RETLIF TESTING LABORATORIES
TEST REPORT R-4009N
SEPTEMBER 18, 2002

FCC COMPLIANCE TEST REPORT
ON

MARKEM CORPORATION
900 - 928MHz FREQUENCY HOPPING SPREAD SPECTRUM
RFID TAG READER
FCC ID: QMEMTM6100

APPLICANT	MANUFACTURER
Markem Corporation 150 Congress Street Keene, NH 03431	SAME

TEST SPECIFICATION: FCC Rules and Regulations Part 15, Subpart C, Para. 15.247

TEST PROCEDURE: ANSI C63.4:1992, FCC Measurement Guideline for Frequency Hopping Spread Spectrum Devices

TEST SAMPLE DESCRIPTION

BRANDNAME: Markem MODEL: 6100

TYPE: RFID Tag Reader

POWER REQUIREMENTS: 15VDC via external 120VAC, 60Hz Power Supply

FREQUENCY BAND OF OPERATION: 902 to 928MHz DSS Frequency Hopping

FREQUENCIES TESTED: 902.726MHz, 914.773MHz and 927.332MHz

FCC ID: QMEMTM6100

APPLICABLE RULE SECTION: Part 15, Subpart C, Section 15.247

TESTS PERFORMED

15.247 (a) (1)(i) 20dB Bandwidth

15.247 (a) (1)(i) Number of Hopping Frequencies

15.247 (a) (1) Carrier Frequency Separation

15.247 (a) (1)(i) Time of Occupancy (Dwell Time)

15.247(c) Radiated Spurious Emissions (30MHz to 9.5GHz)

15.247(c) Conducted Spurious Emissions (30MHz to 9.5GHz)

15.247(c) Bandedge Compliance

15.247(b) Peak Output Power

15.207 AC Line Conducted Emissions (450kHz to 30MHz)

TEST SAMPLE DESCRIPTION

The EUT is a Markem Corporation Model 6100 Frequency Hopping Spread Spectrum RFID Tag Reader powered by 120VAC, 60Hz. The intended use is in industrial/commercial applications for inventory tracking. The equipment is intended to be professionally installed by trained personnel.

ANTENNA DESCRIPTION

The Model 6100 will be sold with two antenna types as follows:

Antenna 1: Linearly Polarized, Cushcraft Model S9028PC, 8dBi Gain
Antenna 2: Circularly Polarized, Cushcraft Model S9028PC, 7dBi Gain

Each antenna type will connect to the Model 6100 via a reverse TNC connector which meets the unique antenna requirement of 15.203.

MEASUREMENT PROCEDURES

15.247 (a) (1) 20dB Bandwidth

With the transmitter operating at maximum data rate the 20dB bandwidth of the 902.726 peak emission was measured using a spectrum analyzer connected to the antenna port. This measurement was repeated at 914.773MHz and at 927.332MHz.

Test Results: The greatest 20dB bandwidth measured was 328.65kHz at 902.726MHz. At 914.773MHz the 20dB bandwidth was 322.65kHz and at 927.332MHz the 20dB bandwidth was 324.65kHz. The 20dB bandwidth measured at all three frequencies met the maximum allowed 20dB bandwidth of 500kHz. See attached plots.

15.247 (a)(1)(i) Time of Occupancy (Dwell Time)

With the transmitter hopping function enabled the time of occupancy (dwell time) was measured using a spectrum analyzer connected to the antenna port. The dwell time at 914.773MHz was measured and determined to be 15msec. The time of occupancy within a ten second period was determined to be 135msec (15msec x 9 occurrences).

Test Results: The 135msec time of occupancy met the maximum allowed time of occupancy of 400msec within a ten second period. See attached plots.

15.247 (a)(1) Channel Carrier Frequency Separation

With the transmitter hopping function enabled the channel carrier frequency separation was measured using a spectrum analyzer connected to the antenna port. The peaks of two adjacent channels were captured and the separation between them was measured.

Test Results: The channel carrier frequency separation was 509kHz which met the requirement of 322kHz which is the 20dB bandwidth of the hopping channel. See attached plot.

15.247 (a)(1) Number of Hopping Frequencies

With the transmitter hopping function enabled the number of hopping frequencies was measured by using a spectrum analyzer connected to the antenna port. With the span set to the frequency band of operation (902 - 928MHz) a plot was taken clearly showing all hopping frequencies.

Test Results: The number of hopping channels is 50 which meets the specified 25 hopping channel minimum for 20dB bandwidth greater than 250kHz. See attached plot.

15.247(b) Peak Output Power

With the transmitter operating at maximum data rate the peak power of the 902.726 peak emission was measured using a spectrum analyzer connected to the antenna port. The span of the spectrum analyzer was approximately 5 times the 20dB bandwidth. This measurement was repeated at 914.773MHz and at 927.332MHz.

Test Results: The peak output power measured at 902.726MHz was 26.1dBm. At 914.773MHz the Peak output power was 23.94dBm and at 927.332 was 24.56dBm. The peak output power measured met the 1watt (30dBm) limit specified in 15.247(b).

De Facto EIRP Limit:

15.247(b)(3) specifies that if transmitting antennas with directional gain of greater than 6dBi are used then the peak output power of the transmitter must be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi. The highest gain antenna used with this transmitter has a gain of 8dBi thereby reducing by 2dB the peak power limit for the transmitter from 30dBm to 28dBm. As the maximum peak power measured was 26.1dBm the de facto EIRP limit is also met.

15.247 (c) Spurious RF Conducted Emissions

With the transmitter operating at maximum data rate the spurious RF conducted emissions were measured using a spectrum analyzer connected to the antenna port. The span of the spectrum analyzer was set wide enough to capture the peak level of the in band emission and all spurious emissions from 30MHz to 9.5GHz.

Test Results: All Spurious RF conducted emissions observed were within the limit specified in 15.247 (b) (20dB down in any 100kHz bandwidth) See attached plots

15.247 (c) Band Edge Compliance of RF Conducted Emissions

With the transmitter operating at maximum data rate the band edge spurious RF conducted emissions were measured using a spectrum analyzer connected to the antenna port. The span of the spectrum analyzer was set wide enough to capture the peak level of the emission operating on the channel closest to the band edge as well as any modulation products falling outside of the authorized band. This procedure was performed for both the upper and lower band edge. The procedure was repeated with the transmitter hopping function enabled.

Test Results: All Spurious RF conducted emissions observed at the band edges were within the limit specified in 15.247 (b) (20dB down in any 100kHz bandwidth) See attached plots

15.247 (c) Spurious Radiated Emissions

The field strength of all emissions observed during spurious RF conducted measurements that fell within restricted bands were measured. The transmitter was placed on a 80cm high wooden test stand which was located 3 meters from the test antenna on an FCC listed open area test site. Emissions from the EUT were maximized by rotating the test sample and adjusting the test sample orientation and antenna polarization. Testing was performed with each of the two transmitter antenna options (7dBi & 8dBi gain antennas). The maximized peak field strength of each emission was measured and recorded and compared to the limit specified in 15.35 (b) (peak limit corresponds to 20dB above the maximum permitted average limit). The spectrum analyzer video bandwidth was then set to 10Hz the peak field strength of each emission was measured. As the dwell time of the hopping channel is less than 100msec (15msec) this peak reading was adjusted by a duty cycle correction factor derived from 20log (dwell/100msec) and the corrected reading was then compared to the average limit specified in 15.209.

Duty Cycle Correction Factor:

Dwell Time = 15msec

20log(15/100) = -16.47dB

Test Results: The measured spurious radiated emissions complied with both the peak and average limits specified in 15.35 (b) and 15.209.

AC Line Conducted Emissions

The transmitter was placed on a 0.8m high wooden test stand above the floor of the test area)ground plane). The rear of the test sample was aligned flush with the rear of the test stand. The test stand was situated such that the test sample was located 0.4m from all other grounded surfaces. The power cord of the test sample was connected to an artificial mains network (LISN). The spectrum analyzer was connected to the RF port of the LISN and measurements were taken in the frequency range of 450kHz to 30MHz on each the hot and neutral leads.

Test Results: The AC line conducted emissions met the limit specified in 15.207 (a) (48dBuV)

RF Exposure

Spread Spectrum Transmitters operating under 15.247 are categorically excluded from routine environmental evaluation for demonstrating RF exposure compliance with respect to MPE or SAR limits however per 15.247(b)(4) must be operated in a manner that ensures the public is not exposed to RF energy levels in access of the commission's guidelines. The device will be professionally installed and the user/installation manual contains the proper cautionary statements and specifies that the antenna be installed so that a minimum separation distance of 20cm will maintained. Based on the transmitter power and maximum antenna gain (see calculation below) the 20cm separation distance exceeds the calculated distance for acceptable MPE power density levels to meet both the Occupational/Controlled Exposure and the General Population/Uncontrolled Exposure requirements of 1.1309. The calculation below uses the more stringent General Population MPE Limits.

$$S = \frac{PG}{4\pi Dsq}$$

D = Minimum Separation Distance in cm

S = Max allowed Power Density in mW/cmsq

Per 1.1309 For Frequency of 900MHz = F/1500 = .6mW/cmsq

Power = Max Power Input to Antenna = 26.1dBm = 407mW

Gain = Max Power Gain of Antenna = 8dBi = 6.3 numeric

$$.6\text{mW/cmsq} = \frac{407 \times 6.3}{4\ (3.14) \times Dsq} = \frac{2564}{12.56 \times Dsq}$$

$$Dsq = \frac{2564}{12.56 \times .6} = 340.23$$

D = sq. root 340.23 = 18.45cm

EQUIPMENT LISTS

20 dB Bandwidth

EN	Type	Manufacturer	Description	Model No.	Cal Date	Due Date
4961	Attenuator	Narda	DC - 18 GHz	757C-30dB	10/15/01	10/15/02
713	EMI Test Receiver	Rohde & Schwarz	20 Hz - 26.5 GHz	ESI26	7/19/02	7/19/03

Band-edge Compliance of RF Conducted Emissions

EN	Type	Manufacturer	Description	Model No.	Cal Date	Due Date
4961	Attenuator	Narda	DC - 18 GHz	757C-30dB	10/15/01	10/15/02
713	EMI Test Receiver	Rohde & Schwarz	20 Hz - 26.5 GHz	ESI26	7/19/02	7/19/03

AC Conducted Emissions

EN	Type	Manufacturer	Description	Model No.	Cal Date	Due Date
4027	LISN	Solar Electronics	10 KHz - 30 MHz	9252-50-R-24BNC	7/7/01	9/7/02
4028	Isolation Transformer	Acme	N/A	120x240	1/25/02	1/25/03
4050	Transient Limiter	Hewlett Packard	9 KHz - 200 MHz	11970K	1/4/02	1/4/03
713	EMI Test Receiver	Rohde & Schwarz	20 Hz - 26.5 GHz	ESI26	7/19/02	7/19/03

Carrier Frequency Separation

EN	Type	Manufacturer	Description	Model No.	Cal Date	Due Date
4961	Attenuator	Narda	DC - 18 GHz	757C-30dB	10/15/01	10/15/02
713	EMI Test Receiver	Rohde & Schwarz	20 Hz - 26.5 GHz	ESI26	7/19/02	7/19/03

Number of Hopping Frequencies

EN	Type	Manufacturer	Description	Model No.	Cal Date	Due Date
4961	Attenuator	Narda	DC - 18 GHz	757C-30dB	10/15/01	10/15/02
713	EMI Test Receiver	Rohde & Schwarz	20 Hz - 26.5 GHz	ESI26	7/19/02	7/19/03

Peak Output Power

EN	Type	Manufacturer	Description	Model No.	Cal Date	Due Date
4961	Attenuator	Narda	DC - 18 GHz	757C-30dB	10/15/01	10/15/02
713	EMI Test Receiver	Rohde & Schwarz	20 Hz - 26.5 GHz	ESI26	7/19/02	7/19/03

Spurious RF Conducted Emissions

EN	Type	Manufacturer	Description	Model No.	Cal Date	Due Date
4961	Attenuator	Narda	DC - 18 GHz	757C-30dB	10/15/01	10/15/02
713	EMI Test Receiver	Rohde & Schwarz	20 Hz - 26.5 GHz	ESI26	7/19/02	7/19/03

Spurious Radiated Emissions

EN	Type	Manufacturer	Description	Model No.	Cal Date	Due Date
3138	10 DB Atten. (50 ohm)	Narda	DC - 5 GHz	768-10	4/18/02	4/18/03
3258	Double Ridge Guide	EMCO	1 - 18 GHz	3115	5/6/02	5/6/03
713	EMI Test Receiver	Rohde & Schwarz	20 Hz - 26.5 GHz	ESI26	7/19/02	7/19/03

Time of Occupancy

EN	Type	Manufacturer	Description	Model No.	Cal Date	Due Date
4961	Attenuator	Narda	DC - 18 GHz	757C-30dB	10/15/01	10/15/02
713	EMI Test Receiver	Rohde & Schwarz	20 Hz - 26.5 GHz	ESI26	7/19/02	7/19/03