BSW6540V/BSW6540VT

High Isolation Absorptive SP4T RF Switch for Automotive 5MHz-10000MHz

Preliminary Datasheet

Product Description

The BSW6540V/BSW6540VT is a 50-ohm matched absorptive SP4T RF switch that provides ultra-high isolation with frequency coverage up to 10 GHz.

The BSW6540V/BSW6540VT is designed with high linearity and reliability, making it suitable for wireless communication applications such as 4G/5G/6G infrastructure .

The BSW6540V/BSW6540VT operates over a wide VDD range of 2.7V to 5.5V and is controlled via 3 logic pins. Additionally, the BSW6540V/BSW6540VT has a bypass mode function that can disable the internal negative voltage, and an external negative Vss can be supplied through pin 20.

The BSW6540V/BSW6540VT is designed with ESD protection circuits at all pins and packaged in an industry standard, fully RoHS2-compliant, 24-Lead, 4mm x 4mm x 0.75mm QFN thin package.

The BSW6540V/BSW6540VT does not require blocking capacitors. If DC is presented at the RF port, add a blocking capacitor.

The BSW6540V/BSW6540VT is pending AEC-Q100 Grade 2 qualification.

Block Diagram

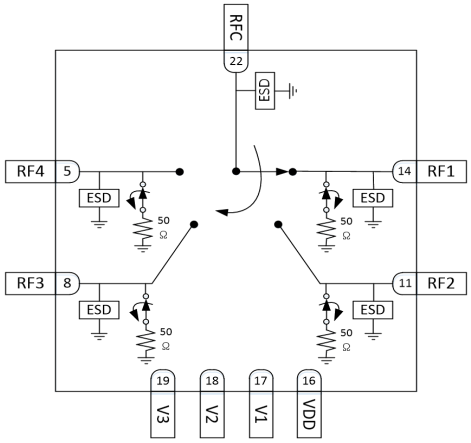
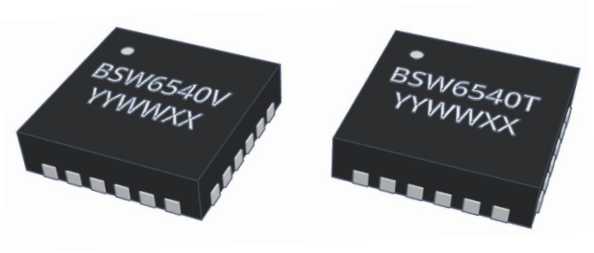


Figure 1. Functional Block Diagram

Applications

- Automotive
- Vehicle to Everything (V2X)
- Wireless communication
- Ultra-Wide-Band (UWB)
- Massive MIMO active Antenna Systems
- Digital Pre-Distortion

Package Type



4mm x 4mm x 0.75mm, 24-Lead QFN Package

Figure 2. Package Type

Device Features

- Pending AEC-Q100 Grade 2 Qualification
- Output frequency range : 5 MHz to 10.0 GHz
- Supply Voltage : 2.7V to 5.5V
- Low Insertion Loss
  - : 0.66dB @ 2GHz
  - : 0.78dB @ 4GHz
  - : 0.85dB @ 6GHz
- High Isolation (RFC to RFx)
  - : 67dB @ 2GHz
  - : 59dB @ 4GHz
  - : 53dB @ 6GHz
- High Input 1dB Compression
  - : 35.6dBm @ 2.35GHz
  - : 35.3dBm @ 3.5GHz
  - : 34.9dBm @ 5.75GHz
- High IIP3
  - : 66dBm @ 2.35GHz
  - : 64dBm @ 3.5GHz
  - : 63dBm @ 5.75GHz
- Operating temperature range : -40°C to +105°C
- ESD, HBM : 1.5kV
- Optional External Negative Supply (Bypass Mode)
- 24-Lead QFN package : 4.0mm x 4.0mm x 0.75mm
- Lead-free/RoHS2-compliant QFN SMT package

Ordering Information

Part Number	Descriptions
BSW6540V	Mass Test in RT(+25°C)
BSW6540VT	Mass Test in LT(-40°C) / RT(+25°C) / HT(+105°C)
BSW6540V-EVB BSW6540VT-EVB	BSW6540V / BSW6540VT Evaluation Board

Electrical Specifications

Typical conditions are Normal Mode[1](VDD = 5V, VSSEXT= 0V) or Bypass Mode[2](VDD = 5V, VSSEXT = -3.5V), T_A = 25°C,
Control Logic V1/V2/V3 Low = 0V, V1/V2/V3 High = 3.3V, Z_L = 50Ω, PCB and RF Connector loss are de-embedded, unless otherwise noted.

Table 1. Electrical Specifications

Parameter	Path	Conditions	Min	Typ	Max	Unit
Operating Frequency			5		10000	MHz
Insertion Loss	RFC - RF1	1GHz 2GHz 3GHz 4GHz 5GHz 6GHz 7GHz 8GHz 9GHz 10GHz		0.58 0.66 0.73 0.78 0.81 0.85 0.81 1.09 1.43 1.75		dB
	RFC - RF2	1GHz 2GHz 3GHz 4GHz 5GHz 6GHz 7GHz 8GHz 9GHz 10GHz		0.58 0.65 0.73 0.78 0.81 0.85 0.82 1.11 1.47 1.93		dB
	RFC - RF3	1GHz 2GHz 3GHz 4GHz 5GHz 6GHz 7GHz 8GHz 9GHz 10GHz		0.58 0.66 0.74 0.78 0.83 0.87 0.83 1.14 1.53 1.95		dB
	RFC - RF4	1GHz 2GHz 3GHz 4GHz 5GHz 6GHz 7GHz 8GHz 9GHz 10GHz		0.59 0.66 0.75 0.80 0.82 0.87 0.84 1.19 1.53 1.78		dB
Return Loss (Active port)	RFC, RFx	5MHz - 8GHz 8GHz - 10GHz		15 10		dB
Return Loss (Terminated port)	RFC, RFx	5MHz - 6GHz 6GHz - 10GHz		20 15		dB

1. Normal Mode : Single external positive supply voltage(VDD) inputted.
2. Bypass Mode : Both external positive supply voltage(VDD) and external negative voltage(VSSEXT) inputted.

Table 1. Electrical Specifications (Cont.)

Parameter		Path	Conditions	Min	Typ	Max	Unit
Input P1dB		RFC - RFx	2.35GHz 3.5GHz 5.75GHz		35.6 35.3 34.9		dBm
Input IP2[3]		RFC - RFx	2.35GHz 3.5GHz 5.75GHz		109 111 106		dBm
Input IP3[3]		RFC - RFx	2.35GHz 3.5GHz 5.75GHz		66 64 63		dBm
2nd Harmonic[4]		RFC - RFx	2.35GHz 3.5GHz 5.75GHz		97 100 94		dBc
3rd Harmonic[4]		RFC - RFx	2.35GHz 3.5GHz 5.75GHz		105 102 97		dBc
Switching Characteristics	Rising Time Falling Time	RFC - RFx	10% RF to 90% RF 90% RF to 10% RF		40 40		ns
	Switching Time	RFC - RFx	50% CTRL to 90% RF 50% CTRL to 10% RF		180 95		ns
	Settling Time	RFC - RFx	50% CTRL to 0.05dB final value Rising Edge 50% CTRL to 0.05dB final value Falling Edge		220 100		ns
Maximum Spurious Level			1MHz - 10MHz > 10MHz[5]		-127 < -140		dBm/10Hz

3. The each-tone Power is +18dBm and Tone spacing is 20kHz .
4. Tone Power is +18dBm.
5. No spurious signals were detected above 10MHz.

Isolation Matrix

Typical conditions are Normal Mode[1](VDD = 5V, VSSEXT= 0V) or Bypass Mode[2](VDD = 5V, VSSEXT = -3.5V), T_A = 25°C, Control Logic V1/V2/V3 Low = 0V, V1/V2/V3 High = 3.3V, Z_L = 50Ω, unless otherwise noted.

Table 2. RFC-to-RFx Isolation

"ON" Port	Frequency	RFC to RFx Isolation				Unit
		RF1	RF2	RF3	RF4	
RF1	1GHz	-	73	68	73	dB
	2GHz	-	67	62	68	
	3GHz	-	62	59	66	
	4GHz	-	59	57	69	
	5GHz	-	57	57	67	
	6GHz	-	53	57	59	
	7GHz	-	49	56	51	
	8GHz	-	45	51	45	
	9GHz	-	42	46	41	
	10GHz	-	37	40	36	
RF2	1GHz	74	-	65	74	
	2GHz	69	-	59	69	
	3GHz	68	-	56	68	
	4GHz	72	-	54	70	
	5GHz	68	-	53	65	
	6GHz	58	-	55	57	
	7GHz	50	-	60	51	
	8GHz	44	-	58	45	
	9GHz	39	-	48	40	
	10GHz	35	-	41	36	
RF3	1GHz	75	64	-	72	
	2GHz	71	59	-	68	
	3GHz	70	56	-	67	
	4GHz	72	54	-	71	
	5GHz	66	53	-	67	
	6GHz	58	55	-	57	
	7GHz	51	60	-	49	
	8GHz	46	59	-	44	
	9GHz	41	49	-	39	
	10GHz	37	41	-	35	
RF4	1GHz	75	68	73	-	
	2GHz	69	62	66	-	
	3GHz	68	59	61	-	
	4GHz	70	57	59	-	
	5GHz	70	57	56	-	
	6GHz	60	58	53	-	
	7GHz	52	56	49	-	
	8GHz	46	51	46	-	
	9GHz	42	47	42	-	
	10GHz	37	40	37	-	

Isolation Matrix

Typical conditions are Normal Mode[1](VDD = 5V, VSSEXT= 0V) or Bypass Mode[2](VDD = 5V, VSSEXT = -3.5V), T_A = 25°C, Control Logic V1/V2/V3 Low = 0V, V1/V2/V3 High = 3.3V, Z_L = 50Ω, unless otherwise noted.

Table 3. RFx-to-RFx Isolation

"ON" Port	Frequency	RFx to RFx Isolation				Unit
		RF1	RF2	RF3	RF4	
RF1	1GHz	-	65	73	69	dB
	2GHz	-	59	67	64	
	3GHz	-	56	63	61	
	4GHz	-	54	60	61	
	5GHz	-	53	58	63	
	6GHz	-	54	54	72	
	7GHz	-	54	50	58	
	8GHz	-	51	46	49	
	9GHz	-	47	42	43	
	10GHz	-	40	37	37	
RF2	1GHz	65	-	72	68	
	2GHz	60	-	65	63	
	3GHz	58	-	59	60	
	4GHz	57	-	56	60	
	5GHz	60	-	51	62	
	6GHz	65	-	48	71	
	7GHz	54	-	44	59	
	8GHz	45	-	41	49	
	9GHz	40	-	37	43	
	10GHz	35	-	33	37	
RF3	1GHz	68	72	-	65	
	2GHz	63	65	-	60	
	3GHz	60	60	-	58	
	4GHz	60	56	-	57	
	5GHz	61	52	-	61	
	6GHz	72	48	-	70	
	7GHz	61	44	-	53	
	8GHz	49	41	-	45	
	9GHz	44	37	-	40	
	10GHz	38	33	-	34	
RF4	1GHz	69	73	65	-	
	2GHz	64	67	59	-	
	3GHz	61	63	56	-	
	4GHz	61	61	54	-	
	5GHz	62	58	54	-	
	6GHz	76	54	54	-	
	7GHz	60	50	54	-	
	8GHz	49	46	52	-	
	9GHz	44	42	48	-	
	10GHz	38	37	40	-	

Product Description

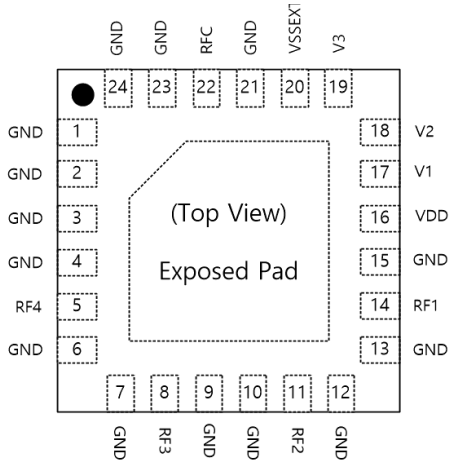


Figure 3. Pin Description

Table 4. Pin Descriptions

No.	Pin Name	Descriptions
16	VDD	Supply Voltage
20	VSSEXT	Normal Mode : Ground Bypass Mode : External negative Voltage
19	V3	Switch control input 3 or Ground (See table 6)
18	V2	Switch control input 2
17	V1	Switch control input 1
5	RF4	RF4 Port
8	RF3	RF3 Port
11	RF2	RF2 Port
14	RF1	RF1 Port
22	RFC	RFC Port
1,2,3,4,6, 7,9,10,12, 13,15,21,23,24	GND	Ground
Pad	Exposed Pad	Ground

Table 5. 3-pin Control Truth Table

V3	V2	V1	RFC-RF1	RFC-RF2	RFC-RF3	RFC-RF4
0	0	0	OFF	OFF	OFF	ON[1]
0	0	1	ON	OFF	OFF	OFF
0	1	0	OFF	ON	OFF	OFF
0	1	1	OFF	OFF	ON	OFF
1	0	0	OFF	OFF	OFF	ON[1]
1	0	1	OFF[2]	OFF[2]	OFF[2]	OFF[2]
1	1	0	OFF[2]	OFF[2]	OFF[2]	OFF[2]
1	1	1	OFF[2]	OFF[2]	OFF[2]	OFF[2]

1. Logic state 000 is redundant RF4 ON state of 100.
2. Logic state 101, 110 and 111 are all path OFF mode.

Table 6. 2-pin Control[1] Truth Table

V2	V1	RFC-RF1	RFC-RF2	RFC-RF3	RFC-RF4
0	0	OFF	OFF	OFF	ON
0	1	ON	OFF	OFF	OFF
1	0	OFF	ON	OFF	OFF
1	1	OFF	OFF	ON	OFF

1. 2-pin control is used only V1 and V2 pin. In this case, V3 pin (Pin 19) must be grounded.

Table 7. Recommended Operating Conditions

	Parameter	Symbol	Min	Typ	Max	Unit
Normal Mode[1]	Supply Voltage	VDD	2.7	5	5.5	V
	Supply Current	IDD	-	200		μA
Bypass Mode[2]	Supply Voltage	VDD	2.7	5	5.5	V
	Supply Current	IDD		160		μA
	Negative Supply Voltage	VSSEXT		-3.5	-3.2	V
Digital Input Voltage (V1/V2/V3)		VIH	1.17	-	3.6	V
		VIL	0	-	0.6	V
Digital Input Current (V1/V2/V3)		ICTRL	-	-	10	uA
Operating Temperature Range		T_A	-40	+25	+105	°C
RF Input Power, CW (Active Port, +25°C)		$P_{Max,Active\_+25℃}$	-	-	31	dBm
RF Input Power, CW (Active Port, +105°C)		$P_{Max,Active\_+105℃}$	-	-	31	dBm
RF Input Power, CW (Terminated Port, +25°C)		$P_{Max,Term\_+25℃}$	-	-	27	dBm
RF Input Power, CW (Terminated Port, +105°C)		$P_{Max,Term\_+105℃}$	-	-	24	dBm

* Specifications are not guaranteed over all recommended operating conditions.
1. Normal Mode : Single external positive supply voltage(VDD) is inputted.
2. Bypass Mode : Both external positive supply voltage(VDD) and external negative voltage(VSSEXT) are inputted.

Table 8. Absolute Maximum Ratings

Parameter			Symbol	Min	Max	Unit
Supply Voltage			VDD	-0.3	5.5	V
Digital Input Voltage			V1/V2/V3	-0.3	3.6	V
Maximum Input Power, CW (+25°C)			$P_{max\_abs\_+25℃}$	-	35	dBm
Maximum Input Power, CW (+105°C)			$P_{max\_abs\_+105℃}$	-	33	dBm
Storage Temperature range			-	-65	+150	°C
ESD	HBM[1]	All pins	-	-	1500	V
	CDM[2]	All pins	-	-	1000	V

1. HBM Standard : AEC-Q100-002
2. CDM Standard : AEC-Q100-011

Typical Performances

Typical conditions are Normal mode, VDD = 5V, T_A = 25°C, V1/V2/V3 Low = 0V, V1/V2/V3 High = 3.3V, Z_L = 50Ω, PCB and RF Connector loss are de-embedded, unless otherwise noted.

Figure 4. Insertion Loss vs Frequency

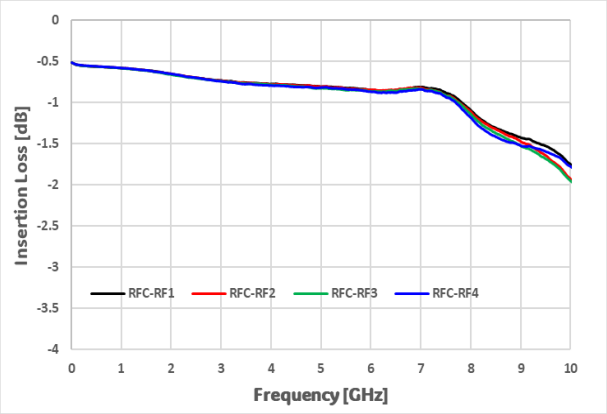


Figure 5. Insertion Loss vs VDD (RFC-RF1)

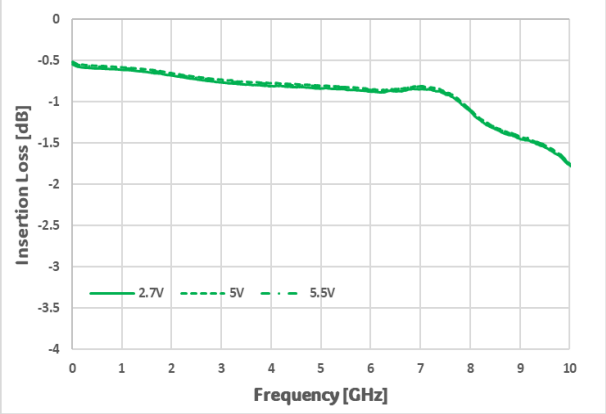


Figure 6. Insertion Loss vs Temp (RFC-RF1)

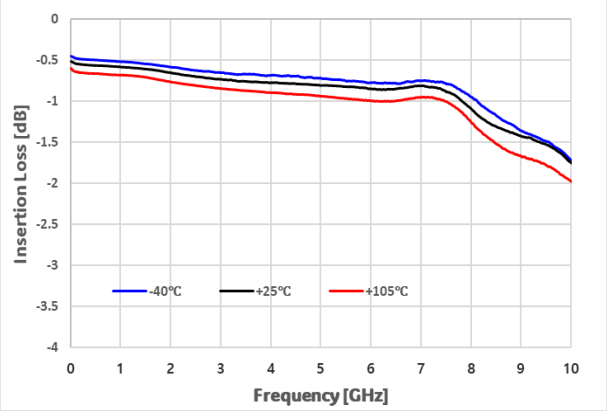


Figure 7. Return Loss vs Frequency (RFC Port)

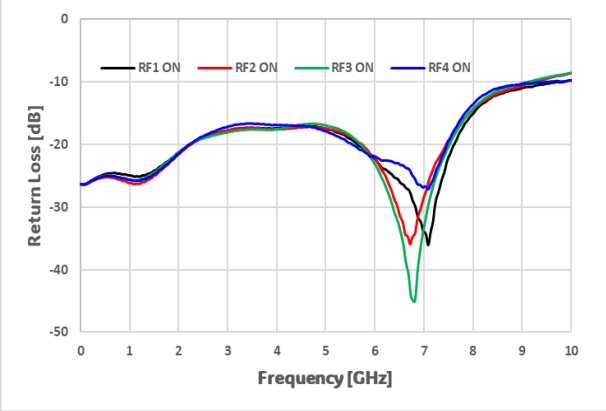


Figure 8. Return Loss vs VDD (RFC Port)

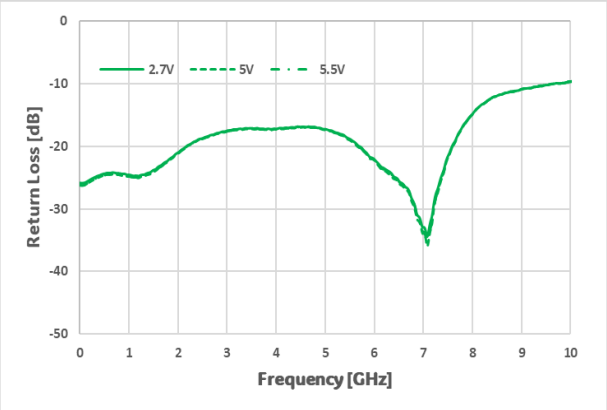
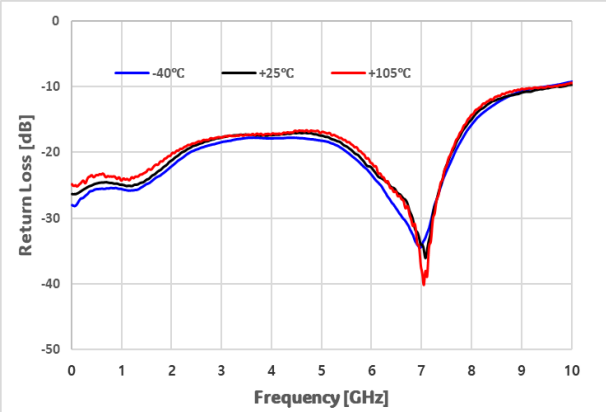


Figure 9. Return Loss vs Temp (RFC Port)



Typical Performances

Typical conditions are Normal mode, VDD = 5V, T_A = 25°C, V1/V2/V3 Low = 0V, V1/V2/V3 High = 3.3V, Z_L = 50Ω, PCB and RF Connector loss are de-embedded, unless otherwise noted.

Figure 10. Return Loss vs Frequency (Active Port)

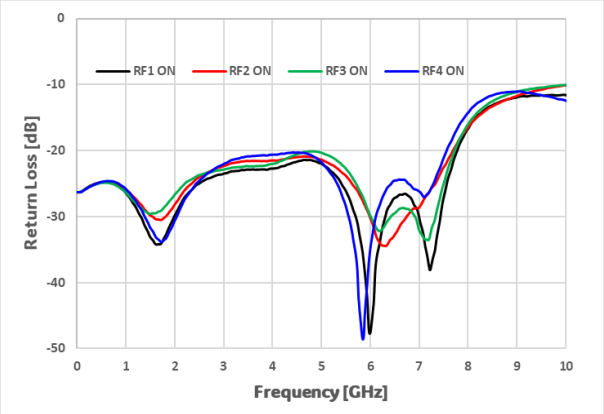


Figure 11. Return Loss vs VDD (Active Port)

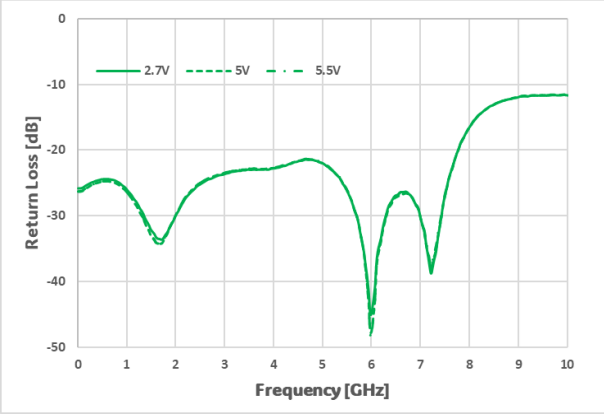


Figure 12. Return Loss vs Temp (Active Port)

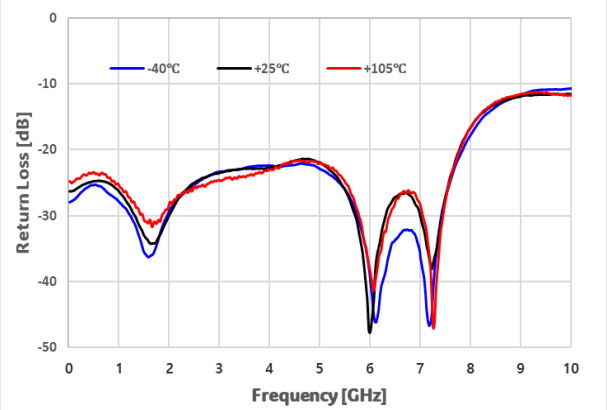


Figure 13. Return Loss vs Frequency (Terminated Port)

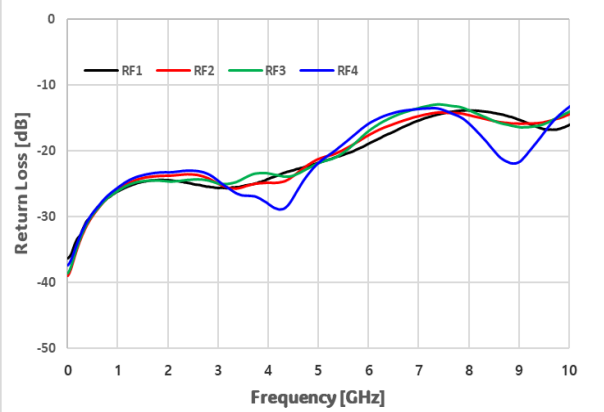


Figure 14. Return Loss vs VDD (Terminated Port)

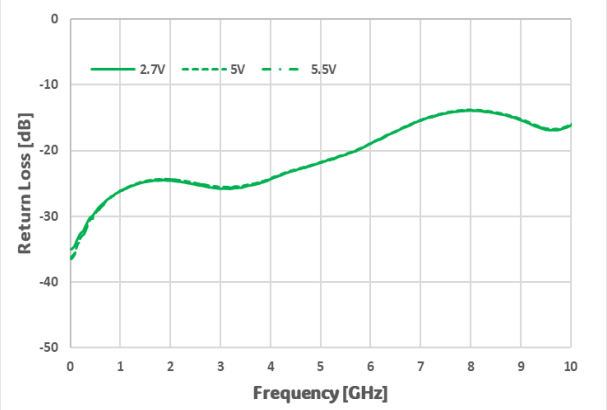
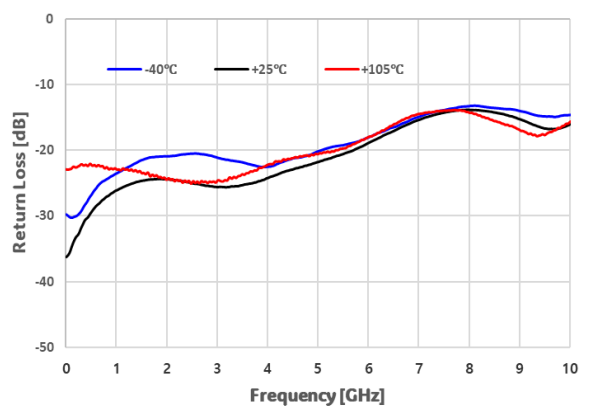


Figure 15. Return Loss vs Temp (Terminated Port)



Typical Performances

Typical conditions are Normal mode, VDD = 5V, T_A = 25°C, V1/V2/V3 Low = 0V, V1/V2/V3 High = 3.3V, Z_L = 50Ω, PCB and RF Connector loss are de-embedded, unless otherwise noted.

Figure 16. Isolation vs Frequency (RFC to RFx)

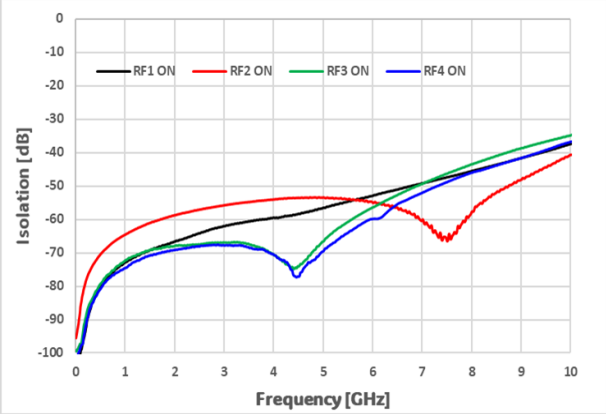


Figure 17. Isolation vs Frequency (RFC to RFx, RF1 ON)

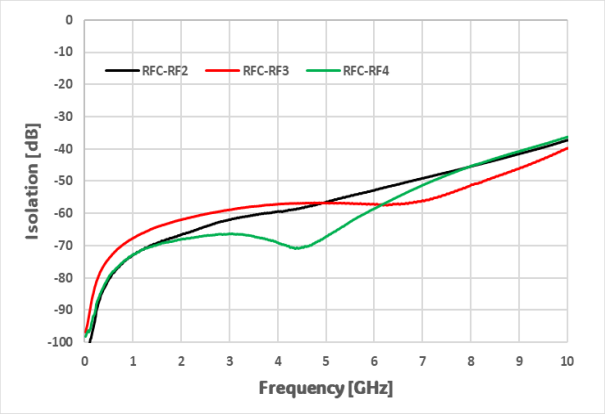


Figure 18. Isolation vs VDD (RFC to RF1, RF2 ON)

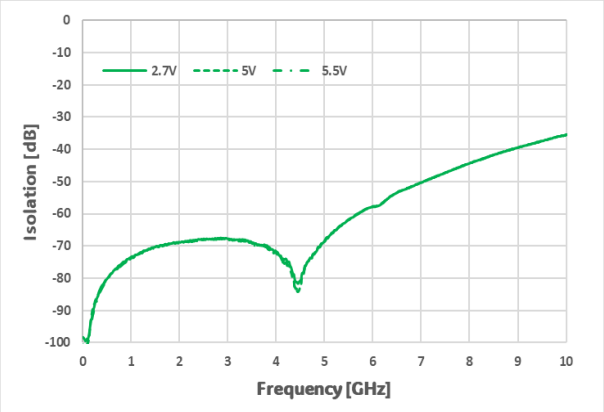


Figure 19. Isolation vs Temp (RFC to RF1, RF2 ON)

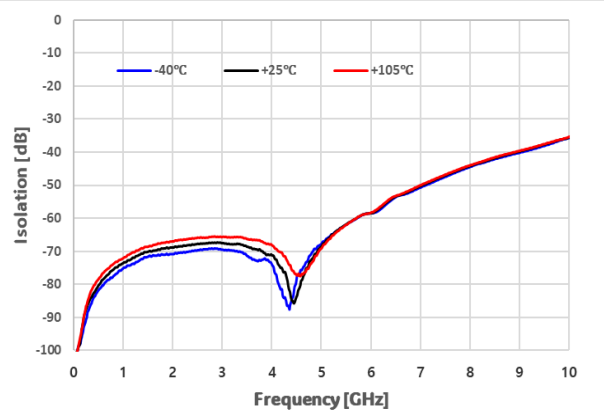


Figure 20. Isolation vs Frequency (RFx to RFx)

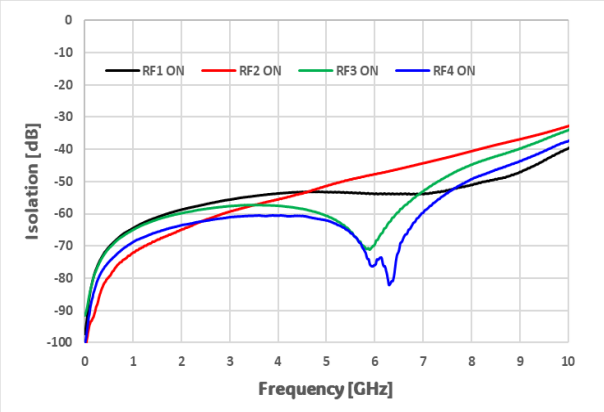
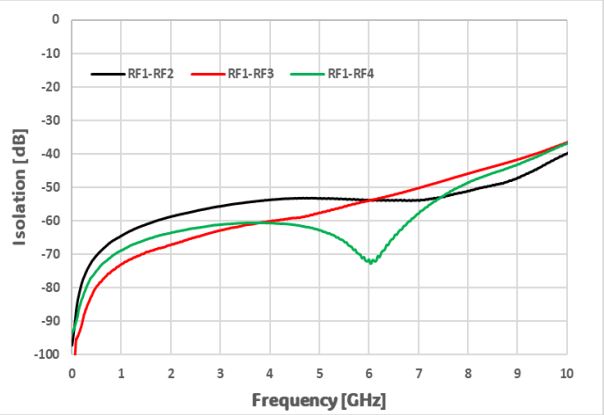


Figure 21. Isolation vs Frequency (RF1 to RFx, RF1 ON)



Typical Performances

Typical conditions are Normal mode, VDD = 5V, T_A = 25°C, V1/V2/V3 Low = 0V, V1/V2/V3 High = 3.3V, Z_L = 50Ω, PCB and RF Connector loss are de-embedded, unless otherwise noted.

Figure 22. Isolation vs VDD (RF1 to RF2, RF1 ON)

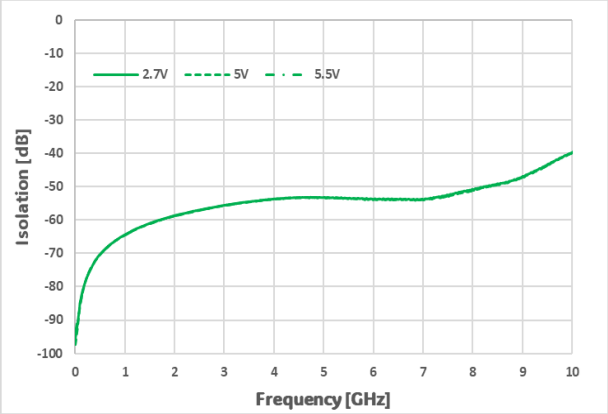


Figure 23. Isolation vs Temp (RF1 to RF2, RF1 ON)

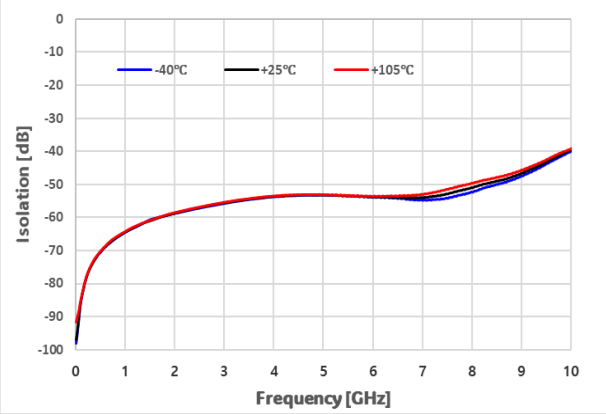


Figure 24. IIP3 vs RF Port

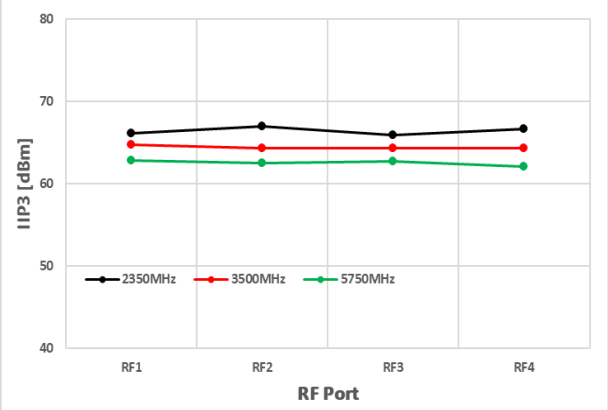
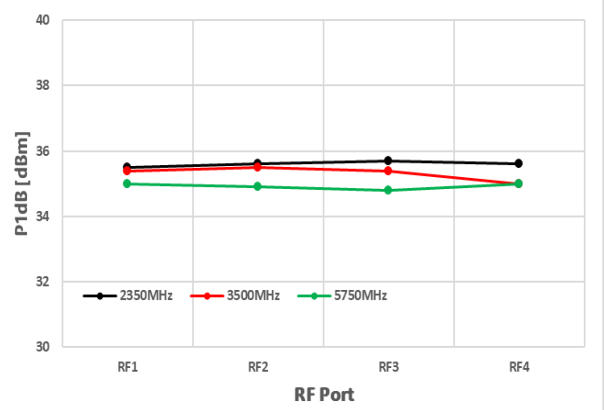
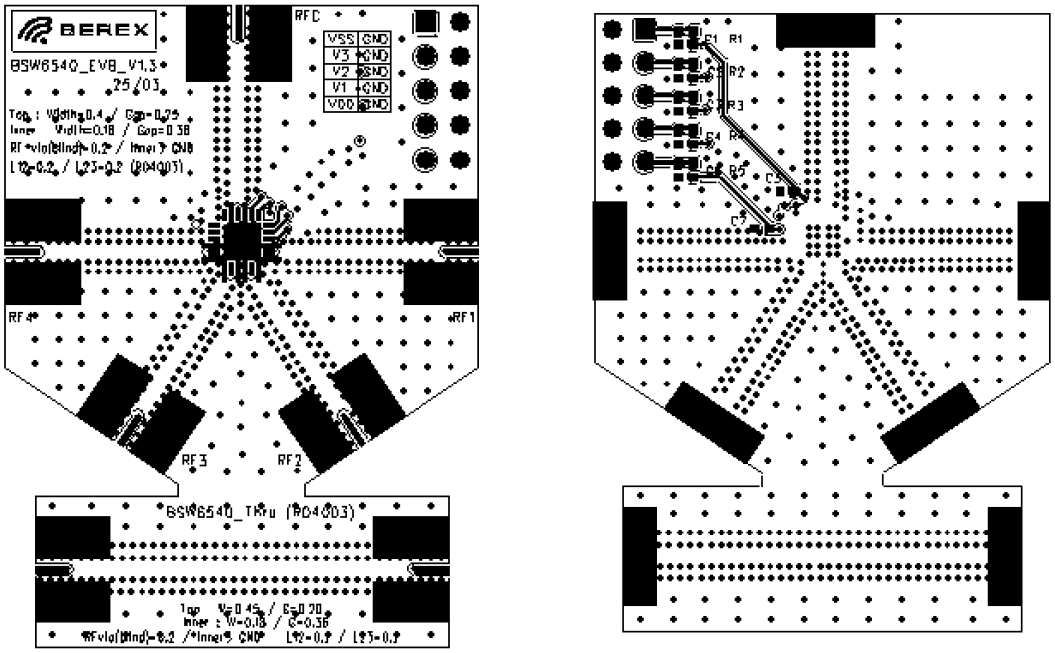


Figure 25. P1dB vs RF Port



Evaluation Board



[Top view] [Bottom view]

Figure 26. Evaluation Board Layout

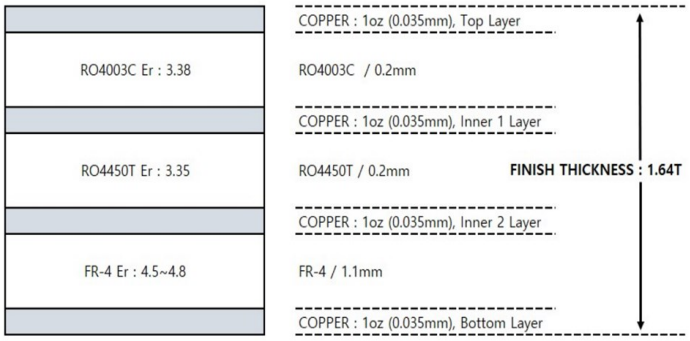


Figure 27. Evaluation Board PCB Layer Information

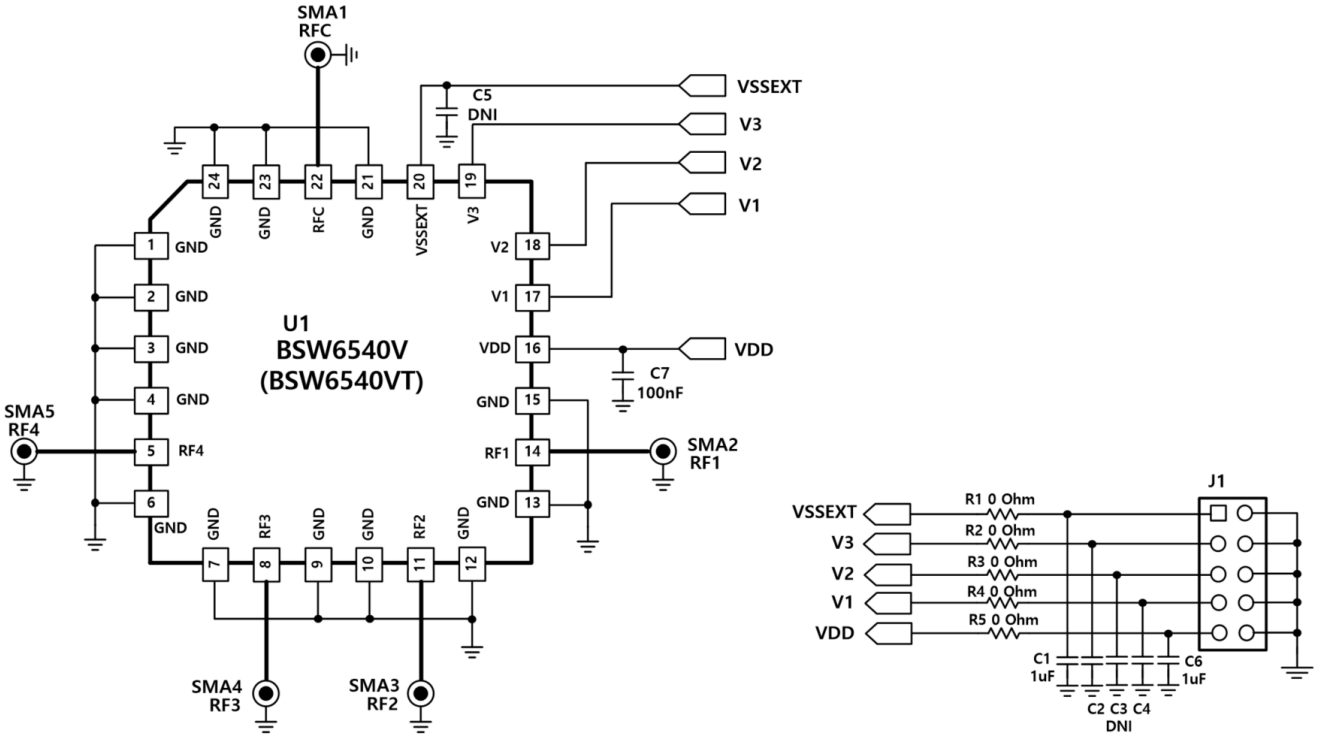
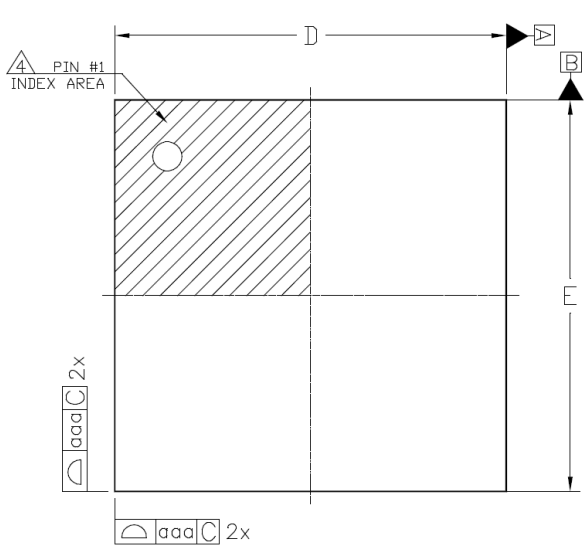


Figure 28. Evaluation Board Schematic

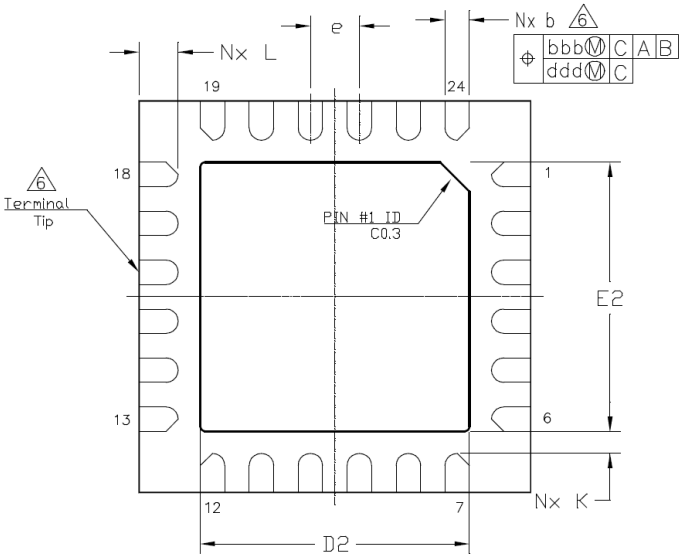
Table 9. Bill of Material - Evaluation Board

No.	Ref Des	Part Qty	Part Number	Remark
1	C1,C6	2	CAP 1005 1uF J 50V	
2	C7	1	CAP 1005 100nF J 50V	C7 should be placed near the Device
3	C2,C3,C4,C5	4	CAP 1005 DNI	
4	R1,R2,R3,R4,R5	5	RES 1005 0 ohm J 50V	
5	J1	1	2x5 Pin Header	2.54mm pitch
6	RFC,RF1,RF2,RF3,RF4	5	SMA_END_LAUNCH	
7	U1	1	BSW6540V (BSW6540VT)	

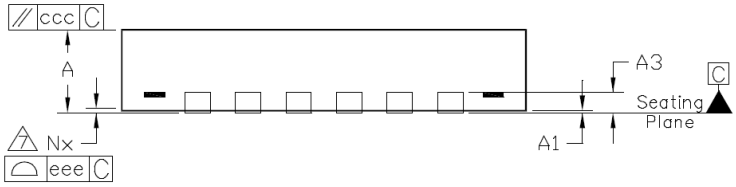
Package Outline Drawing



[Top View]



[Bottom View]



[Side View]

NOTES:

1. Dimensioning and tolerancing conform to ASME Y14.5–2009.
2. All dimensions are in millimeters.
3. N is the total number of terminals.
4. The location of the marked terminal #1 identifier is within the hatched area.
5. ND and NE refer to the number of terminals each D and E side respectively.
6. Dimension b applies to the metallized terminal and is measured between 0.15mm and 0.3mm from the terminal tip. If the terminal has a radius on the other end of it, dimension b should not be measured in that radius area.
7. Coplanarity applies to the terminals and all other bottom surface metallization.

Dimension Table (Notes 1,2)				
Symbol Thickness	Min	Nominal	Max	Note
A	0.70	0.75	0.80	
A1	0.00	0.02	0.05	
A3	---	0.203 Ref.	---	6
b	0.20	0.25	0.30	
D		4.00 BSC		
E		4.00 BSC		
e		0.50 BSC		
D2	2.65	2.70	2.75	
E2	2.65	2.70	2.75	
K	0.2	---	---	
L	0.30	0.40	0.50	
aaa		0.05		
bbb		0.10		
ccc		0.10		
ddd		0.05		
eee		0.08		
N		24		3
ND		6		5
NE		6		5

Figure 29. Package Outline Drawing

Recommended Land Pattern

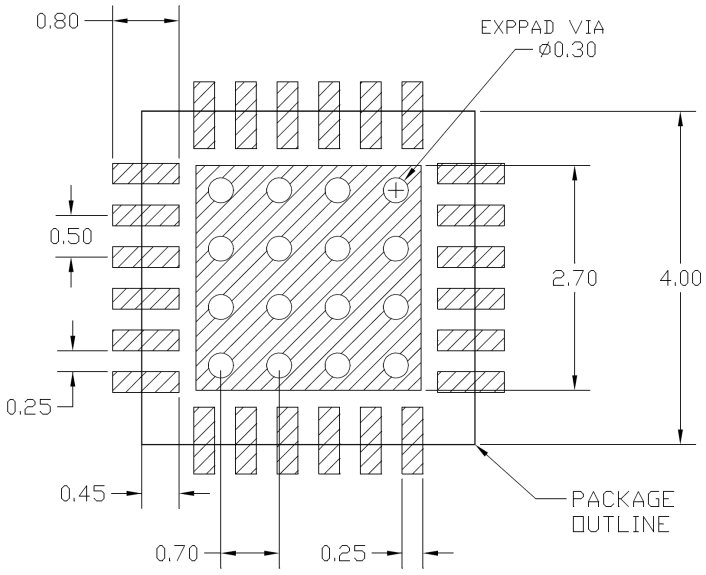


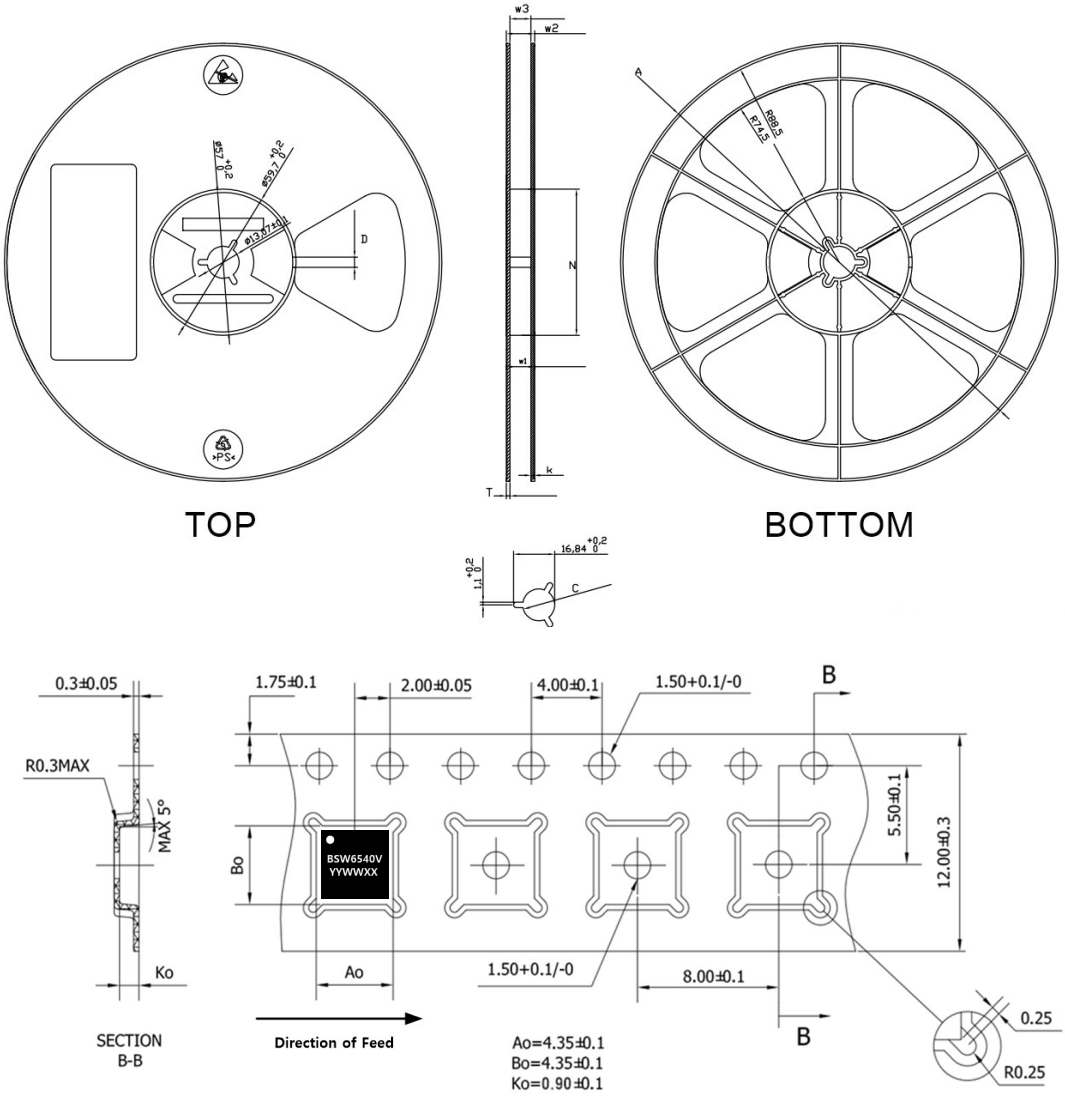
Figure 30. Recommended Land Pattern

Package Marking

Marking information	
BSW6540V	Device Name : BSW6540V
BSW6540T	Device Name : BSW6540VT
YY	Year
WW	Work Week
XX	Wafer Run Number

Figure 31. Package Marking

Tape & Reel (TBD)



Packaging information:	
Tape Width	12mm
Reel Size	7inch
Device Cavity Pitch	8mm
Device Per Reel	1000EA

Figure 32. Tape & Reel

Lead plating finish

100% Tin Matte finish

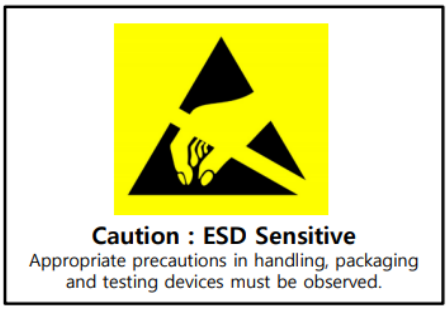
(All BeRex products undergo a 1 hour, 150°C Anneal bake to eliminate tin whisker growth concerns.)

ESD / MSL Rating

ESD information1 :	
Rating	Class 1C (1500V)
Test	Human Body Model (HBM)
Standard	AEC-Q100-002

ESD information2 :	
Rating	Class C3 (1000V)
Test	Charged Device Model (CDM)
Standard	AEC-Q100-011

MSL information:	
Rating	Level 1 at +260°C convection reflow
Standard	JEDEC Standard J-STD-020



Proper ESD procedures should be followed when handling the device.

RoHS Compliance

This part is compliant with Restrictions on the use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive 2011/65/EU as amended by Directive 2015/863/EU.

This product also is compliant with a concentration of the Substances of Very High Concern (SVHC) candidate list which are contained in a quantity of less than 0.1%(w/w) in each components of a product and/or its packaging placed on the European Community market by the BeRex and Suppliers.

NATO CAGE code:

2	**N**	**9**	**6**	**F**