Using Vishay Infrared Receivers in a Wi-Fi Environment

By Michael Laemmlen and John Fisher

In recent years, Wi-Fi connectivity has penetrated most consumer electronic devices used for media reproduction. New TVs, satellite receiver and cable boxes, and streaming devices are more often than not built with Wi-Fi capabilities at multiple frequencies: 2.4 GHz and 5 GHz. Most of these appliances continue to support an infrared (IR)-based remote control link, often even when the device also supports a newer RF-based remote control.

IR remote control receivers are built with highly sensitive wideband input stages and are able to detect signals near the noise level of their circuitry. In noisy environments, such as with both low- and high-frequency electromagnetic interference (EMI), the receiver may be noise-triggered, typically manifesting itself in the form of spurious pulses at its output. Most Vishay IR receiver packages are designed with metal shields to effectively guard the receiver against low-frequency EMI. However, these metal shields have not proven entirely satisfactory against high-frequency EMI in the GHz range used for Wi-Fi.

Empirical testing has shown that a number of factors play a role in the robustness of a package to RF noise. The internal shield design, differences in receiver IC design, the automatic gain control (AGC) setting programmed into the chip: all of these factors affect the receiver's sensitivity to RF. Metal holders may improve or worsen RF robustness, depending on their design. Adding RF capacitors between the supply and ground, and between the output and ground, is another proven - albeit expensive - method to improve the RF rejection. Such capacitors may serve as an emergency measure once an RF problem is detected when a design is already in an advanced stage. The primary design goal, however, is to not require them. The most significant factors governing whether an IR receiver exhibits RF triggered noise are the power level of the RF signal and the distance the receiver package is mounted away from the RF antenna. Lowering the power and increasing the distance both lower the chance of disturbance.

In this application note, the effects of all these factors are quantified as an aid to selecting the most appropriate Vishay IR receivers in Wi-Fi environments. Testing methodology and test data supporting the recommendations are presented.

TEST METHODOLOGY

Test Equipment

The RF signal source used for all the tests was an off-the-shelf WLAN router in combination with a USB network interface controller (NIC) fulfilling the IEEE 802.11ac specification for 5 GHz and IEEE 802.11n for 2.4 GHz. The USB NIC had a maximum output power of 200 mW and contained an integrated RF antenna. It was observed in all tests that the device under test (DUT) was more sensitive to noise at 5 GHz at a power level of 200 mW than to the less powerful noise at 2.4 GHz at 100 mW. A repeatable RF noise environment was created by placing the test board containing the DUT at a measured distance from the NIC antenna. A streaming routine was then initiated that sent a large file from the NIC to the router.

Test PCB Layout and Spatial Location with Respect to the RF Antenna

Bare TSOP38138 mounted on a test PCB

Fig. 1

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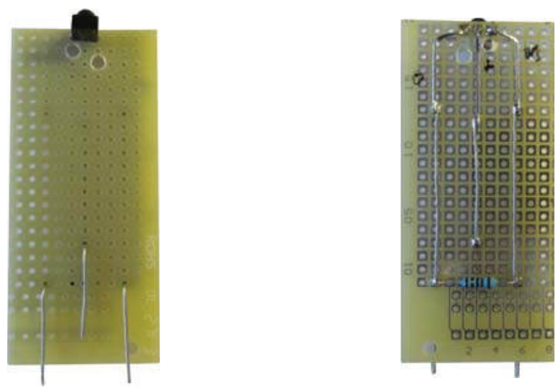

Front of PCB

Back of PCB
(with 1 kΩ pull-up for fast edges, no capacitor)

Fig. 2

Note

- For tests with metal holders, the holders were always connected to GND potential.

The length of each supply and output line was 0.5 m. To avoid coupling effects, no crossovers or turns in leads were allowed.

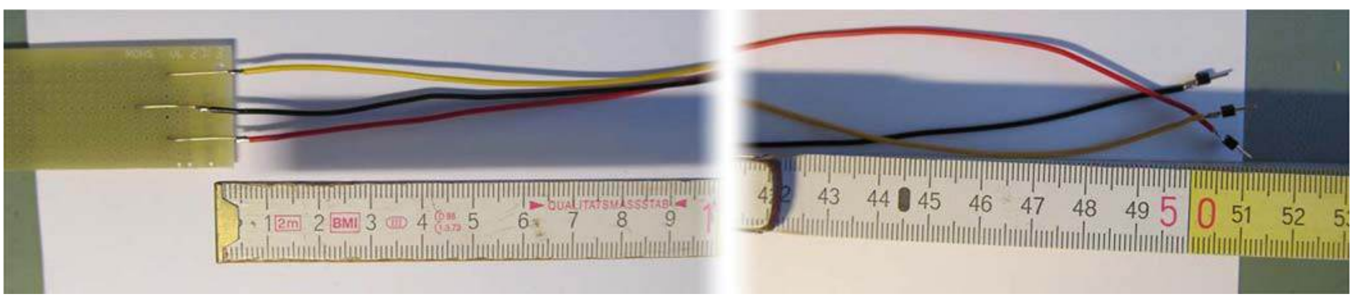

Fig. 3

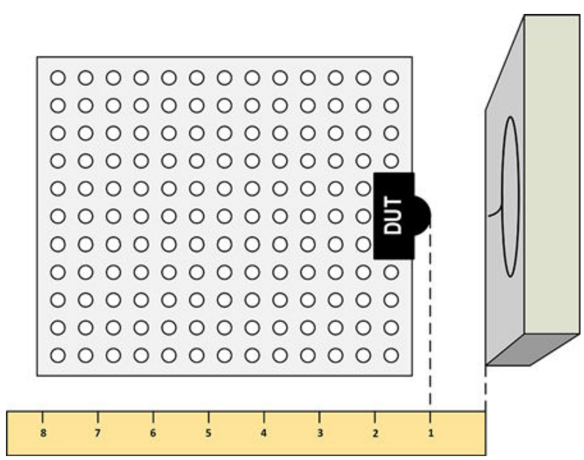

Fig. 4

The DUT was positioned a known distance from the RF antenna prior to transmission of the RF test pattern.

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Test Conditions

All measurements were performed in dark ambient. IR receivers contain an AGC that reacts to the ambient light levels. In dark ambients, the receiver's gain will settle to its maximum sensitivity level, thus providing a repeatable known state. This maximum gain level is also the operating condition most susceptible to seeing a disturbance from noise.

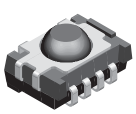
Measurement 1: the DUT was mounted at a set distance from the RF antenna. The RF data transmission was then initiated from the NIC to the router, and any spurious pulses at the output of the IR receiver were counted within 60-second intervals. This procedure was repeated several times, and an average value was calculated. The test board was then moved to a new position from the antenna and the test was repeated.

Measurement 2: the distance between the DUT and the RF antenna was adjusted during data transmission to find the "threshold" distance. The threshold distance is defined as the minimum distance between the DUT and the antenna for which there is no significant disturbance to the IR receiver. At distances closer than the threshold, spurious pulses became a problem. At distances equal to and further than the threshold, no noise issues could be observed.

Note

- In all tables, an orange tinted background denotes devices containing the "Aether" receiver IC, the devices with a green tinted background contain the "Methone" receiver IC. The Methone IC architecture is generally more robust against RF noise.

SUMMARY OF TEST RESULTS: SURFACE-MOUNT PACKAGES

PACKAGE	FREQUENCY (GHz)	DUT	5 cm	3 cm	1 cm	0 cm	THRESHOLD (cm)
Panhead 	2.4	TSOP36338	0	0	0	700	1
		TSOP36438	0	0	0	100	1
		TSOP6338	0	0	0	0	0
		TSOP6438	0	0	0	0	0
	5	TSOP36338	> 20 000	> 20 000	> 20 000	> 20 000	19
		TSOP36438	2300	2700	2800	2700	19
		TSOP6338	800	15 000	15 000	17 000	11
		TSOP6438	30	250	3000	7000	6
Heimdall 	2.4	TSOP75338	0	0	0	250	1
		TSOP75438	0	0	0	170	1
		TSOP77338	0	0	0	0	0
		TSOP77438	0	0	0	0	0
	5	TSOP75338	9000	9300	15 000	> 20 000	11
		TSOP75438	700	1100	1900	2700	11
		TSOP77338	0	0	0	0	0
		TSOP77438	0	0	0	0	0
Belobog 	2.4	TSOP37338	0	0	20	7000	2
		TSOP37438	0	0	0	400	1
		TSOP57338	0	0	0	0	0
		TSOP57438	0	0	0	0	0
	5	TSOP37338	1300	8000	10 000	> 20 000	10
		TSOP37438	900	1700	2300	5000	10
		TSOP57338	0	0	0	8000	1
		TSOP57438	0	0	0	4000	1

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SUMMARY OF TEST RESULTS: LEADED PACKAGES WITHOUT HOLDER

PACKAGE	FREQUENCY (GHz)	DUT	5 cm	3 cm	1 cm	0 cm	THRESHOLD (cm)
Minicast 	2.4	TSOP38338	0	0	2000	5000	2
		TSOP38438	0	0	300	500	2
		TSOP58338	0	0	0	0	0
		TSOP58438	0	0	0	0	0
	5	TSOP38338	900	4700	12 500	> 20 000	10
		TSOP38438	150	600	800	1800	6
		TSOP58338	0	0	0	300	1
		TSOP58438	0	0	0	300	1
Mold 	2.4	TSOP34338	0	30	12000	15 000	4
		TSOP34438	0	20	1200	1300	4
		TSOP4338	0	0	0	0	0
		TSOP4438	0	0	0	0	0
	5	TSOP34338	< 20 000	< 20 000	< 20 000	< 20 000	18
		TSOP34438	2500	3000	3500	4200	16
		TSOP4338	0	20	7000	15 500	4
		TSOP4438	0	10	1900	3000	4
Minimold 	2.4	TSOP33338	0	0	60	3000	2
		TSOP33438	0	0	0	80	1
		TSOP53338	0	0	0	0	0
		TSOP53438	0	0	0	0	0
	5	TSOP33338	2400	16 000	20 000	> 20 000	17
		TSOP33438	500	1300	1700	2700	15
		TSOP53338	0	0	0	400	1
		TSOP53438	0	0	0	400	1

Note

- The results shown in the table for leaded packages without holders are also valid when using these parts in plastic holders. Vishay makes a wide variety of holders in both plastic and metal. The plastic material has no effect on the RF characteristics. If the base part has acceptable RF characteristics for an application, it is safe to use the same part in combination with a plastic holder. Metal holders usually will change the RF characteristics, sometimes for the worse. But with careful design, it can be shown that metal holders can also be constructed that achieve an even higher robustness than the base part. This is the topic of the next section.

TEST RESULTS OF LEADED PARTS WITH A SELECTION OF METAL HOLDERS

A metal holder is one of the few practical means of changing the RF characteristics of a particular IR receiver once it is already in production. Given that a holder is often required in many chassis designs in order to accurately position the receiver behind an IR window, any gains that can be achieved in RF shielding via the holder are then a bonus. A study was undertaken to compare the RF suppression of the base part with several standard metal holders, these same metal holders modified by encasing them as fully as possible with copper sheet, and the same metal holders with an additional ground connection on the front face but without a copper sheet. The testing was only carried out on AGC1 and AGC3 type parts. AGC1 and AGC3 typically perform worse than AGC4, for example, with respect to RF noise suppression. The rationale for testing with these less robust, odd-numbered AGCs was to achieve a more easily observable effect from our tests, as a holder design cannot be shown to improve performance if the base part already fully suppresses the noise. The reader should keep in mind that generally, the results will be better than those presented here for AGC4 type parts. Vishay recommends using AGC4 whenever the burst lengths in your data are all longer than 10 carrier cycles.

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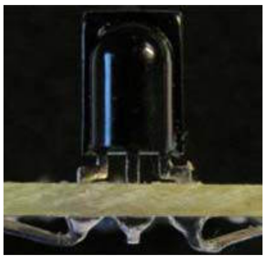
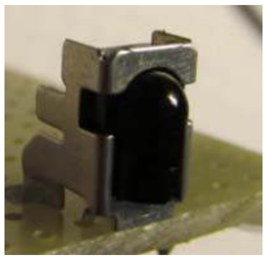
Minicast Package with Metal Holders CA1, CB1, and CC1

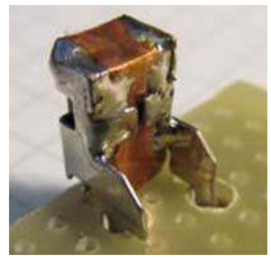
TSOP38138 and TSOP58138 bare parts and with a CA1 holder in three versions:



TSOP38138
TSOP58138



Standard CA1



CA1 holder, Cu shield

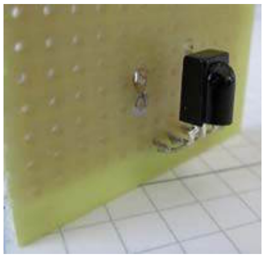
CA1 face GND

SUMMARY OF TEST RESULTS

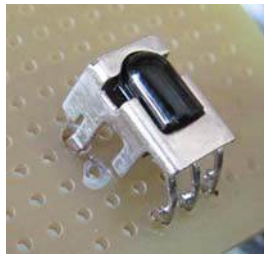
PACKAGE	FREQUENCY (GHz)	DUT	5 cm	3 cm	1 cm	0 cm	THRESHOLD (cm)
Minicast CA1 	2.4	TSOP38138 base part	0	0	10	12 000	2
		TSOP38138 CA1 standard	0	0	3	9300	1
		TSOP38138 CA1 Cu shield	0	0	12	9000	2
		TSOP38138 CA1 face GND	0	0	0	40	1
		TSOP58138 base part	0	0	0	0	0
		TSOP58138 CA1 standard	0	0	0	0	0
		TSOP58138 CA1 face GND	0	0	0	0	0
	5	TSOP38138 base part	140	1800	12 500	> 20 000	8
		TSOP38138 CA1 standard	0	130	3900	14 000	5
		TSOP38138 CA1 Cu shield	0	285	1700	18 200	5
		TSOP38138 CA1 face GND	0	0	700	14 000	2
		TSOP58138 base part	0	0	60	2200	2
		TSOP58138 CA1 standard	0	0	0	0	0
		TSOP58138 CA1 face GND	0	0	0	0	0

Using Vishay Infrared Receivers in a Wi-Fi Environment

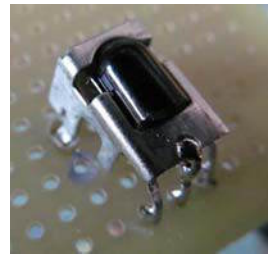
TSOP38138 and TSOP58138 bare parts and with a CB1 holder in two versions:



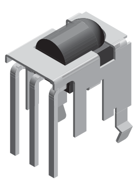
TSOP38138
TSOP58138



Standard CB1



CB1 face GND

SUMMARY OF TEST RESULTS							
PACKAGE	**FREQUENCY (GHz)**	**DUT**	**5 cm**	**3 cm**	**1 cm**	**0 cm**	**THRESHOLD (cm)**
Minicast CB1 	2.4	TSOP38138 base part	5	50	5500	> 20 000	5
		TSOP38138 CB1 standard	0	1	600	> 20 000	2
		TSOP38138 CB1 face GND	700	4500	> 20 000	> 20 000	9
		TSOP58138 base part	0	0	0	0	0
		TSOP58138 CB1 standard	0	0	0	0	0
		TSOP58138 CB1 face GND	0	0	0	0	0
	5	TSOP38138 base part	> 20 000	> 20 000	> 20 000	> 20 000	25
		TSOP38138 CB1 standard	1	250	250	> 20 000	4
		TSOP38138 CB1 face GND	0	0	1	> 20 000	1
		TSOP58138 base part	0	0	100	> 20 000	2
		TSOP58138 CB1 standard	0	0	0	4	0
		TSOP58138 CB1 face GND	0	0	0	30	1

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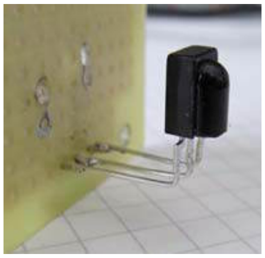
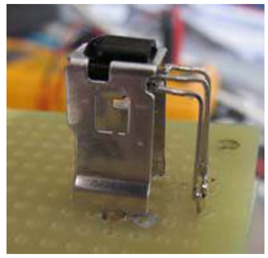
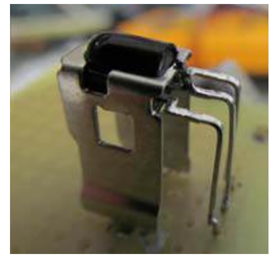
TSOP38138 and TSOP58138 bare parts and with a CC1 holder in two versions:



TSOP38138
TSOP58138

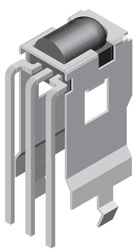


Standard CC1



CC1 face GND

SUMMARY OF TEST RESULTS

PACKAGE	FREQUENCY (GHz)	DUT	5 cm	3 cm	1 cm	0 cm	THRESHOLD (cm)
Minicast CC1 	2.4	TSOP38138 base part	0	3	60	2000	2
		TSOP38138 CC1 standard	0	0	10 000	> 20 000	3
		TSOP38138 CC1 face GND	0	20	4000	> 20 000	4
		TSOP58138 base part	0	0	0	0	0
		TSOP58138 CC1 standard	0	0	0	0	0
		TSOP58138 CC1 face GND	0	0	0	0	0
	5	TSOP38138 base part	14 500	> 20 000	> 20 000	> 20 000	12
		TSOP38138 CC1 standard	700	10 000	> 20 000	> 20 000	8
		TSOP38138 CC1 face GND	500	13 000	> 20 000	> 20 000	8
		TSOP58138 base part	0	0	20	> 20 000	2
		TSOP58138 CC1 standard	0	0	0	500	1
		TSOP58138 CC1 face GND	0	0	0	6000	1

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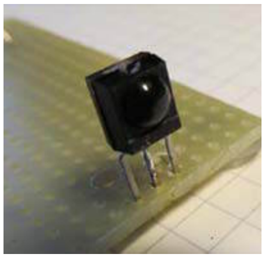
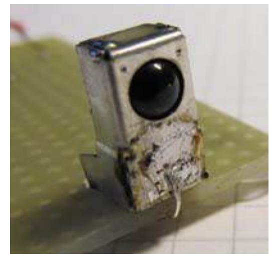
Mold Package with Metal Holders JH1, CD1, and CZ1

TSOP34338 and TSOP4338 bare parts and with a JH1 holder in two versions:

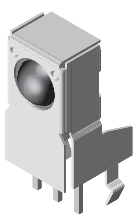


TSOP34338
TSOP4338

Standard JH1



JH1 face GND

SUMMARY OF TEST RESULTS							
PACKAGE	**FREQUENCY (GHz)**	**DUT**	**5 cm**	**3 cm**	**1 cm**	**0 cm**	**THRESHOLD (cm)**
Mold JH1 	2.4	TSOP34338 base part	0	0	600	10 000	2
		TSOP34338 JH1 standard	0	0	3000	16 500	2
		TSOP34338 JH1 face GND	0	0	1500	15 000	2
		TSOP4338 base part	0	0	0	0	0
		TSOP4338 JH1 standard	0	0	0	0	0
		TSOP4338 JH1 face GND	0	0	0	0	0
	5	TSOP34338 base part	< 20 000	< 20 000	< 20 000	< 20 000	13
		TSOP34338 JH1 standard	0	0	2	2200	1
		TSOP34338 JH1 face GND	0	4	2500	< 20 000	2
		TSOP4338 base part	20	4000	16 200	17 600	6
		TSOP4338 JH1 standard	0	0	0	1	0
		TSOP4338 JH1 face GND	0	0	0	5	0

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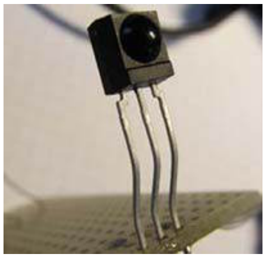
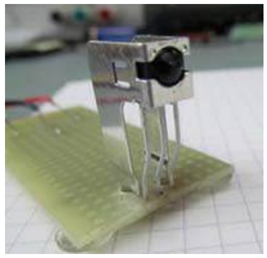
TSOP34338 and TSOP4338 bare parts and with a CD1 holder in three versions:

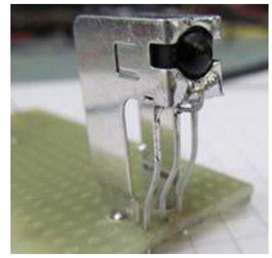


TSOP34338
TSOP4338

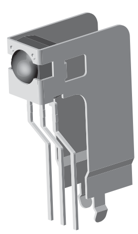


Standard CD1

CD1 Cu strip

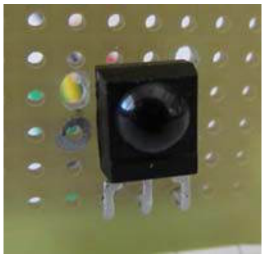


CD1 face GND

SUMMARY OF TEST RESULTS							
PACKAGE	**FREQUENCY (GHz)**	**DUT**	**5 cm**	**3 cm**	**1 cm**	**0 cm**	**THRESHOLD (cm)**
Mold CD1 	2.4	TSOP34338 base part	0	25	6100	12 000	4
		TSOP34338 CD1 standard	0	2	9000	17 400	3
		TSOP34338 CD1 Cu shield	0	0	6500	13 000	3
		TSOP34338 CD1 face GND	0	0	5	70	1
		TSOP4338 base part	0	0	0	0	0
		TSOP4338 CD1 standard	0	0	0	0	0
		TSOP4338 CD1 face GND	0	0	0	0	0
	5	TSOP34338 base part	9000	13 500	> 20 000	> 20 000	17
		TSOP34338 CD1 standard	> 20 000	> 20 000	> 20 000	> 20 000	28
		TSOP34338 CD1 Cu shield	22	3600	> 20 000	> 20 000	7
		TSOP34338 CD1 face GND	17 500	> 20 000	> 20 000	> 20 000	20
		TSOP4338 base part	0	0	13 000	> 20 000	3
		TSOP4338 CD1 standard	0	400	17 000	> 20 000	5
		TSOP4338 CD1 face GND	0	0	200	8000	2

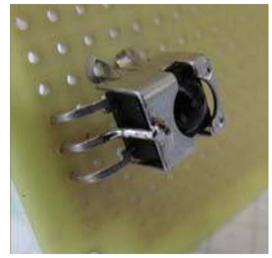
Using Vishay Infrared Receivers in a Wi-Fi Environment

TSOP34338 and TSOP4338 bare parts and with a CZ1 holder in two versions:



TSOP34338
TSOP4338

Standard CZ1



CZ1 face GND

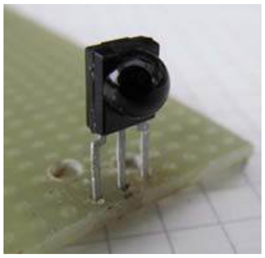
SUMMARY OF TEST RESULTS

PACKAGE	FREQUENCY (GHz)	DUT	5 cm	3 cm	1 cm	0 cm	THRESHOLD (cm)
Mold CZ1 	2.4	TSOP34338 base part	0	10	2300	11 000	4
		TSOP34338 CZ1 standard	0	1	1500	11 000	3
		TSOP34338 CZ1 face GND	300	2500	15 000	> 20 000	8
		TSOP4338 base part	0	0	0	0	0
		TSOP4338 CZ1 standard	0	0	0	0	0
		TSOP4338 CZ1 face GND	0	0	0	0	0
	5	TSOP34338 base part	5000	18 000	> 20 000	> 20 000	13
		TSOP34338 CZ1 standard	4500	> 20 000	> 20 000	> 20 000	10
		TSOP34338 CZ1 face GND	0	15	100	16 500	4
		TSOP4338 base part	0	0	8000	> 20 000	2
		TSOP4338 CZ1 standard	0	0	500	20 000	2
		TSOP4338 CZ1 face GND	0	0	0	500	1

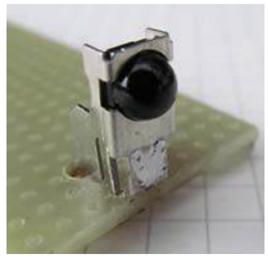
Using Vishay Infrared Receivers in a Wi-Fi Environment

Minimold Package with Metal Holders CA1

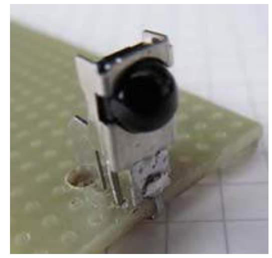
TSOP33338 and TSOP53338 bare parts and with a CA1 holder in two versions:



TSOP33338
TSOP53338



Standard CA1



CA1 face GND

SUMMARY OF TEST RESULTS

PACKAGE	FREQUENCY (GHz)	DUT	5 cm	3 cm	1 cm	0 cm	THRESHOLD (cm)
Minimold CA1 	2.4	TSOP33338 base part	0	0	30	2000	2
		TSOP33338 CA1 standard	0	0	100	5000	2
		TSOP33338 CA1 face GND	0	0	0	3	0
		TSOP53338 base part	0	0	0	0	0
		TSOP53338 CA1 standard	0	0	0	0	0
		TSOP53338 CA1 face GND	0	0	0	0	0
	5	TSOP33338 base part	5000	19 000	> 20 000	> 20 000	13
		TSOP33338 CA1 standard	0	400	1800	4000	5
		TSOP33338 CA1 face GND	1	50	4500	> 20 000	5
		TSOP53338 base part	0	0	0	0	0
		TSOP53338 CA1 standard	0	0	0	0	0
		TSOP53338 CA1 face GND	0	0	0	0	0