# Statement for RF Exposure

| | |
|---|---|
| **Statement No.** | **14862952H-R1** |
| **Customer** | **Keyence Corporation** |
| **Description of EUT** | **Level sensor** |
| **Model Number of EUT** | **FR-SH01** |
| **FCC ID** | **RF41754B** |
| **Test standard** | **FCC Part 15 Subpart C** |
| **Test result** | **Complied** |

**[FCC rule]**
**§1.1310 Radiofrequency radiation exposure limits.**
The criteria listed in table 1 shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

**Table 1—Limits for Maximum Permissible Exposure (MPE)**

| Frequency range (MHz) | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density ($mW/cm^2$) | Averaging time (minutes) |
|---|---|---|---|---|
| **(A) Limits for Occupational/Controlled Exposures** | | | | |
| 0.3–3.0 | 614 | 1.63 | *(100) | 6 |
| 3.0–30 | 1842/f | 4.89/f | *($900/f^2$) | 6 |
| 30–300 | 61.4 | 0.163 | 1.0 | 6 |
| 300–1500 | | | f/300 | 6 |
| 1500–100,000 | | | 5 | 6 |
| **(B) Limits for General Population/Uncontrolled Exposure** | | | | |
| 0.3–1.34 | 614 | 1.63 | *(100) | 30 |
| 1.34–30 | 824/f | 2.19/f | *($180/f^2$) | 30 |
| 30–300 | 27.5 | 0.073 | 0.2 | 30 |
| 300–1500 | | | f/1500 | 30 |
| 1500–100,000 | | | 1.0 | 30 |

f = frequency in MHz
* = Plane-wave equivalent power density
Note 1 to Table 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.
Note 2 to Table 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

**[About fundamental measurement (Average)]**

**Test Procedure**
The test was performed based on “Procedures for testing millimeter-wave systems” of ANSI C63.10-2013.
The peak power were measured with an RF detector that has a detection bandwidth that encompasses the 57-71 GHz band and has a video bandwidth of at least 10 MHz.

The carrier levels were measured in the far field. The distance of the far field was calculated from follow equation.

$$r = \frac{2D^2}{\lambda}$$

where

*r* is the distance from the radiating element of the EUT to the edge of the far field, in m
*D* is the largest dimension of both the radiating element and the test antenna (horn), in m
*Lambda* is the wavelength of the emission under investigation [300/f (MHz)], in m

| Frequency | Wavelength | Maximum Dimention | | | Far Field | Tested |
|---|---|---|---|---|---|---|
| | | EUT | Test | Maximum | Boundary | Distance |
| | *Lambda* | | Antenna | *D* | *r* | |
| [GHz] | [mm] | [m] | [m] | [m] | [m] | [m] |
| 63 | 4.8 | 0.01940 | 0.03759 | 0.03759 | 0.594 | 0.65 |

The test was performed based on stages 1-4 following;
Stage 1:
Connect the measurement antenna for the fundamental frequency band to the mm-wave RF detector.
Place the measurement antenna at a test distance that is in the far-field of the measurement antenna.
Place the measurement antenna in the main beam of the EUT then maximize the fundamental emission.
The maximum direction was searched under carefully since beam-widths are extremely narrow.
Record the peak voltage from DSO as DSO Reading.

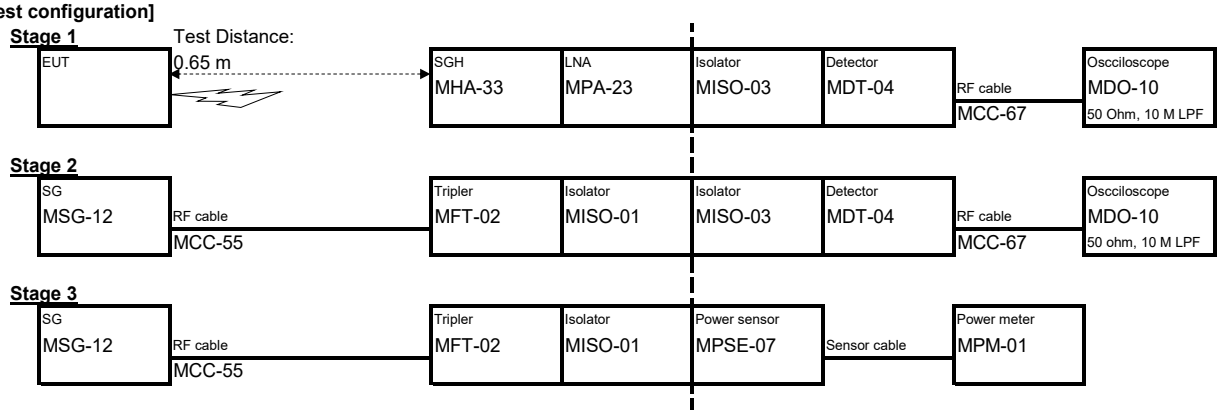
Stage 2:
Disconnect the measurement antenna from the RF input port of the instrumentation system.
Connect a mm-wave source to the RF input port of the instrumentation system via a waveguide variable attenuator.
The mm-wave source shall be unmodulated.
Adjust the frequency of the mm-wave source to the center of the frequency range occupied by the transmitter.
Adjust the amplitude of the mm-wave source and/or the variable attenuator such that the DSO indicates a voltage equal to the peak voltage recorded in Stage 1.
The output level of mm-wave source at this time is recorded as SG Reading.

Stage 3:
Disconnect the waveguide variable attenuator from the RF input port of the instrumentation system.
Without changing any settings, connect the waveguide variable attenuator to a wideband mm-wave power meter with a thermocouple detector or equivalent.
Measure the power and record it as PM reading.

Stage 4:
Correct the peak substitution power at the input to the measurement instrument, as recorded in Stage 3, for any external gain and/or attenuation between the measurement antenna and the measurement instrument that was not included in the substitution power measurement.

The test results and limit are rounded off to one decimal place, so some differences might be observed.

[Test configuration]




**Test data : APPENDIX**
**Test result : Pass**

# EIRP
(Test data)

| | | |
|---|---|---|
| Test place | Ise EMC Lab. | |
| Semi Anechoic Chamber | No. 4 | No. 4 |
| Date | July 11, 2023 | July 13, 2023 |
| Temperature / Humidity | 21 deg. C / 55 % RH | 21 deg. C / 49 % RH |
| Engineer | Junki Nagatomi | Sayaka Hara |
| Mode | Tx | |

Stage 1 Stage 2 Stage 3 Stage 4

| Symbol Pattern | Center Frequency [GHz] | DSO Reading (RMS) [mV] | S/G Setting Power [dBm] | P/M Reading [dBm] | LNA Gain [dB] | Rx Ant. Gain [dBi] | Tested Distance [m] | FSL [dB] | EIRP (Burst Average) Result [dBm] | [mW] | Duty Factor *1) [dB] | EIRP (Timed Average) Result [dBm] | [mW] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 60.50 | 2.16 | 9.20 | -12.28 | 25.20 | 23.74 | 0.65 | 64.34 | 3.12 | 2.06 | 18.11 | -14.99 | 0.04 |
| 2 | 60.00 | 2.15 | 9.15 | -12.44 | 25.37 | 23.67 | 0.65 | 64.26 | 2.79 | 1.91 | 18.11 | -15.32 | 0.03 |
| 3 | 61.00 | 2.06 | 9.51 | -13.19 | 25.03 | 23.80 | 0.65 | 64.41 | 2.39 | 1.74 | 18.11 | -15.72 | 0.03 |
| 4 | 59.50 | 2.23 | 9.36 | -12.23 | 25.45 | 23.70 | 0.65 | 64.19 | 2.82 | 1.92 | 18.11 | -15.29 | 0.03 |
| 5 | 60.50 | 2.08 | 9.14 | -12.75 | 25.20 | 23.74 | 0.65 | 64.34 | 2.65 | 1.85 | 18.11 | -15.46 | 0.03 |

Calculating formula:
FSL (Free Space path Loss) = 10 * log10(( 4 * Pi * Tested Distance / Lambda ) ^2)
EIRP (Burst Average) = P/M Reading - Rx Ant. Gain - LNA Gain + FSL
EIRP (Timed Average) = EIRP (Burst Average) - Duty Factor

*1) Duty Factor

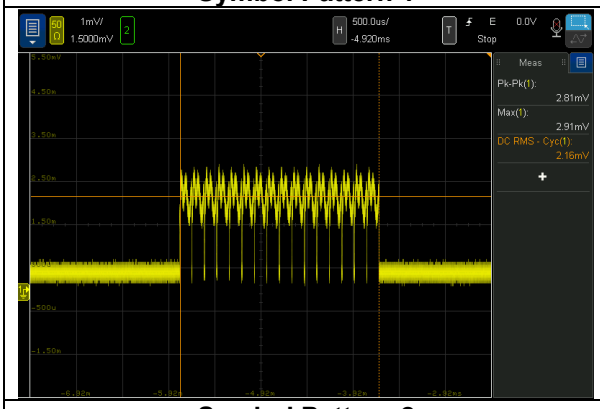
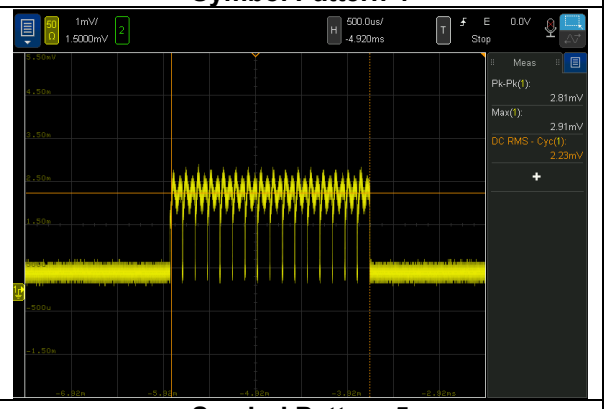
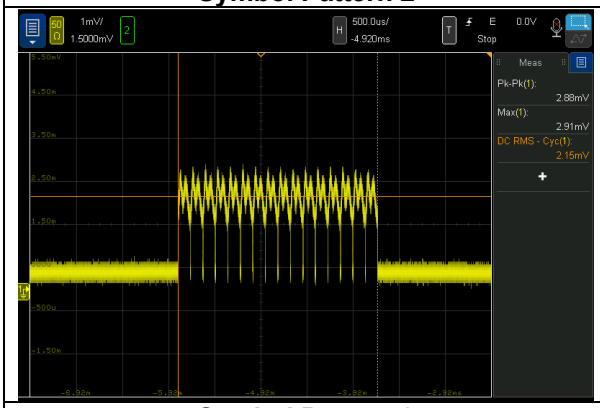
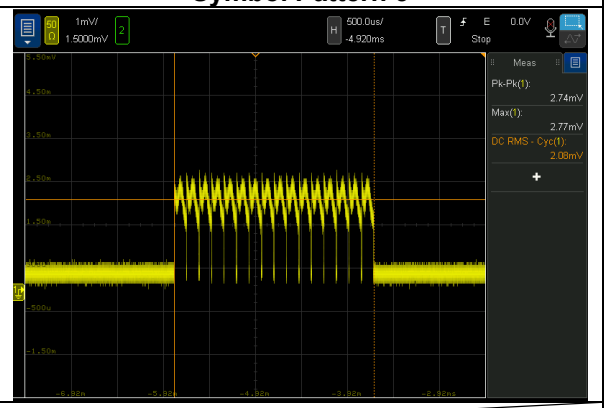
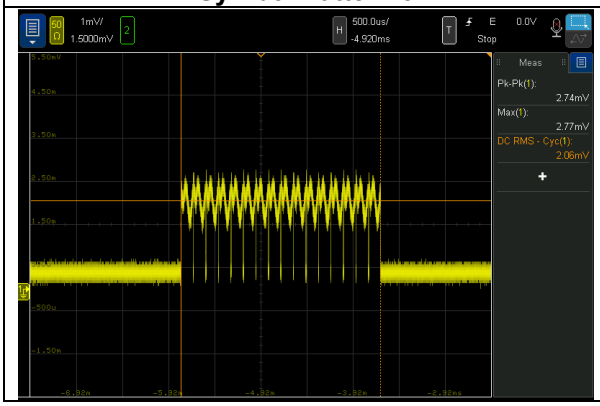
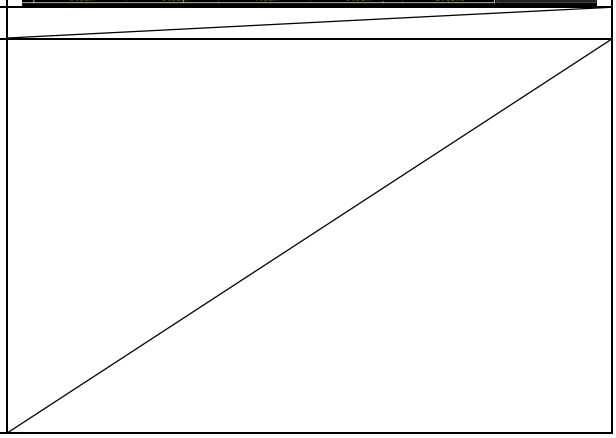
| Tx ON+OFF Time [ms] | Tx ON Time [ms] | Duty Factor [dB] |
|---|---|---|
| 140.000 | 2.166 | 18.11 |

Calculating formula:
Duty factor = 10 * log (Tx ON + OFF Time / Tx ON Time)

*1) Refer to Duty Cycle data page.

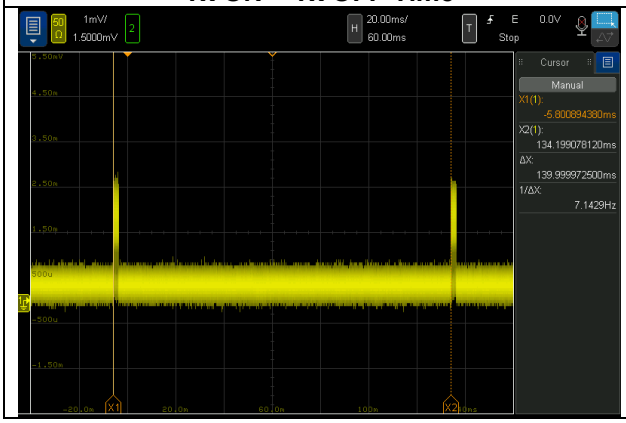
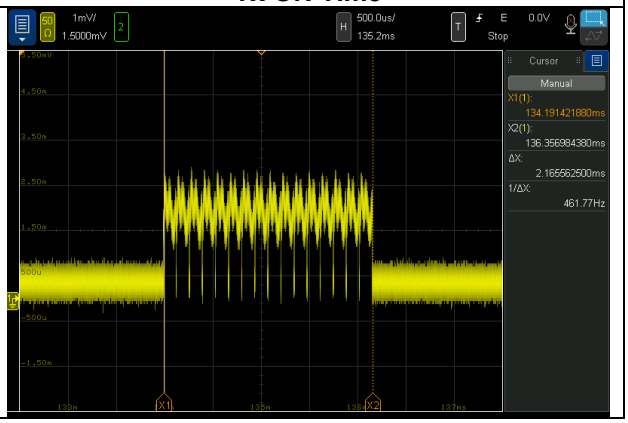
# EIRP

[Data]

| Symbol Pattern 1 | Symbol Pattern 4 |
|---|---|
|  |  |
| **Symbol Pattern 2** | **Symbol Pattern 5** |
|  |  |
| **Symbol Pattern 3** | |
|  |  |

# Duty Cycle
(Test Data)

| | |
|---|---|
| Test place | Ise EMC Lab. |
| Semi Anechoic Chamber | No. 4 |
| Date | July 11, 2023 |
| Temperature / Humidity | 21 deg. C / 55 % RH |
| Engineer | Junki Nagatomi |
| Mode | Tx Symbol Pattern 1 |

| Tx ON + Tx OFF Time | Tx ON Time |
|---|---|
|  |  |

## Test instruments

**Test equipment**

| Test Item | Local ID | LIMS ID | Description | Manufacturer | Model | Serial | Last Calibration Date | Cal Int |
|---|---|---|---|---|---|---|---|---|
| MPE | MAEC-04 | 142011 | AC4_Semi Anechoic Chamber(NSA) | TDK | Semi Anechoic Chamber 3m | DA-10005 | 05/22/2022 | 24 |
| MPE | MAEC-04-SVSWR | 142017 | AC4_Semi Anechoic Chamber(SVSWR) | TDK | Semi Anechoic Chamber 3m | DA-10005 | 04/14/2023 | 24 |
| MPE | MCC-55 | 141326 | Microwave Cable | Suhner | SUCOFLEX101 | 2874(1m) / 2877(5m) | 03/07/2023 | 12 |
| MPE | MCC-67 | 141329 | Microwave Cable 1G-40GHz | Suhner | SUCOFLEX102 | 28635/2 | 04/10/2023 | 12 |
| MPE | MDO-10 | 211944 | Digital Storage Oscilloscope | Keysight Technologies Inc | DSOX6002A | MY59380318 | 11/07/2022 | 12 |
| MPE | MDPLX-01 | 142026 | Diplexer | OML INC. | DPL26 | - | 11/25/2022 | 12 |
| MPE | MDT-04 | 142528 | Detector | Millitech | DET-15-RPFW0 | 34 | - | - |
| MPE | MFT-02 | 142545 | Fullband Tripler | Millitech | MUT-15-LF000 | 19 | - | - |
| MPE | MHA-33 | 180634 | Horn Antenna | SAGE Millimeter, Inc. | SAZ-2410-15-S1 | 17343-01 | 06/20/2023 | 12 |
| MPE | MISO-03 | 142592 | Waveguide Isolator | Millitech | FBI-15-RSES0 | 1858 | - | - |
| MPE | MJM-29 | 142230 | Measure, Tape, Steel | KOMELON | KMC-36 | - | - | - |
| MPE | MMM-10 | 141545 | DIGITAL HiTESTER | HIOKI E.E. CORPORATION | 3805 | 51201148 | 01/18/2023 | 12 |
| MPE | MOS-15 | 141562 | Thermo-Hygrometer | CUSTOM. Inc | CTH-201 | 0010 | 01/13/2023 | 12 |
| MPE | MPA-23 | 142055 | Power Amplifier | SAGE Millimeter, Inc. | SBP-5037532015-1515-N1 | 11599-01 | 03/22/2023 | 12 |
| MPE | MPM-01 | 141801 | Power Meter | Keysight Technologies Inc | E4417A | GB41290639 | 04/11/2023 | 12 |
| MPE | MPSE-07 | 142238 | Power sensor | Keysight Technologies Inc | V8486A | MY44420112 | 06/16/2023 | 12 |
| MPE | MSG-12 | 141892 | Signal Generator | Keysight Technologies Inc | E8257D | US49280311 | 11/24/2022 | 12 |
| MPE | MISO-01 | 142590 | Waveguide Isolator | Keysight Technologies Inc | V365A | 60004 | - | - |

***Hyphens for Last Calibration Date and Cal Int (month) are instruments that Calibration is not required (e.g. software), or instruments checked in advance before use.**

**The expiration date of the calibration is the end of the expired month.**
**As for some calibrations performed after the tested dates, those test equipment have been controlled by means of an unbroken chains of calibrations.**

**All equipment is calibrated with valid calibrations. Each measurement data is traceable to the national or international standards.**

**Test item:**

**MPE: Maximum Permissible Exposure**

## [Results]

| Mode | Average EIRP* [mW] | Separation Distance [cm] | Power Density Result [mW/cm$^2$] | Power Density Limit [mW/cm$^2$] |
|---|---|---|---|---|
| Average Power | 2.06 | 20 | 0.0004 | 1 |

Calculating formula:
Power Density = Average EIRP / (4 * Pi * Separation Distance ^ 2)

This EIRP was measured in sufficient far field of 0.65 m distance and calculated at 20 cm.

Even the RF Specification EIRP, the power density is below the RF Exposure Limit of 1 mW/cm^2.