GENTEX CORPORATION

Technical Report to the FCC and ISED Regarding Gentex Corporation – Integrated Toll Module

Model: UAGTMD
FCC ID: NZLUAGTMD
ISED: 4112A-UAGTMD

Emission Designator: 5M29L1D
9/13/21

A report concerning approval for Gentex Corporation model UAGTMD
Please issue grant immediately upon review.

Measurements Made by:

Bolay Pannell
Digitally signed by Bolay Pannell
Date: 2021.09.13 15:13:38 -04'00'

Bolay Pannell
Laboratory Validation Engineer III
Gentex Corporation

Measurements Reviewed by:

Daniel Brasier
Digitally signed by Daniel Brasier
Date: 2021.09.14 08:59:44 -04'00'

Dan Brasier
Laboratory Development Engineer II
Gentex Corporation

Report Prepared, and Submitted by:

Brian Miller
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Date: 2021.09.13 15:18:51 -04'00'

Brian Miller
Laboratory Group Leader – Regulatory II
Gentex Corporation

Report Approved by:

Craig Harder, Laboratory Manager II (EMC)
Digitally signed by Craig Harder, Laboratory Manager II (EMC)
Date: 2021.09.14 09:45:39 -04'00'

Craig Harder
Laboratory Manager II
Gentex Corporation

Test Report Revision

REV Number	Date	Author	Description
1.0	8/23/21	Brian Miller	Initial Release.
2.0	9/7/21	Brian Miller	Updated per Notified Body feedback.
3.0	9/13/21	Brian Miller	Updated per additional Notified Body feedback.

Results relate only to the items tested as received.

Compliance has been evaluated based on the Lab Manual section 7.6.2. The decision rule used regarding measurement uncertainty was to determine results solely on whether the measured values met the defined acceptance criteria without factoring in measurement uncertainty values.

1. General Information

1.1. Product Description

The Gentex Corporation Integrated Toll Module is a Radio-Frequency Identification (RFID) transponder OEM device that is installed into the automobile rearview mirror. The installation is provided by trained technicians during the course of the manufacture of the automobile. It is powered by the 12 Volt system of the automobile.

The unit is designed for the periodic operation as a toll module.

The unit is supplied to the automobile manufacturer without harness. For testing purposes a typical assembly and 2-conductor cable harness were used to power to the unit.

The unit is only operational when interrogated by a reader operating in the same protocol.

The antenna system is an integral part of the unit. It cannot be altered nor replaced by the user. Service of this system is only available from the Automobile Manufacturer's Dealerships and Gentex Corporation.

1.2. Related Grants

This device will have functionality that is covered under 47 CFR Part 90 and ISED Canada RSS-137. The device will have FCC ID # of NZLUAGTMD and ISED ID # of 4112A-UAGTMD.

1.3. Test Methodology

Radiated Emissions testing was performed according to ANSI C63.26:2015. The power source for this product is a 12V automotive vehicle battery, thus conducted emissions measurements are not required.

The unit is supplied to the automobile manufacturer without harness. For testing purposes a 2-conductor cable harness was used to interface to the unit.

1.4. Test Facility

The 3-meter semi-anechoic chamber where these measurements were taken is located on the grounds of Gentex Corporation's Corporate Labs, in the city of Zeeland, county of Ottawa, state of Michigan, United States of America.

For radiated measurements above 1 GHz, RF absorbing material is placed between the antenna and EUT in accordance with ANSI C63.4:2014 Section 5.5 and chamber manufacturer's instructions.

Tabletop testing was conducted on a 3m turntable described in the site recertification report. The 3m chamber has been added to our A2LA scope of accreditation on 4/18/2019 and includes accreditation to ANSI C63.4:2014, ANSI C63.10:2013, and C63.26:2015. Our 3m chamber is registered with the ISED under Site# 4112A-2 and FCC under registration number 357351.

Corporate Mailing/Shipping Address	Site Address
Gentex Corporation	Gentex Corporation
600 N. Centennial Street	380 Riley Street
Zeeland, MI 49464	Zeeland, MI 49464

1.5. Accreditation

The Gentex Corporate EMC Lab is accredited to ISO/IEC 17025 by the American Association for Laboratory Accreditation (A2LA). Our laboratory scope and accreditation certificate #2529.01 are available from their web site www.a2la.org. Our scope of accreditation covers ANSI C63.4:2014, ANSI C63.10:2013, ANSI C63.26:2015 and Radiated Emissions at 3m, FCC 47 CFR Part 90, ISED RSS-137.

2. Product Labeling

2.1. Identifiers

The FCC Identifier assigned is FCC ID: NZLUAGTMD. The ISED certification number is 4112A-UAGTMD. These identifiers will be labeled on the product housing.

The label will be imprinted on the exterior of the mirror housing using molding tool that will permanently affix the label.

Because of the small size of the device and because the installation is inside a portion of the automobile, the following statements will appear in the user's manual. Refer to attachment "Users Manual.pdf" for the entire text of the user's manual.

> "This device complies with FCC rules Part 15 and with applicable ISED RSS standards. Operation is subject to the following two conditions:
> (1) This device may not cause harmful interference,
> (2) This device must accept any interference that may be received including interference that may cause undesired operation.
> WARNING: The transmitter has been tested and complies with FCC and ISED rules. Changes or modifications not expressly approved by the party responsible for the compliance could void the user's authority to operate the device."

The term "ISED:" before the certification/registration number only signifies that ISED technical specifications were met.

ISED: 4112A-UAGTMD FCC ID: NZLUAGTMD MODEL: UAGTMD

2.2. Label Drawing and Location on Product

The label drawing is included in the "Label.pdf" attachment.

A diagram showing the location of the label on the assembly is included in the "Label Location.pdf" attachment.

3. Test Configuration

Radiated Emission measurements presented in the report were made in accordance with ANSI C63.26-2015. The EUT was placed on a 1 x 1.5m non-metallic table elevated 80cm above a conducting ground plane for measurements below 1GHz and elevated to 1.5m for measurements above 1GHz. The harness was run straight down from the center of the turntable to a power supply connection sitting at the base of the table. The power supply is located beneath the floor of the chamber.

For radiated measurements above 1 GHz, RF absorbing material is placed between the antenna and EUT in accordance with ANSI C63.4:2014 Section 5.5 and chamber manufacturer's instructions.

4. Block Diagram

For system block diagram please refer to attachment named "Block Diagram.pdf"

5. Conducted Emissions Measurements

Conducted Measurements are not required for this product.

6. Radiated Emissions Data

6.1. Date(s) Tested: 8/11/21 – 8/23/21

6.2. Test ID(s): Test-071211 – Test-071213

6.3. Test Method Deviations: None.

6.4. Temperature and Humidity conditions

	Measured Value	Unit
Temperature	22.0	ºC
Humidity	44.1	%R.H.

6.5. Summary of Results

Measurement		Margin	Frequency - Duty Cycle
Worst Case Output Power	-0.01 dBm	30.01 dB	915MHz
Worst Case Harmonic	-45.42 dBm	45.42 dB	1829.8MHz
Maximum Occupied BW	5.29MHz	6.71MHz	915MHz

- **Measurement Uncertainty:** The standard uncertainty of measurement has been determined in accordance with the ISO Guide to the Expression of Uncertainty in Measurements. The estimation of measurement uncertainty reported is the expanded uncertainty for a coverage factor of k=2.26 and confidence interval of approximately 95%.

  Expanded Uncertainty $U_{(k=2.26)}$ is as follows:

  - Radiated Emissions – Bicon (30-250 MHz): 4.5 dB
  - Radiated Emissions – LPA (250-1000 MHz): 4.2 dB
  - Radiated Emissions – DRWG (1-18 GHz): 5.0 dB
  - Frequency: 0.15ppm

6.6. Test Equipment Setup and Procedure

6.6.1. Test Equipment Used

Description	Model #	ID Number	Cal Due
EMCO LPA Antenna [250-1000MHz]	3148	H6192	5/3/24
Com-Power Double Ridged Waveguide [1-18GHz]	AHA-118	8893	11/25/22
ETS-Lindgren Double Ridged Waveguide [10-40GHz]	3116C	7257	3/18/22
Rohde & Schwarz EMI Receiver	ESR26	6595	10/12/21
Cables, attenuator and port feed through	various	CF GCL	4/30/22
Miteq Preamplifier	AMF-4D-0050100-24-10P	S/N:2053240	12/31/21
3m Chamber SW	N/A	SW30	3/31/22

EMI Receiver Settings Emissions:

Detector Function:	Peak
Resolution Bandwidth:	120 kHz (below 1GHz)
	1MHz (above 1GHz)

EMI Receiver (in Spectrum Analyzer mode) Settings Occupied Bandwidth:

Detector:	Peak
Resolution Bandwidth:	1 MHz (to determine peak level)
	120 kHz (to determine occupied bandwidth)
Video Bandwidth:	3 MHz (to determine peak level)
	300 kHz (to determine occupied bandwidth)

For the testing, the EUT was placed at the center of a non-conducting table 80cm above the ground plane pursuant to ANSI C63.26:2015 for stand-alone equipment. The 2-conductor harness was run straight down from the center of the turntable to a power supply sitting at the base of the table.

Equipment is placed in one of the three orthogonal orientations, End, Side, and Flat where applicable. These orientations are described below in Figure 6.2.1. For this model, only orientation Side was tested.

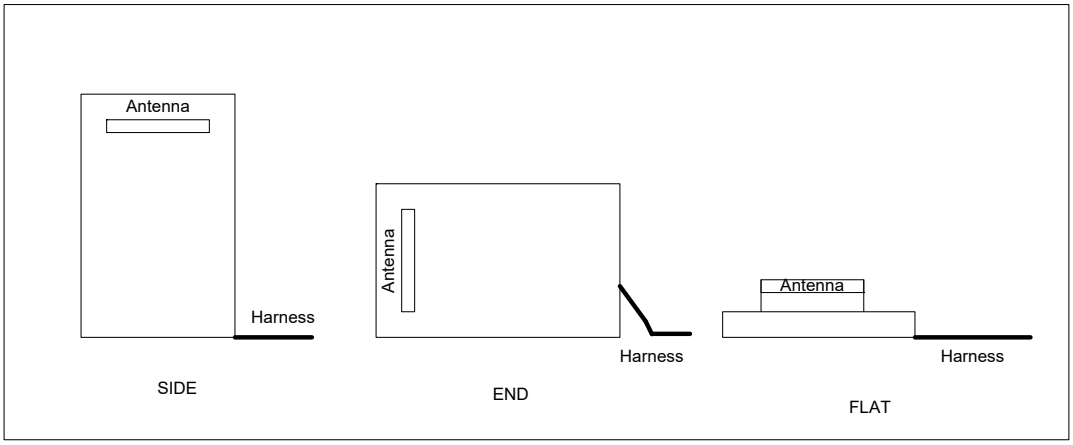


Figure 6.2.1 EUT Orthogonal Orientations

While in the prescribed orientation, the vertical antenna positioner sweeps in elevation from 1 to 4m in height until the operator finds the peak. The 3m turntable is then rotated through 360 degrees until a peak is found. The table is stopped at the peak location and the peak in elevation re-verified. Procedure is repeated for applicable orientations/measurement antenna polarizations.

6.7. Measured Data – See Appendix A

7. Other Attachments and Description

7.1. User Manual

Please refer to attachment “User_manual.pdf”.

7.2. Schematics / Tuning Information

For schematics, please refer to exhibit “Schematics.pdf”.

7.3. Emission Designation

According to TRC-43, the emission designation for this product is 5M29L1D. Where “5M29” is the highest measured occupied bandwidth, “L” indicates the device uses pulse width modulation, “1” indicates the modulation as being single channel, digital information and “D” indicates that data is being transmitted.

7.4. Theory of Operation

Please refer to attachment “Theory of operation”

7.5. Label Drawing and Location on Complete Assembly

For a drawing of the label and the position of the label on the finished assembly refer to “Label Location”.

7.6. Photos

For interior photos, refer to exhibit “Interior Photographs”.

For exterior photos, refer to exhibit “Exterior Photographs”.

For test setup photos, refer to exhibit “Test Setup Photographs”.

8. Formula and Sample Calculation

The EMI Receiver used for making the measurements in this report automatically corrects for cable correction and antenna factors using values stored in memory taken from the most recent calibration (in the case of antenna factors), periodic cable loss measurements, and preamplifier gain.

Formula 1: FS(dBuV/m) = M(dBuV) + AF(dB/m) + CF(dB) – AG(dB)

The presented field strength is computed by the EMI Receiver by taking the measured level and adding to it the antenna factor and cable loss corrections. The measurements presented were gathered using the EMI Receiver’s peak-hold capability.

Transmitter Output Power:

Per ANSI C63.26:2015 Section 5.2.7(d)

Formula 2: EIRP (dBm) = dBuV/m+(20*(Log(D)))-104.8
-where D is the measurement distance in meters.

Formula 3: ERP (dBm) = EIRP – 2.15

Harmonic Emissions:

Formula 4: Minimum Required Attenuation (dB) = 55 + 10 * Log (P) where (P) is the highest emission (watts) of the transmitter inside the licensee’s sub-band.

Formula 5: Level Below Carrier (dBc) = ERP(dBm) – Harmonic Measured Level (dBm)

Occupied Bandwidth

Formula 6: OBW Margin = 12 – OBW
-where 12 is the limit in MHz and OBW is the measured occupied bandwidth in MHz.

Frequency Stability

Formula 7: Measured Variation (ppm) = ABS((X-Y)/20))*1000000 where X is the measured frequency in hertz and Y is the measured frequency at 20 degrees Celsius with an input voltage of 12V

Appendix A

A. Radiated (Tx) Measurements

1. Transmitter Output Power –

The radio frequency power output was measured in a 3m Semi-Anechoic chamber. The design offers no provision for connection to the antenna port. The Effective Radiated Power or E.R.P was calculated based on the peak power measurement. The DUT was placed on a turntable elevated as required above the ground plane at 3 meters from the measurement antenna. The turntable was rotated through 360 degrees to locate the maximum amplitude emission. The frequency spectrum was searched for the maximum emission generated. Emission level was measured and recorded for the maximum amplitude. For measurement of the modulated signal, due to an occupied bandwidth greater than 5MHz, a Channel Power or Integrated measurement was performed allowing for a bandwidth greater than the occupied bandwidth. See screenshot below for reference.

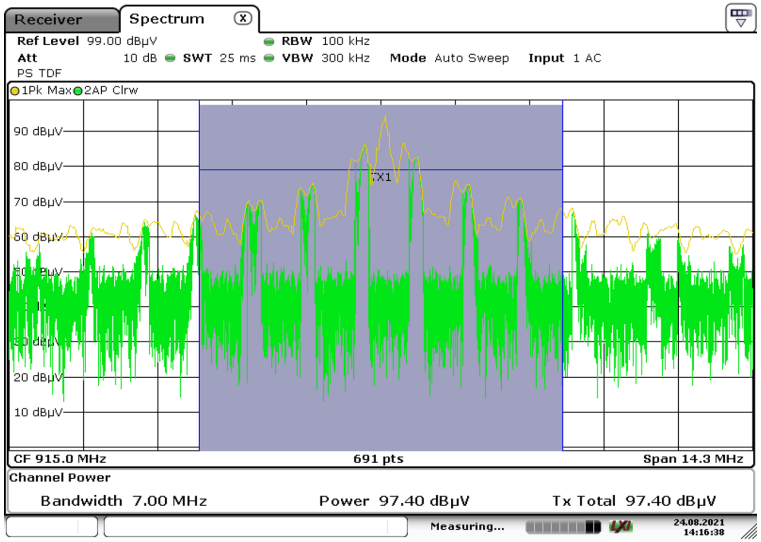
The device was found to be in compliance with the limits of Part 90.205 and RSS-137 section 6.4 of 30W or 44.77dBm ERP with +/-1 dB manufacturers rated value.

Frequency (MHz)	Orientation	Mode	RF Measurement (dBuV/m)	EIRP (W)	EIRP (dBm)	ERP (dBm)
915	Side	CW	97.31	0.0016	2.05	-0.10
915	Side	Modulated	97.4	0.0016	2.14	-0.01

T*he peak power measurement includes the corrections for antenna gain, cable loss, and preamp gain where applicable.*

Per ANSI C63.26:2015 Section 5.2.7(d) Formula: EIRP (dBm) = dBuV/m+(20*(Log(D)))-104.8 where D is the measurement distance in meters.

ERP (dBm) = EIRP – 2.15


Receiver
Spectrum
Ref Level 99.00 dBµV
RBW 100 kHz
Att 10 dB SWT 25 ms VBW 300 kHz Mode Auto Sweep Input 1 AC
PS TDF
1Pk Max 2AP Clrw
90 dBµV
80 dBµV
70 dBµV
60 dBµV
20 dBµV
10 dBµV
TX1
CF 915.0 MHz
691 pts
Span 14.3 MHz
Channel Power
Bandwidth 7.00 MHz
Power 97.40 dBµV
Tx Total 97.40 dBµV
Measuring...
24.08.2021
14:16:38
Date: 24.AUG.2021 14:16:37

2. Occupied Bandwidth

The DUT demonstrated compliance with the requirements of Paragraphs 47CFR Part 2.1046(a), 90.209 and RSS-137 paragraph 6.1.2 of 12MHz. See plot below for reference.

Frequency (MHz)	Mode	Occupied Bandwidth (MHz)	Limit (MHz)	Margin
915	Modulated	5.29	12	6.71

3. Modulation Characteristics

The radio frequency output was coupled to a Rhode & Schwarz ESU26 Receiver. The receiver was used to observe the radio frequency spectrum with the transmitter operating in normal mode.

The transmitter operates providing digital data, transmitted signals modulated in amplitude/width/duration. The DUT demonstrated compliance with the specifications of Paragraphs 47CFR Part 2.1046(a), 90.205, and RSS-137.

4. Harmonic Emissions

Data was taken per 47CFR Part 2.1051 and applicable parts of 47CFR 90.210 and RSS-137. The frequency spectrum from 9 kHz to 10 GHz was observed.

The DUT demonstrated compliance with the specifications of 47CFR Part 2.1051, 2.1057, 90.210(k) and RSS-137.

The table shows that the minimum level below the carrier was 45.42dBc which is within limit.

Formula: Minimum Required Attenuation = 55 + 10 * Log (P) where (P) is the highest emission (watts) of the transmitter inside the licensee's sub-band.

CW Minimum Attenuation

55 + 10 * Log (P) = dB where (P) is the highest CW emission (watts)

Modulated Minimum Attenuation

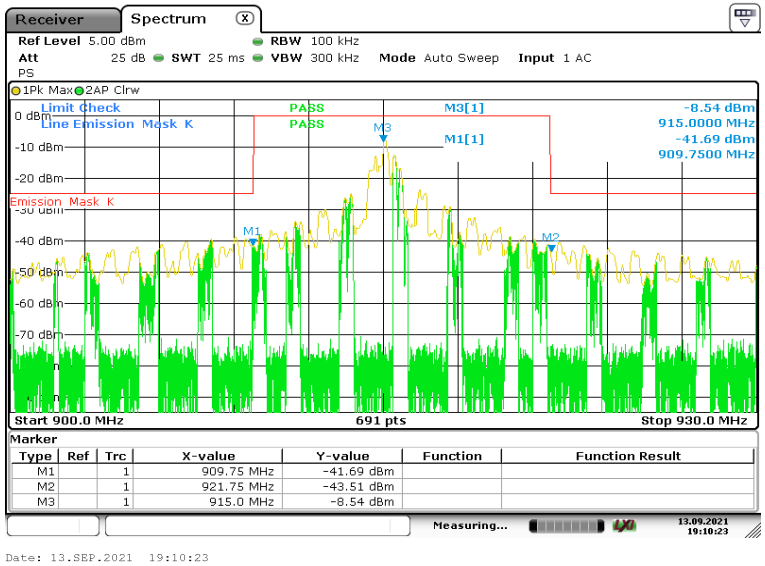
55 + 10 * Log (P) = dB where (P) is the highest Modulated emission (watts)

Orientation	Measurement Frequency	Polarization	Measured Level (dBm)	Minimum Required Attenuation	Level Below Carrier (dBc)
CW					
Side	1829.8	H	-45.42	**27.1**	**45.42**
	1829.8	V	-58.81		58.81
	2744.7	H	-50.70		50.70
	2744.7	V	-62.37		62.37
	3659.6	H	-54.53		54.53
	3659.6	V	-54.97		54.97
	4574.5	H	-56.98		56.98
	4574.5	V	-55.35		55.35
	5489.4	H	-64.32		64.32
	5489.4	V	-61.59		61.59
	6404.3	H	-58.61		58.61
	6404.3	V	-62.47		62.47
Modulated					
Side	1829.8	H	-45.66	**21.41**	45.66
	1829.8	V	-60.37		60.37
	2744.7	H	-51.72		51.72
	2744.7	V	-64.18		64.18
	3659.6	H	-55.76		55.76
	3659.6	V	-55.07		55.07
	4574.5	H	-57.57		57.57
	4574.5	V	-55.63		55.63
	5489.4	H	-63.03		63.03
	5489.4	V	-63.93		63.93
	6404.3	H	-60.27		60.27
	6404.3	V	-59.75		59.75

5. Emission Mask

Transmitters used in the radio services governed by this part must comply with the emissions masks outlined in this section. Paragraph 90.210(k) specifies the out of band emission limitations for this equipment. The spurious emissions for the device were measured at the maximum power output condition. The conducted measurement was corrected for cable loss via corrections loaded to the receiver.

The DUT demonstrated compliance with the specifications of Paragraphs 47CFR 2.1051, 2.1057, 90.210(k), and RSS-137, see plot below for reference.



Modulated Mode

6. Frequency Stability

Frequency stability measurements were taken in a temperature chamber. Per RSS-137 section 6.3, the carrier frequency shall not depart from the reference frequency in excess of +/- 2.5 ppm for any type of equipment unless indicated otherwise. *Note: Fixed Non-LMS transmitters with an emission bandwidth located more than 40kHz from the band edge, intermittenly operated hand-held readers and mobile transponders are exempt from meeting the frequency stability limit.*

Frequency Stability				
Temperature (C)	Input Voltage (V)	Nominal Frequency (Hz)	Measured Frequency (Hz)	Measured Variation (ppm)
-30	10.2	915,070,000	915,040,000	32.784
-30	12.0	915,070,000	915,042,500	30.052
-30	13.8	915,070,000	915,038,800	34.096
-20	10.2	915,070,000	914,961,300	**118.789**
-20	12.0	915,070,000	914,962,500	117.477
-20	13.8	915,070,000	914,962,500	117.477
-10	10.2	915,070,000	915,028,800	45.024
-10	12.0	915,070,000	915,028,800	45.024
-10	13.8	915,070,000	915,028,800	45.024
0	10.2	915,070,000	915,040,000	32.784
0	12.0	915,070,000	915,040,000	32.784
0	13.8	915,070,000	915,040,000	32.784
10	10.2	915,070,000	915,058,800	12.240
10	12.0	915,070,000	915,058,800	12.240
10	13.8	915,070,000	915,058,800	12.240
20	10.2	915,070,000	915,070,000	0.000
20	12.0	N/A	915,070,000	N/A
20	13.8	915,070,000	915,070,000	0.000
30	10.2	915,070,000	915,075,000	5.464
30	12.0	915,070,000	915,075,000	5.464
30	13.8	915,070,000	915,075,000	5.464
40	10.2	915,070,000	915,077,500	8.196
40	12.0	915,070,000	915,077,500	8.196
40	13.8	915,070,000	915,077,500	8.196
50	10.2	915,070,000	915,071,300	1.421
50	12.0	915,070,000	915,071,300	1.421
50	13.8	915,070,000	915,071,300	1.421