Molex (Montreal-Suzhou) General Overview

April 30, 2020

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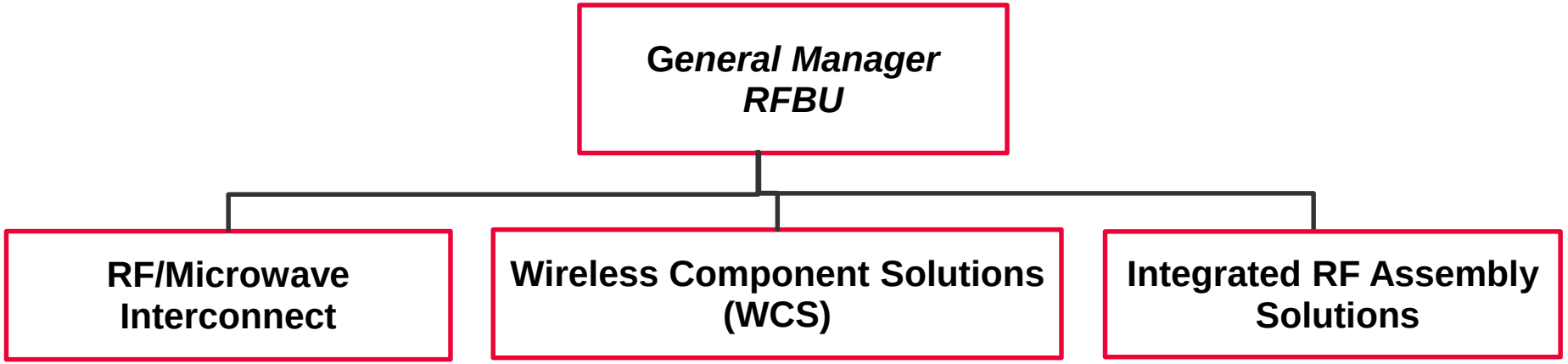
one company › a world of innovation

Molex RF/Microwave Business Unit



- MXI – Mooresville, IN (HQ)
- MXTW - New Taipei City, Taiwan
- MXJS – Zhenjiang, Jiangsu, China

- Molex Montreal – Pt. Claire, Quebec, Canada
- SDP China – Suzhou, Jiangsu, China

- MXCT (FCT) – Torrington, CT
- MXTW - New Taipei City, Taiwan
- MXJS – Zhenjiang, Jiangsu, China
- MXGDL – Guadalajara, Mexico

"Vision Statement"

RFMS' vision is to become a global leader as a RF/Microwave products provider by bringing greater value to its customers through highly engineered, innovative RF sub-assemblies, **components** and interconnect solutions.

Molex's SDP Telecom Operational Capacity

Montreal

12,000 sq. foot Facility

Advanced R&D Facility

Suzhou

80,000 (+20,000) sq. foot Facility

Low-Cost High Volume Manufacturing Site

Global Supply Chain	
Components	3+ Million units / Month
Site Solution Products	100k units / Month
Radio-Link Products	100k units / Month

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Product Categories

Components

Radio Backhaul

Site Solutions



Components

Ferrite Devices

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Components

Ferrite Devices (Circulators/Isolators)

SMT

Drop-in

Coaxial

- Frequency Range : 350 MHz to 40 GHz
- Single, Double or Multi-Junction Configuration
- Low-Loss & Low PIM Performance
- Proprietary Ferrite Material Technology
- Flanged waveguide variants part of our Radio Backhaul Portfolio

Industry Leader in high power Base Station circulators/isolators with over 2 M assemblies manufactured every month



Isolator/Circulator Evolving Roadmap

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Relationship Between Main Parameters

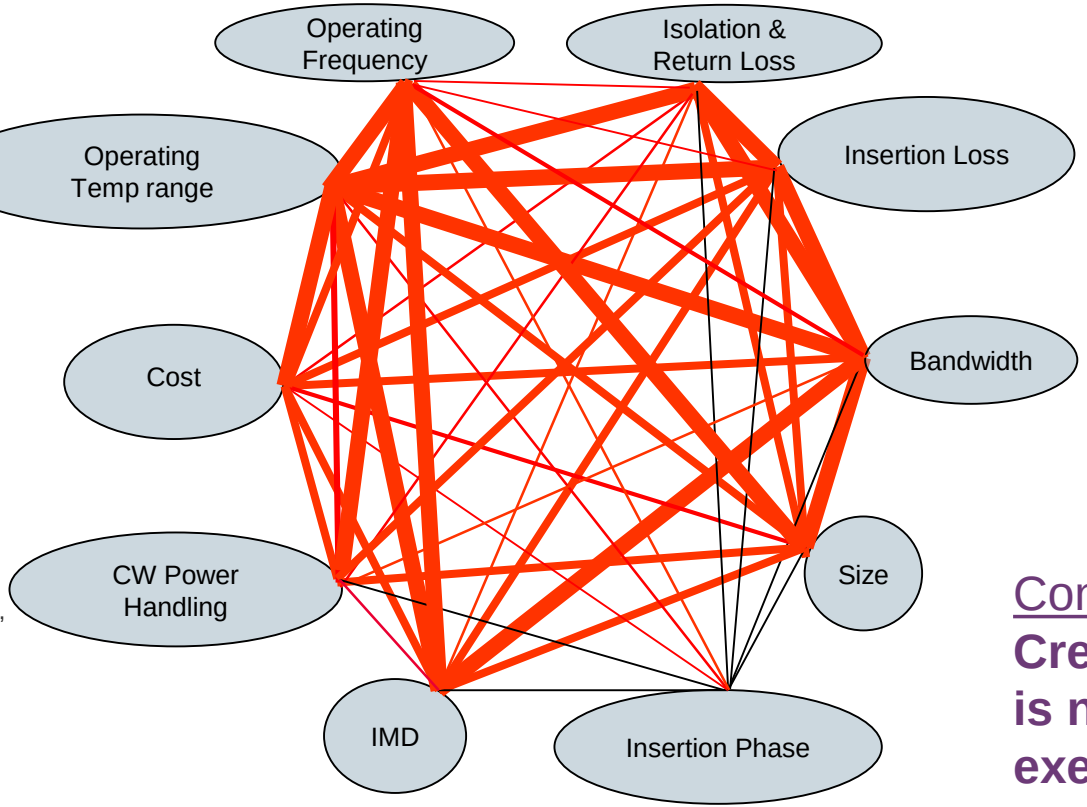
Note: This chart includes only the main parameters.

Exclusions:

- Harmonics,
- Peak power,
- OOB Reflection loss,
- OOB Attenuation,
- Group delay,
- Deviation of GD,
- Phase flatness,
- …etc.

Technological factors to take into account:

- Mechanical precision of parts,
- Assembly precision,
- Material parameters limitation,
- Material parameters variation,
- Cavity resonances,
- …etc.



Conclusion:

Creating balance is not a simple exercise!

Costs and Cost Drivers

- By far, the greatest influence on potential cost savings is:

Customer awarded volumes

- Greater volumes allow for transition to automated fabrication, reducing human touch time and facilitating increased efficient yields
- Small volume machined bodies can evolve to medium volume MIM variants or high volume stamped alternatives (all only cost justifiable when volumes increase)

- Greater economies of scale from suppliers for all internal parts used (multi-use or unique components). Leverage to negotiate lower material costs rolls up to total COG reduction

Costs and Cost Drivers (continued)

- The second largest cost driver is the number of concurrent technical requirements that all have to be balanced
  - For a given body/footprint size, over a defined operating frequency range and with a defined thermal operating range, if a designer only has to focus on optimizing the solution to achieve the best insertion loss possible, it's relatively easy
    - Several low cost components can be used to in order to achieve the desired performance
  - When the same designer as asked in addition to the same mechanical limitations, frequency range, in addition to IL he also needs to optimize for IMD, IS&RL both in-band and out of band, plus harmonics concurrently while the thermal range is further increased, his challenge becomes exponentially more complex
    - To potentially achieve all concurrent requirements, the designer must utilize more complex internal components, with tighter mechanical tolerances, heightened flatness requirements, often made from far more expensive raw materials with lower yields, to obtain requested results
    - More specs also require more time for both tuning and Quality Department verification (time = cost)

Variable Cost Contribution Ranking

1. Housing body and cover

- SMT is always more expensive than an equivalent size drop-in alternative; yet RAN producers are all shifting to predominantly SMT
- Proportionally smaller is not proportionally less expensive; it can be more expensive due to the greater precision required to be able to achieve the equivalent results in the smaller size

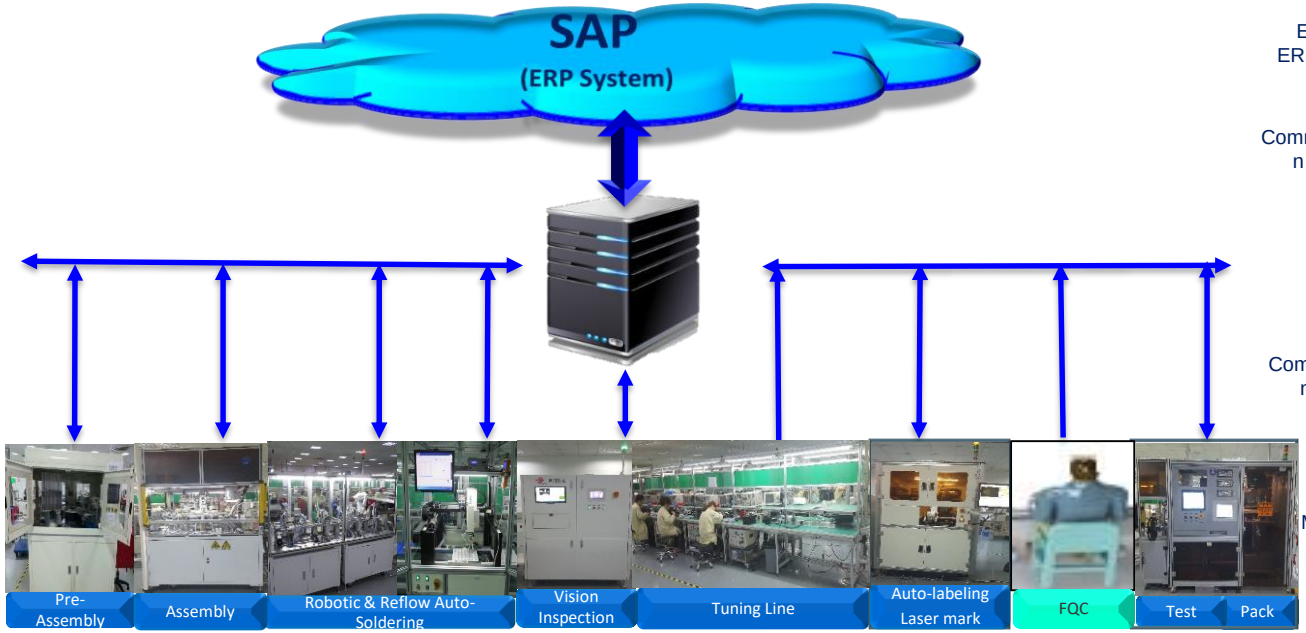
2. Ferrites

- Second largest contributor to overall cost are the ferrites
- Pure ferrites are always less expensive than Ferrite Dielectric Assemblies (FDAs - which include an additional dielectric ring) however as footprint requirements shrink FDAs become a necessary component

3. Direct labor; the third major contributor to total variable costs in mass-production

- Learning curve is lengthy to become efficient in manual assembly and tuning (6-8 weeks); switching to automated assembly or tuning requires capital investment approvals, and a volume based business case to justify. Molex remains committed to increasing its Automation quotient
- Employee turnover reduces short-term yield and increases “real” unit cost; thankfully SDP & Molex has successfully taken initiatives to reduce DL turnover in Suzhou

SDP Automation Line Architecture



Notes:

- Automation manufacturing process map for Isolator / circulator;
- Automation machine / line reserve hardware and software communication interface for MES system connection;
  - Products related information collecting by automation machine / line to auto-upload to MES system core algorithm for analysis, manufacturing report generating & status monitoring;
  - Automation machine operation status, preventive maintenance, machine related statistical data collecting and analysis;
- MES system communicates with ERP (SAP) system to exchange production, material, planning related information;

Existing Machine
Planned Machine
Technical Study

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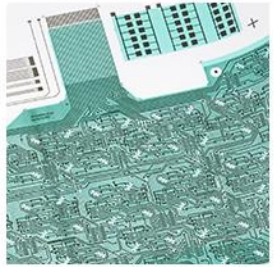
Ongoing R&D Initiatives on Isolators / Circulators

- **Developing Wide-Band Solutions**
- **Evolution of SMT circulator for 5G**
- **Integrated Isolator/Circulator Solutions**
- **High Frequency and MM Wave SMT Circulator**





Wide Band Solutions

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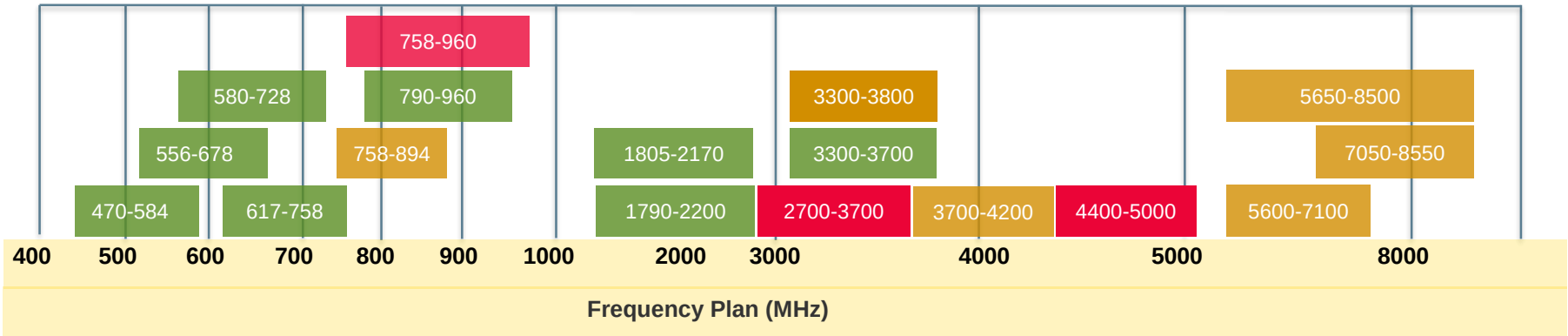
Existing Frequency Coverage of WB and Dual-Band Solutions



In Production

Samples sent to customer

In Development

- Devices are typically more than 15 % bandwidth
- They mostly cover two or more LTE/5G bands

Performance of WB Solutions

Frequency Band (MHz)	Bandwidth (%)	Size W×L×H or Dia × H	Insertion Loss (dB)	Isolation (dB)	Return Loss (dB)	Power Handling (W) (1)	Peak Power (W)	Temperature Range (°C)
470-584	21.6	1.25”x1.25”x 9mm	0.65 / 0.5 typ	15/18 typical	15/18 typical	100	400	-40 to 90
790-960	19.4	1”x1”x 9mm	0.35	18	18	250	2500	-40 to 105
729-894	20.3	1.25”x1.5”x 9mm	0.3	20	20	220/150	1200	-40 to 90
1790-2200	20.5	1.25”x1.5”x 10mm	0.35/0.3 typ	20/22 typ	20/22 typ	300	1500	-40 to 125
617-758	20.5	1.25”x1.5”x 9mm	0.35	18/20 typ	18/20 typ	150	1500	-40 to 105
3300-3800	12	Ø10.0mm x6.5mm	0.35	19	19	20	200	-40 to 105
3300-3800	14	Ø7mm x 4mm	0.6	16	16	15	30	-40 to 105
4400-5000	12.76	Ø7mm x 4mm	0.6	16	16	15	30	-40 to 105
3700-4200	12.65	Ø10.0mm x 6.5mm	0.35	20	20	20	200	-40 to 105
5600-7100	23.62	Ø12.7mmx 6mm	0.5/0.4 typ	18/19 typ	18/19 typ	10/10	TBD (3)	-40 to 85
7050-8550	19.23	Ø12.7mmx 6mm	0.5/0.4 typ	18/19 typ	18/19 typ	10/10	TBD (3)	-40 to 85
5650-8500	41.1	Ø12.7mm x 6mm	0.6/0.5 typ	17/18 typ	17/18 typ	20/10	TBD (3)	-40 to 85

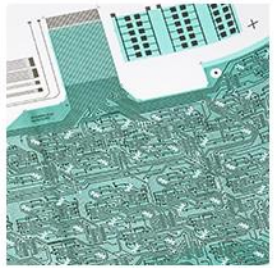
1. For circulator: forward power specified. For isolators: forward power/reverse power
2. Floating pin solution available at this time. Fixed pin can be developed.
3. No information available at this time

In Production

Samples sent to customer

In Development





Evolution of SMT Circulator for 5G

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SMT Isolators for 5G bands

- Traditional “fixed pin” Strip line solutions available in limited versions to 15 GHz (approaching upper frequency limits of this structure type)
- Adopting “embedded ferrite” structures for 15 GHz and above


23 GHz


26 & 28 GHz


39 GHz

2019

2018

2017

2016

3 GHz | 5 GHz | 10GHz | 15 GHz | 20 GHz | 40 GHz

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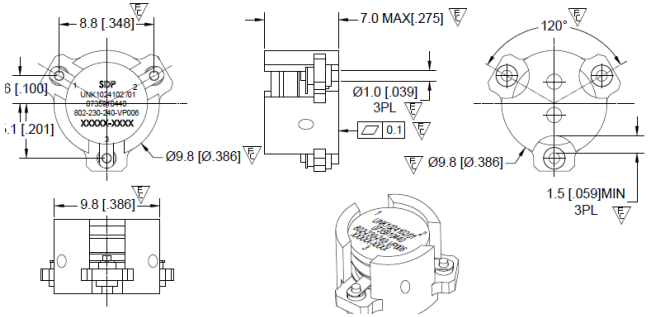
10mm Circulator Format

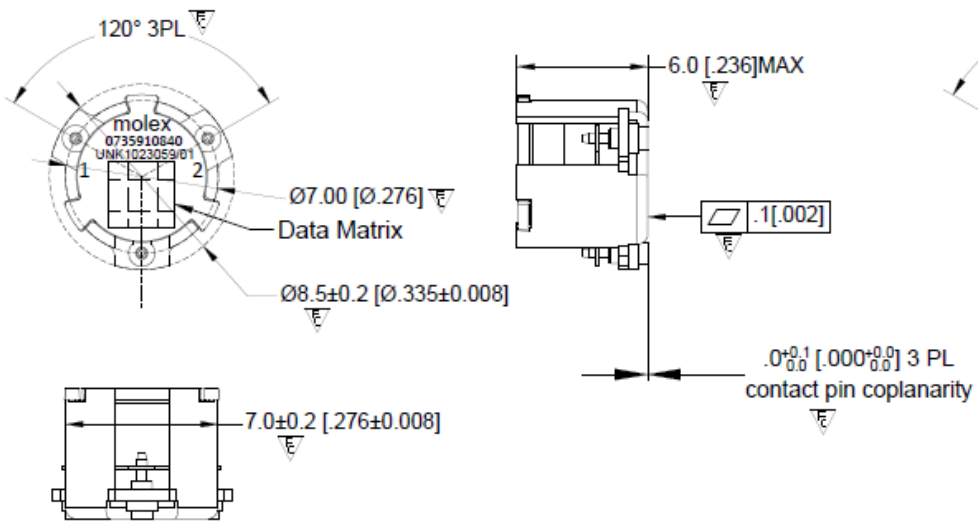


	Start Freq. (MHz)	Stop Freq. (MHz)	Return Loss (dB)	Isolation (dB)	Insertion Loss (dB)	IMD (dBc)	Temp Range (°C)
5G sub 6 GHz Europe	3600	3800	22	21	0.25	-60	-40~105
5G sub 6 GHz China	3400	3600	22	21	0.25	-60	-40~105
5G sub 6 GHz China	3400	3800	20	20	0.3	-60	-40~105
5G sub 6 GHz China	4400	4500	22	21	0.25	-60	-40~105
5G sub 6 GHz China	4800	5000	22	21	0.25	-60	-40~105
5G sub 6 GHz Korea	3400	3700	21	20	0.25	-60	-40~105
AAS B40	2300	2400	22	21	0.25	-60	-40~105
AAS B41	2496	2690	20	20	0.3	-60	-40~105

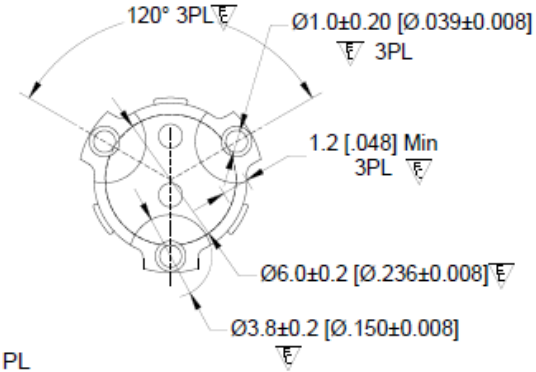
Production | Development

7mm Circulator

- Small size circulator



Typical Mechanical Outline



Physical Sample

7mm Circulator Electrical Performance

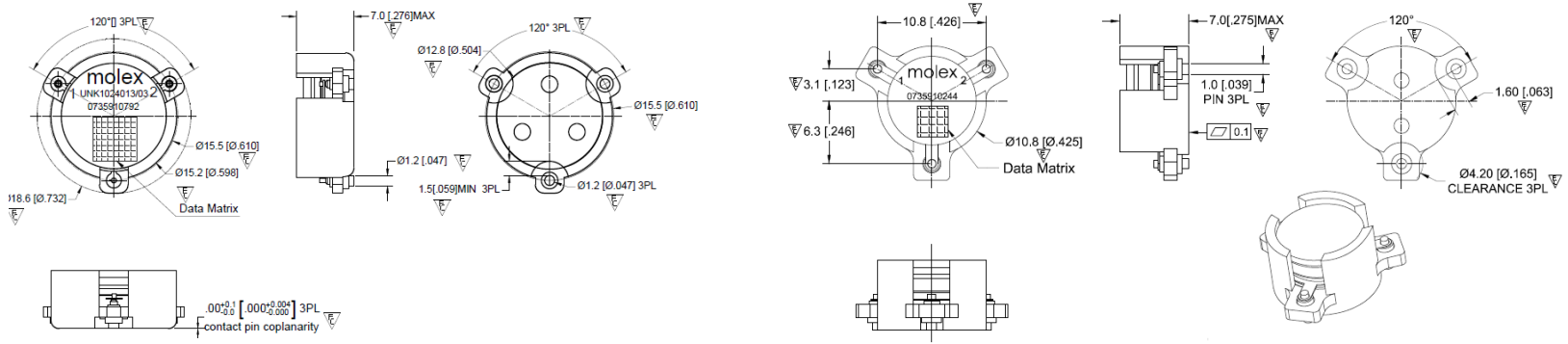
- Major Bands between 2.3 GHz to 6.0 GHz are available or under development

	Start Freq. (MHz)	Stop Freq (MHz)	Return Loss (dB)	Isolation (dB)	Insertion Loss (dB)	IMD (dBc)	Temp Range (°C)
5G sub 6 GHz Europe	3600	3800	20	20	0.35	-60	-40~105
5G sub 6 GHz US	3550	3700	20	20	0.35	-60	-40~105
5G sub 6 GHz China	3400	3600	20	20	0.35	-60	-40~105
5G sub 6 GHz China	3400	3800	18	18	0.4	-60	-40~105
5G sub 6 GHz China	4400	4500	20	20	0.35	-60	-40~105
5G sub 6 GHz China	4800	5000	20	20	0.35	-60	-40~105
5G sub 6 GHz Korea	3400	3700	20	20	0.35	-60	-40~105
AAS B40	2300	2400	20	20	0.35	-60	-40~105
AAS B41	2496	2690	18	18	0.4	-60	-40~105

Production | Development

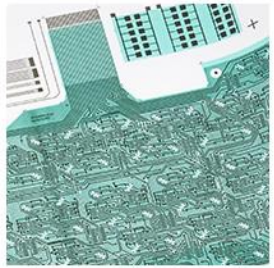
AAS WB Circulators

Size (mm)	Start Freq. (MHz)	Stop Freq. (MHz)	Return Loss (dB)	Isolation (dB)	Insertion Loss (dB)	IMD (dBc)	Temp Range (°C)
7	3300	3800	16	16	0.6	-60 (2*1W)	-40~105
	4400	5000	16	16	0.6	-60 (2*1W)	-40~105
	3400	3800	16	16	0.5	-65 (2*2.5W)	-40~100
8	3400	3800	17	17	0.4	-65 (2*2.5W)	-40~100
10	3400	3800	20	20	0.3	-60 (2*5W)	-40~105
	4400	5000	20	20	0.35	-60 (2*5W)	-40~105
11	2300	2700	18	18	0.4	-62 (2*5W)	-40~105
	3400	3800	20	20	0.3	-62 (2*5W)	-40~105
	4400	5000	20	20	0.4	-62 (2*5W)	-40~105
15	2300	2700	21	21	0.3	-70 (2*5W)	-40~105
	3400	3800	21	21	0.3	-70 (2*5W)	-40~105
	4400	5000	21	21	0.4	-70 (2*5W)	-40~105



Production Development





Integrated Isolator/Circulator

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Integrated Solutions

General Advantages

Flexibility
- Concept can be adapted to virtually any existing isolator design

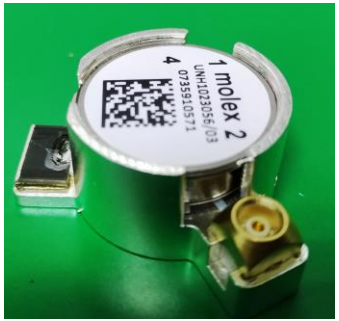
Electrical Performance
- Reduced overall IL (compared against discrete components)
- RL improves versus discrete components
- Matching challenges of sequential discrete components eliminated

Reduced Land Pattern
- Improved space utilization allowing for compression of board design

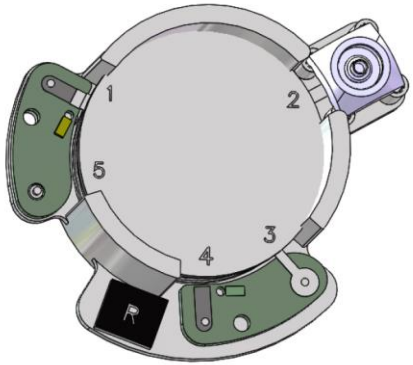
Cost Saving
- Can be less expensive than separate isolator and other components,
- Less components to manage on the radio assembly BOM

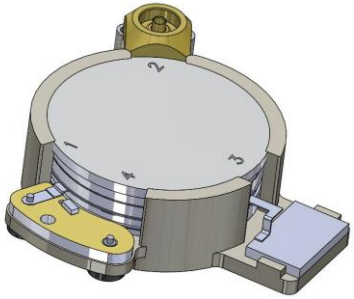
R&D Initiatives

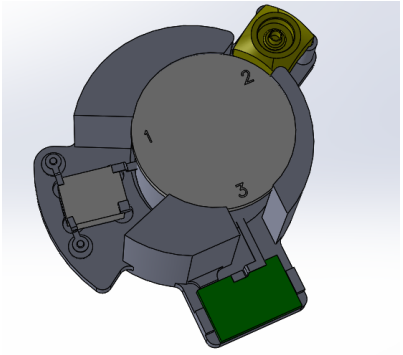
Integrated Solutions



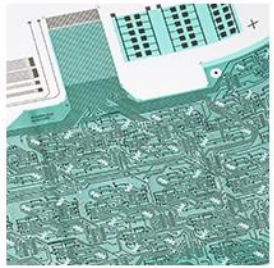
Variety of connectorized SMT Isolators/Circulators with Directional Coupler(s) and Electronic Switch











High Frequency and mm WAVE SMT Products

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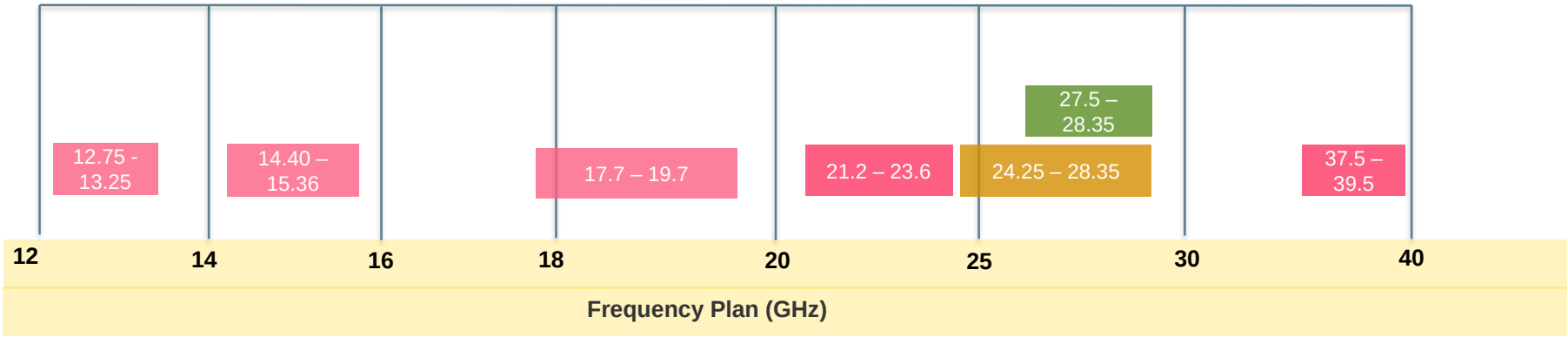
Existing Frequency Coverage



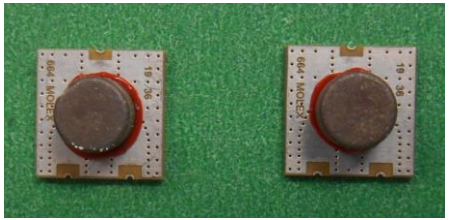
In Production

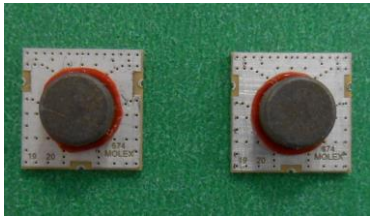
In Development Stage, Samples sent to customer

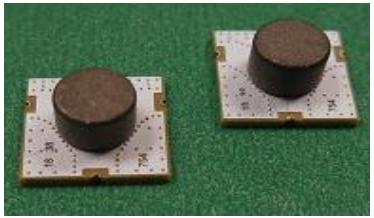
In Development

R&D Initiatives

SMT mm Wave Circulators







Operating Frequency Range, GHz	Insertion Loss, dB, Max	Isolation, dB, Min	Return Loss, dB, Min	Sample Shipped or not	Trial Run Finished or not
21.20 to 23.60	1.0	18	18	Yes	No
24.24 to 28.35	1.0	17	17	Yes	No
27.5 to 28.35	1.0	16	17	Yes	Yes
37.5 to 39.5	1.2	15	15	Yes	No

TEMPERATURE RANGE -40 to +85°C
POWER (CW) up to 5 W
Size 7.0×7.0×3.5mm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