Qualcomm

RF360
Europe GmbH

Data sheet

SAW duplexer

Small cell & femtocell
LTE band 2

Part number:	B8047
Ordering code:	B39202B8047P810
Date:	March 17, 2021
Version:	2.1

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Anzinger Straße 13
81671 Munich, Germany

Table of contents

1 Application

- Low-loss SAW duplexer for LTE small cell & femtocell systems (Band 2)
- LTE band 2 downlink (TX): pass band 1930 – 1990 MHz
- LTE band 2 uplink (RX): pass band 1850 – 1910 MHz
- Usable pass band 60 MHz

2 Features

- Industrial grade qualified family
- Package size 2.5$_{\pm 0.1}$ mm × 2.0$_{\pm 0.1}$ mm
- Package height 0.5 mm (max.)
- Approximate weight 0.01 g
- RoHS compatible
- Package for Surface Mount Technology (SMT)
- Ni/Au-plated terminals
- Electrostatic Sensitive Device (ESD)
- Moisture Sensitivity Level 2a (MSL2a)

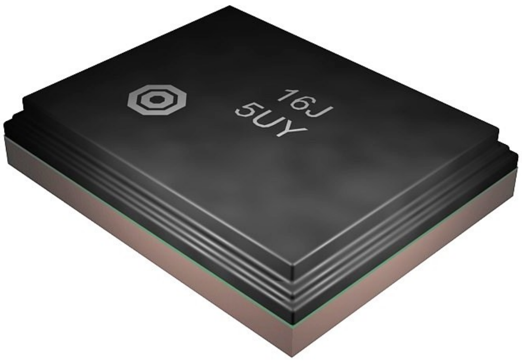

Figure 1: Picture of component with example of product marking.

3 Package

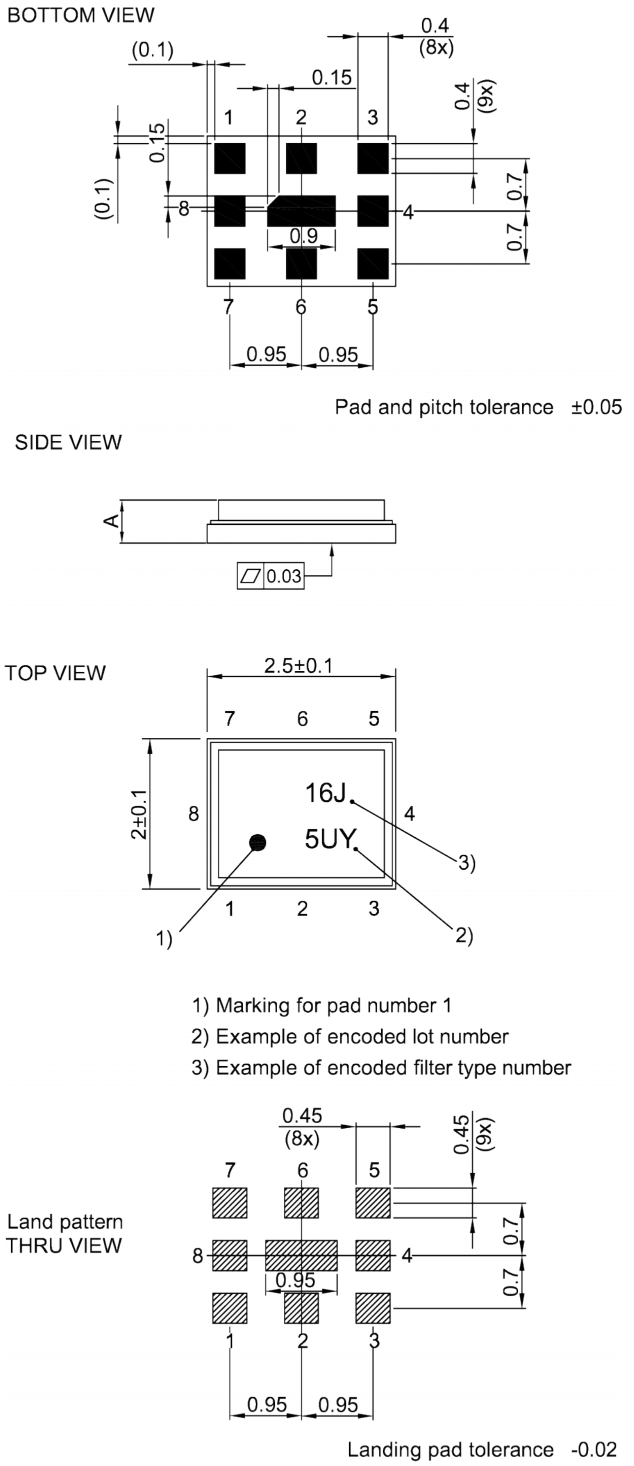

Figure 2: Drawing of package with package height A = 0.5 mm (max.). See Sec. Package information (p. 26).

4 Pin configuration

- 1 TX
- 3 RX
- 6 ANT
- 2, 4, 5, 7, 8, 9 Ground

5 Matching circuit

- L_{p1} = 8.2 nH
- L_{p6} = 3.6 nH

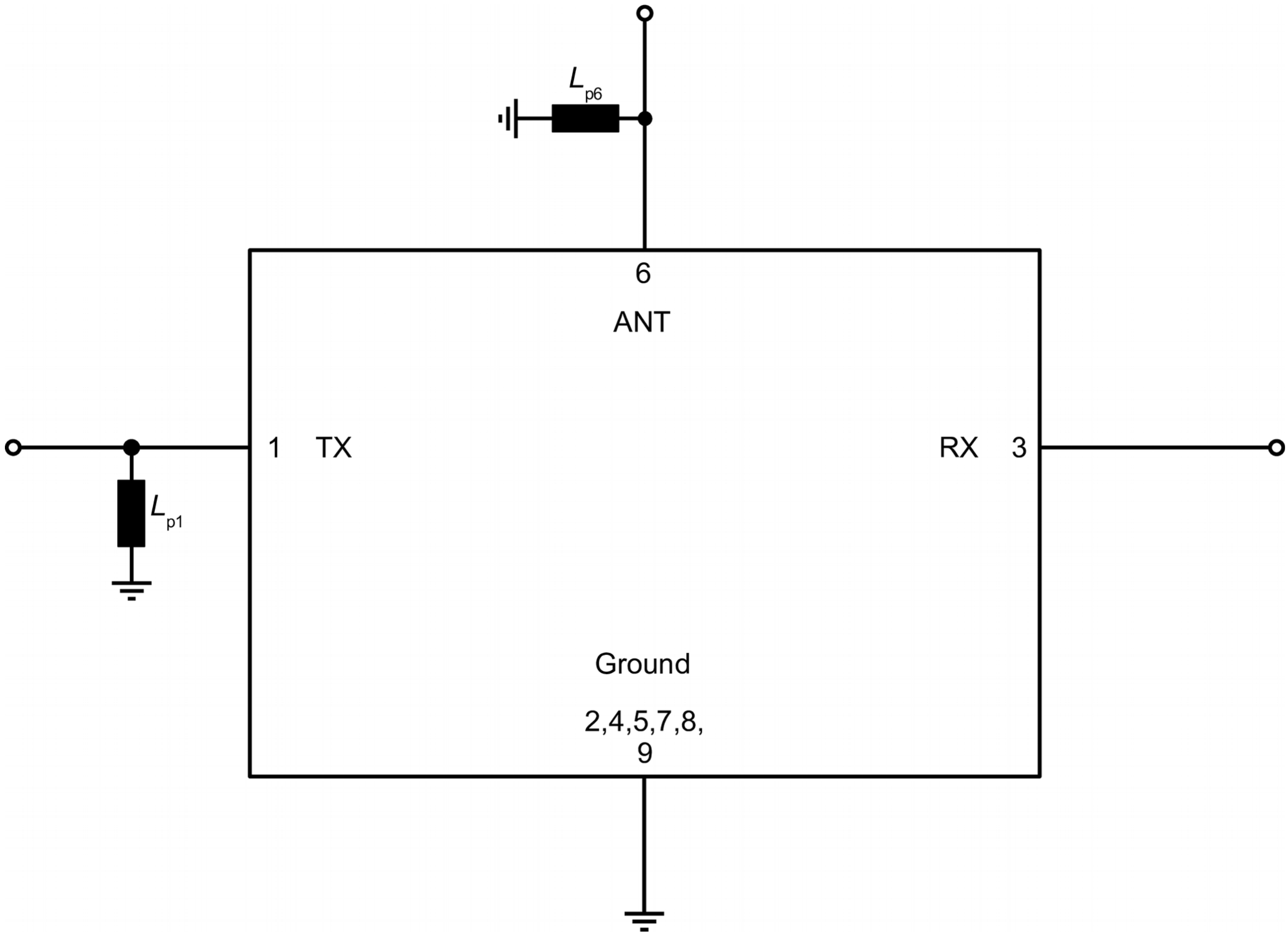

Figure 3: Schematic of matching circuit.

6 Characteristics

6.1 TX – ANT

Temperature range for specification	T_{SPEC}	= −10 °C ... +85 °C
TX terminating impedance	Z_{TX}	= 50 Ω // 8.2 nH[1)]
ANT terminating impedance	Z_{ANT}	= 50 Ω // 3.6 nH[1)]
RX terminating impedance	Z_{RX}	= 50 Ω

Characteristics TX – ANT				min. for T_{SPEC}	typ. @ +25 °C	max. for T_{SPEC}	
Center frequency			f_C	—	1960	—	MHz
Insertion attenuation			α_{INT} 2)				
	1930 ... 1935	MHz		—	1.7	2.7	dB
	1935 ... 1985	MHz		—	1.4	2.7	dB
	1985 ... 1990	MHz		—	1.4	2.7	dB
Maximum insertion attenuation			α_{max}				
	1930.24 ... 1989.76	MHz		—	2.0	3.0	dB
Amplitude ripple (p-p)			$\Delta\alpha$				
	1930.24 ... 1989.76	MHz		—	0.9	2.0	dB
Maximum VSWR			$VSWR_{max}$				
@ TX port	1930.24 ... 1989.76	MHz		—	1.5	2.0	
@ ANT port	1930.24 ... 1989.76	MHz		—	1.4	2.0	
Maximum error vector magnitude			EVM_{max} 3)				
	1932.4 ... 1987.6	MHz		—	1.0	—	%
Minimum attenuation			α_{min}				
	50 ... 1574	MHz		35	37	—	dB
	1574 ... 1606	MHz		35	38	—	dB
	1606 ... 1710	MHz		35	39	—	dB
	1710 ... 1780	MHz		35	42	—	dB
	1780 ... 1850.24	MHz		35	44	—	dB
	1850.24 ... 1909.76	MHz		45	48	—	dB
	2110 ... 2200	MHz		35	45	—	dB
	2200 ... 2300	MHz		35	45	—	dB
	2400 ... 2500	MHz		5	16	—	dB
	2500 ... 2535	MHz		5	50	—	dB
	2535 ... 5150	MHz		35	42	—	dB
	5150 ... 5850	MHz		30	42	—	dB

1) See Sec. Matching circuit (p. 6).
2) Integrated attenuation α_{INT}: Averaged power $|S_{ij}|^2$ over the center 4.5 MHz of LTE 5 MHz (25 RB) channels.
3) Error Vector Magnitude (EVM) based on definition in 3GPP TS 25.141.

Temperature range for specification	T_{SPEC}	= −40 °C ... +95 °C
TX terminating impedance	Z_{TX}	= 50 Ω // 8.2 nH[1)]
ANT terminating impedance	Z_{ANT}	= 50 Ω // 3.6 nH[1)]
RX terminating impedance	Z_{RX}	= 50 Ω

Characteristics TX – ANT				**min.** for T_{SPEC}	**typ.** @ +25 °C	**max.** for T_{SPEC}	
Insertion attenuation			α_{INT} [2)]				
	1930 ... 1935	MHz		—	1.7	3.0	dB
	1935 ... 1985	MHz		—	1.4	3.0	dB
	1985 ... 1990	MHz		—	1.4	3.0	dB
Maximum insertion attenuation			α_{max}				
	1930.24 ... 1989.76	MHz		—	2.0	3.5	dB
Amplitude ripple (p-p)			$\Delta\alpha$				
	1930.24 ... 1989.76	MHz		—	0.9	2.5	dB
Maximum VSWR			$VSWR_{max}$				
@ TX port	1930.24 ... 1989.76	MHz		—	1.5	2.0	
@ ANT port	1930.24 ... 1989.76	MHz		—	1.4	2.0	
Maximum error vector magnitude			EVM_{max} [3)]				
	1932.4 ... 1987.6	MHz		—	1.0	—	%
Minimum attenuation			α_{min}				
	50 ... 1574	MHz		35	37	—	dB
	1574 ... 1606	MHz		35	38	—	dB
	1606 ... 1710	MHz		35	39	—	dB
	1710 ... 1780	MHz		35	42	—	dB
	1780 ... 1850.24	MHz		35	44	—	dB
	1850.24 ... 1909	MHz		45	48	—	dB
	1909 ... 1909.76	MHz		35	59	—	dB
	2110 ... 2200	MHz		35	45	—	dB
	2200 ... 2300	MHz		35	45	—	dB
	2400 ... 2500	MHz		5	16	—	dB
	2500 ... 2535	MHz		5	50	—	dB
	2535 ... 5150	MHz		35	42	—	dB
	5150 ... 5850	MHz		30	42	—	dB

1) See Sec. Matching circuit (p. 6).
2) Integrated attenuation α_{INT}: Averaged power $|S_{ij}|^2$ over the center 4.5 MHz of LTE 5 MHz (25 RB) channels.
3) Error Vector Magnitude (EVM) based on definition in 3GPP TS 25.141.

6.2 ANT – RX

Temperature range for specification	T_{SPEC}	= −10 °C ... +85 °C
TX terminating impedance	Z_{TX}	= 50 Ω // 8.2 nH[1)]
ANT terminating impedance	Z_{ANT}	= 50 Ω // 3.6 nH[1)]
RX terminating impedance	Z_{RX}	= 50 Ω

Characteristics ANT – RX				**min.** for T_{SPEC}	**typ.** @ +25 °C	**max.** for T_{SPEC}	
Center frequency			f_C	—	1880	—	MHz
Insertion attenuation			α_{INT} [2)]				
	1850... 1855	MHz		—	1.6	2.7	dB
	1855... 1905	MHz		—	1.5	2.7	dB
	1905... 1910	MHz		—	1.6	2.7	dB
Maximum insertion attenuation			α_{max}				
	1850.24... 1909.76	MHz		—	2.0	3.0	dB
Amplitude ripple (p-p)			$\Delta\alpha$				
	1850.24... 1909.76	MHz		—	1.0	2.0	dB
Maximum VSWR			$VSWR_{max}$				
@ ANT port	1850.24... 1909.76	MHz		—	1.6	2.0[3)]	
@ RX port	1850.24... 1909.76	MHz		—	1.6	2.0[4)]	
Maximum error vector magnitude			EVM_{max} [5)]				
	1852.4... 1907.6	MHz		—	1.3	—	%
Minimum attenuation			α_{min}				
	50... 1574	MHz		35	42	—	dB
	1574... 1606	MHz		35	48	—	dB
	1606... 1710	MHz		35	50	—	dB
	1710... 1780	MHz		30	40	—	dB
	1780... 1830	MHz		10	37	—	dB
	1930.24... 1989.76	MHz		45	52	—	dB
	1989.76... 2110	MHz		35	48	—	dB
	2110... 2200	MHz		35	54	—	dB
	2200... 2250	MHz		35	55	—	dB
	2250... 2300	MHz		5	45	—	dB
	2400... 2500	MHz		5	30	—	dB
	2500... 5150	MHz		20	30	—	dB
	5150... 5850	MHz		15	26	—	dB

1) See Sec. Matching circuit (p. 6).
2) Integrated attenuation α_{INT}: Averaged power $|S_{ij}|^2$ over the center 4.5 MHz of LTE 5 MHz (25 RB) channels.
3) Valid for temperature T = -10 °C...+45 °C, VSWR 2.2 for -10°C … +85°C.
4) Valid for temperature T = -10 °C...+45 °C, VSWR 2.1 for -10°C … +85°C.
5) Error Vector Magnitude (EVM) based on definition in 3GPP TS 25.141.

Temperature range for specification	T_{SPEC}	= −40 °C ... +95 °C
TX terminating impedance	Z_{TX}	= 50 Ω // 8.2 nH[1]
ANT terminating impedance	Z_{ANT}	= 50 Ω // 3.6 nH[1]
RX terminating impedance	Z_{RX}	= 50 Ω

Characteristics ANT – RX				**min.** for T_{SPEC}	**typ.** @ +25 °C	**max.** for T_{SPEC}	
Insertion attenuation			α_{INT} [2]				
	1850 ... 1855	MHz		—	1.6	3.0	dB
	1855 ... 1905	MHz		—	1.5	3.0	dB
	1905 ... 1910	MHz		—	1.6	3.0	dB
Maximum insertion attenuation			α_{max}				
	1850.24 ... 1909.76	MHz		—	2.0	3.5	dB
Amplitude ripple (p-p)			$\Delta\alpha$				
	1850.24 ... 1909.76	MHz		—	1.0	2.5	dB
Maximum VSWR			$VSWR_{max}$				
@ ANT port	1850.24 ... 1909.76	MHz		—	1.6	2.3	
@ RX port	1850.24 ... 1909.76	MHz		—	1.6	2.3	
Maximum error vector magnitude			EVM_{max} [3]				
	1852.4 ... 1907.6	MHz		—	1.3	—	%
Minimum attenuation			α_{min}				
	50 ... 1574	MHz		35	42	—	dB
	1574 ... 1606	MHz		35	48	—	dB
	1606 ... 1710	MHz		35	50	—	dB
	1710 ... 1780	MHz		30	40	—	dB
	1780 ... 1830	MHz		10	37	—	dB
	1930.24 ... 1931.5	MHz		30	61	—	dB
	1931.5 ... 1989.76	MHz		45	52	—	dB
	1989.76 ... 2110	MHz		35	48	—	dB
	2110 ... 2200	MHz		35	54	—	dB
	2200 ... 2250	MHz		35	55	—	dB
	2250 ... 2300	MHz		5	45	—	dB
	2400 ... 2500	MHz		5	30	—	dB
	2500 ... 5150	MHz		20	30	—	dB
	5150 ... 5850	MHz		15	26	—	dB

[1] See Sec. Matching circuit (p. 6).
[2] Integrated attenuation α_{INT}: Averaged power $|S_{ij}|^2$ over the center 4.5 MHz of LTE 5 MHz (25 RB) channels.
[3] Error Vector Magnitude (EVM) based on definition in 3GPP TS 25.141.

6.3 TX – RX

Temperature range for specification	T_{SPEC}	= −10 °C ... +85 °C
TX terminating impedance	Z_{TX}	= 50 Ω // 8.2 nH[1)]
ANT terminating impedance	Z_{ANT}	= 50 Ω // 3.6 nH[1)]
RX terminating impedance	Z_{RX}	= 50 Ω

Characteristics TX – RX				**min.** for T_{SPEC}	**typ.** @ +25 °C	**max.** for T_{SPEC}	
Isolation			α_{INT} [2)]				
	1850... 1910	MHz		47	50	—	dB
	1930... 1990	MHz		48	56	—	dB
Minimum isolation			α_{min}				
	1850.24... 1909.76	MHz		47	50	—	dB
	1930.24... 1989.76	MHz		48	55	—	dB

1) See Sec. Matching circuit (p. 6).
2) Integrated attenuation α_{INT}: Averaged power $|S_{ij}|^2$ over the center 4.5 MHz of LTE 5 MHz (25 RB) channels.

Temperature range for specification	T_{SPEC}	= −40 °C ... +95 °C
TX terminating impedance	Z_{TX}	= 50 Ω // 8.2 nH[1)]
ANT terminating impedance	Z_{ANT}	= 50 Ω // 3.6 nH[1)]
RX terminating impedance	Z_{RX}	= 50 Ω

Characteristics TX – RX				**min.** for T_{SPEC}	**typ.** @ +25 °C	**max.** for T_{SPEC}	
Isolation			α_{INT} [2)]				
	1850 ... 1910	MHz		47	50	—	dB
	1930 ... 1990	MHz		45	56	—	dB
Minimum isolation			α_{min}				
	1850.24 ... 1909	MHz		47	50	—	dB
	1909 ... 1909.76	MHz		37	58	—	dB
	1930.24 ... 1931.5	MHz		35	63	—	dB
	1931.5 ... 1989.76	MHz		48	55	—	dB

1) See Sec. Matching circuit (p. 6).
2) Integrated attenuation α_{INT}: Averaged power $|S_{ij}|^2$ over the center 4.5 MHz of LTE 5 MHz (25 RB) channels.

7 Maximum ratings

Operable temperature	T_{OP} = −40 °C ... +95 °C	
Storage temperature	T_{STG}[1)] = −40 °C ... +95 °C	
DC voltage	$\|V_{DC}\|$[2)] = 0 V	
ESD voltage		
	V_{ESD}[3)] = 350 V	Machine model.
	V_{ESD}[4)] = 350 V	Human body model.
Input power	P_{IN}	
@ TX port: 1930.24 ... 1989.76 MHz	28 dBm[5)]	5 MHz LTE downlink signal (25 RB) for 100000 h @ 55 °C. P_{IN} average – 39 dBm peak. Source and load impedance 50 Ω.
@ TX port: other frequency ranges	10 dBm	Source and load impedance 50 Ω.
@ RX port	26 dBm[5)]	5 MHz LTE uplink signal (25 RB) for 5000 h @ 55 °C. P_{IN} average – 32 dBm peak. Source and load impedance 50 Ω.

1) Not valid for packaging material. Storage temperature for packaging material is −25 °C to +40 °C.
2) In case of applied DC voltage blocking capacitors are mandatory.
3) According to JESD22-A115B (MM – Machine Model), 10 negative & 10 positive pulses.
4) According to JESD22-A114F (HBM – Human Body Model), 1 negative & 1 positive pulse.
5) Expected lifetime according to power durability tests, and wear out models.

8 Transmission coefficients

8.1 TX – ANT

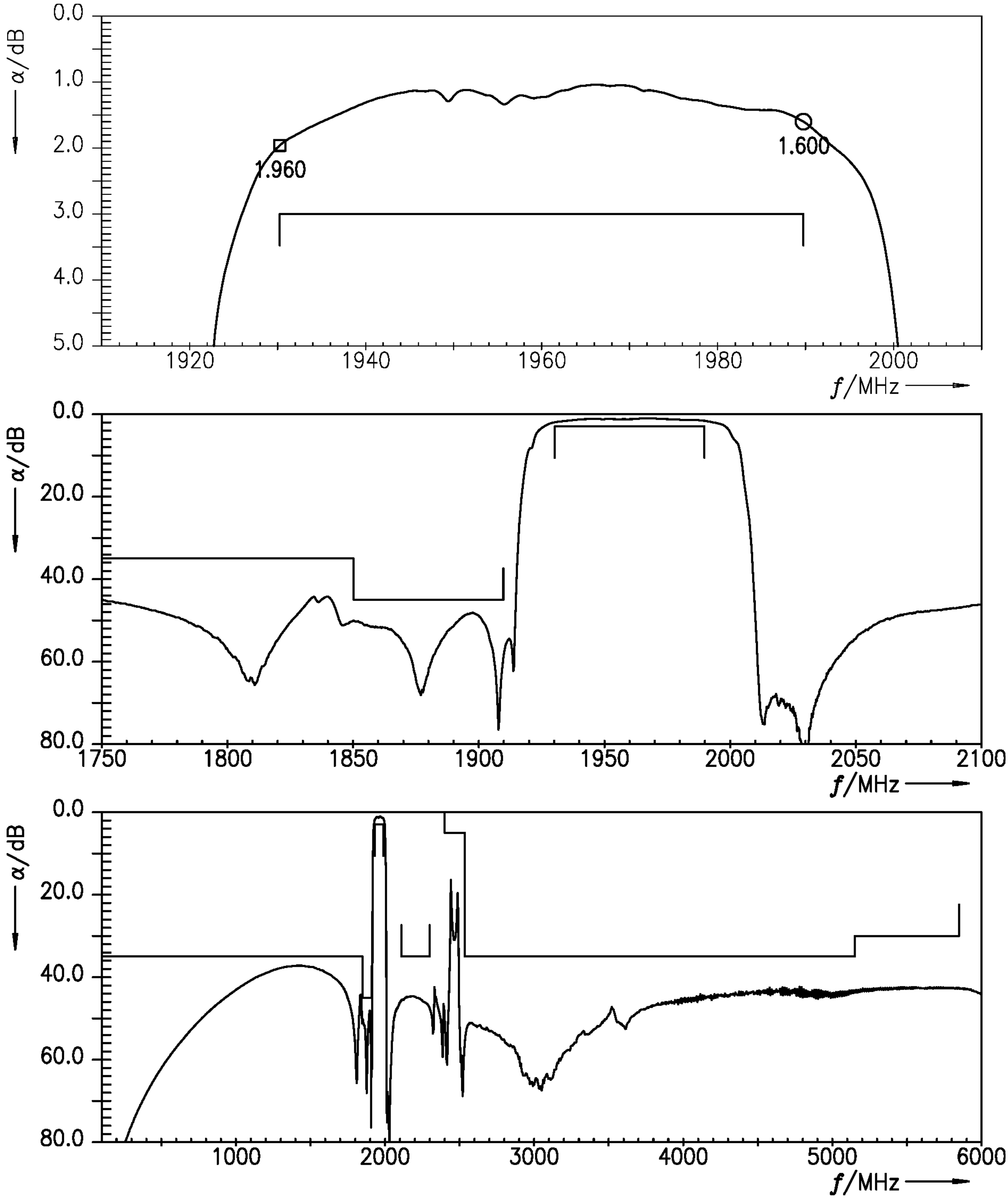

Figure 4: Attenuation TX – ANT.

8.2 ANT – RX

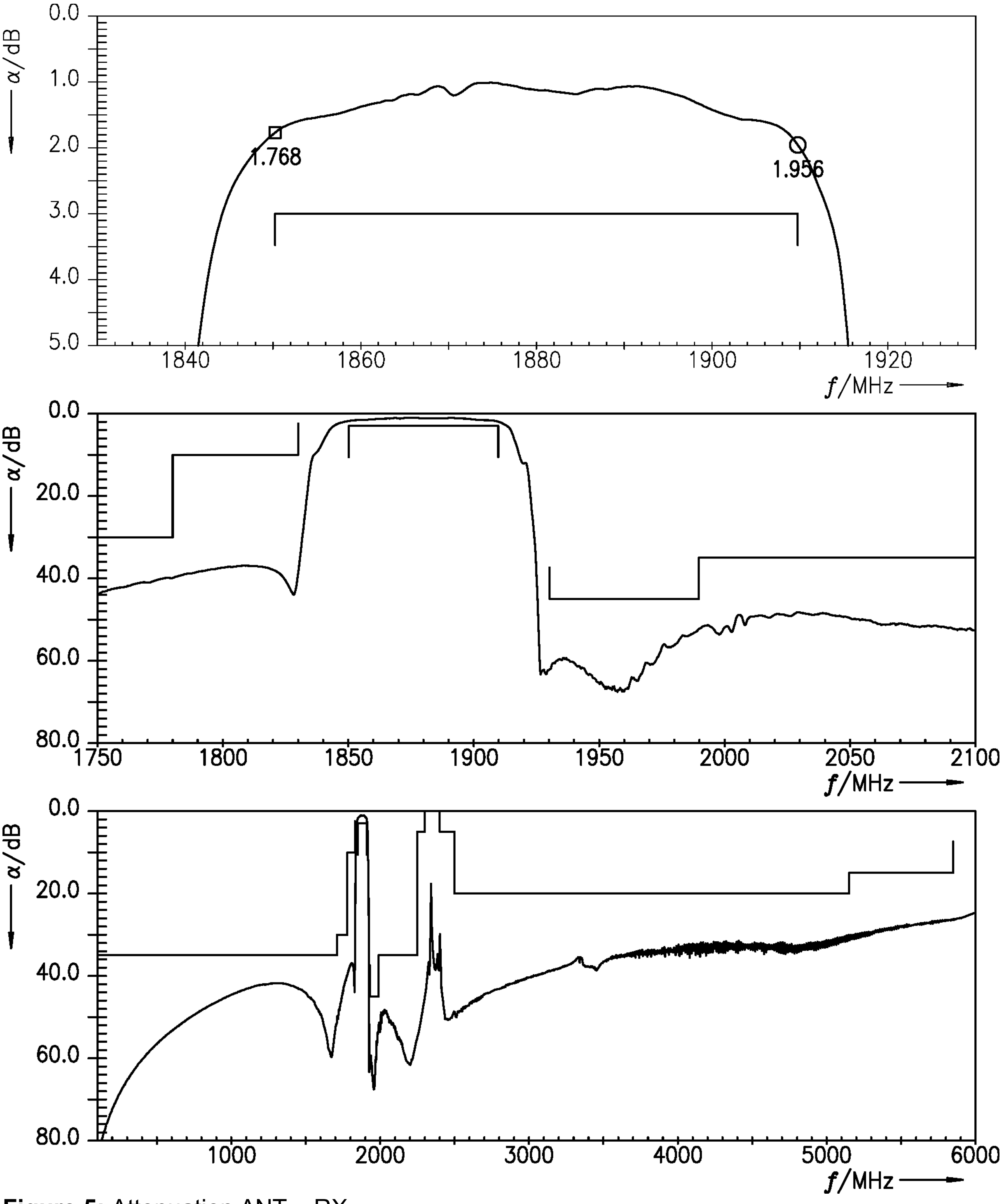

Figure 5: Attenuation ANT – RX.

8.3 TX – RX

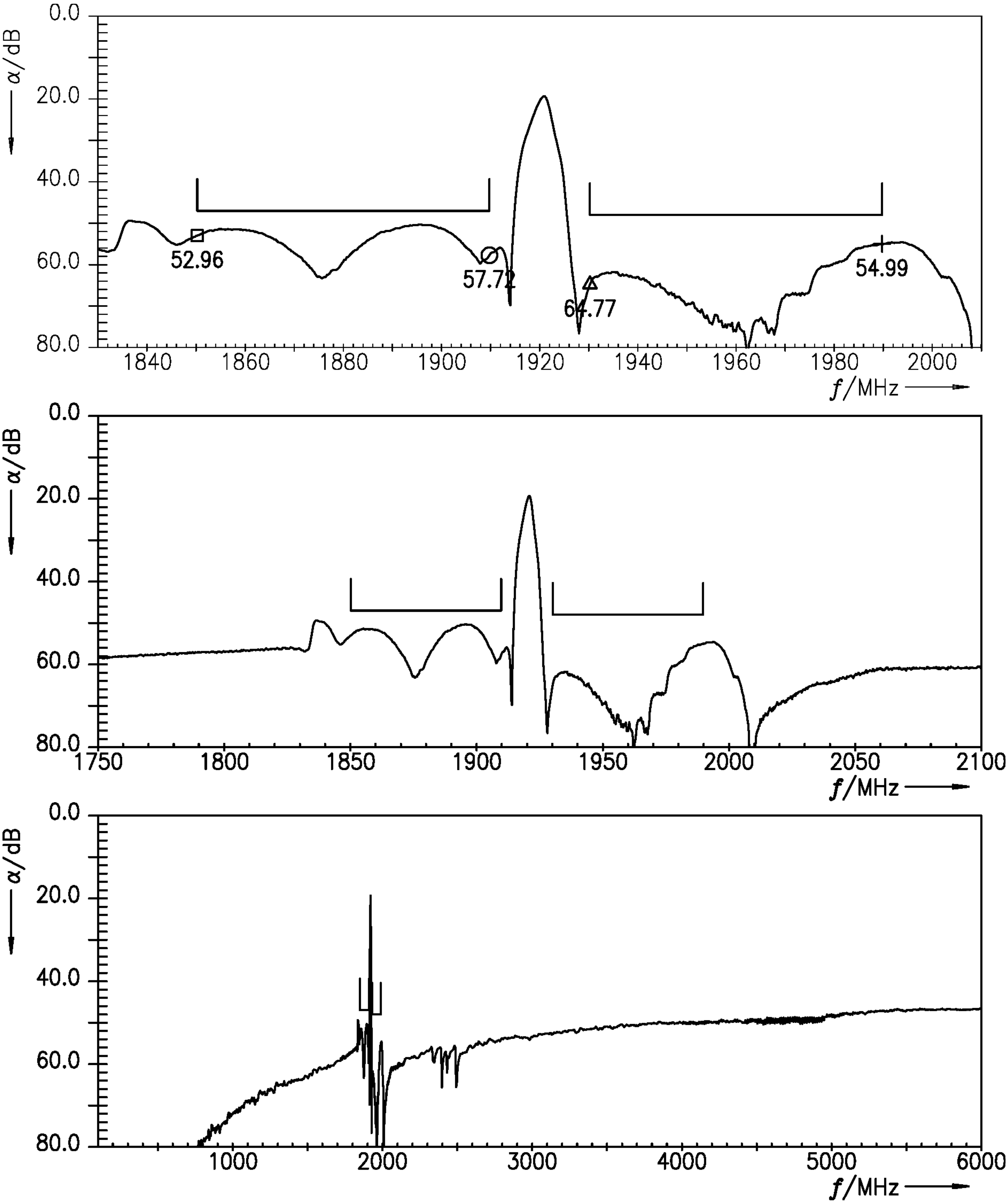

Figure 6: Isolation TX – RX.

9 Reflection coefficients

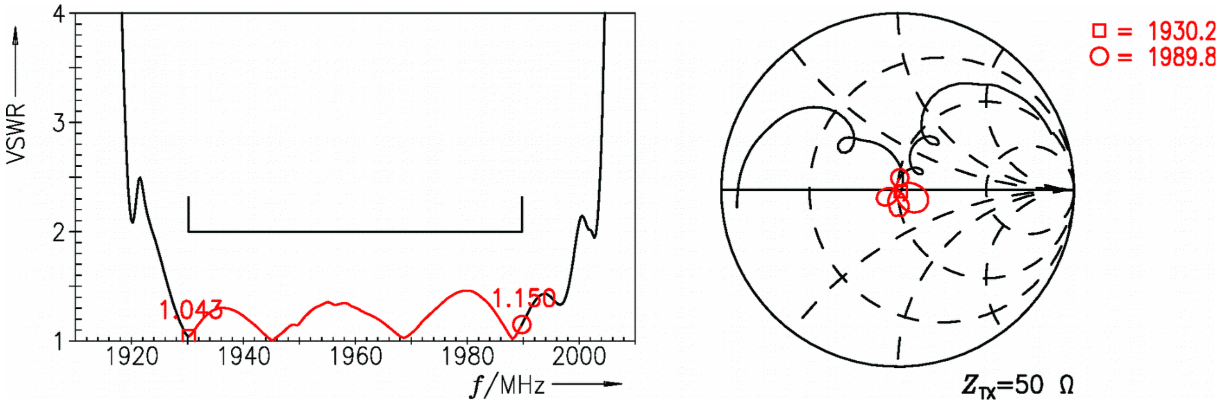

Figure 7: Reflection coefficient at TX port.

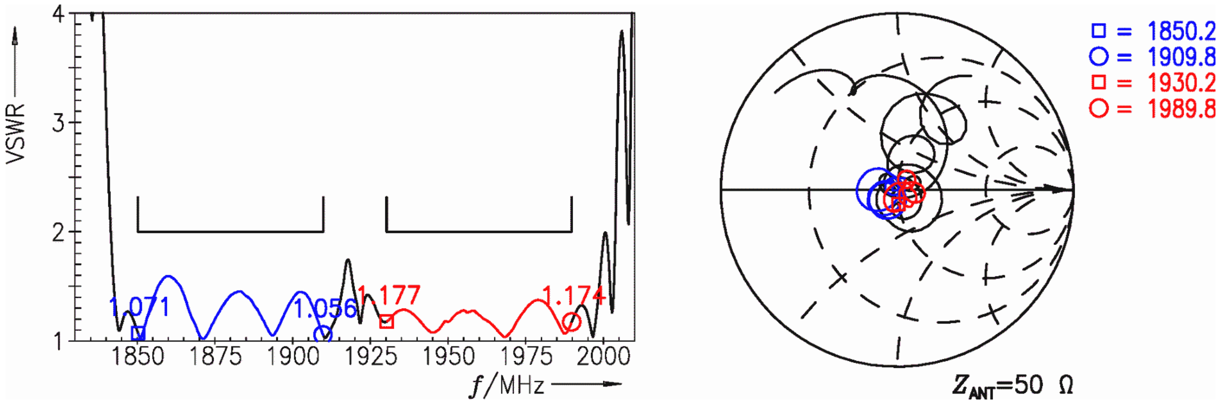

Figure 8: Reflection coefficient at ANT port.

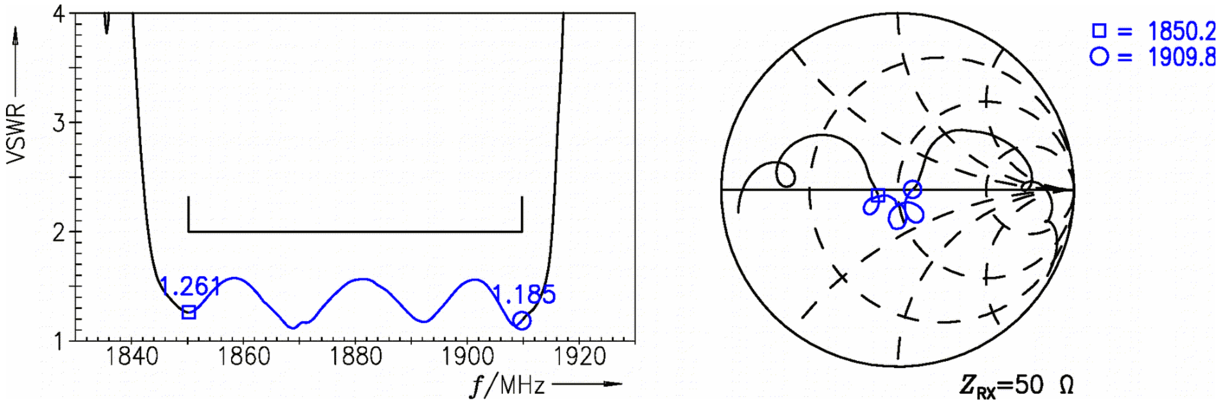

Figure 9: Reflection coefficient at RX port.

10 EVMs

10.1 TX – ANT

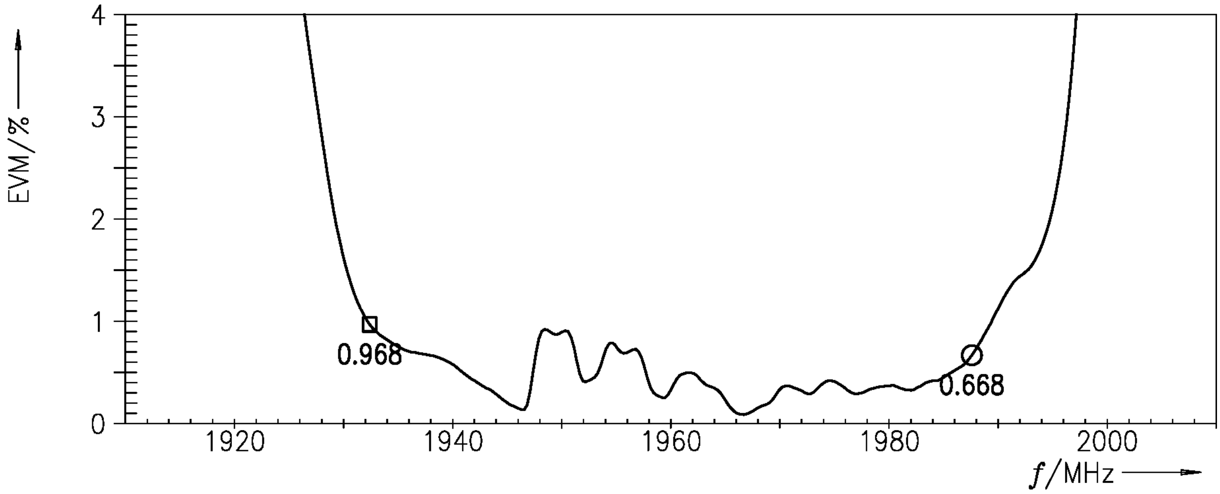

Figure 10: Error vector magnitude TX – ANT.

10.2 ANT – RX

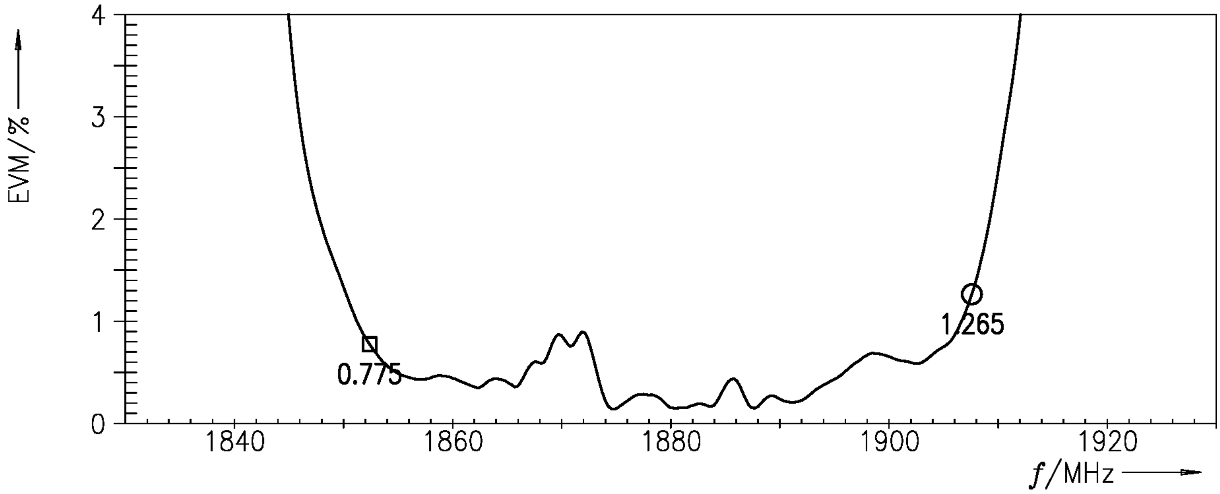

Figure 11: Error vector magnitude ANT – RX.

11 Packing material

11.1 Tape

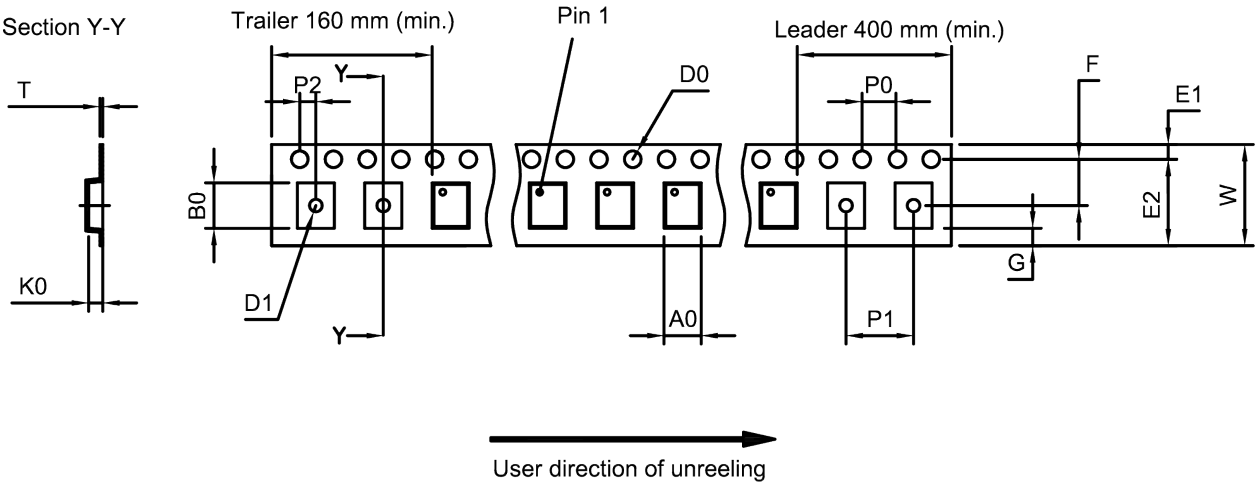

Figure 12: Drawing of tape (first-angle projection) for illustration only and not to scale. The valid tape dimensions are listed in Table 1.

A_0	$2.25_{\pm 0.05}$ mm
B_0	$2.75_{\pm 0.05}$ mm
D_0	$1.5_{+0.1/-0}$ mm
D_1	1.0 mm (min.)
E_1	$1.75_{\pm 0.1}$ mm

E_2	6.25 mm (min.)
F	$3.5_{\pm 0.05}$ mm
G	0.75 mm (min.)
K_0	$0.6_{\pm 0.05}$ mm
P_0	$4.0_{\pm 0.1}$ mm

P_1	$4.0_{\pm 0.1}$ mm
P_2	$2.0_{\pm 0.05}$ mm
T	$0.25_{\pm 0.03}$ mm
W	$8.0_{+0.3/-0.1}$ mm

Table 1: Tape dimensions.

11.2 Reel with diameter of 180 mm

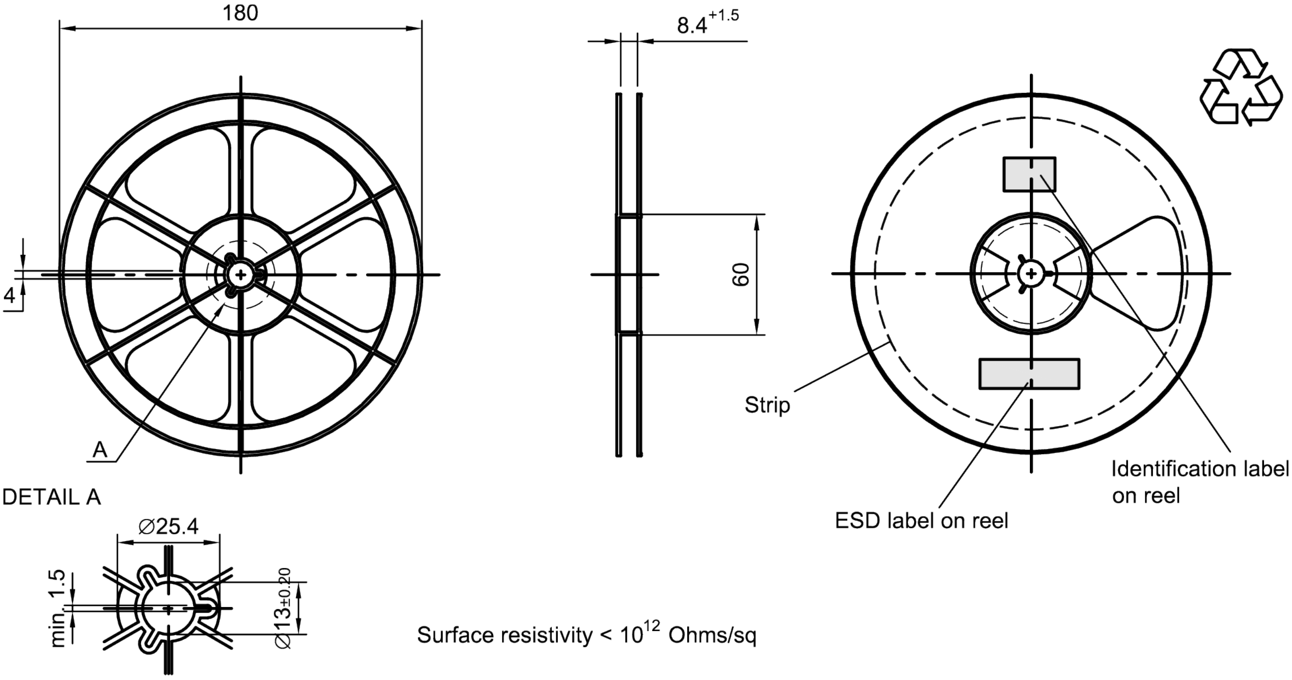

Figure 13: Drawing of reel (first-angle projection) with diameter of 180 mm.

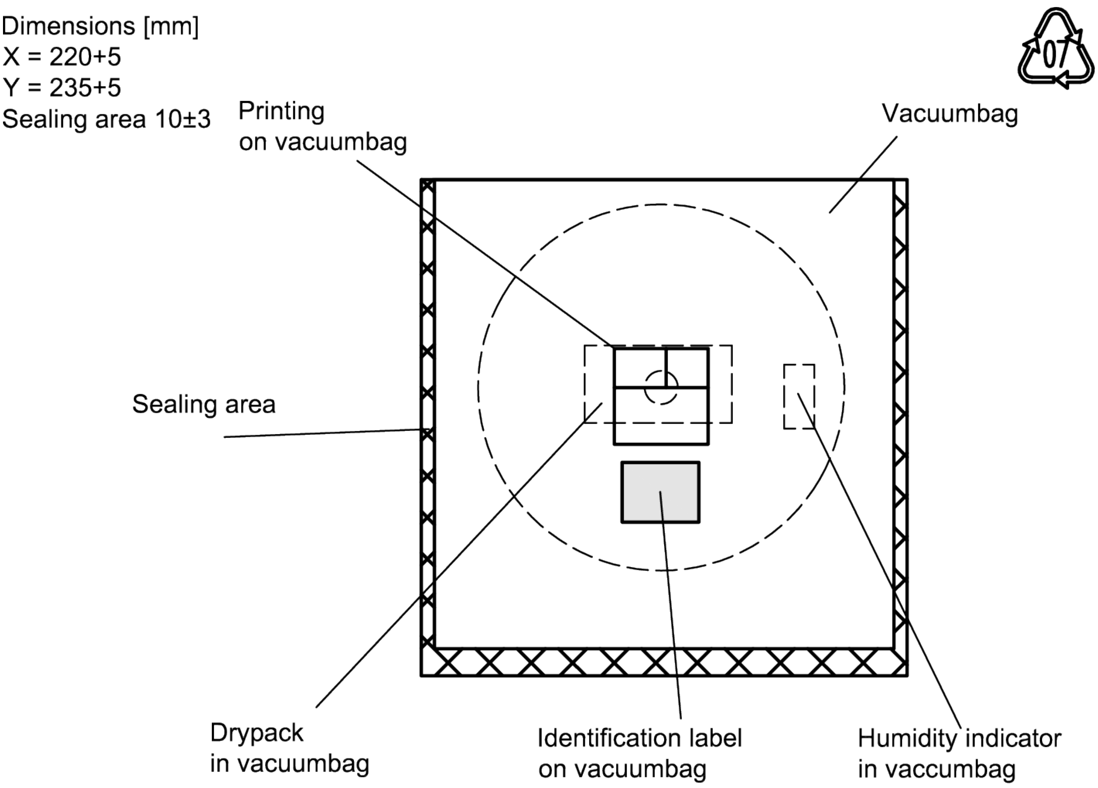

Figure 14: Drawing of moisture barrier bag (MBB) for reel with diameter of 180 mm.

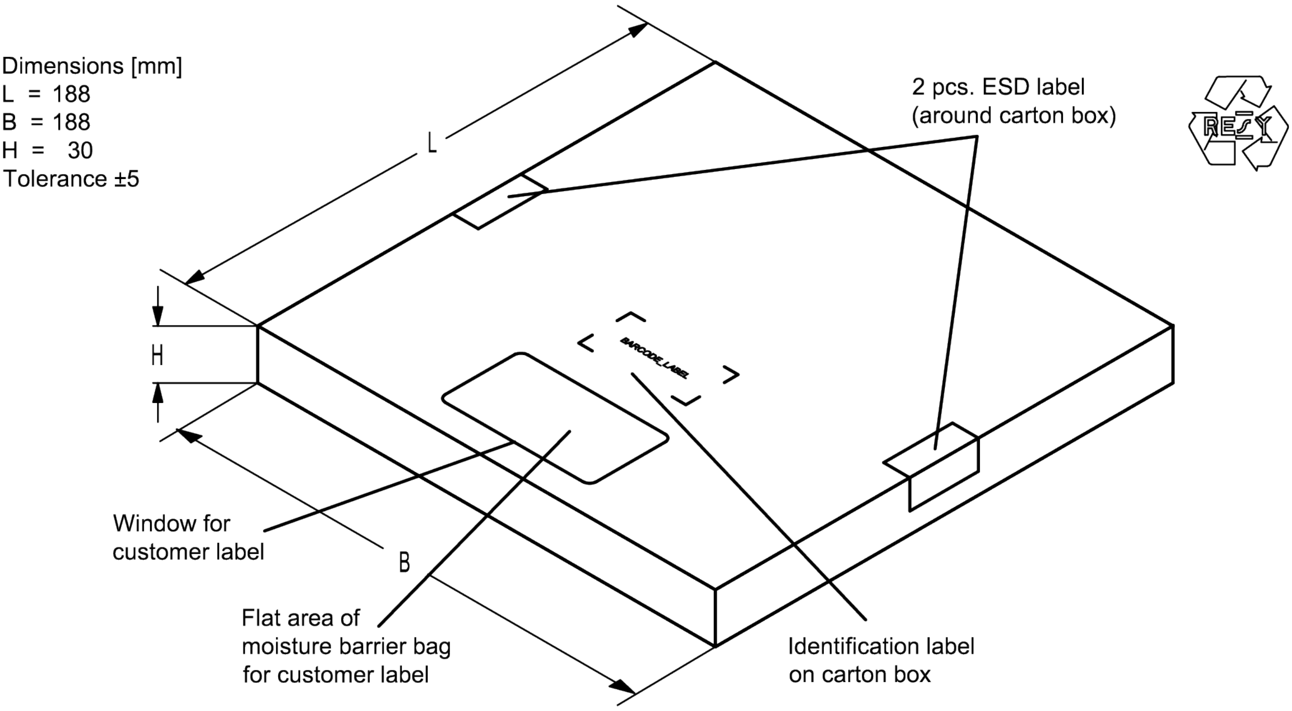

Figure 15: Drawing of folding box for reel with diameter of 180 mm.

11.3 Reel with diameter of 330 mm

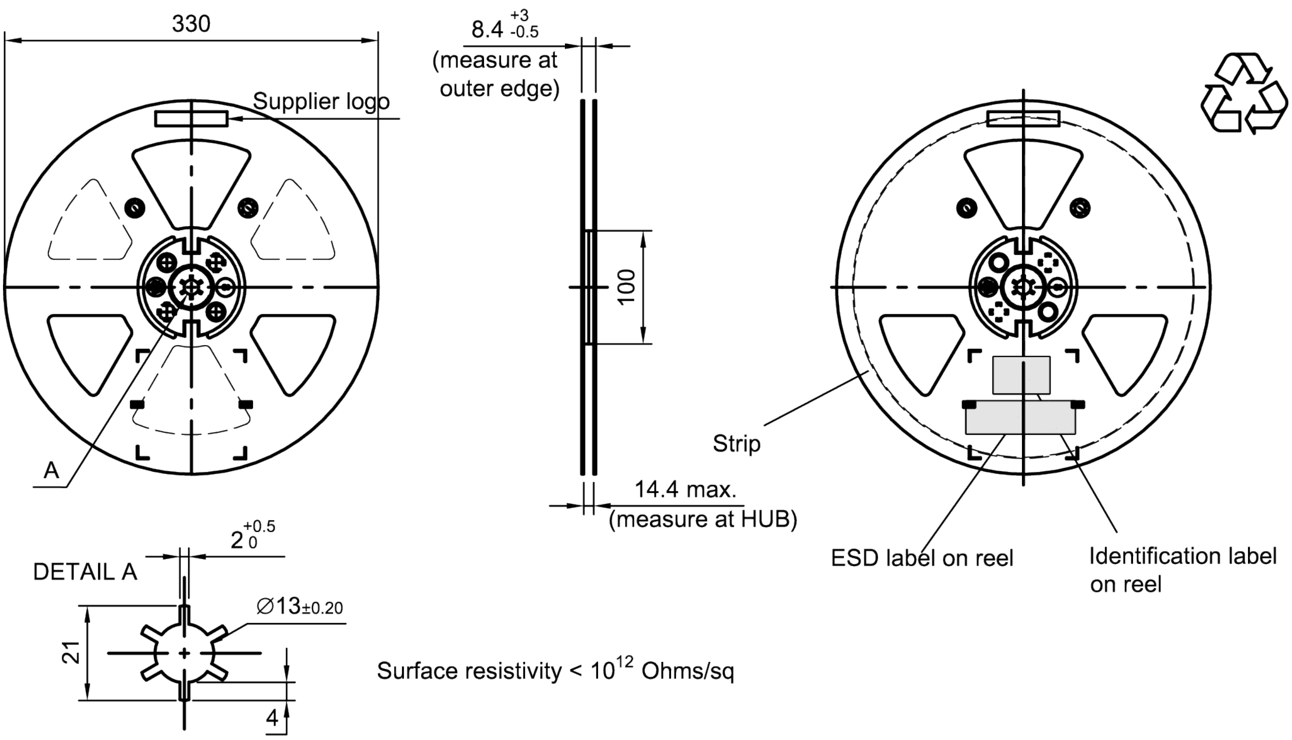

Figure 16: Drawing of reel (first-angle projection) with diameter of 330 mm.

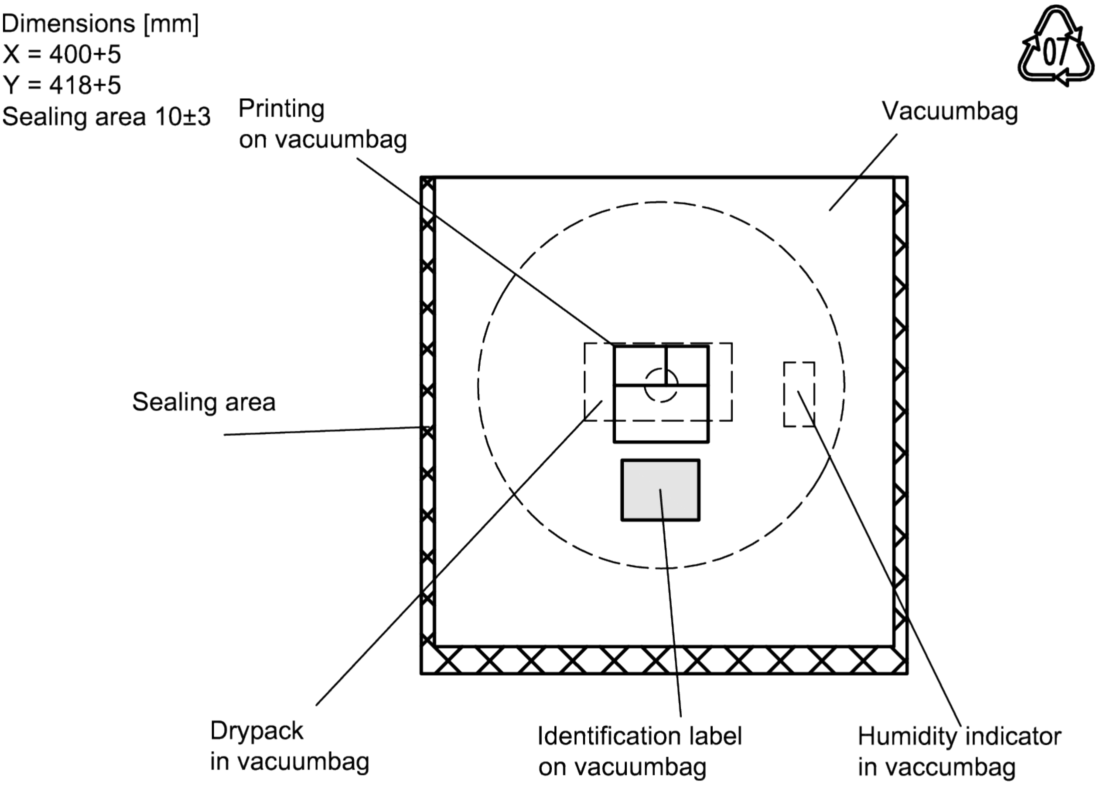

Figure 17: Drawing of moisture barrier bag (MBB) for reel with diameter of 330 mm.

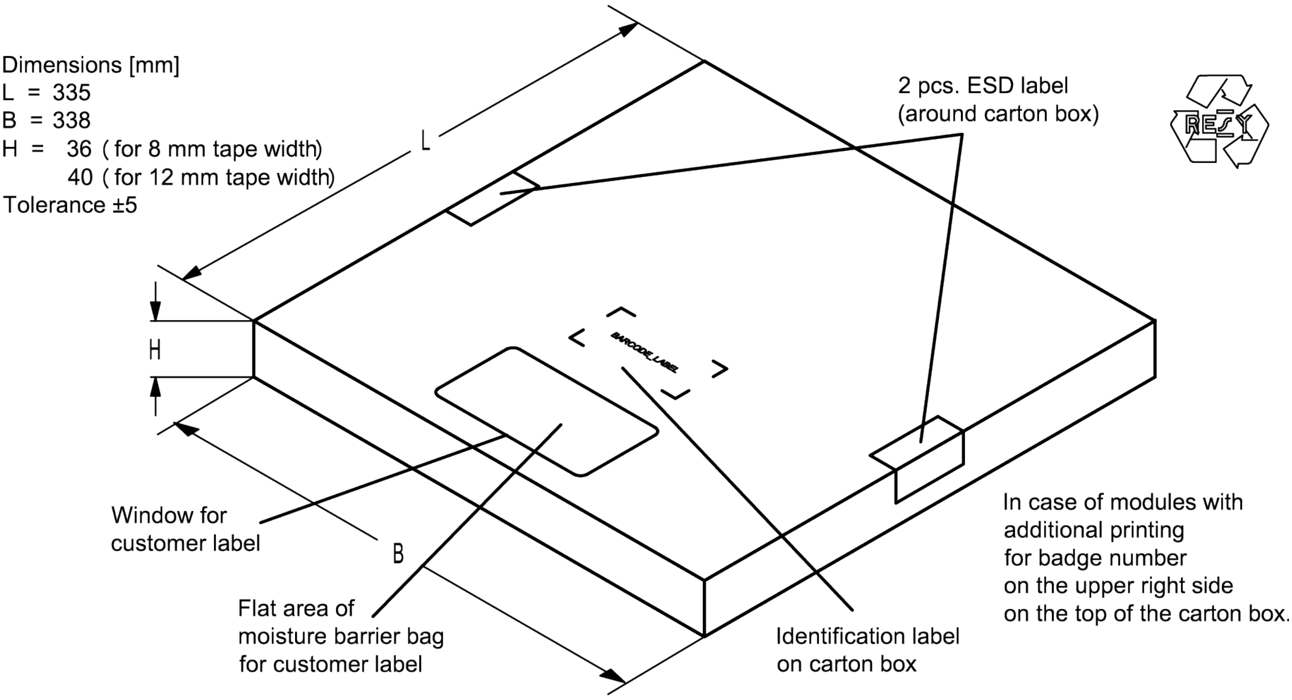

Figure 18: Drawing of folding box for reel with diameter of 330 mm.

12 Marking

Products are marked with product type number and lot number encoded according to Table 2:

- Type number:

  The 4 digit type number of the ordering code, e.g., B3xxxxB1234xxxx,
  is encoded by a special BASE32 code into a 3 digit marking.

  Example of decoding type number marking on device in decimal code.

  16J => **1234**

  1 x 32^2 + **6** x 32^1 + **18 (=J)** x 32^0 = **1234**

  The BASE32 code for product type B8047 is 7VF.

- Lot number:

  The last 5 digits of the lot number, e.g., **12345**,
  are encoded based on a special BASE47 code into a 3 digit marking.

  Example of decoding lot number marking on device in decimal code.

  5UY => **12345**

  5 x 47^2 + **27 (=U)** x 47^1 + **31 (=Y)** x 47^0 = **12345**

Adopted BASE32 code for type number			
Decimal value	Base32 code	Decimal value	Base32 code
0	0	16	G
1	1	17	H
2	2	18	J
3	3	19	K
4	4	20	M
5	5	21	N
6	6	22	P
7	7	23	Q
8	8	24	R
9	9	25	S
10	A	26	T
11	B	27	V
12	C	28	W
13	D	29	X
14	E	30	Y
15	F	31	Z

Adopted BASE47 code for lot number			
Decimal value	Base47 code	Decimal value	Base47 code
0	0	24	R
1	1	25	S
2	2	26	T
3	3	27	U
4	4	28	V
5	5	29	W
6	6	30	X
7	7	31	Y
8	8	32	Z
9	9	33	b
10	A	34	d
11	B	35	f
12	C	36	h
13	D	37	n
14	E	38	r
15	F	39	t
16	G	40	v
17	H	41	\
18	J	42	?
19	K	43	{
20	L	44	}
21	M	45	<
22	N	46	>
23	P		

Table 2: Lists for encoding and decoding of marking.

13 Soldering profile

The recommended soldering process is in accordance with IEC 60068-2-58 – 3rd edit and IPC/JEDEC J-STD-020B.

ramp rate	≤ 3 K/s
preheat	125 °C to 220 °C, 150 s to 210 s, 0.4 K/s to 1.0 K/s
T > 220 °C	30 s to 70 s
T > 230 °C	min. 10 s
T > 245 °C	max. 20 s
T ≥ 255 °C	–
peak temperature T_{peak}	250 °C +0/-5 °C
wetting temperature T_{min}	230 °C +5/-0 °C for 10 s ± 1 s
cooling rate	≤ 3 K/s
soldering temperature T	measured at solder pads

Table 3: Characteristics of recommended soldering profile for lead-free solder (Sn95.5Ag3.8Cu0.7).

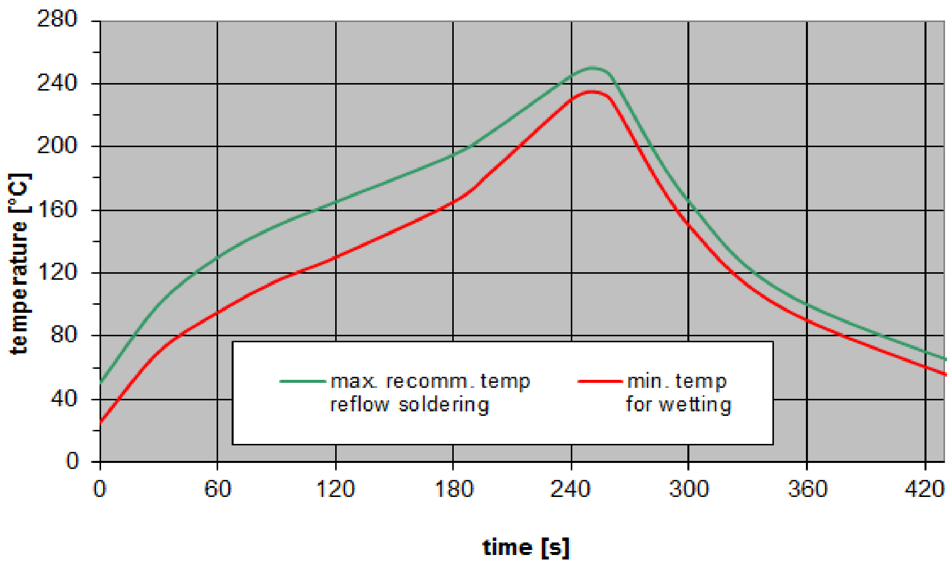

Figure 19: Recommended reflow profile for convection and infrared soldering – lead-free solder.

14 Annotations

14.1 RoHS compatibility

ROHS-compatible means that products are compatible with the requirements according to Art. 4 (substance restrictions) of Directive 2011/65/EU of the European Parliament and of the Council of June 8th, 2011, on the restriction of the use of certain hazardous substances in electrical and electronic equipment ("Directive") with due regard to the application of exemptions as per Annex III of the Directive in certain cases.

14.2 Scattering parameters (S-parameters)

The pin/port assignment is available in the headers of the S-parameter files. Please contact your local RF360 sales office.

14.3 Ordering codes and packing units

Ordering code	Packing unit
B39202B8047P810	5000 pcs

Table 4: Ordering codes and packing units.

15 Cautions and warnings

15.1 Display of ordering codes for RF360 products

The ordering code for one and the same product can be represented differently in data sheets, data books, other publications and the website of RF360, or in order-related documents such as shipping notes, order confirmations and product labels. The varying representations of the ordering codes are due to different processes employed and do not affect the specifications of the respective products. Detailed information can be found on the Internet under https://rffe.qualcomm.com/.

15.2 Material information

Due to technical requirements components may contain dangerous substances. For information on the type in question please also contact one of our sales offices.

For information on recycling of tapes and reels please contact one of our sales offices.

15.3 Moldability

Before using in overmolding environment, please contact your local RF360 sales office.

15.4 Package information

Landing area

The printed circuit board (PCB) land pattern (landing area) shown is based on RF360 internal development and empirical data and illustrated for example purposes, only. As customers' SMD assembly processes may have a plenty of variants and influence factors which are not under control or knowledge of RF360, additional careful process development on customer side is necessary and strongly recommended in order to achieve best soldering results tailored to the particular customer needs.

Dimensions

Unless otherwise specified all dimensions are understood using unit millimeter (mm).

Dimensions do not include burrs.

Projection method

Unless otherwise specified first-angle projection is applied.

16 ESD protection of SAW filters

SAW filters are **E**lectro **S**tatic **D**ischarge sensitive devices. To reduce the probability of damages caused by ESD, special matching topologies have to be applied.

In general, “ESD matching” has to be ensured at that filter port, where electrostatic discharge is expected.

Electrostatic discharges predominantly appear at the antenna input of RF receivers. Therefore, only the input matching of the SAW filter has to be designed to short circuit or to block the ESD pulse.

Below three figures show recommended “ESD matching” topologies.

For wide band filters the high-pass ESD matching structure needs to be at least of 3rd order to ensure a proper matching for any impedance value of antenna and SAW filter input. The required component values have to be determined from case to case.

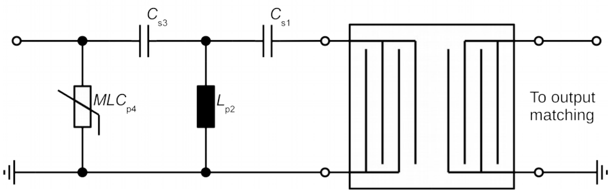

Figure 20: MLC varistor plus ESD matching.

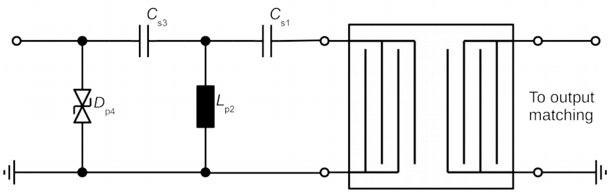

Figure 21: Suppressor diode plus ESD matching.

In cases where minor ESD occur, following simplified “ESD matching” topologies can be used alternatively.

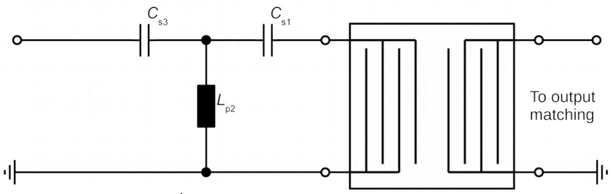

Figure 22: 3rd order high-pass structure for basic ESD protection.

In all three figures the shunt inductor L_{p2} could be replaced by a shorted microstrip with proper length and width. If this configuration is possible depends on the operating frequency and available PCB space.

Effectiveness of the applied ESD protection has to be checked according to relevant industry standards or customer specific requirements.

For further information, please refer to RF360 Application report: **“ESD protection for SAW filters”.** This report can be found under https://rffe.qualcomm.com.

17 Important notes

The following applies to all products named in this publication:

1. Some parts of this publication contain **statements about the suitability of our products for certain areas of application**. These statements are based on our knowledge of typical requirements that are often placed on our products in the areas of application concerned. We nevertheless expressly point out **that such statements cannot be regarded as binding statements about the suitability of our products for a particular customer application.** As a rule, RF360 Europe GmbH and its affiliates are either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always ultimately incumbent on the customer to check and decide whether an RF360 product with the properties described in the product specification is suitable for use in a particular customer application.
2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified.** In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or life-saving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.
3. **The warnings, cautions and product-specific notes must be observed.**
4. In order to satisfy certain technical requirements, **some of the products described in this publication may contain substances subject to restrictions in certain jurisdictions (e.g. because they are classed as hazardous)**. Useful information on this will be found in our Material Data Sheets on the Internet (https://rffe.qualcomm.com). Should you have any more detailed questions, please contact our sales offices.
5. We constantly strive to improve our products. Consequently, **the products described in this publication may change from time to time**. The same is true of the corresponding product specifications. Please check therefore to what extent product descriptions and specifications contained in this publication are still applicable before or when you place an order. We also **reserve the right to discontinue production and delivery of products**. Consequently, we cannot guarantee that all products named in this publication will always be available.
   The aforementioned does not apply in the case of individual agreements deviating from the foregoing for customer-specific products.