers Groove, Illinois

Founded in 1955

~29,000 employees

New York Stock Exchange under "DOV"

dovercorporation.com

- Engineered Systems
- Fluids
- Refrigeration & Food Equip.

DESTACO

Environmental Solutions Group

Microwave Products Group

TWG

VSG

markem·imaje

DOVER DIGITAL PRINTING

OKInternational

Core Products

Microwave Products Group
A DOVER COMPANY

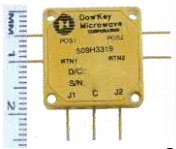
Filters


Surface Mount

Coaxial

Waveguide

Switches




Surface Mount

Coaxia


Waveguide

Integrated Microwave Assemblies (IMA)

Software-define Preselector module

18GHz IMA

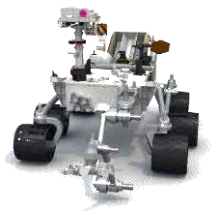
Down Converter W/LNA

Switch Matrix

Switch Heritage

1970-1979	
1972	
818-SPDT	SYMPHONIE
1975	
700-TRANSFER	METEOSAT
1976	
33-WAVEGUIDE	TELESTAR
300-TRANSFER	MAROTS
707-TRANSFER	SPACE SHUTTLE
1977	
700-TRANSFER	CRRES
700-TRANSFER	SCATHA
909-SPDT	SEASAT
1978	
707-TRANSFER	EXOSAT
707-TRANSFER	INTELSAT V
1979	
707-TRANSFER	SATCOM
800-SPDT	TDRSS
808-SPDT	INSAT
909-SPDT	RADARSAT
1980-1989	

APOLLO 17
GPSII, GPS-IIF, GPSIII
MARS SCIENCE LAB
MUOS
Galileo
GOES-R, S, T, U
JCSAT 17
IRIDIUM CONSTELLATION
KEPLER
EUTELSAT
SKYNET
INMARSAT
GLONASS
TDRSS

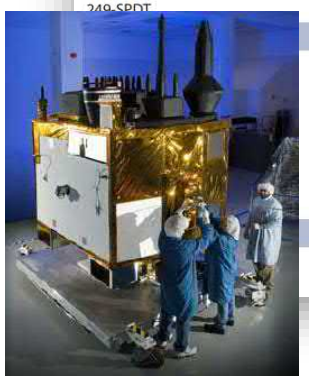


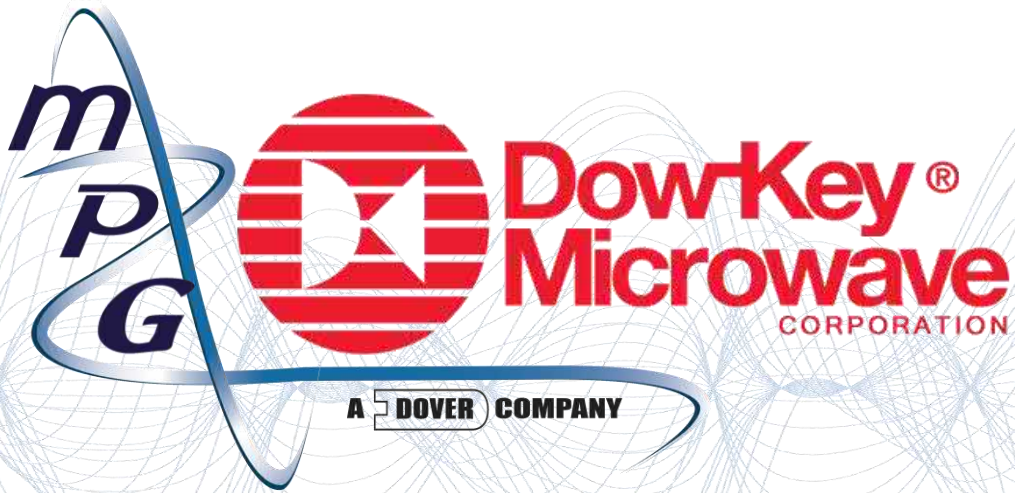
1986	
707-TRANSFER	EURECA
707-TRANSFER	ERS 1
909-SPDT	SKYNET
1987	
707-TRANSFER	EUTELSAT
959-DP3T	ANIK E
1988	
33-WAVEGUIDE	EUTELSAT II
33-WAVEGUIDE	ENVISAT RA-2
707-TRANSFER	INSAT II
737-T-SWITCH	ITALSAT

1990-1999	
1990	
33-WAVEGUIDE	SPOT 4 HELIOS
737-T-SWITCH	TELCOM II
1992	
33-WAVEGUIDE	TURKSAT
33-WAVEGUIDE	AMOS
707-TRANSFER	SAX
818-SPDT	CENTAUR
1993	

SPACE SHUTTLE
DEEP IMPACT
TURKSAT
AMOS
ISRO
INSAT
NovaSAR
CyGNSS
NGSAR
COMSAT NG
RapidEye
LSAT
ATLAS
KOMPSAT
SYMPHONIE

2000-2013	
2000	
406H-SPDT	ALOS
413H-TRANSFER	FOS
919-SPDT	SST
406H-SPDT	OPTUS
411H-TRANSFER	NEW SKIES
700-TRANSFER	CORIOLIS
426H-SPDT	GOES
2001	
707-TRANSFER	SMART I
707-TRANSFER	CLOUD SAT
249-SPDT	DOCOMO
	DEEP IMPACT
	GPS
	GE 15/16
	INMARSAT IV
	INSAT III
	DEEP IMPACT
	PEGASUSA
	LRO





Past – Present – Future

The Dow-Key Co. Telegraph Key

- Paul Peel Dow starts making telegraphic speed keys to benefit operators (1942-1943)
- Dow “KEY-municator” showcases a professional cast metal telegraph key with chrome base and red paddles with transistorized oscillator (1960)
- Dow-Key Co. purchased & moved to California (1969)

Dow-Key Microwave

Facility

- 40K Sq ft facility located in Ventura, California
- Design, manufacture, assembly, and full environmental test capability
- Two Class 7 clean rooms for Space and Military programs
- RF Performance test up to 70GHz
- Special test includes:
  - Corona and Multipaction
  - Passive intermodulation (PIM)
  - Vibration

Product Offering

Switches & Switch Blocks

Commercial & Military Switches

- Electromechanical Coaxial Switches
- Electromechanical Waveguide Switches

Space Qualified Switches

- Electromechanical Coaxial Switches
- Electromechanical Waveguide Switches

Matrices & Systems

- Electromechanical Coaxial Matrices
- Solid State Matrices

Fiber Optic Matrices

- O-O-O Solutions
  Switching in the Optical Domain

Product Offering

Switches & Switch Blocks

Electromechanical Coaxial Switches

SPDT (SMA,TNC Connectors)

2/3 (SMA,TNC)

Transfer (SMA, TNC)

HP T-Switch (TNC)

T-Switch (SMA)

PCB Mount Switches

Iso-Switches

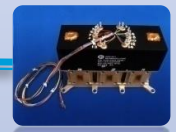
Space Qualified Switches

Waveguide Switches

Transfer Switches

R - Switches

Switch Packs



Switch Blocks
And Subsystems

High Power Coaxial Switches

High Power Switches

T-Switch

PROGRAMS

- BIOMASS
- AMOS
- G-SAT
- INSAT
- MUOS
- TDRS-K
- TDRS-L
- TDRS-M
- TDRS- N
- WGS

Various PN Covering Frequency Ranges from 376 MHz to 4.6 GHz
Multipaction Tested with Input RF Peak Power 280 – 1200 W *(Depending on Operating Frequency Range)*

SPDT

PROGRAMS

- GPS III
- GPSFII
- GLONASS

Frequency Range from 1151 to 1600 MHz
Multipaction Tested with Input RF Peak Power 650 W @ 1550 MHz

Transfer

PROGRAMS

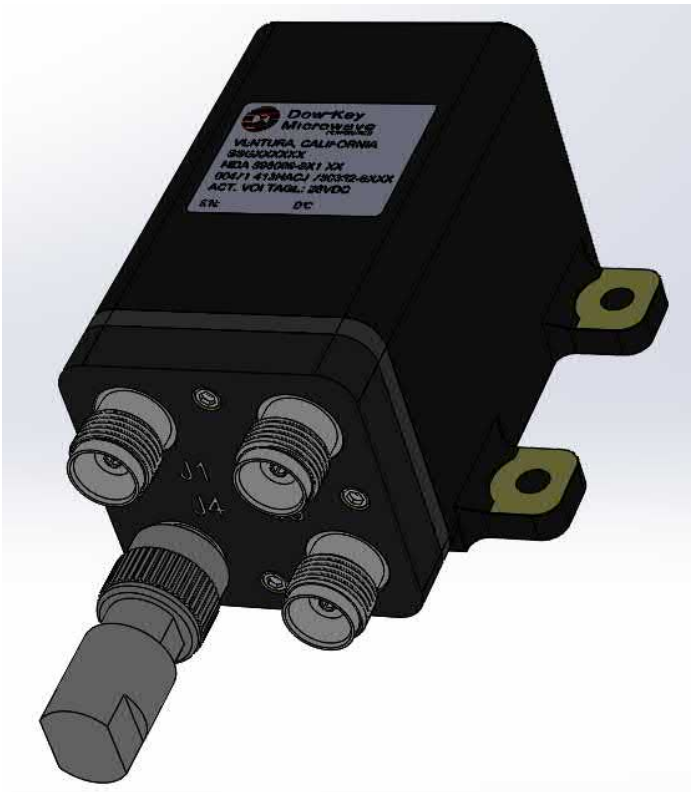
- GALILEO
- AMSAT
- FOS
- ACES

Frequency Range from 1237 to 1600 MHz
Multipaction Tested with Input RF Peak Power 855 W @ 1600 MHz

Hermetically Sealed High Power C-Switch

PROGRAMS

Dream Chaser



Parameters	Specification
Impedance	50 Ω
Frequency(MHz)	2,000 – 2,300
VSWR, Max	1.17:1
Insertion Loss	0.30 dB
Isolation, Min	65 dB
RF Power, Ave	60 W
Multipaction @ Corona Input RF Peak Power	**100 W**
Operating Volt	22-29
Mass	385 Grams
Operating Temp	-24°C to +61°C
Random Vibration	75 grms

Low Power Coaxial Switches

Low Power SP6T

PROGRAM

AMOS 4

SP6T

Operates from DC to 18 GHz

Spec	Qualified
Impedance	50 ohm
Frequency(MHz)	14,000-16,000
VSWR, Max	1.13:1
Insertion Loss	0.3 dB
Isolation, Min	60 dB
RF Power, Ave	10 W
RF Power, Peak	N/A
Operating Volt	22-29
Mass	**320 Grams**
Operating Temp	-25°C to +75°C
Random Vib	21 grms

Low Mass C-Switch

Qualified & Flight Pending

Spec	Qualified
Impedance	50 ohm
Frequency(MHz)	30-27,000
VSWR, Max	1.35:1
Insertion Loss	0.35 dB
Isolation, Min	75 dB
RF Power, Ave	2 W
Operating Volt	22-29
Mass, Max	**53 Grams**
Operating Temp	-55°C to +85°C
Random Vibration	26 grms

Low Mass T-Switch

Qualification & Flight Pending

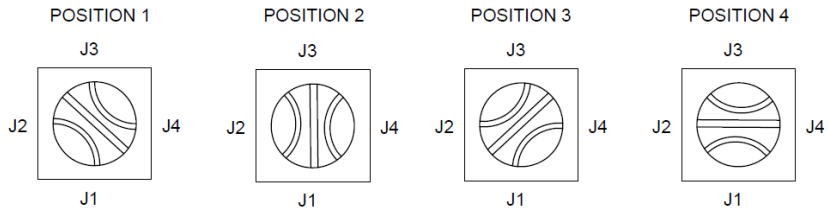
Spec	Qualified
Impedance	50 ohm
Frequency(MHz)	DC-22,000
VSWR, Max	1.50:1
Insertion Loss	0.5 dB
Isolation, Min	65 dB
RF Power, Ave	2 W
Operating Volt	22-29
Mass, Max	**67 Grams**
Operating Temp	-30°C to +85°C
Random Vibration	15 grms

Waveguide Switches

WR-112, WR-90, WR-75, WR-62, WR-42, WR-34, WR-28, WR-15

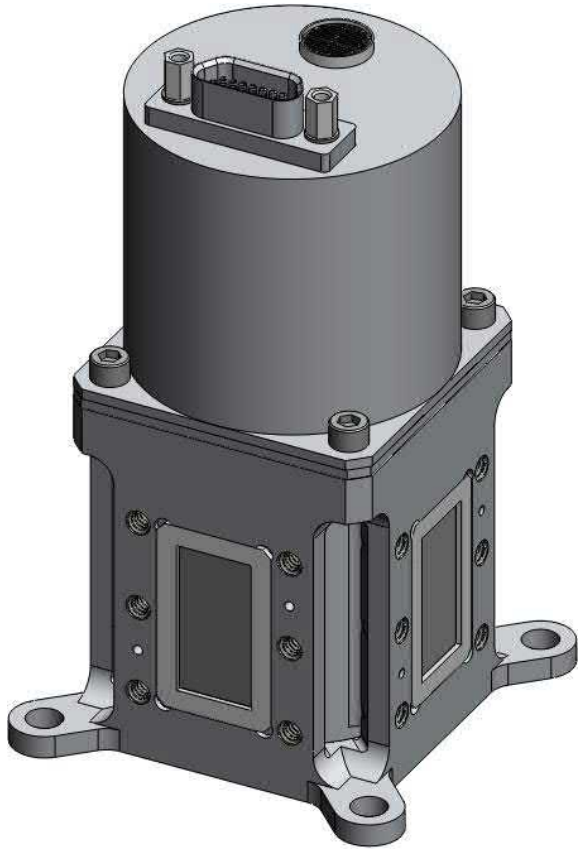
Waveguide Product Offering

Size	C-type	R-type
WR-112 (7.05 – 10.0 GHz)	X	IRAD
WR-90 (8.2 – 12.4 GHz)	X	
WR-75 (10.0 – 15.0 GHz)	X	X
WR-62 (12.4 – 18.0 GHZ)	X	
WR-51 (15.0 – 22.0 GHz)		X
WR-42 (18.0 – 26.5 GHz)	X	X
WR-34 (22.0 – 33.0 GHz)	X	X
WR-28 (26.5 – 40 GHz)	X	
WR-22 (33 – 50 GHz)		IRAD
WR-15 (50 – 75 GHz)	X	X



R-Type Switches are Equipped with the Sequential Actuator

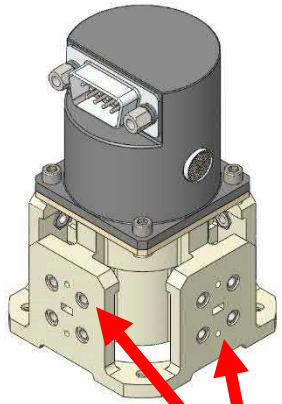
WR75 C-Switch Qualified for SSL in 2017

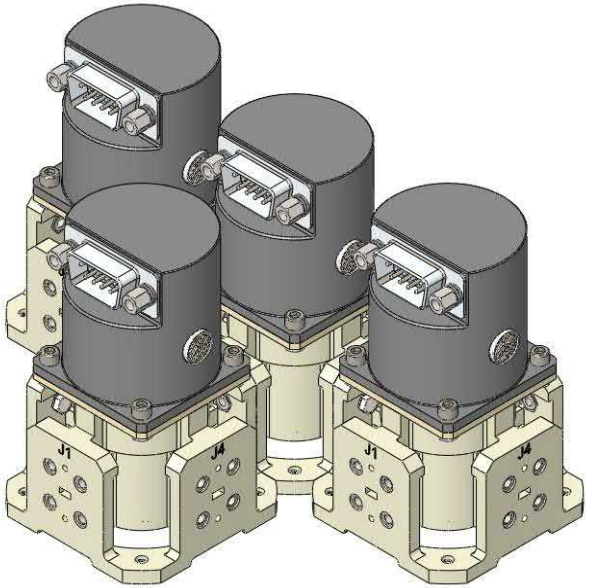


Operating Frequency Range: 10.7 – 14.5 GHz
Insertion Loss: 0.06 dB
Return Loss: 25 dB
Power Dissipation: 300 W
Multipaction Rated Power: 2105 W
Multipaction Test/path: 4200 W

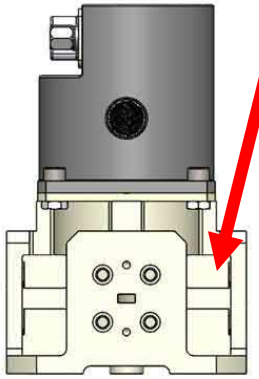
Modularity / Flexibility – Waveguide Switches

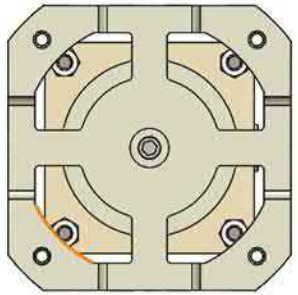
Traditional Approach





Extrude Outwards





Build as Needed

Switch Blocks

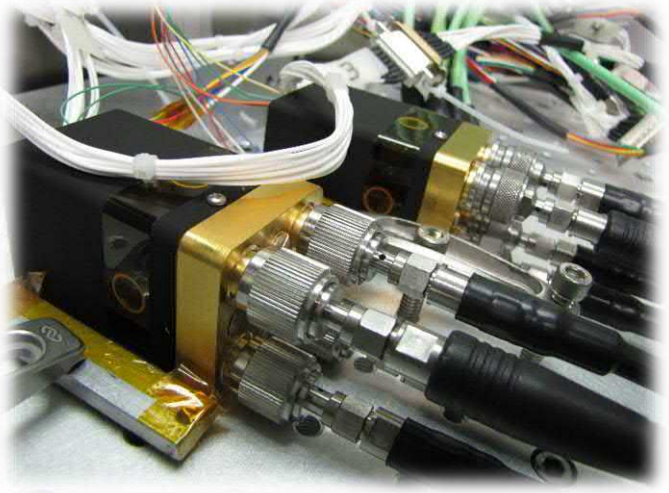
&

Assembly Capabilities

Space Qualified Sub-Assembly Capabilities

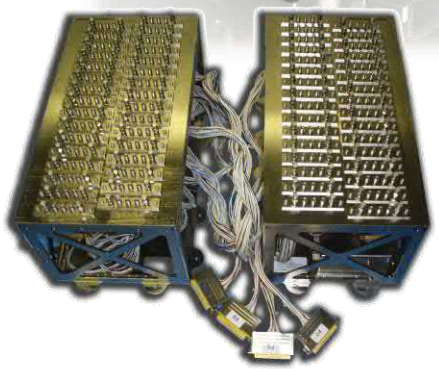
Our Capabilities:

- Design and Analysis
- Integration and Test
- Supplier Program Management



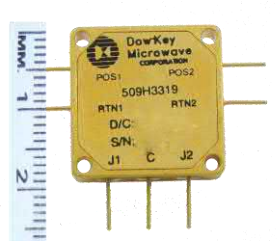
Switch Block Assembly with:

- Power Dividers
- Terminations
- Circulators
- Attenuators
- Isolators



Dow-Key's Direction & Goals

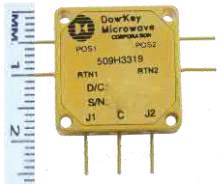
Invest in the Space Products Growth



- Dedicated Technical Team
  - Active IRAD Programs
  - Feasibility Study – Exploration of new Switching Solutions
    - Looking for customer feedback
    - New Smaller and Lighter interconnect solution
  - Alternative solutions for Redundancy Systems
- Investment in the Infrastructure
- **Continuous Improvement Commitment**
  - Shipping Over **40,000 switches/year** (single shift)
    - Over 600 Space switches / year

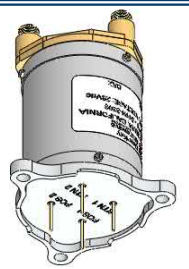
Innovation

Drop-In SPDT Switch 509H-3319



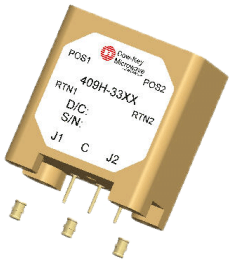
Designed in FY1999
Qualified in FY2017

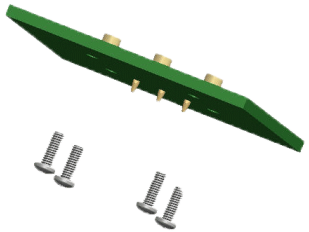
Concept of Switches with SMPM-T Connectors



Switch Type	SPDT	Transfer	T-Switch
Volume Reduction	84%	63%	43%
Mass Reduction	79%	62%	38%

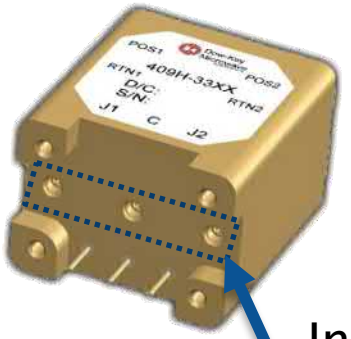
Concept of a SPDT Switch with SMPS Connectors for Solderless Installation on a Microstrip Board.



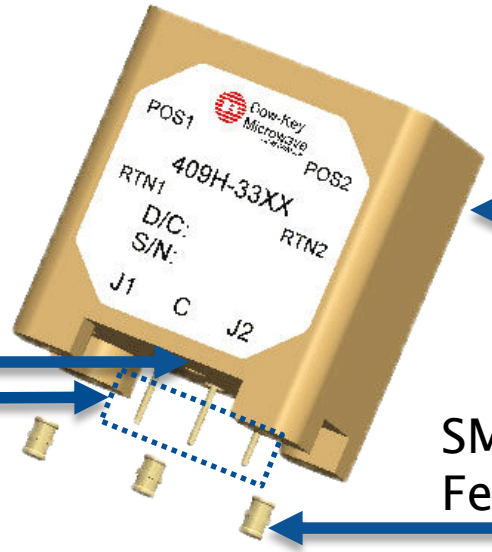


Innovation

SPDT Coaxial Switch



Internal SMPS
Male Connector
Smooth Bore

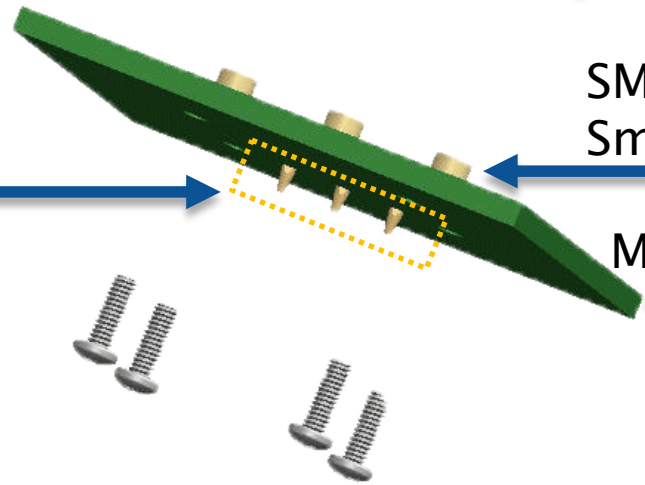


SPDT Switch

SMPS Female to
Female Bullet

DC Terminal Pin

DC Contact Sockets



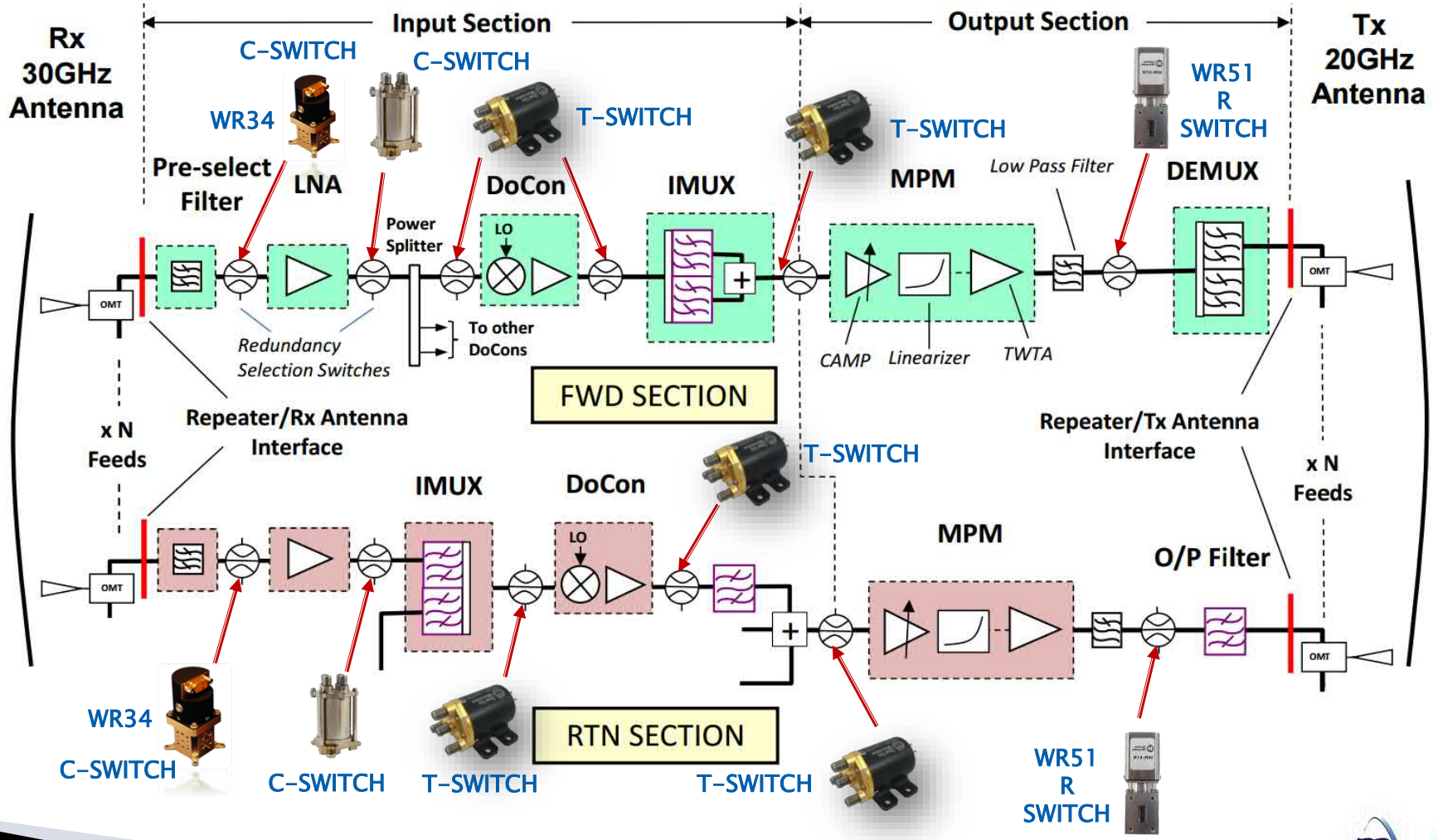
SMPS Male Connector
Smooth Bore

Microwave Substrate

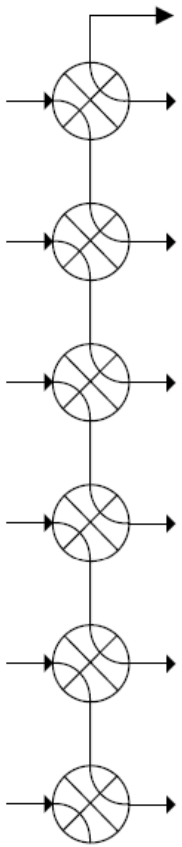
Redundancy Solutions

Ka-Band HTS Satellite – Payload Architecture

Dow-Key Offers Switch Solution For Each Payload Segment

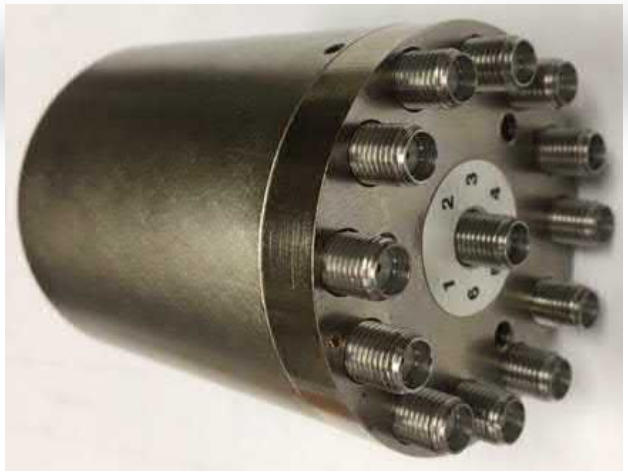


Alternative Redundancy Solution



Thru Connectivity

Redundant Device Connected



7 to 6 Matrix

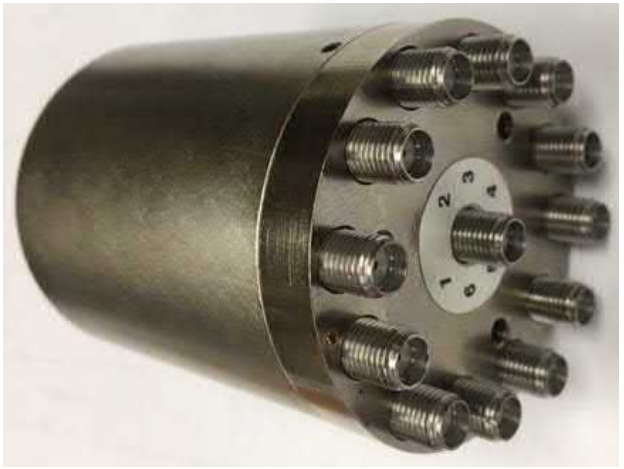
- Single switch package
- Size 2" DIA x 2.5" (10 in^3)
- Mass ~200 grams
- Reduced Insertion Loss and simplified phase matching due to single RF contact

Alternative Redundancy Solution

Multiple Configurations Available

Building Blocks

- SP6T: 7 to 6
- SP8T: 9 to 8
- SP12T: 13 to 12



- CanBus Control is potential

Alternative Redundancy Solution

Case Study

Redundancy Solution for Low Noise Amplifiers

Requirements

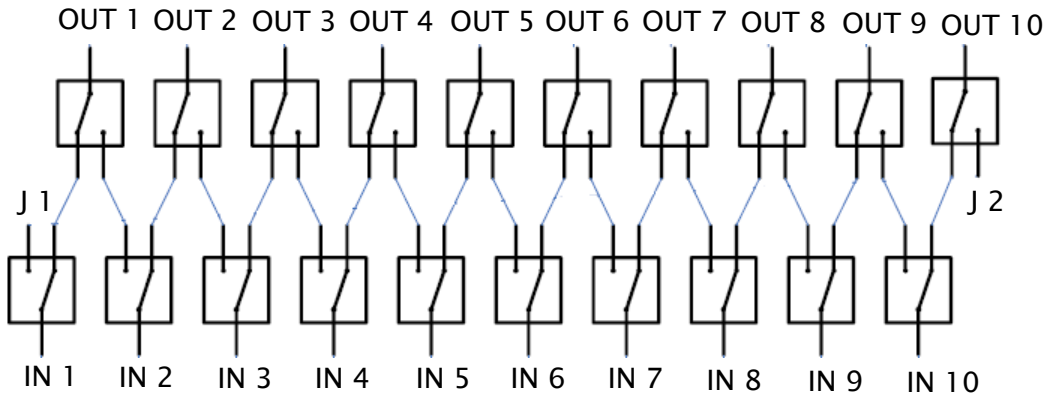
Input Stage

Input SWM – Target Requirement	Value
RF Interface	WR 75
Insertion Loss	< 0.5 dB
Isolation	> 40 dB
Max input level	-55 dBm
Center frequency	15 GHz
Bandwidth	500 MHz

Output Stage

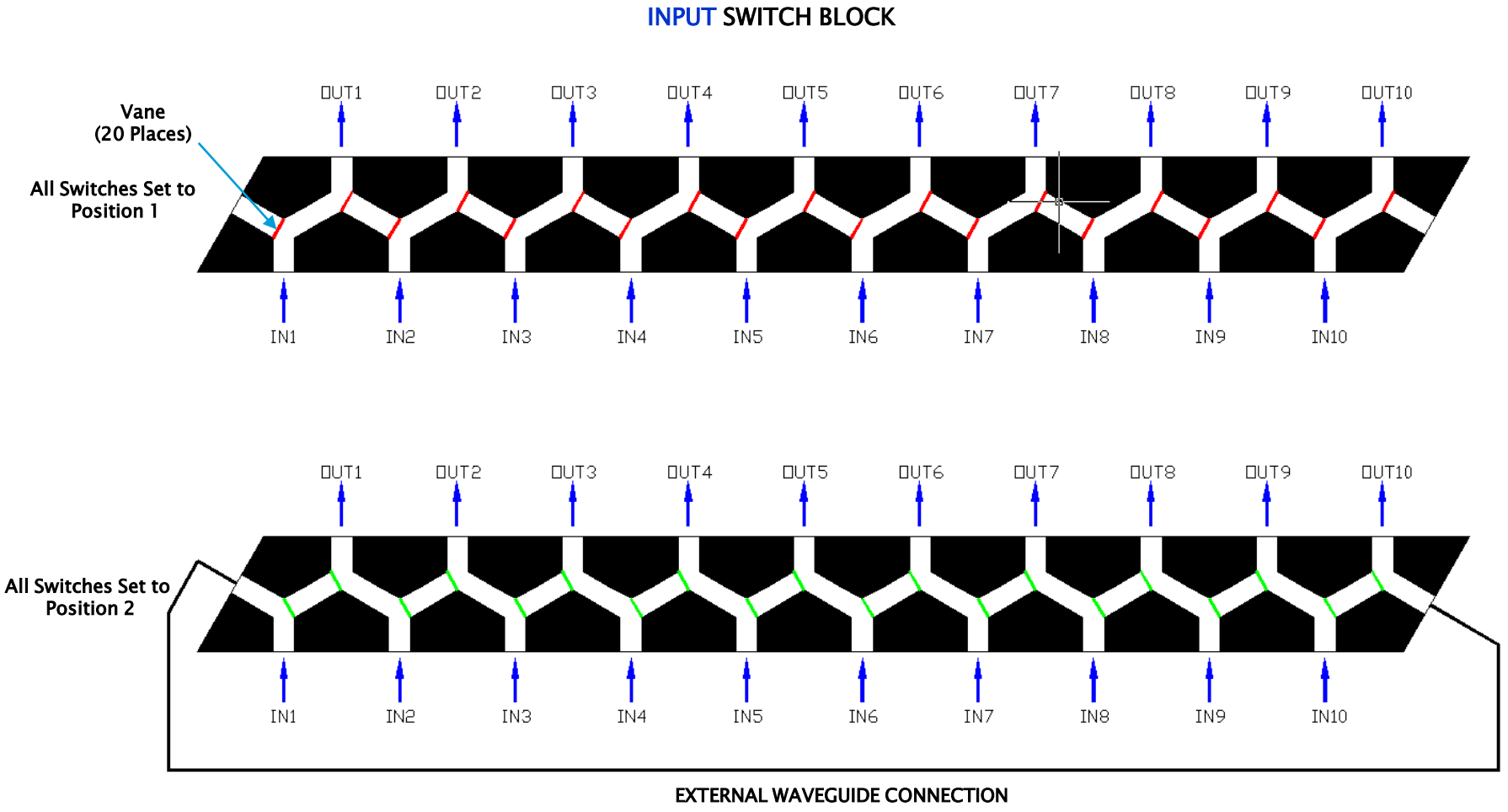
Output SWM – Target Requirement	Value
RF Interface	SMK (2.92mm)
Insertion Loss	< 4 dB
Isolation	> 40 dB
Max input level	+16 dBm
Frequency range	17.5 to 20.5 GHz
Bandwidth	500 MHz

Schematic



Alternative Redundancy Solution

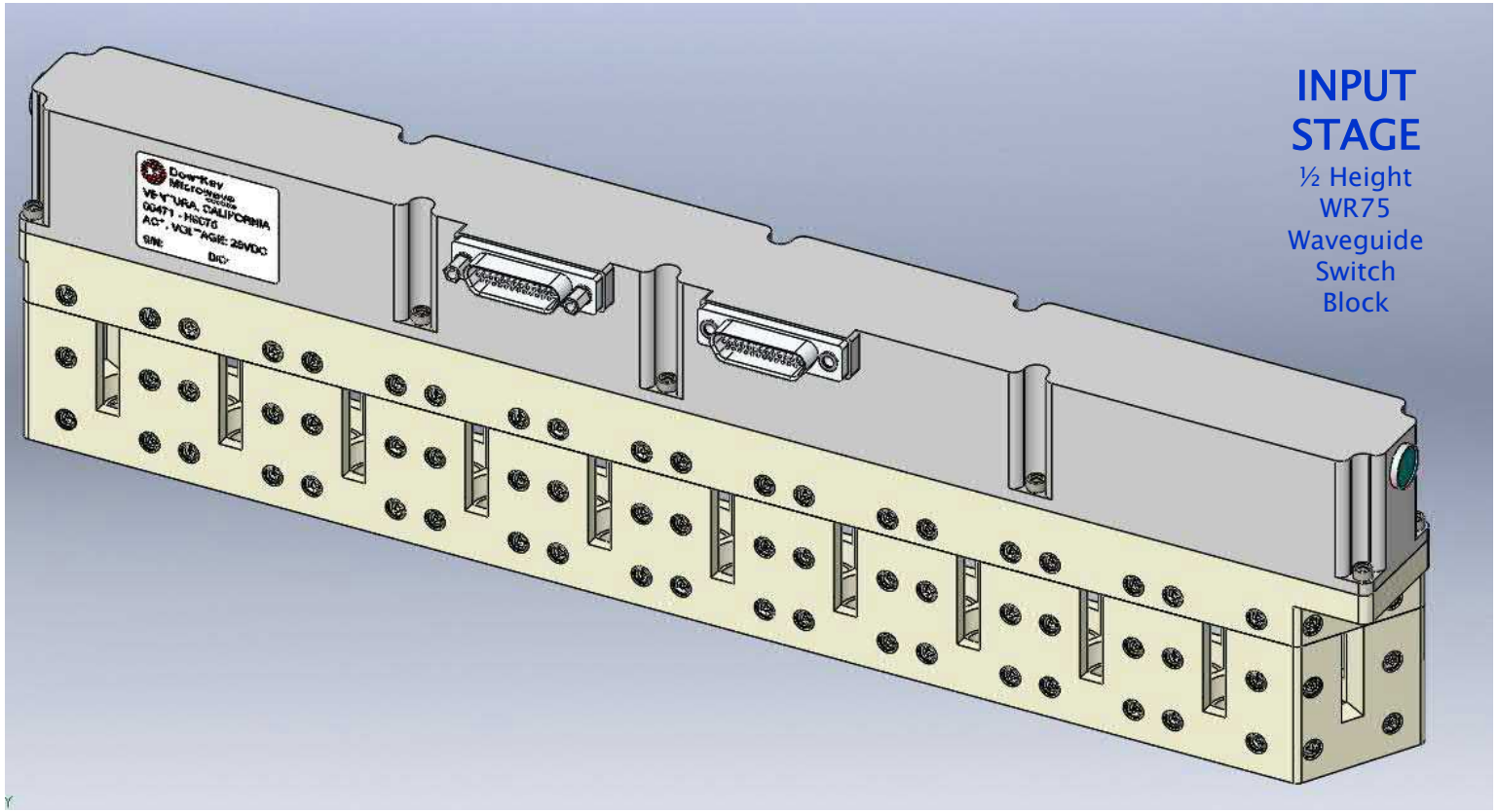
Redundancy Solution for Low Noise Amplifiers



Alternative Redundancy Solution

Redundancy Solution for Low Noise Amplifiers

INPUT SWITCH BLOCK

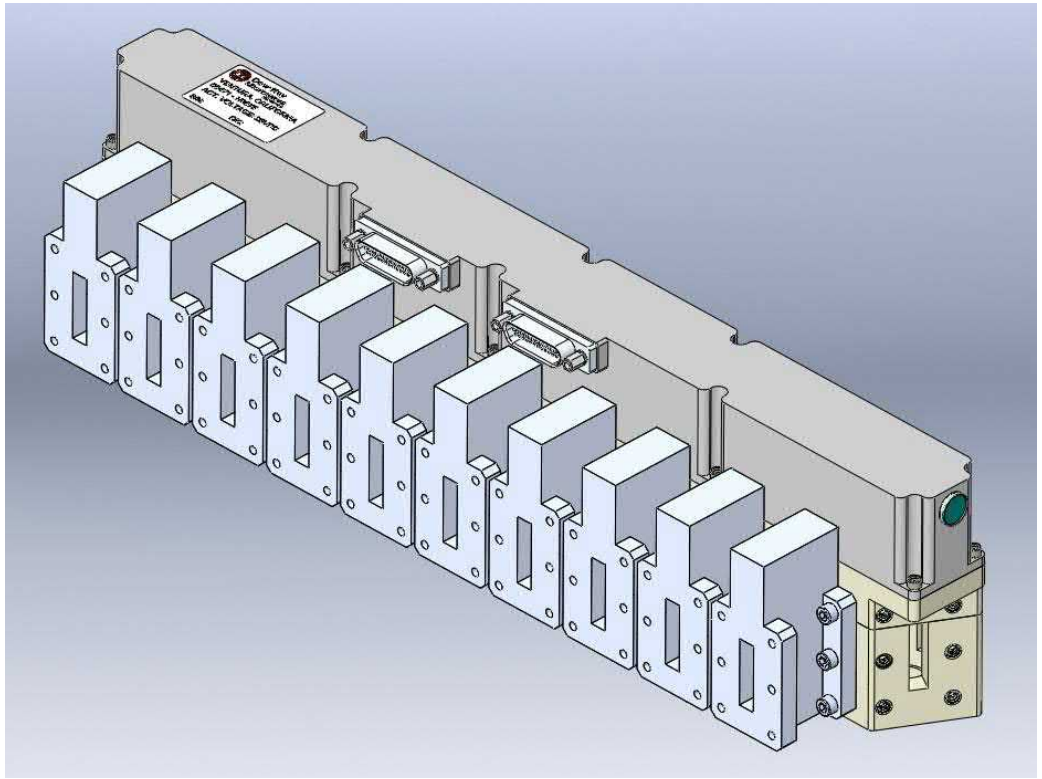


Insertion Loss .3 dB @ 20.5 GHz (Specification .5dB)
Envelope 11” x 1” x 2.8”

Alternative Redundancy Solution

Redundancy Solution for Low Noise Amplifiers

INPUT SWITCH BLOCK WITH ISOLATORS



Insertion Loss .55 dB @ 20.5 GHz (Specification .5dB)
Envelope 11” x 2” x 2.8”

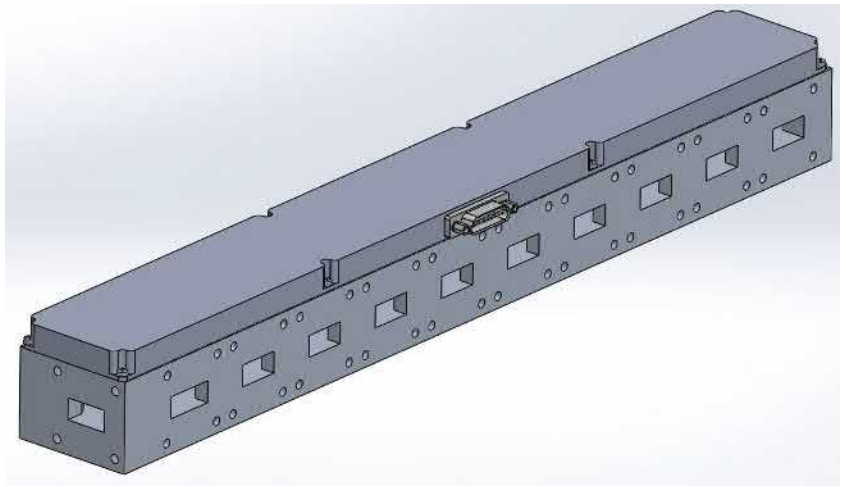
Alternative Redundancy Solution

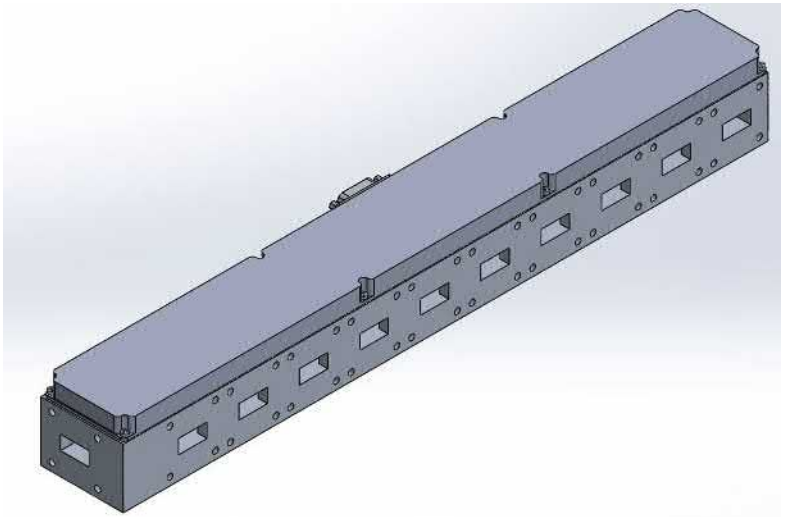
Redundancy Solution for Low Noise Amplifiers

OUTPUT SWITCH BLOCK

Ferrite Switch Solution

WR62 Waveguide



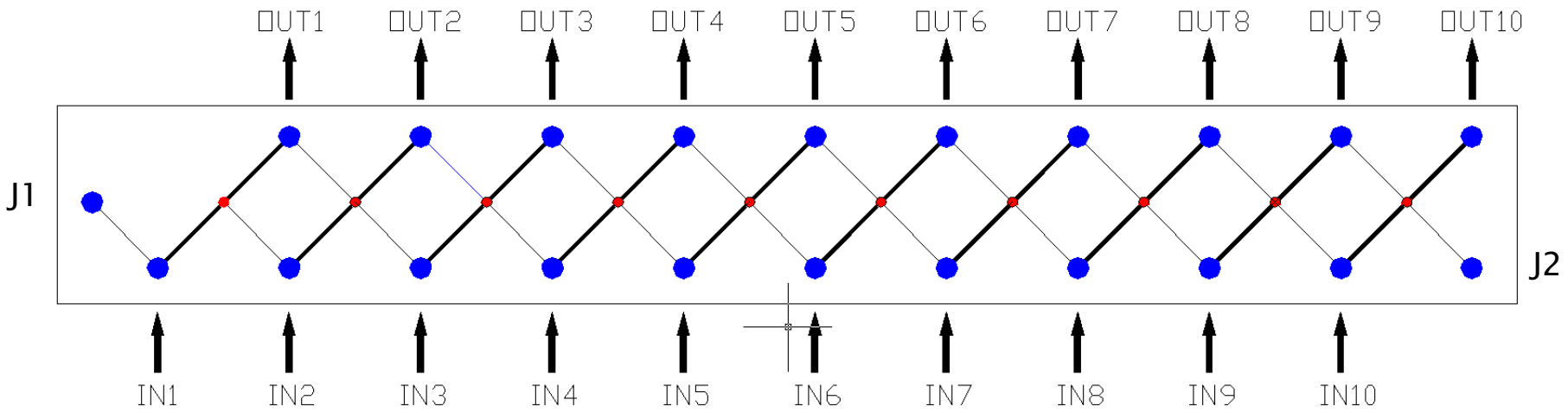


Insertion Loss @ 20.5 GHz .5 -.7 dB Max (Specification 4 dB)
Envelope 11.9" x 2.8" x 2.9"

Alternative Redundancy Solution

Redundancy Solution for Low Noise Amplifiers

OUTPUT SWITCH BLOCK

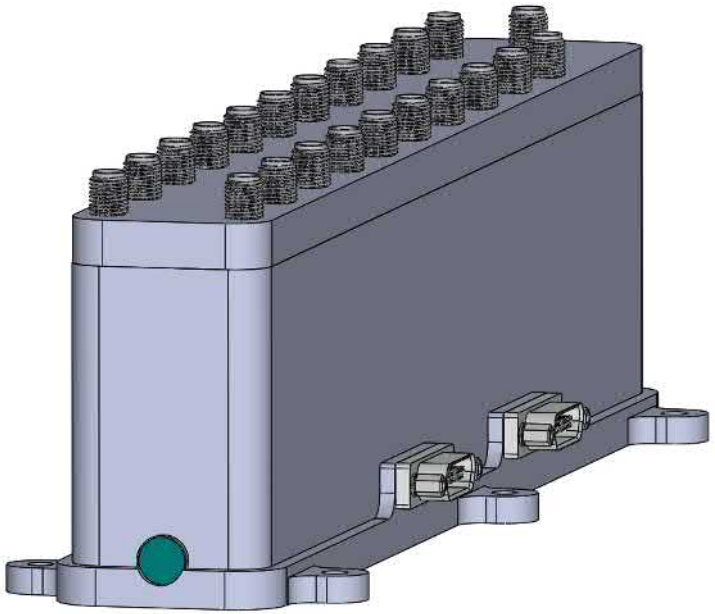


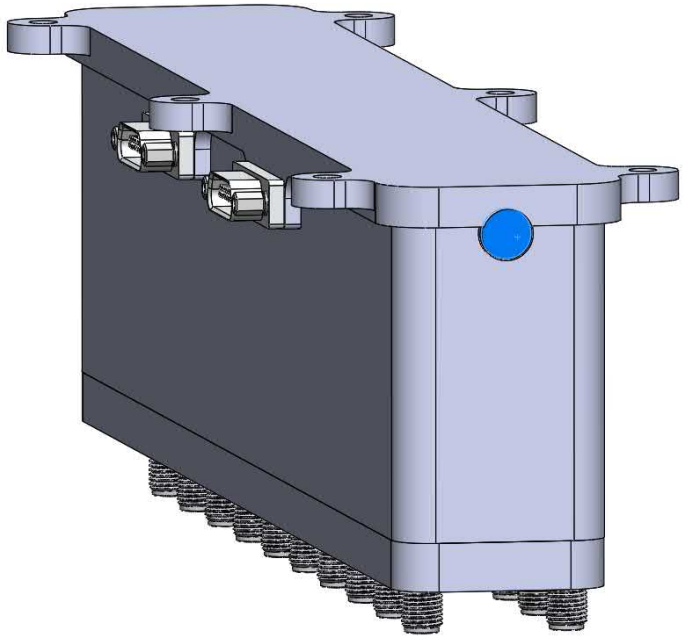
Alternative Redundancy Solution

Redundancy Solution for Low Noise Amplifiers

OUTPUT SWITCH BLOCK

Coaxial EM Solution Based on Qualified Components





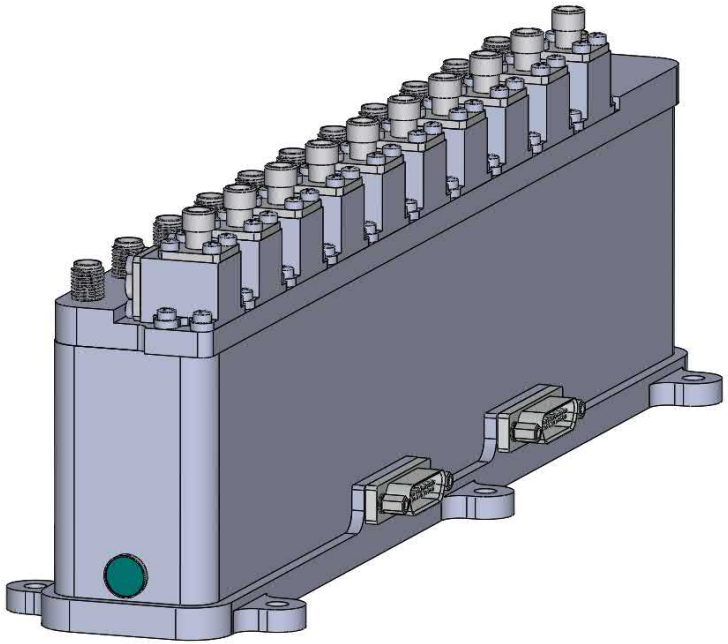
Insertion Loss @ 20.5 GHz .7 dB Max (Specification 4 dB)
Envelope 11.9” x 2.8” x 2.8”

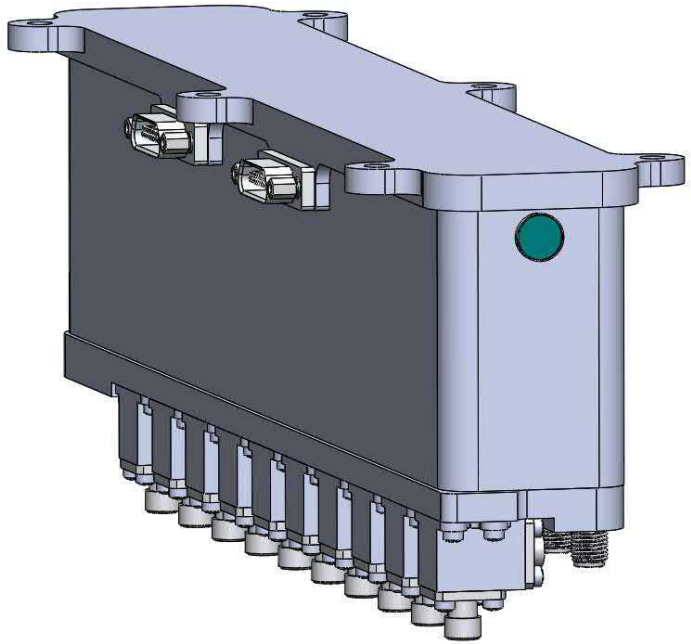
Alternative Redundancy Solution

Redundancy Solution for Low Noise Amplifiers

OUTPUT SWITCH BLOCK WITH ISOLATORS

Coaxial EM Solution Based on Qualified Components





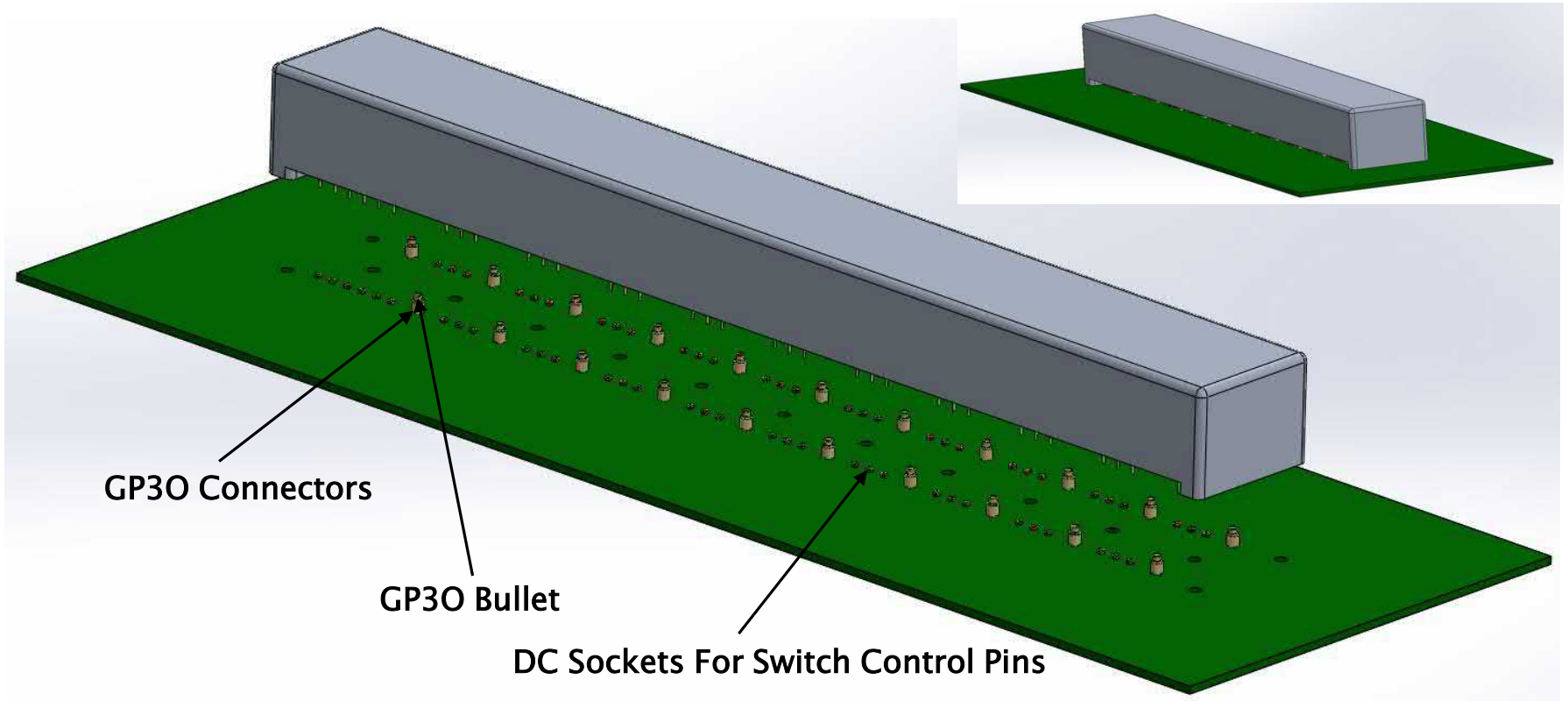
Insertion Loss @ 20.5 GHz .7 dB Max (Specification 4 dB)
Envelope 11.9” x 2.8” x 2.9”

Alternative Redundancy Solution

Redundancy Solution for Low Noise Amplifiers

OUTPUT SWITCH BLOCK

PCB Mounted Solution



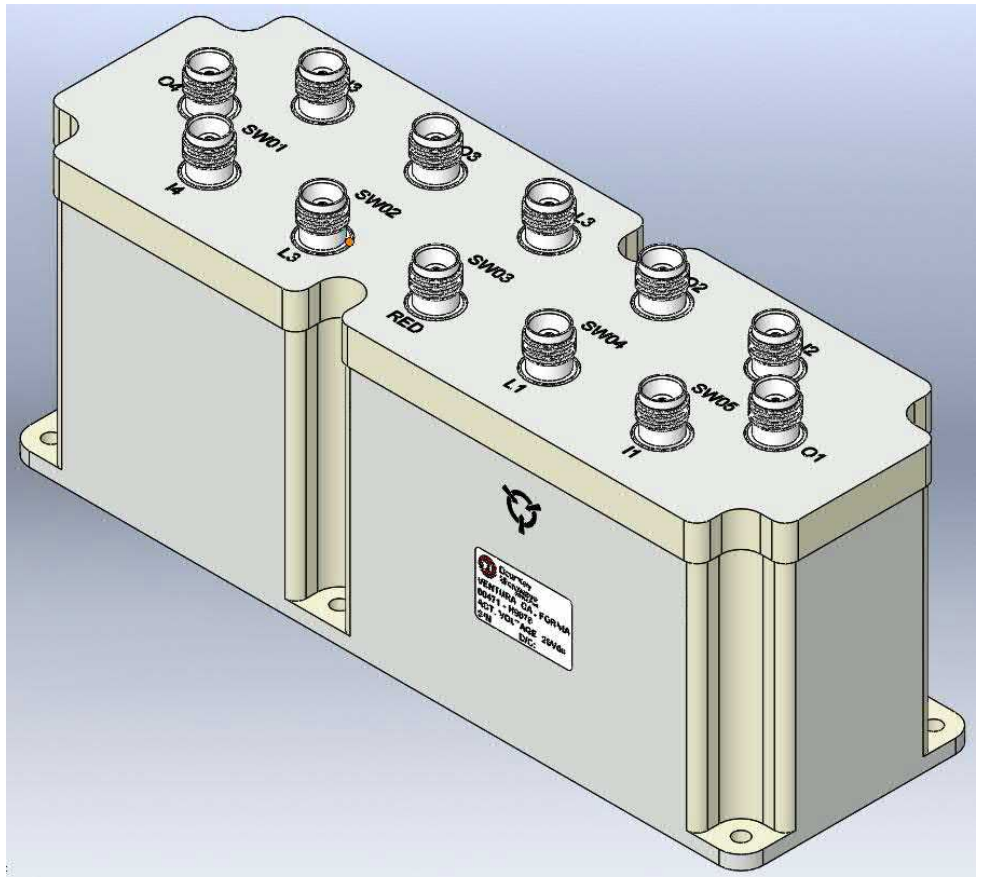
Insertion Loss @ 20.5 GHz .7 dB Max (Specification 4 dB)
Envelope 9.3” x 1.2” x 0.88”

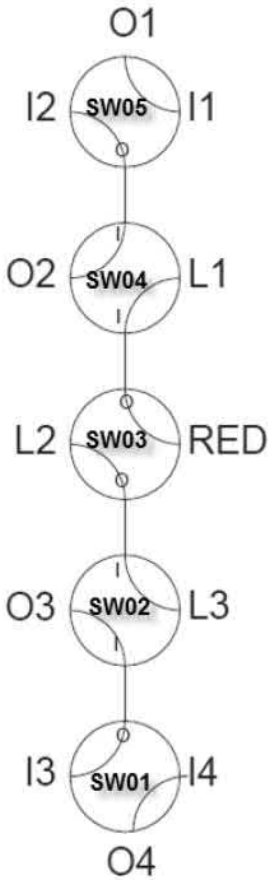
Redundancy Solutions Based on Integrated Switch Blocks

Alternative Redundancy Solution

Redundancy Solution

5/4 OUTPUT SWITCH BLOCK

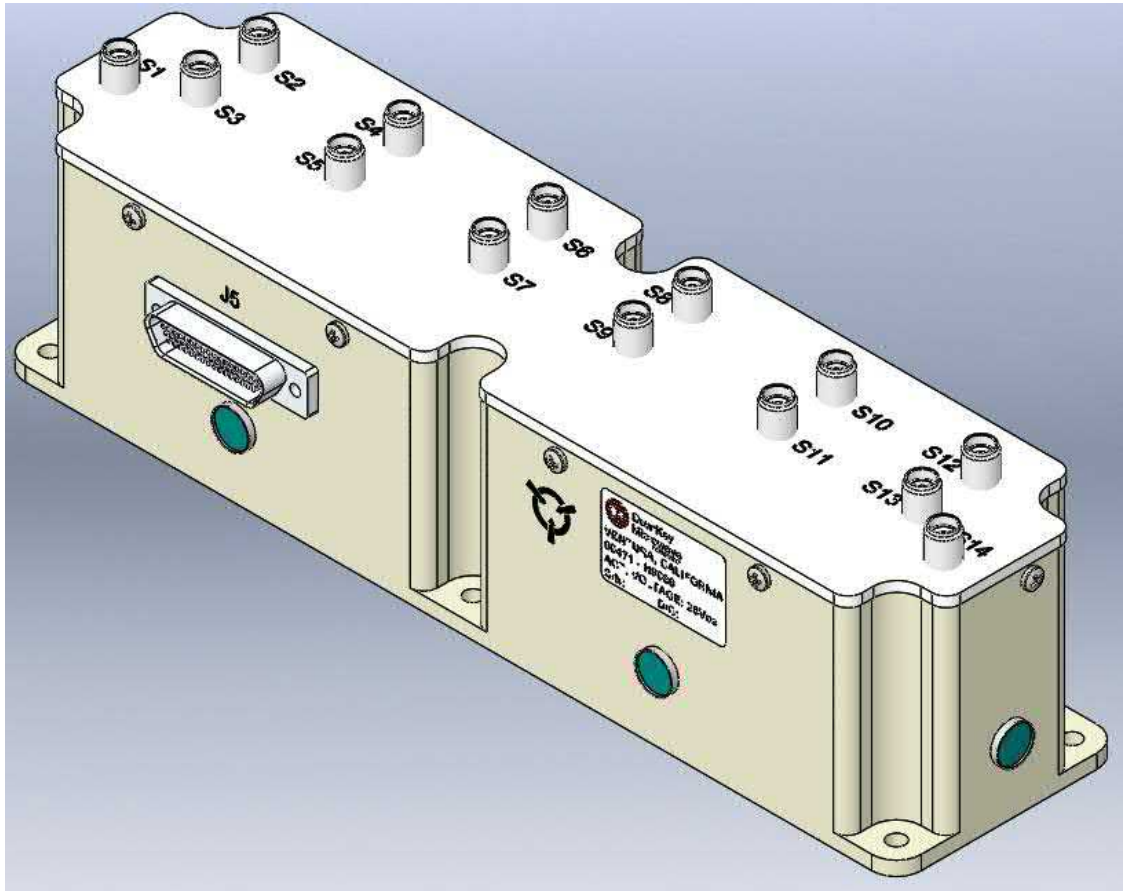




Alternative Redundancy Solution

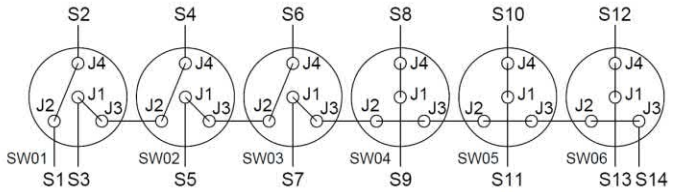
Redundancy Solution

INPUT/OUTPUT SWITCH BLOCK



6-Pack
T-Switch Block

Schematic

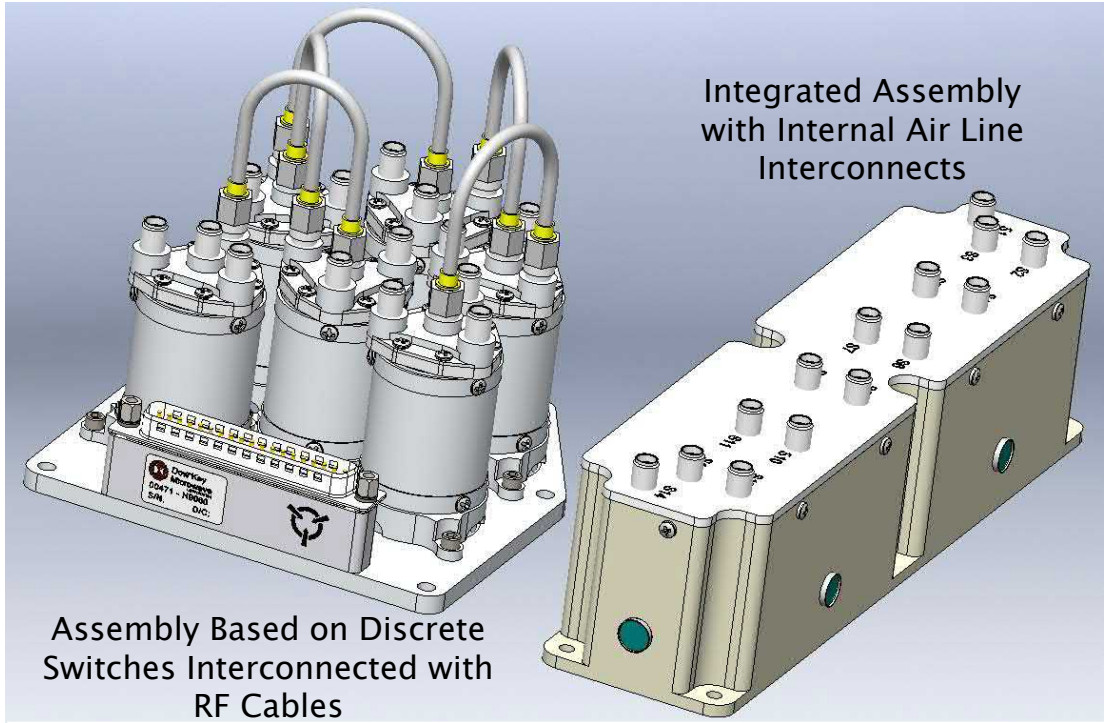


SMA Connector Version
Operating Frequency Range DC-22GHz

K - Connector Version
Operating Frequency Range 17.5 - 31 GHz

Alternative Redundancy Solution

6 Pack T-Switch Block



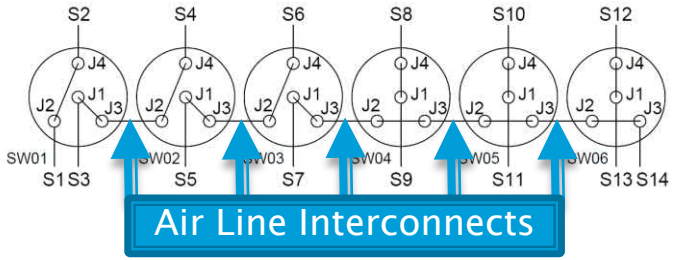
Assembly Based on Discrete Switches Interconnected with RF Cables

Solution Type	Discrete Assembly	Integrated Assembly
Envelope Dimensions	6.19"x4.4"x3.2"	7.91"x2"x2"
Envelope Volume	87.16 in^3	31.64 in^3
Mass	580 grams	480 grams

Benefits of the Integrated Assembly

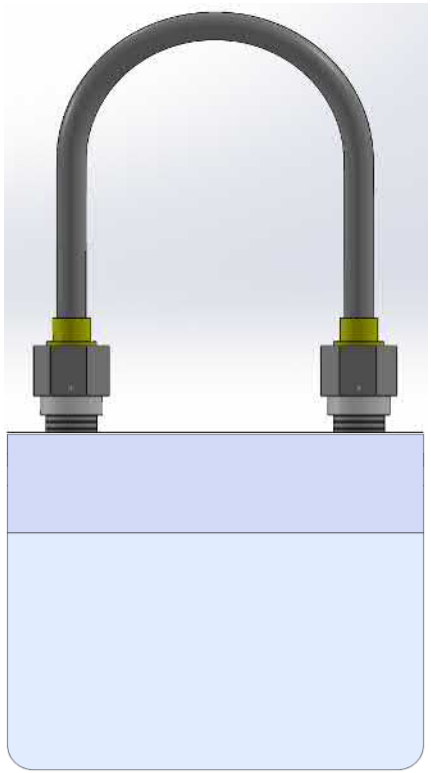
- Smaller Size/Volume
- Reduced Mass
- Improved RF Performance
  - Lower Insertion Loss
  - Better VSWR
- Lower Cost
- Easier System Level Integration Process (Open Access to Install RF Cables)

Schematic



Alternative Redundancy Solution

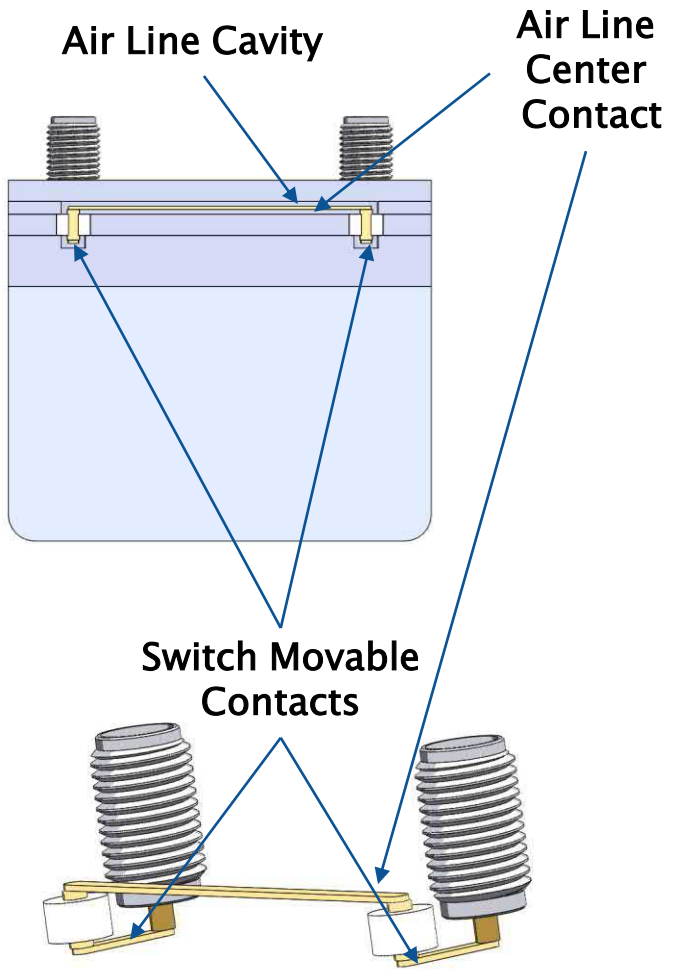
Old Solution with the RF Cable



Benefits of the Air Line Solution

- ❖ Lower Mass
- ✓ *RF Cable and Two Connectors Replaced by much Smaller and Lighter Internal Parts)*
- ❖ Improved RF Performance
- ❖ Lower Cost
- ✓ *Since RF Cables and Connectors are Often Classified as Components, an Additional Screening (on the Component Level) is Required. The Cost of the Additional Screening Process is Significantly Impacting the Product Final Cost and the Unit Price.*

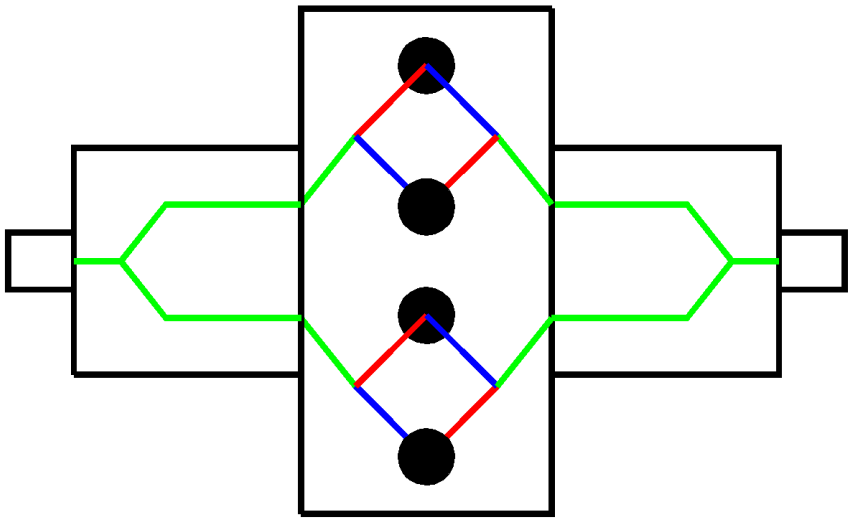
New Solution with the Air Line



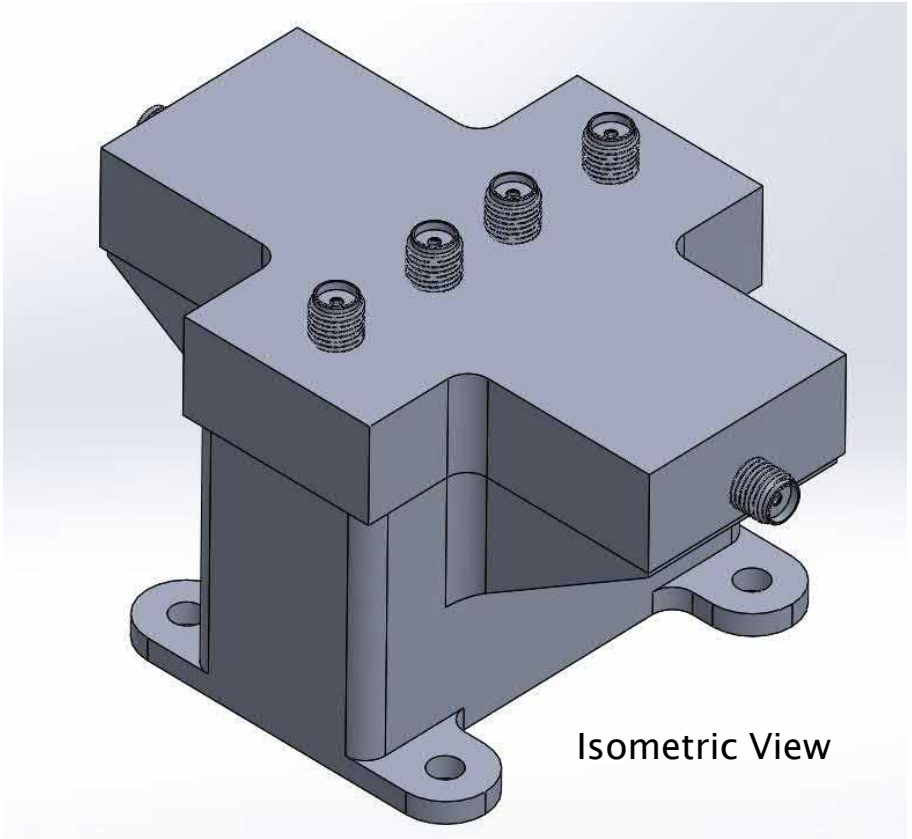
Alternative Redundancy Solution

Redundancy Solution

Switch Block
2X Transfer Switch
2X Power Divider



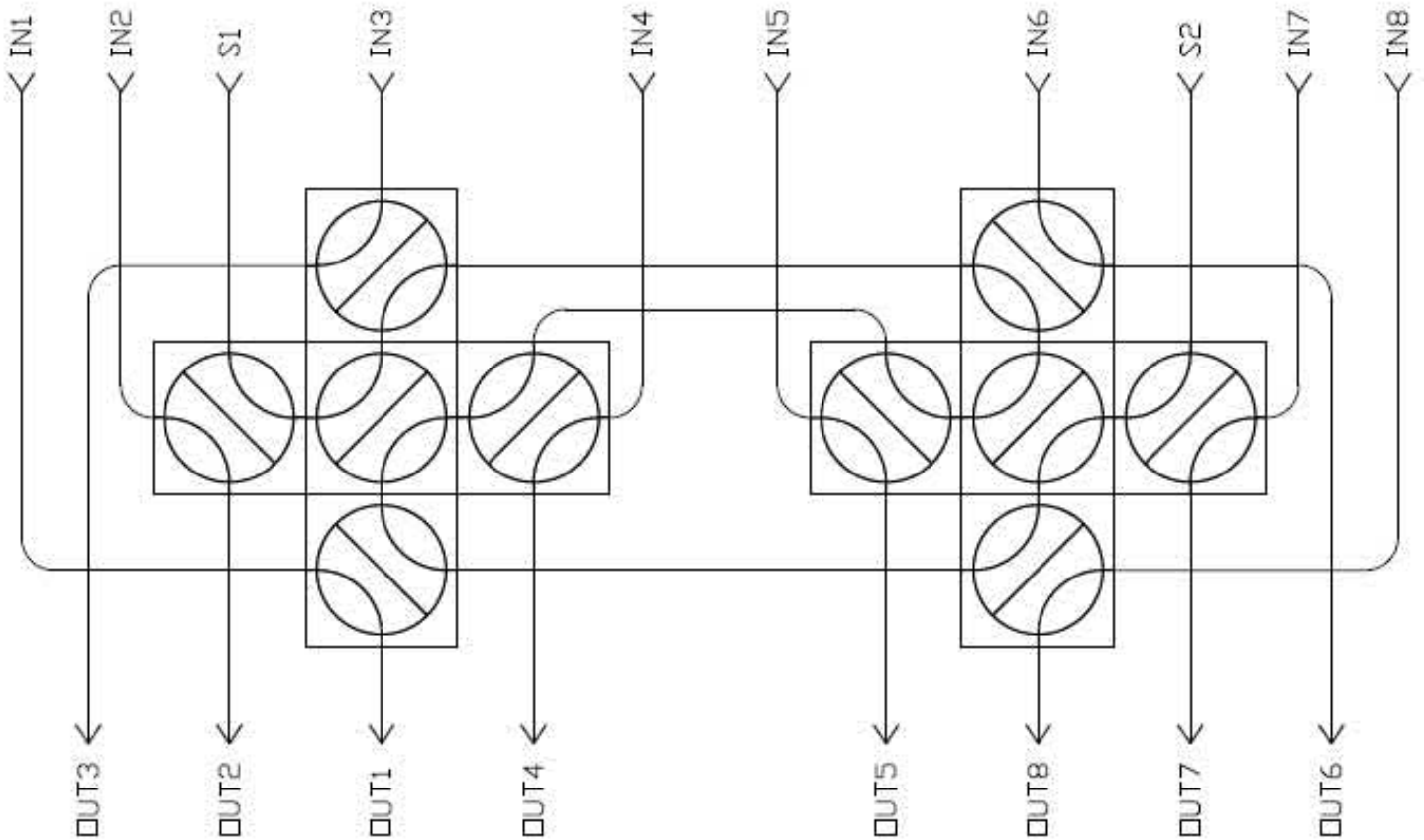
OUTPUT SWITCH BLOCK



Isometric View

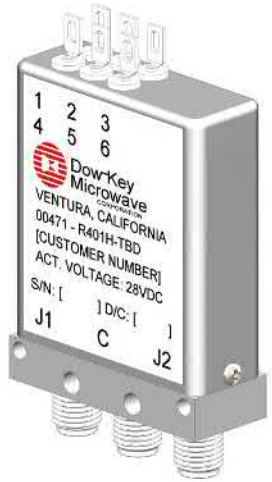
Envelope 3.4” x 2.5” x 2.05”

Innovative Redundancy Solutions



Schematic of the 10:8 Waveguide Block

NewSpace Initiative



Coaxial Switches for NewSpace Applications

(Upgraded Military Grade Switches)
Lower Cost – Shorter Lead Time

RUPP tronik

Beratung und Vertrieb ▪ HF- und Mikrowellentechnik

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