VMMK-3113
2 - 6 GHz Directional Detector in SMT Package

AVAGO TECHNOLOGIES

## Data Sheet

Lead (Pb) Free
RoHS 6 fully
compliant

Description

The VMMK-3113 is a small and easy-to-use, broadband, directional detector operating in various frequency bands from 2 to 6 GHz with typical insertion loss of 0.3 dB. It is housed in the Avago Technologies' industry-leading and revolutionary sub-miniature chip scale package (GaAsCap wafer scale leadless package) which is small and ultra thin yet can be handled and placed with standard 0402 pick and place assembly equipment. The VMMK-3113 provides a wide detecting power level from -5 to +36 dBm with excellent input and output return losses. A typical of 13 dB directivity is provided, and the detector requires only 1.5 V DC biasing with small current drawn of 0.18 mA.

WLP0402, 1 mm x 0.5 mm x 0.25 mm
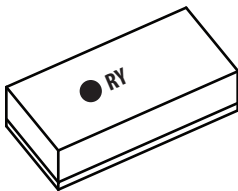
Pin Connections (Top View)
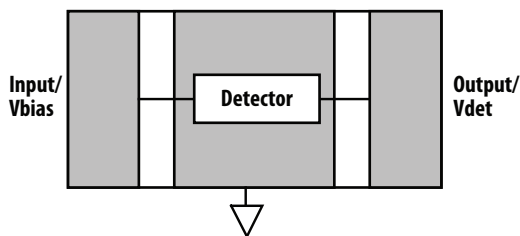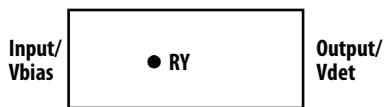
Note:
"R" = Device Code
"Y" = Month Code

Features

- 1 x 0.5 mm surface mount package
- Ultrathin (0.25 mm)
- Wide frequency range: 2 to 6 GHz
- Wide dynamic range
- Low Insertion loss
- Directivity: 10-13 dB typ.
- In and output match: 50 ohm

Specifications (4 GHz, Vb = 1.5 V, Zin = Zout = 50 Ω)

- Bias Current: 0.18 mA typical
- Insertion Loss: 0.25 dB
- Detector output offset voltage: 62 mV typical
- Detector Output voltage at +20 dBm: 830 mV typical

Applications

- Base Station
- Point-to-Point Radio
- Monitoring Power Amplifier Output Power
- Power Control Loop Detector

Electrical Specifications

Table 1. Absolute Maximum Rating [1]

Sym	Parameters/Condition	Unit	Absolute Max
Vbias	Bias Voltage (RF Input)	V	2
Ibias	Bias Current	mA	1
$P_{in, max}$	CW RF Input Power (RF Input) [2]	dBm	+37
Tch	Max channel temperature	°C	150

Notes
1. Operation of this device above any one of these parameters may cause permanent damage
2. With the DC (typical bias) and RF applied to the device at board temperature, Tb = 25° C

Table 2. DC and RF Specifications

T_A = 25° C, Freq = 4 GHz, V_b = 1.5 V, Z_{in} = Z_{out} = 50 Ω unless otherwise specified

| Symbol	Parameters / Condition	Unit	Min	Typical	Max
Ibias [1]	Bias Current	mA	0.11	0.18	0.25
I.L. [1]	Insertion Loss at 2 GHz at 4 GHz at 6 GHz	dB		 0.2 0.25 0.35	
IRL [1]	Input Return Loss at 2 GHz at 6 GHz	dB		 20 30	
ORL [1]	Output Return Loss at 2 GHz at 6 GHz	dB		 20 30	
Dir [2]	Directivity at 2 GHz at 6 GHz	dB		 13 10	
Voffset [1,3]	Detector output offset voltage	mV	45	62	75
Vdet [4]	Detector Output Voltage at +20 dBm	mV	710	830	950

Notes
1. Measured data obtained from wafer-probing, losses from measurement system de-embedded from final data, Vbias = 1.5 V applied through a broadband bias tee.
2. Measured by reversing the detector and applying RF power to the output port. Directivity is defined as the difference in dB between the power applied in the forward direction and the power required in the reverse direction to produce the same Vdet voltage.
3. Voffset is measured with RF input power turned off.
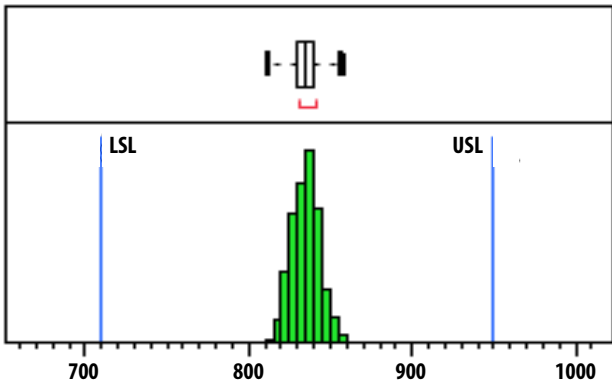4. Vdet is measured with +20 dBm RF input power at 4 GHz.

Product Consistency Distribution Charts at 4 GHz, Vbias = 1.5 V
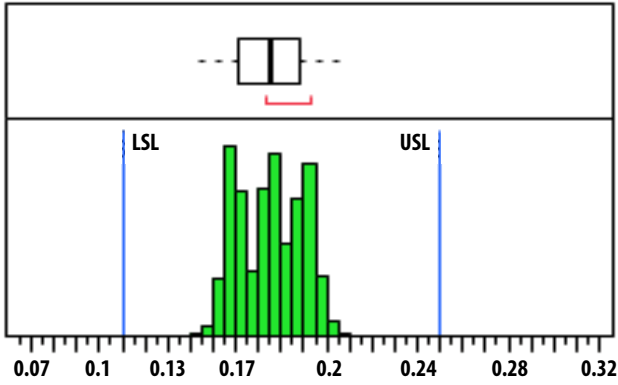
Ibias: Mean = 0.18 mA, LSL = 0.11 mA, USL = 0.25 mA
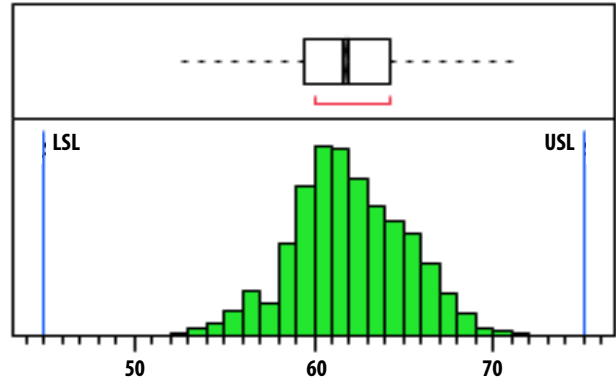
Voffset: Mean = 62 mV, LSL = 45 mV, USL = 75 mV

Notes:
Distribution data sample sized is based on at least 56 Kpcs taken from MPV lots.
Future wafers allocated to this product may have nominal values anywhere between the upper and lower limits.

Vdet_On @Pin = +20 dBm: Mean = 830 mV, LSL = 710 mV, USL = 950 mV

VMMK-3113 Typical Performance

S-parameter data obtained using 300 µm G-S-G probe substrate; bias was brought in via broadband bias tees. Power vs. Vdet data obtained using CPW PCB (Fig. 8). Losses calibrated out to the package reference plane.
(T_A = 25° C, Vbias = 1.5 V, Z_{in} = Z_{out} = 50 Ω unless otherwise specified)
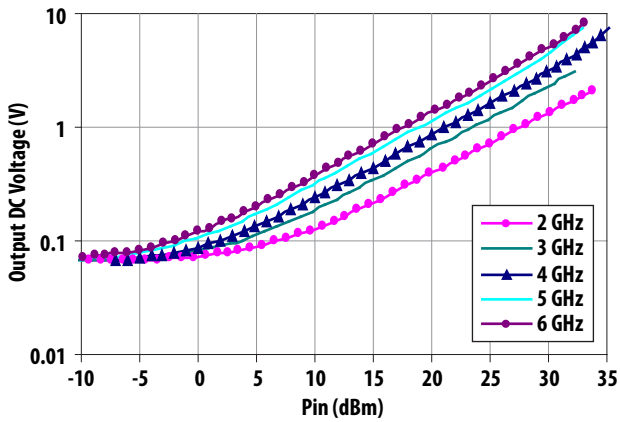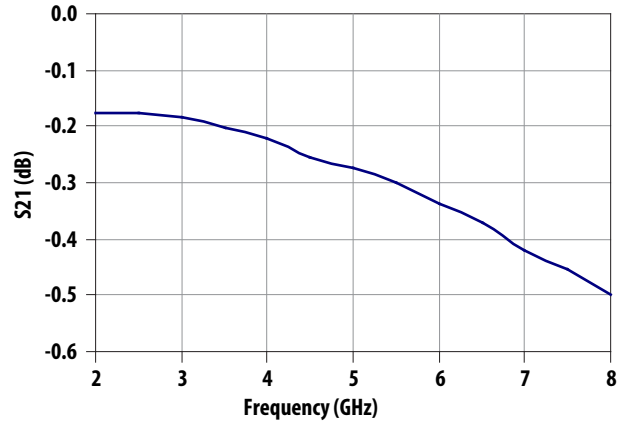

Figure 1. Vdet vs. Input Power

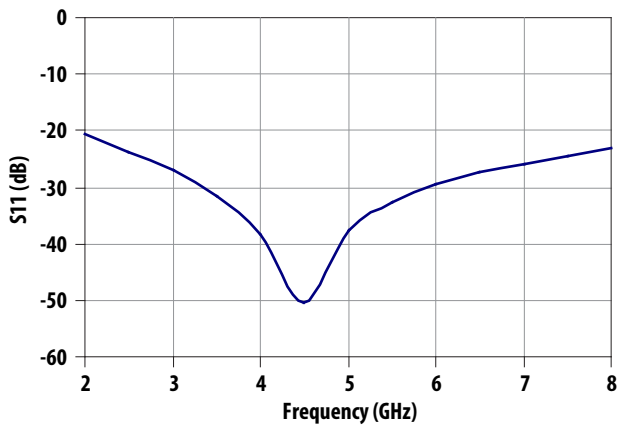Figure 2. Insertion Loss vs. Frequency

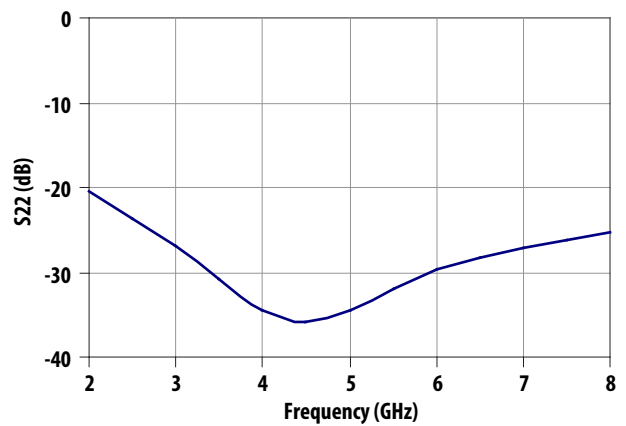Figure 3. Input Return Loss

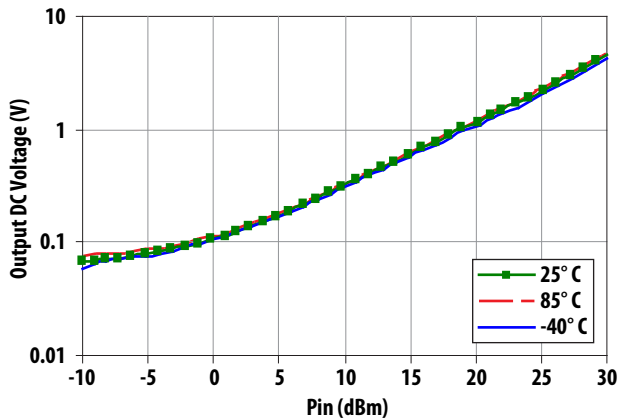Figure 4. Output Return Loss

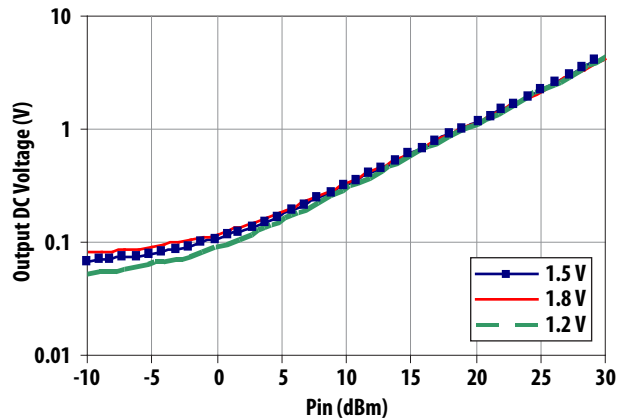Figure 5. Pin vs. Vdet Over Temperature at 5 GHz

Figure 6. Pin vs. Vdet Over Vbias at 5 GHz

4

Typical Scattering Parameters

Data obtained with 300 μm G-S-G probing on 0.016 inch thick PCB substrate, broadband bias tees, losses calibrated out to the package reference plane. $T_A = 25°\,C$, $Z_{in} = Z_{out} = 50\,\Omega$.

Freq GHz	S11 dB	Mag	Phase	S21 dB	Mag	Phase	S12 dB	Mag	Phase	S22 dB	Mag	Phase
2	-20.510	0.094	-93.247	-0.177	0.980	-6.266	-0.173	0.980	-6.180	-20.427	0.095	-101.463
2.5	-23.795	0.065	-96.729	-0.175	0.980	-10.918	-0.168	0.981	-10.844	-23.609	0.066	-109.386
3	-27.210	0.044	-100.439	-0.185	0.979	-15.053	-0.176	0.980	-14.995	-26.936	0.045	-120.474
3.5	-31.801	0.026	-106.901	-0.204	0.977	-18.956	-0.193	0.978	-18.874	-30.692	0.029	-133.388
4	-38.489	0.012	-116.523	-0.224	0.975	-22.697	-0.215	0.976	-22.629	-34.610	0.019	-156.714
4.5	-50.458	0.003	158.435	-0.252	0.971	-26.293	-0.246	0.972	-26.240	-35.756	0.016	159.280
5	-37.788	0.013	77.835	-0.278	0.969	-29.805	-0.276	0.969	-29.737	-34.289	0.019	121.538
5.5	-32.956	0.023	75.632	-0.304	0.966	-33.247	-0.304	0.966	-33.233	-31.972	0.025	107.389
6	-29.525	0.033	70.485	-0.340	0.962	-36.672	-0.332	0.963	-36.638	-29.709	0.033	94.364
6.5	-27.412	0.043	67.065	-0.376	0.958	-40.046	-0.370	0.958	-39.973	-28.156	0.039	85.050
7	-25.832	0.051	64.494	-0.419	0.953	-43.393	-0.413	0.954	-43.343	-27.092	0.044	79.658
7.5	-24.510	0.060	61.489	-0.455	0.949	-46.676	-0.457	0.949	-46.621	-26.125	0.049	75.308
8	-23.274	0.069	57.947	-0.497	0.944	-49.953	-0.493	0.945	-49.944	-25.224	0.055	71.475
8.5	-22.338	0.076	55.975	-0.545	0.939	-53.170	-0.535	0.940	-53.183	-24.792	0.058	67.661
9	-21.280	0.086	53.332	-0.593	0.934	-56.468	-0.581	0.935	-56.451	-24.308	0.061	64.388
9.5	-20.336	0.096	49.754	-0.628	0.930	-59.723	-0.636	0.929	-59.666	-23.649	0.066	61.034
10	-19.593	0.105	47.269	-0.679	0.925	-62.894	-0.675	0.925	-62.891	-23.375	0.068	57.891
10.5	-18.915	0.113	44.343	-0.727	0.920	-66.115	-0.718	0.921	-66.044	-22.999	0.071	55.712
11	-18.230	0.123	40.531	-0.773	0.915	-69.297	-0.772	0.915	-69.249	-22.627	0.074	53.202
11.5	-17.615	0.132	36.763	-0.823	0.910	-72.453	-0.817	0.910	-72.457	-22.639	0.074	50.226
12	-17.022	0.141	33.339	-0.873	0.904	-75.626	-0.870	0.905	-75.602	-22.350	0.076	47.382
12.5	-16.415	0.151	29.923	-0.924	0.899	-78.817	-0.927	0.899	-78.789	-22.103	0.079	44.734
13.5	-15.530	0.167	23.063	-1.028	0.888	-85.113	-1.028	0.888	-85.091	-21.777	0.082	40.253
14	-15.016	0.178	19.714	-1.079	0.883	-88.259	-1.074	0.884	-88.221	-21.598	0.083	38.324
14.5	-14.652	0.185	16.035	-1.124	0.879	-91.439	-1.124	0.879	-91.391	-21.587	0.083	36.581
15	-14.213	0.195	12.290	-1.184	0.873	-94.535	-1.183	0.873	-94.519	-21.525	0.084	32.464
15.5	-13.778	0.205	8.663	-1.238	0.867	-97.695	-1.244	0.867	-97.703	-21.391	0.085	29.879
16	-13.359	0.215	5.366	-1.303	0.861	-100.814	-1.298	0.861	-100.827	-21.100	0.088	25.740
16.5	-13.053	0.223	1.934	-1.357	0.855	-103.970	-1.352	0.856	-103.976	-21.250	0.087	23.284
17	-12.807	0.229	-1.698	-1.411	0.850	-107.100	-1.417	0.850	-107.115	-21.190	0.087	21.666
17.5	-12.421	0.239	-4.902	-1.466	0.845	-110.230	-1.468	0.845	-110.251	-21.051	0.089	18.287
18	-12.125	0.248	-9.010	-1.527	0.839	-113.397	-1.526	0.839	-113.352	-21.170	0.087	15.062
18.5	-11.737	0.259	-12.613	-1.583	0.833	-116.520	-1.589	0.833	-116.498	-20.848	0.091	10.368
19	-11.353	0.271	-16.280	-1.651	0.827	-119.573	-1.655	0.827	-119.567	-20.436	0.095	6.045
19.5	-11.103	0.279	-20.084	-1.708	0.822	-122.710	-1.704	0.822	-122.755	-20.355	0.096	4.124
20	-10.836	0.287	-23.825	-1.768	0.816	-125.834	-1.770	0.816	-125.851	-20.265	0.097	1.197

VMMK-3113 Biasing Information

Biasing and Operation

The VMMK-3113 is a 3 terminal device consisting of a "through" 50 ohm line connecting directly between the RF Input and RF Output ports, and a directional coupler with a full wave detector that provides a dc output proportional to RF power input. As with any high frequency device, good grounding is required on the common port under the device for it to produce low loss in the "through" mode. A suggested PCB layout with appropriate grounding will be cover later in the application section.

With only 3 terminals available, the DC bias and detected voltage are internally dc coupled to the input and output terminals respectively. The key to successful operation of the VMMK-3113 is the use of low loss bias decoupling networks connected to both the RF Input and the RF Output ports. Figure 7 shows a simple biasing circuit.

The bias decoupling networks provide a low loss ac coupled RF path to the device, a means of biasing the device on the input, and a means of extracting the detected voltage on the output of the device. Bias decoupling networks in the 2 to 6 GHz frequency range can be easily produced using simple lumped resistors and lumped capacitors. All SMT components are suggested to be of 0402 or 0201 size. The detector needs two DC blocking caps, C1 and C2, on the

input and output ports. This can be accomplished by using SMT capacitors with values chosen for the frequency of operation; e.g. 3.9 pF is suggested for 3-5GHz operation Nominal bias voltage of 1.5 V or 0.16 mA is required for proper operation. Biasing on the input is by a way of a large value resistor R1. Its value can be computed using the following equation:
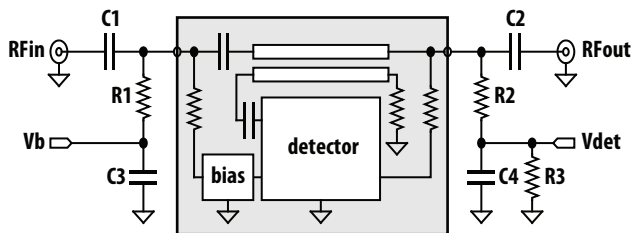
$$R1 = (Vb - 1.5) / 0.00015$$

where Vb is the supply voltage.

Detected DC voltage is extracted on the output by a way of a large value resistor R2, in the range of 10 kΩ. Bypassing capacitors C3 and C4 are needed to prevent RF influence on the dc lines. Suggested value for bypass capacitors is 1 pF.

At zero RF input power, and at 1.5 V supply bias, a nominal 62 mV offset voltage appears at the detected output port. The internal output source resistance for the detector is approximately 20 kΩ. Resistor R3 can be used as an external load resistor for the detector. Its value can be optimized for the desired Vout vs. RF input curve.

Figure 8 shows a photo of a VMMK-3113 populated PCB used to obtain the Vdet vs. Input Power characterization data from 2 to 6 GHz.

Component	Description
C1, C2	2 pF to 8 pF
R1	(Vb - 1.5) / 0.00015 Ω
R2	10 kΩ
C3, C4	1 pF to 2 pF
R3	External load resistor (optional)

Figure 7. Biasing the VMMK-3113 Detector Module

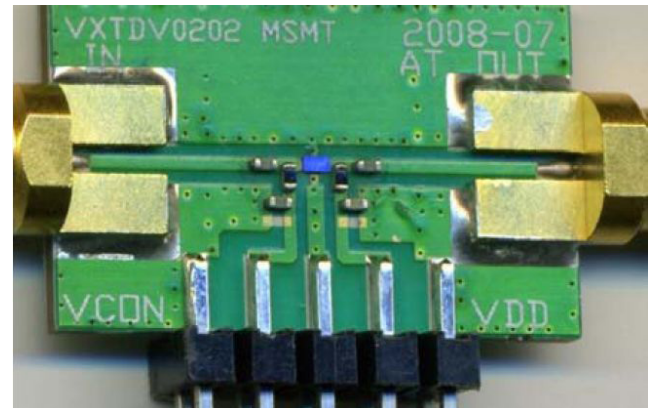Pins: GND   Vb   GND   Cdet   GND

Figure 8. VMMK-3113 Charaterization Board

S Parameter Measurements

The S-parameters are measured on a 0.016 inch thick RO4003 printed circuit test board, using 300 µm G-S-G (ground signal ground) probes. Coplanar waveguide is used to provide a smooth transition form the probes to the device under test. The presence of the ground plane on top of the test board results in excellent grounding at the device under test. A combination of SOLT (Short – Open – Load – Thru) and TRL (Thru - Reflect - Line) calibration techniques are used to correct for the effects of the test board, resulting in accurate device S parameters.

Package and Assembly Notes

For detailed description of the device package and assembly notes, please refer to Application Note 5378.

ESD Precautions

Note: These devices are ESD sensitive. The following precautions are strongly recommended. Ensure that an ESD approved carrier is used when die are transported from one destination to another. Personal grounding is to be worn at all times when handling these devices. For more detail, refer to Avago Application Note A004R: Electrostatic Discharge Damage and Control.

Ordering Information

Part Number	Devices Per Container	Container
VMMK-3113-BLKG	100	Antistatic Bag
VMMK-3113-TR1G	5000	7" Reel

Package Dimension Outline
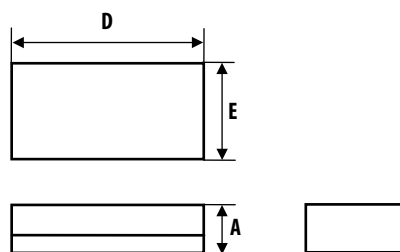
Dimensions Symbol	Min (mm)	Max (mm)
E	0.500	0.585
D	1.004	1.085
A	0.225	0.275

Note:
All dimensions are in mm

Reel Orientation

REEL

USER FEED DIRECTION

CARRIER TAPE

Device Orientation

USER FEED DIRECTION

4 mm

8 mm

TOP VIEW

END VIEW
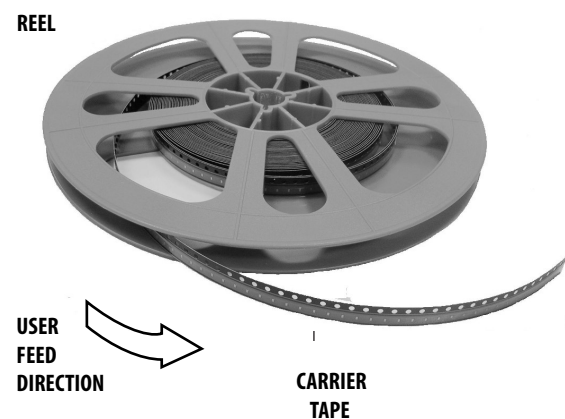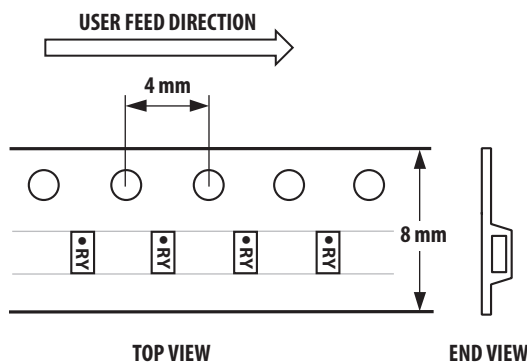
Notes:
"R" = Device Code
"Y" = Month Code

Tape Dimensions

Scale 5:1
A–A SECTION

Ao = 0.73±0.05 mm

Bo = 1.26±0.05 mm

Ko = 0.35 $^{+0.05}_{+0}$ mm
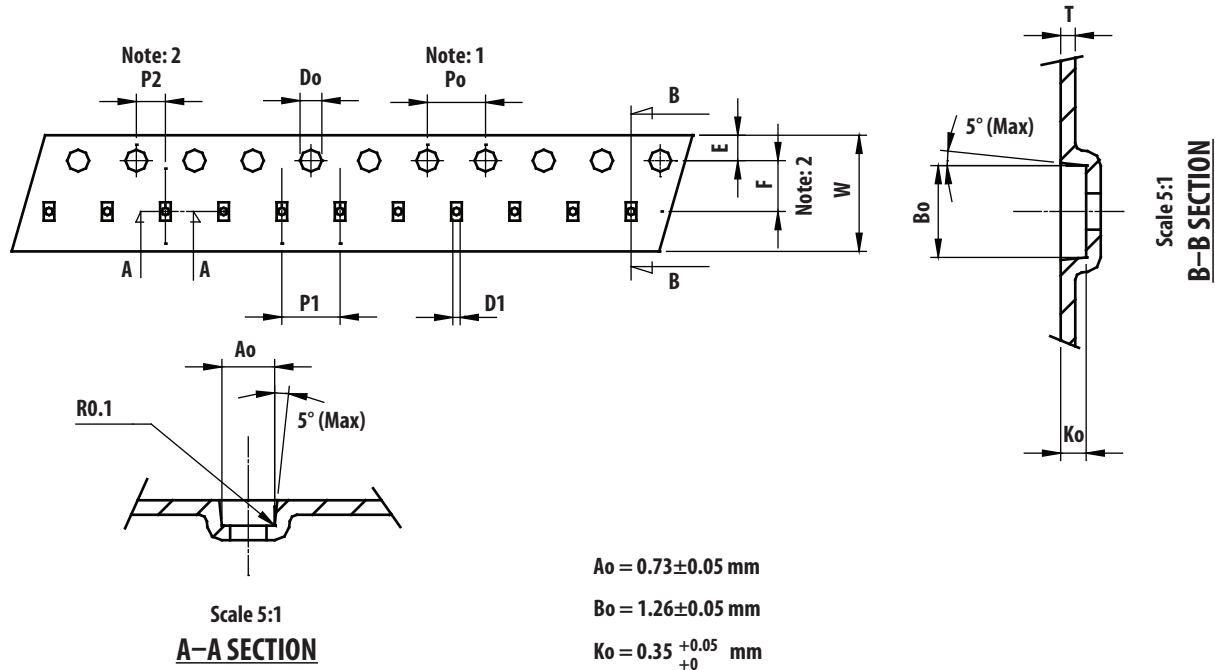
Unit: mm

Symbol	Spec.
K1	–
Po	4.0±0.10
P1	4.0±0.10
P2	2.0±0.05
Do	1.55±0.05
D1	0.5±0.05
E	1.75±0.10
F	3.50±0.05
10Po	40.0±0.10
W	8.0±0.20
T	0.20±0.02

Notice:
1. 10 Sprocket hole pitch cumulative tolerance is ±0.1 mm.
2. Pocket position relative to sprocket hole measured as true position of pocket not pocket hole.
3. Ao & Bo measured on a place 0.3 mm above the bottom of the pocket to top surface of the carrier.
4. Ko measured from a plane on the inside bottom of the pocket to the top surface of the carrier.
5. Carrier camber shall be not than 1 m per 100 mm through a length of 250 mm.

For product information and a complete list of distributors, please go to our web site: **www.avagotech.com**

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