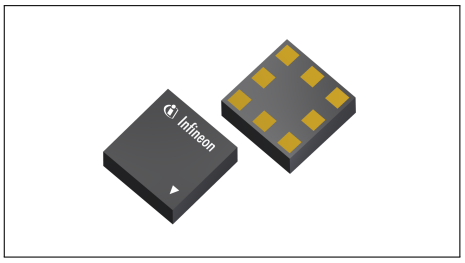
# BGSA12UGL8

## Low Resistance SPDT Antenna Aperture Switch

### Features

- SPDT designed for high-linearity antenna aperture switching and RF tuning applications
- Ultra low $R_{ON}$ resistance of 0.59 Ω at each port in ON state
- Low $C_{OFF}$ capacitance of 270 fF at each port in OFF state
- > 40 V RF voltage OFF state handling
- Low harmonic generation
- Supply voltage range: 1.65 to 3.6 V
- Small form factor 1.1 mm x 1.1 mm
- RoHS and WEEE compliant package



1.1 x 1.1 mm$^2$

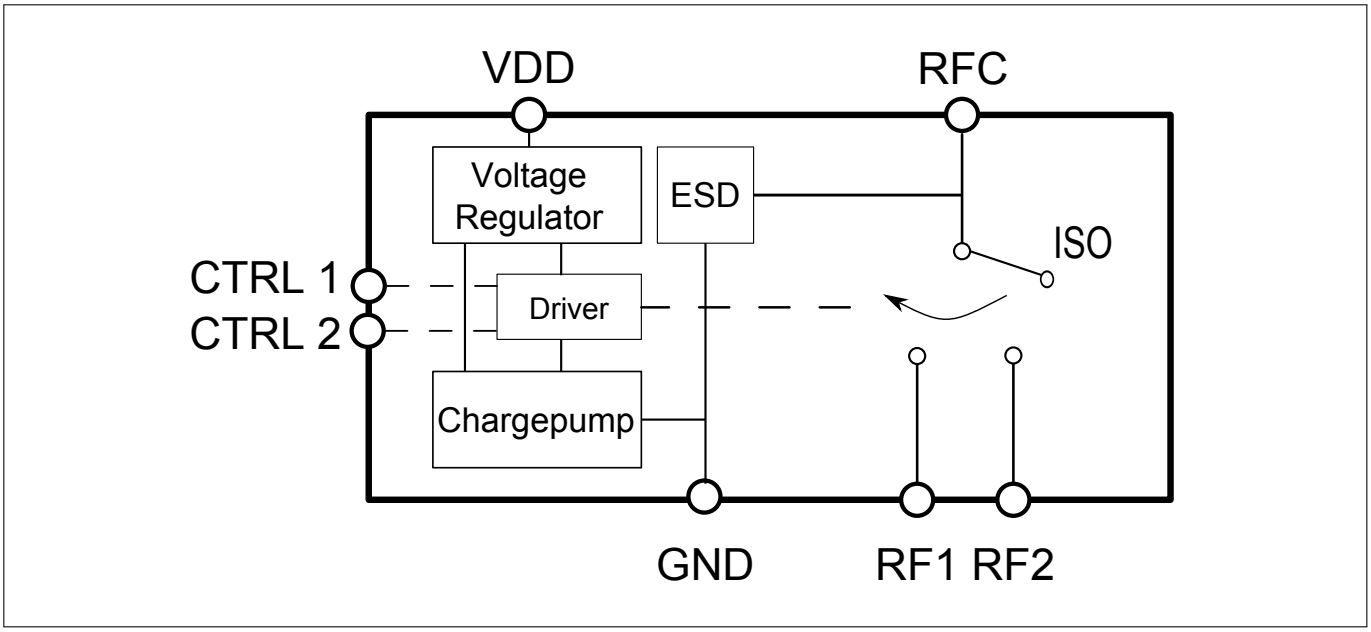
### Application

- Impedance Tuning
- Antenna Tuning
- Inductance Tuning
- Tunable Filters

### Product Validation

Qualified for industrial applications according to the relevant tests of JEDEC47/20/22.

### Block diagram



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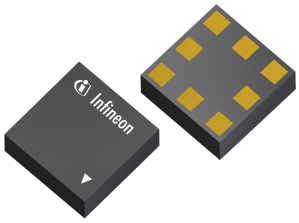
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# 1 Features




- SPDT designed for high-linearity antenna aperture switching and RF tuning applications
- Ultra low $R_{ON}$ resistance of 0.59 Ω at each port in ON state
- Low $C_{OFF}$ capacitance of 270 fF at each port in OFF state
- > 40 V RF voltage OFF state handling
- Low harmonic generation
- GPIO control interface - including 4 control states
- Supply voltage range: 1.65 to 3.6 V
- No RF parameter change within supply voltage range
- Small form factor 1.1 mm x 1.1 mm
- Suitable for EDGE/ CDMA/WCDMA/ C2K/ LTE Applications
- RoHS and WEEE compliant package

## Description

The BGSA12UGL8 is a versatile Single Pole Double Throw (SPDT) RF antenna aperture switch optimized for low $C_{OFF}$ as well as low $R_{ON}$ enabling applications up to 6.0 GHz. This single supply chip integrates with a 2 bits control logic featuring also a low current standby mode. Unlike GaAs technology, the 0.1 dB compression point exceeds the switch maximum input power level, resulting in linear performance at all signal levels and external DC blocking capacitors at the RF ports are only required if DC voltage is applied externally. Due to its very high RF voltage ruggedness, it is suited for switching any reactive devices such as inductors and capacitors in RF matching circuits without significant losses in quality factors.

| Product Name | Marking | Package |
|---|---|---|
| BGSA12UGL8 | A | TSLP-8-1 |

# 2 Maximum Ratings

**Table 1: Maximum Ratings, Table I** at $T_A$ = 25 °C, unless otherwise specified

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Frequency Range | $f$ | 0.4 | – | – | GHz | [1] |
| Supply voltage [2] | $V_{DD}$ | -0.5 | – | 6 | V | only for infrequent and short duration time periods |
| Storage temperature range | $T_{STG}$ | -55 | – | 150 | °C | – |
| RF input power | $P_{RF_max}$ | – | – | 41 | dBm | Pulsed RF input duty cycle of 25 % and 4620 µs in ON-state, measured per 3GPP TS 45.005, test condition schematic in Fig. 2 and Fig. 3. |
| RF voltage | $V_{RF_max}$ | – | – | 50 | V | Short term peaks (1 µs in 0.1 % duty cycle), exceeding typical linearity, $R_{ON}$ and $C_{OFF}$ parameters, in Isolation mode, test condition schematic in Fig. 1 |
| ESD capability, CDM [3] | $V_{ESD,CDM}$ | -1 | – | +1 | kV | |
| ESD capability, HBM [4] | $V_{ESD,HBM}$ | -1 | – | +1 | kV | |
| ESD capability, system level (RF port) [5] | $V_{ESD,ANT}$ | -8 | – | +8 | kV | RFx vs system GND, with 27 nH shunt inductor |
| Junction temperature | $T_J$ | – | – | 125 | °C | – |
| Maximum DC-voltage on RF-Ports and RF-Ground | $V_{RFDC}$ | 0 | – | 0 | V | No DC voltages allowed on RF-Ports |
| Control Voltage Levels | $V_{CTRL}$ | -0.7 | – | 3.3 | V | – |

[1] Switch has a low-pass response. For higher frequencies, losses have to be considered for their impact on thermal heating. The DC voltage at RF ports $V_{RFDC}$ has to be 0 V.
[2] Note: Consider potential ripple voltages on top of $V_{DD}$. Including RF ripple, $V_{DD}$ must not exceed the maximum ratings: $V_{DD} = V_{DC} + V_{RIPPLE}$.
[3] Field-Induced Charged-Device Model JS-002-2014. Simulates charging/discharging events that occur in production equipment and processes. Potential for CDM ESD events occurs whenever there is metal-to-metal contact in manufacturing.
[4] Human Body Model ANSI/ESDA/JEDEC JS-001 ($R$ = 1,5 kΩ, $C$ = 100 pF).
[5] IEC 61000-4-2 ($R$ = 330 Ω, $C$ = 150 pF), contact discharge.

**Warning: Stresses above the max. values listed here may cause permanent damage to the device. Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit. Exposure to conditions at or below absolute maximum rating but above the specified maximum operation conditions may affect device reliability and life time. Functionality of the device might not be given under these conditions.**

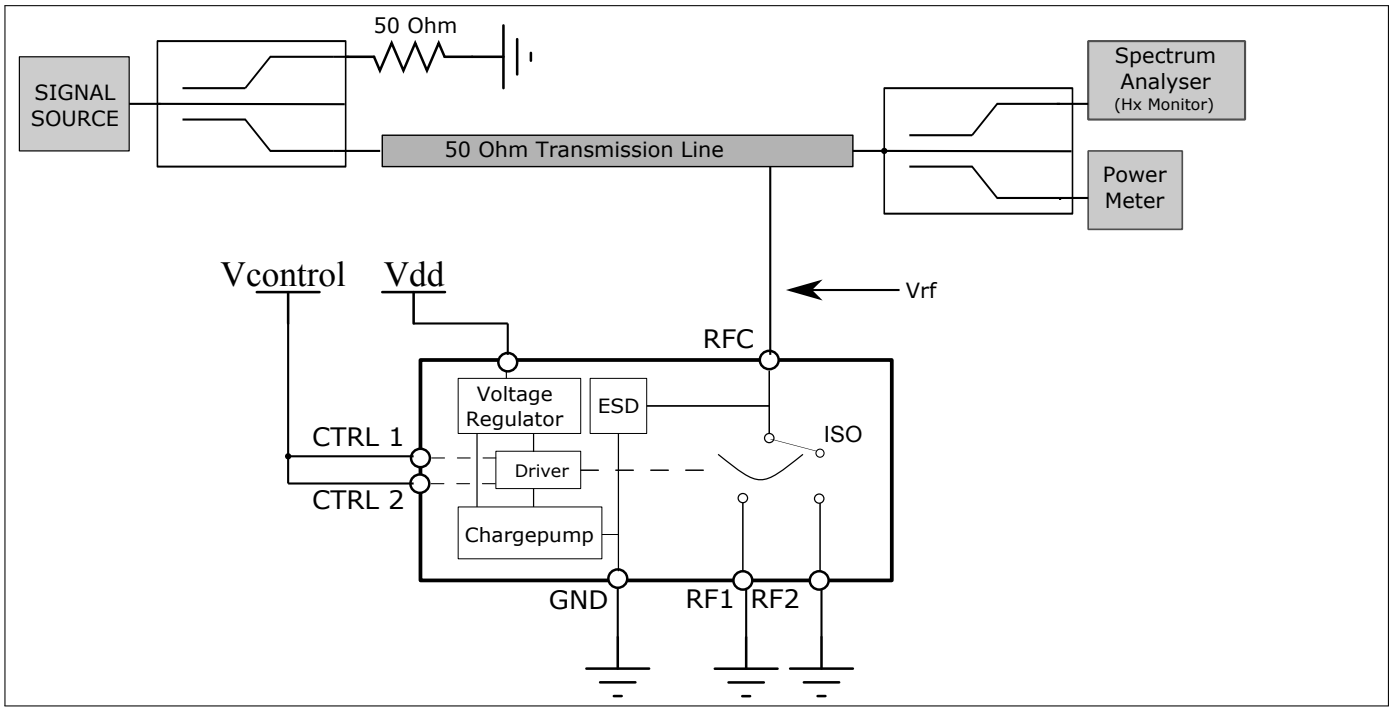



**Figure 1:** RF operating voltage measurement configuration - OFF mode

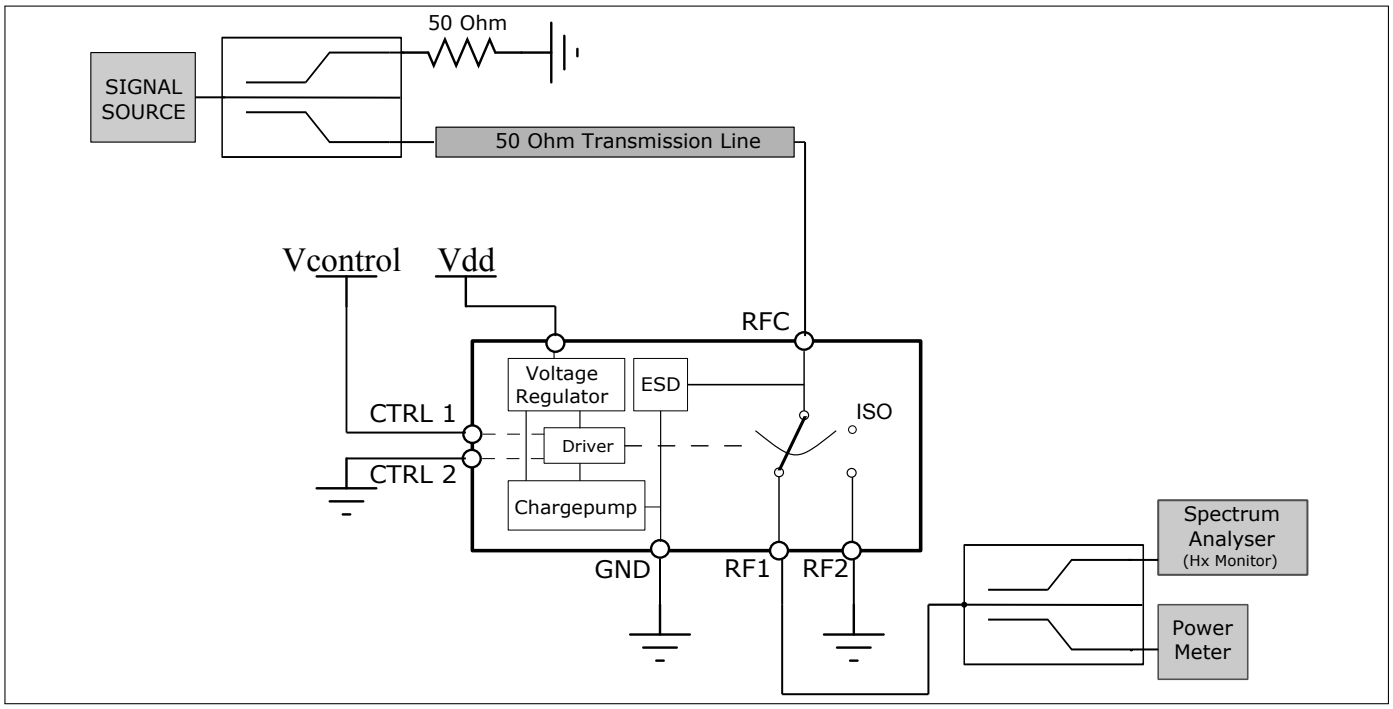



**Figure 2:** RF operating and Harmonics generation voltage measurement configuration - RF1 ON mode

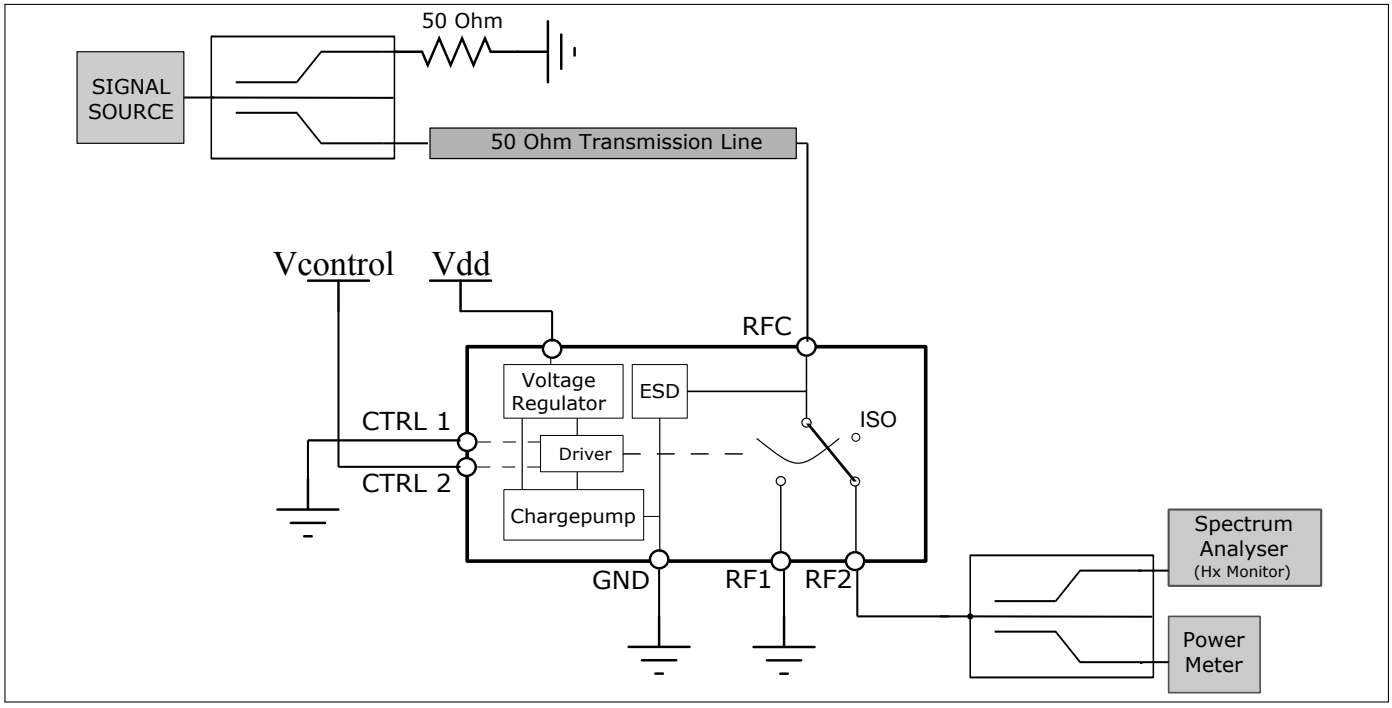



**Figure 3:** RF operating and Harmonics generation voltage measurement configuration - RF2 ON mode

# 3 DC Characteristics

**Table 2: Operation Ranges**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Supply voltage | $V_{DD}$ | 1.65 | 2.8 | 3.6 | V | – |
| Supply current | $I_{DD}$ | 45 | 60 | 350[1] | µA | [1] $T_A$ = 85 °C, $P_{IN}$ = 40 dBm, ON mode |
| Supply current in low power mode | $I_{DD,LP}$ | – | – | 1 | µA | $T_A$ = −40 °C...+85 °C, $V_{DD}$ = 1.65 - 3.6 V |
| Control voltage low | $V_{CTRL,low}$ | 0 | – | 0.45 | V | – |
| Control voltage high | $V_{CTRL,high}$ | 1.2 | 1.8 | 2.85 | V | $V_{CTRL,high} \ll V_{DD}$ |
| Control current low | $I_{CTRL,low}$ | -1 | 0 | 1 | µA | – |
| Control current high | $I_{CTRL,high}$ | -1 | 0 | 4 | µA | $V_{CTRL,high} \ll V_{DD}$ 1 MΩ Pull-Down resistor at Control Pins |
| Ambient temperature | $T_A$ | -40 | 25 | 85 | °C | – |
| RF switching time | $t_{ST}$ | 4.7 | 5 | 5.5 | µs | $P_{IN}$ = 0 dBm, $Z_0$ = 50 Ω, $T_A$ = −40 °C... +85 °C $V_{DD}$ = 1.65 - 3.6 V |
| Startup time | $t_{PUP}$ | 5 | 6 | 7 | µs | Ref. Fig. 4 and Fig. 5 |

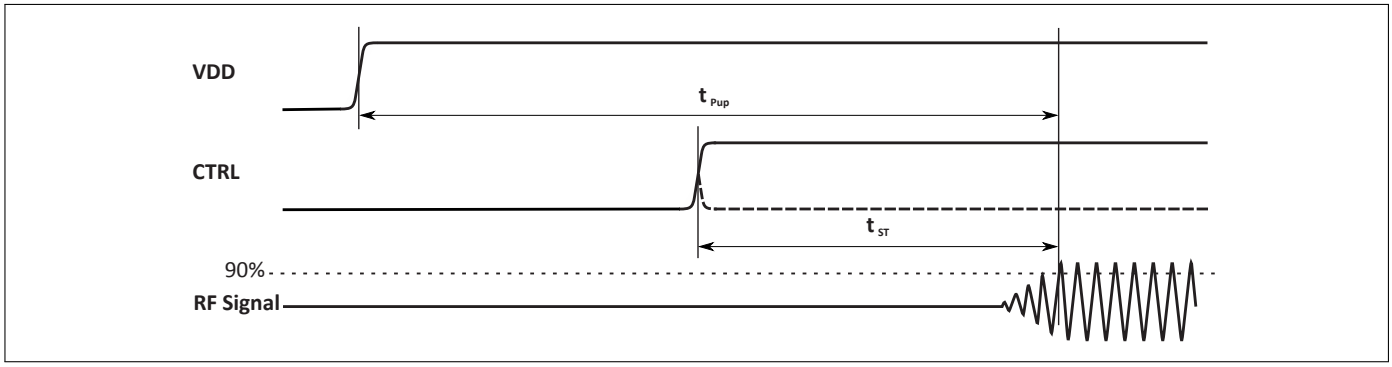



**Figure 4:** Power Up settling time and switching time

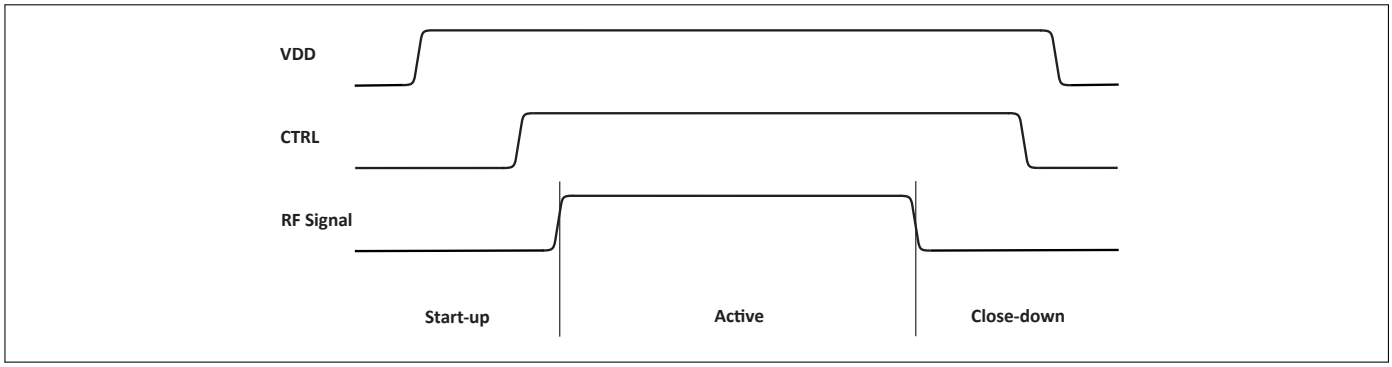



**Figure 5:** Timing of Control and RF signals for valid operation

# 4 RF Small Signal Characteristics

| Parameter | Symbol | Values | | | Unit | STATE / Notes |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Frequency range | $f$ | 0.4 | | 6.0 | GHz | |
| RF1 or RF2 to RFc ON DC resistance | $R_{ON}$ | 0.5 | 0.59 | 0.7 | Ω | $V_{DD}$ = 1.65 - 3.6 V, $T_A$ = 25 °C, Four-terminal sensing method |
| RF1 or RF2 to RFc OFF DC resistance | $R_{OFF}$ | 38 | 42.5 | 45 | kΩ | |
| RF1 or RF2 to RFc OFF capacitance | $C_{OFF}$ | 235 | 270 | 305 | fF | $V_{DD}$ = 1.65 - 3.6 V, $T_A$ = 25 °C, extracted from Isolation (S21) measurement $Z_0$ = 50 Ω |

**Table 3: RF electrical parameters**

| Parameter | Symbol | Values | | | Unit | STATE / Notes |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| **Insertion Loss: RF1 to RFc or RF2 to RFc (SPDT mode)** [1,2,3] | | | | | | |
| 698 - 960 MHz | $IL_{SPDT}$ | 0.07 | 0.14 | 0.25 | dB | $V_{DD}$ = 1.65 - 3.6 V, $Z_0$ = 50 Ω, $T_A$ = −40 °C...+85 °C |
| 961 - 1710 MHz | | 0.20 | 0.26 | 0.39 | dB | |
| 1711 - 1910 MHz | | 0.24 | 0.31 | 0.45 | dB | |
| 1911 - 2169 MHz | | 0.33 | 0.39 | 0.55 | dB | |
| 2170 - 2690 MHz | | 0.40 | 0.48 | 0.65 | dB | |
| 3300 - 3800 MHz | | 0.69 | 0.88 | 1.25 | dB | |
| 3801 - 4800 MHz | | 0.69 | 1.2 | 1.75 | dB | |
| 4801 - 6000 MHz | | 1.3 | 1.9 | 2.3 | dB | |
| **Isolation: RF1 to RFc or RF2 to RFc (SPDT mode)** [1,2,3] | | | | | | |
| 698 - 960 MHz | $ISO_{SPDT}$ | 23 | 24 | 25 | dB | $V_{DD}$ = 1.65 - 3.6 V, $Z_0$ = 50 Ω, $T_A$ = −40 °C...+85 °C |
| 961 - 1710 MHz | | 15.5 | 17 | 18 | dB | |
| 1711 - 1910 MHz | | 14.5 | 16 | 17 | dB | |
| 1911 - 2169 MHz | | 14 | 15 | 16 | dB | |
| 2170 - 2690 MHz | | 12 | 13.5 | 15 | dB | |
| 3300 - 3800 MHz | | 9.5 | 11 | 12 | dB | |
| 3801 - 4800 MHz | | 9 | 10.5 | 11.5 | dB | |
| 4801 - 6000 MHz | | 8 | 8.8 | 10.5 | dB | |

1) Valid for all RF power levels, no compression behavior
2) SOLT-calibrated, $P_{IN}$ = 0 dBm
3) On application board without any matching components

**Table 3: RF electrical parameters** (continued)

| Parameter | Symbol | Values | | | Unit | STATE / Notes |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| **Isolation: RFc to RFx (Isolation mode, no switch selection)**[1,2,3] | | | | | | |
| 698 - 960 MHz | $ISO_{ISO}$ | 17 | 18 | 19 | dB | $VP_{DD}$ = 1.65 - 3.6 V, $Z_0$ = 50 Ω, $T_A$ = −40 °C...+85 °C |
| 961 - 1710 MHz | | 10.5 | 11.5 | 12.5 | dB | |
| 1711 - 1910 MHz | | 10 | 11 | 12 | dB | |
| 1911 - 2169 MHz | | 9 | 10 | 11 | dB | |
| 2170 - 2690 MHz | | 8 | 9 | 10 | dB | |
| 3300 - 3800 MHz | | 7 | 8 | 9 | dB | |
| 3801 - 4800 MHz | | 6.5 | 7.5 | 8.5 | dB | |
| 4801 - 6000 MHz | | 5.5 | 7 | 8.5 | dB | |
| **Isolation: RF1 to RF2 or RF2 to RF1 (SPDT mode)**[1,2,3] | | | | | | |
| 698 - 960 MHz | $ISO_{SPDT}$ | 19 | 21 | 23 | dB | $V_{DD}$ = 1.65 - 3.6 V, $Z_0$ = 50 Ω, $T_A$ = −40 °C...+85 °C |
| 961 - 1710 MHz | | 14 | 16 | 18 | dB | |
| 1711 - 1910 MHz | | 13 | 15 | 17 | dB | |
| 1911 - 2169 MHz | | 12 | 14 | 16 | dB | |
| 2170 - 2690 MHz | | 11 | 13 | 15 | dB | |
| 3300 - 3800 MHz | | 8 | 10 | 12 | dB | |
| 3801 - 4800 MHz | | 7 | 9 | 11 | dB | |
| 4801 - 6000 MHz | | 6 | 8 | 10 | dB | |
| **Isolation: RF1 to RF2 or RF2 to RF1 (Isolation mode, no switch selection)**[1,2,3] | | | | | | |
| 698 - 960 MHz | $ISO_{ISO}$ | 34 | 36 | 38 | dB | $V_{DD}$ = 1.65 - 3.6 V, $Z_0$ = 50 Ω, $T_A$ = −40 °C...+85 °C |
| 961 - 1710 MHz | | 25 | 27 | 29 | dB | |
| 1711 - 1910 MHz | | 23 | 25 | 27 | dB | |
| 1911 - 2169 MHz | | 21 | 23 | 25 | dB | |
| 2170 - 2690 MHz | | 18 | 20 | 22 | dB | |
| 3300 - 3800 MHz | | 14 | 16 | 18 | dB | |
| 3801 - 4800 MHz | | 12 | 14 | 16 | dB | |
| 4801 - 6000 MHz | | 10 | 12 | 14 | dB | |

1) Valid for all RF power levels, no compression behavior
2) SOLT-calibrated, $P_{IN}$ = 0 dBm
3) On application board without any matching components

# 5 RF Large Signal Parameter

**Table 4: RF large signal specifications at $T_A$ = 25 °C**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Max. RF Operating Voltage | $V_{RF_opr}$ | – | – | 40 | V | In Isolation mode, test condition schematic in Fig. 1 for H2/H3 < -40 dBm @ 50 Ω |
| Max. RF Operating Power | $V_{RF_pwr}$ | – | – | 40 | dBm | RF1 or RF2 in ON mode, test condition schematic in Fig. 2 or Fig. 3 for H2/H3 < -40 dBm @ 50 Ω |
| **Harmonic Generation up to 12.75 GHz** | | | | | | |
| All RF Ports - Second Order Harmonics | $P_{H2}$ | 95 | 105 | - | dBc | 25 dBm, 50 Ω, $f_0$ = 824 MHz, test condition in Fig. 2 an Fig. 3 |
| All RF Ports - Third Order Harmonics | $P_{H3}$ | 110 | 120 | – | dBc | 25 dBm, 50 Ω, $f_0$ = 824 MHz, test condition in Fig. 2 an Fig. 3 |
| All RF Ports - Second Order Harmonics | $P_{H2}$ | 80 | 90 | – | dBc | 36 dBm, 50 Ω, $f_0$ = 824 MHz, test condition in Fig. 2 an Fig. 3 |
| All RF Ports - Third Order Harmonics | $P_{H3}$ | 90 | 100 | – | dBc | 36 dBm, 50 Ω, $f_0$ = 824 MHz, test condition in Fig. 2 an Fig. 3 |
| All RF Ports - Third Order Harmonics | $P_{H3}$ | 90 | 100 | – | dBc | 36 dBm, 50 Ω, $f_0$ = 1800 MHz, test condition in Fig. 2 an Fig. 3 |
| All RF Ports - Second Order Harmonics | $P_{H2}$ | 95 | 105 | – | dBc | 25 dBm, 50 Ω, $f_0$ = 1800 MHz, test condition in Fig. 2 an Fig. 3 |
| All RF Ports - Third Order Harmonics | $P_{H3}$ | 110 | 120 | – | dBc | 25 dBm, 50 Ω, $f_0$ = 1800 MHz, test condition in Fig. 2 an Fig. 3 |
| All RF Ports - Second Order Harmonics | $P_{H2}$ | 80 | 90 | – | dBc | 36 dBm, 50 Ω, $f_0$ = 1800 MHz, test condition in Fig. 2 an Fig. 3 |
| Higher order harmonic products | $P_{Hx}$ | 105 | – | – | dBc | 25 dBm, 50 Ω |
| **Intermodulation Distortion IMD2** | | | | | | |
| IIP2, low | $IIP2_L$ | 110 | 114 | – | dBm | IIP2 conditions table 5 |
| IIP2, high | $IIP2_H$ | 117 | 120 | – | dBm | |
| **Intermodulation Distortion IMD3** | | | | | | |
| IIP3 | $IIP3$ | 71 | 75 | – | dBm | IIP3 conditions table 6 |
| **SV LTE Intermodulation** | | | | | | |
| IIP3,SVLTE | $IIP3_{SV}$ | 71 | 75 | – | dBm | SV-LTE conditions table 7 |

**Table 5: IIP2 conditions table**

| Band | In-Band Frequency [MHz] | Blocker Frequency 1 [MHz] | Blocker Power 1 [dBm] | Blocker Frequency 2 [MHz] | Blocker Power 2 [dBm] |
|---|---|---|---|---|---|
| Band 1 Low | 2140 | 1950 | 20 | 190 | -15 |
| Band 1 High | 2140 | 1950 | 20 | 4090 | -15 |
| Band 5 Low | 881.5 | 836.5 | 20 | 45 | -15 |
| Band 5 High | 881.5 | 836.5 | 20 | 1718 | -15 |

**Table 6: IIP3 conditions table**

| Band | In-Band Frequency [MHz] | Blocker Frequency 1 [MHz] | Blocker Power 1 [dBm] | Blocker Frequency 2 [MHz] | Blocker Power 2 [dBm] |
|---|---|---|---|---|---|
| Band 1 | 2140 | 1950 | 20 | 1760 | -15 |
| Band 5 | 881.5 | 836.5 | 20 | 791.5 | -15 |

**Table 7: SV-LTE conditions table**

| Band | In-Band Frequency [MHz] | Blocker Frequency 1 [MHz] | Blocker Power 1 [dBm] | Blocker Frequency 2 [MHz] | Blocker Power 2 [dBm] |
|---|---|---|---|---|---|
| Band 5 | 872 | 827 | 23 | 872 | 14 |
| Band 13 | 747 | 786 | 23 | 747 | 14 |
| Band 20 | 878 | 833 | 23 | 2544 | 14 |

# 6 Logic Table

**Table 8: Logic Table**

| CTRL 1 | CTRL 2 | Mode |
|---|---|---|
| 0 | 0 | Low power mode |
| 0 | 1 | RF2 connected to RFC |
| 1 | 0 | RF1 connected to RFC |
| 1 | 1 | Isolation mode (no switch selection) |

# 7 Application Information

## Pin Configuration and Function

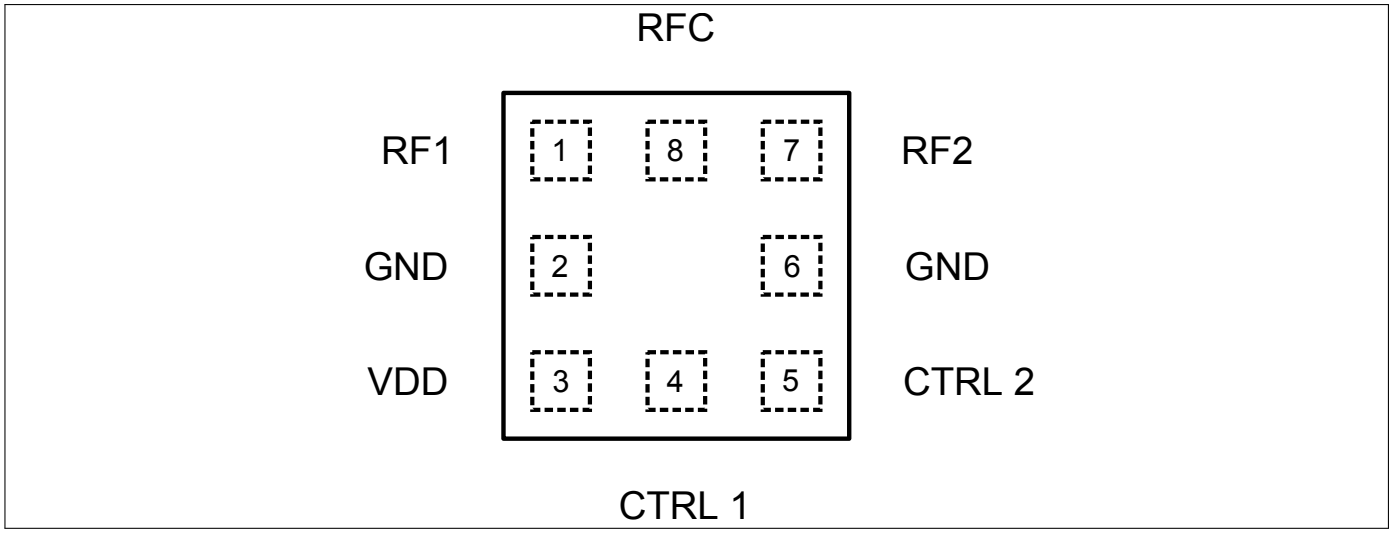



**Figure 6:** BGSA12UGL8 Pin Configuration (top view)

**Table 9: Pin Definition and Function**

| Pin No. | Name | Function |
|---|---|---|
| 1 | RF1 | RF port |
| 2 | GND | Ground |
| 3 | VDD | DC Supply Voltage |
| 4 | CTL1 | Control Pin 1 |
| 5 | CTL2 | Control Pin 2 |
| 6 | GND | Ground |
| 7 | RF2 | RFport |
| 8 | RFC | Common RF |

# 8 Package Information

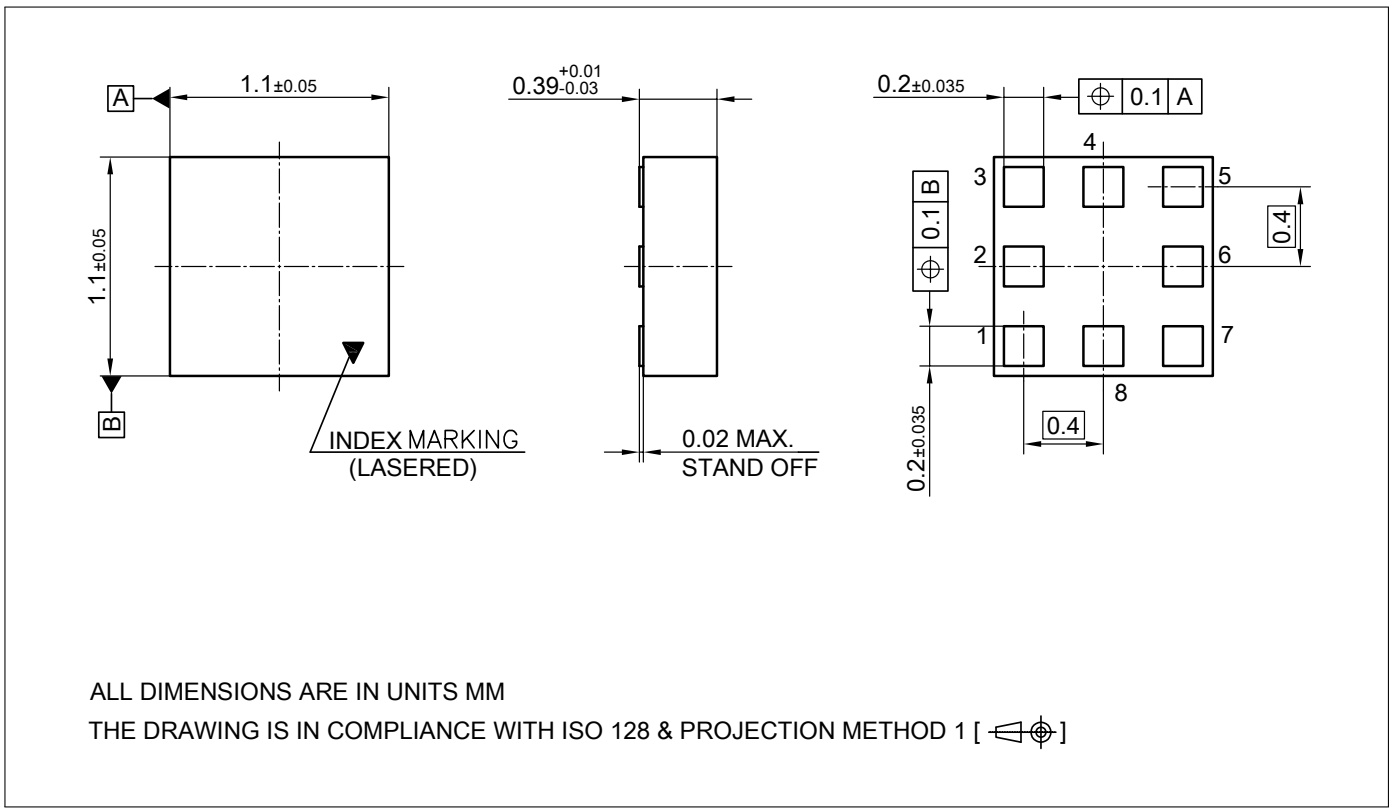



**Figure 7:** TSLP-8-1 Package Outline (top, side and bottom views)

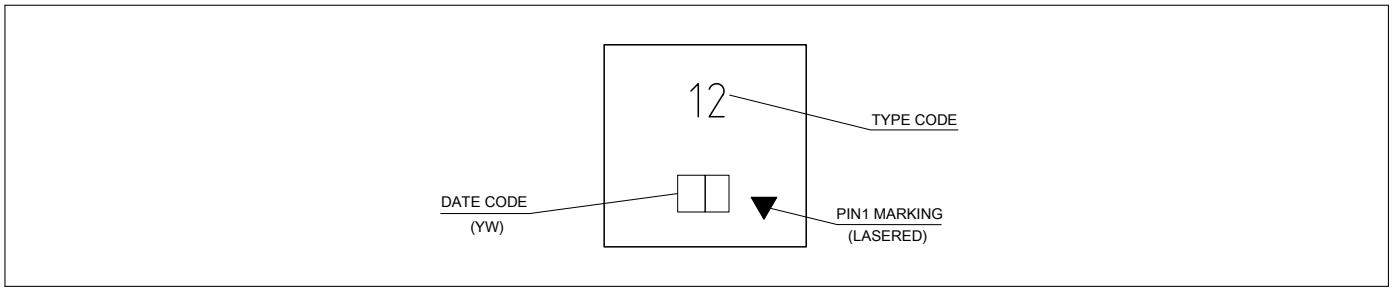



**Figure 8:** Marking Specification (top view): Date code digits Y and W defined in Table 10/11

**Table 10: Year date code marking - digit "Y"**

| Year | "Y" | Year | "Y" | Year | "Y" |
|---|---|---|---|---|---|
| 2000 | 0 | 2010 | 0 | 2020 | 0 |
| 2001 | 1 | 2011 | 1 | 2021 | 1 |
| 2002 | 2 | 2012 | 2 | 2022 | 2 |
| 2003 | 3 | 2013 | 3 | 2023 | 3 |
| 2004 | 4 | 2014 | 4 | 2024 | 4 |
| 2005 | 5 | 2015 | 5 | 2025 | 5 |
| 2006 | 6 | 2016 | 6 | 2026 | 6 |
| 2007 | 7 | 2017 | 7 | 2027 | 7 |
| 2008 | 8 | 2018 | 8 | 2028 | 8 |
| 2009 | 9 | 2019 | 9 | 2029 | 9 |

**Table 11: Week date code marking - digit "W"**

| Week | "W" | Week | "W" | Week | "W" | Week | "W" | Week | "W" |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A | 12 | N | 23 | 4 | 34 | h | 45 | v |
| 2 | B | 13 | P | 24 | 5 | 35 | j | 46 | x |
| 3 | C | 14 | Q | 25 | 6 | 36 | k | 47 | y |
| 4 | D | 15 | R | 26 | 7 | 37 | l | 48 | z |
| 5 | E | 16 | S | 27 | a | 38 | n | 49 | 8 |
| 6 | F | 17 | T | 28 | b | 39 | p | 50 | 9 |
| 7 | G | 18 | U | 29 | c | 40 | q | 51 | 2 |
| 8 | H | 19 | V | 30 | d | 41 | r | 52 | 3 |
| 9 | J | 20 | W | 31 | e | 42 | s | 53 | M |
| 10 | K | 21 | Y | 32 | f | 43 | t | | |
| 11 | L | 22 | Z | 33 | g | 44 | u | | |

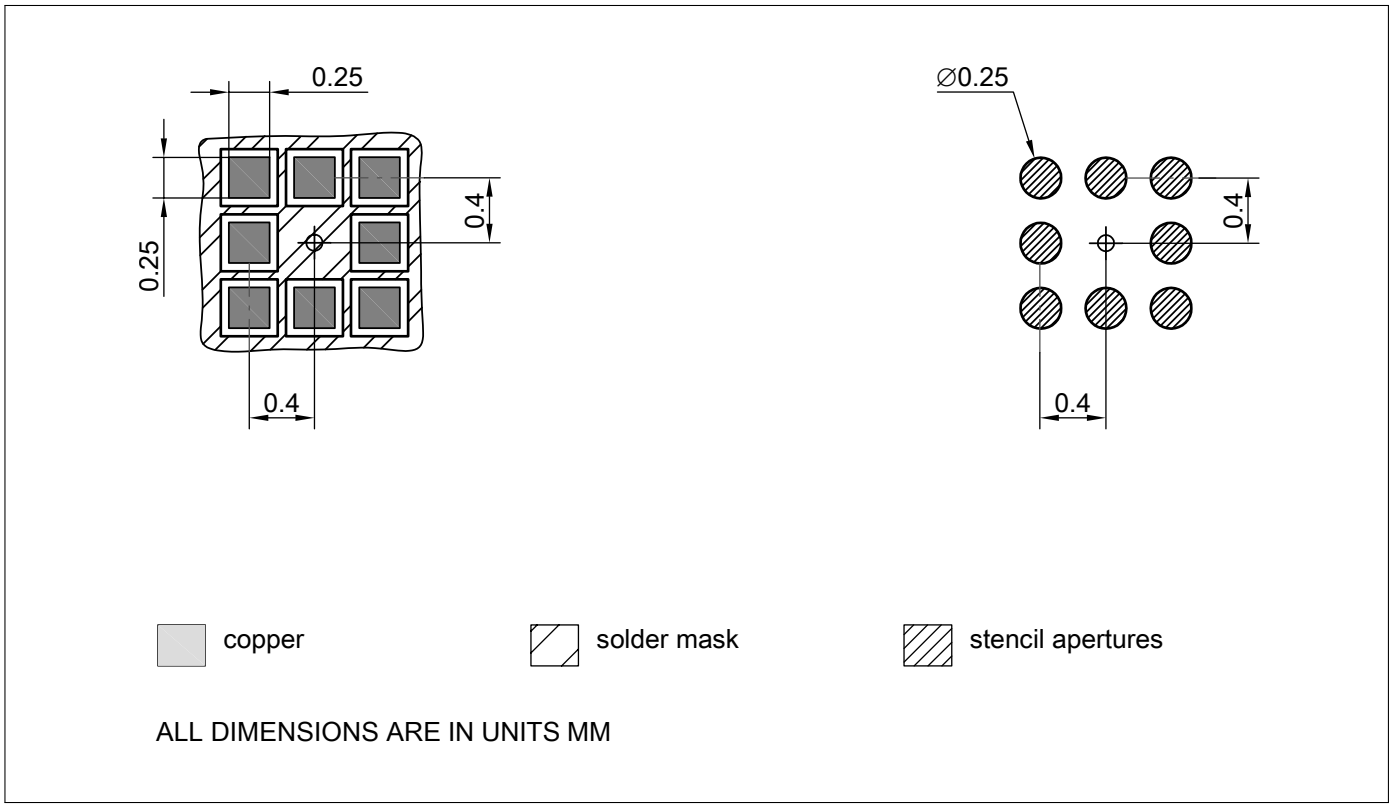



**Figure 9:** Footprint Recommendation

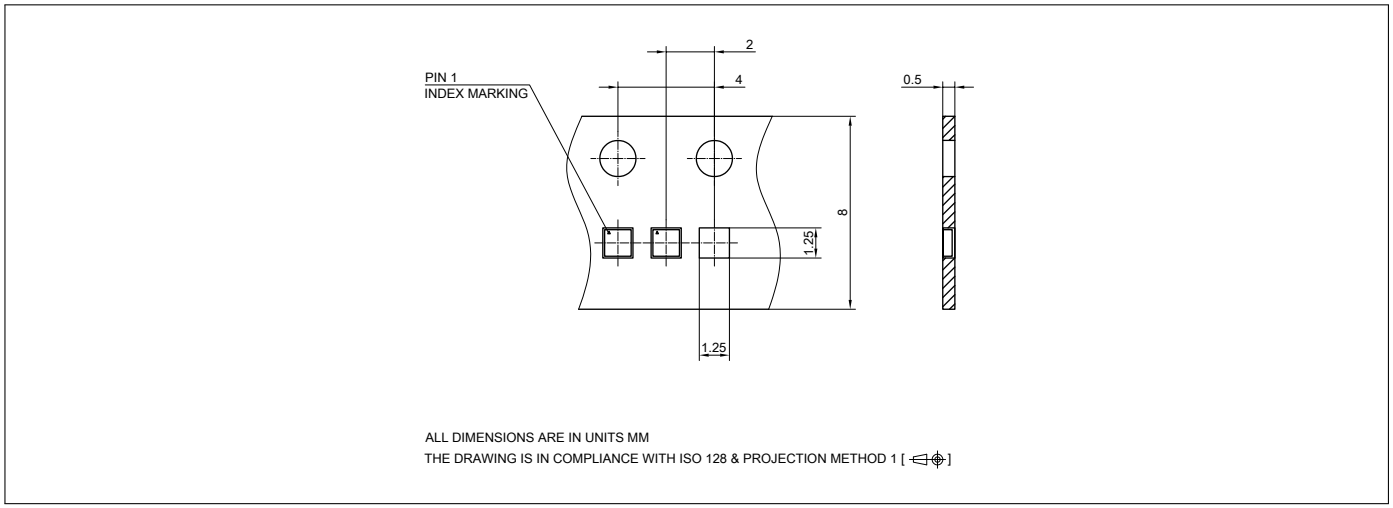



**Figure 10:** TSLP-8-1 Carrier Tape

| Revision History | |
|---|---|
| **Creation of document Revision 2.3, 2019-08-13** | |
| **Page or Item** | **Subjects (major changes since previous revision)** |
| 6 | Updated Vddmin to 1.65V |

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