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Electromagnetic Emissions Test Report and Request for Class II Permissive Change pursuant to FCC Part 15, Subpart C for an Intentional on the Savi Technology, Inc. Model: Savi Reader 410R

FCC ID:	KL7-410R-V1
GRANTEE:	Savi Technology, Inc. 450 National Avenue Mountain View, CA. 94043-2238
TEST SITE:	Elliott Laboratories, Inc. 684 W. Maude Avenue Sunnyvale, CA 94086
REPORT DATE:	March 2, 2000
FINAL TEST DATE:	February 2, 2000
AUTHORIZED SIGNATORY:	Mark R. Briggs Manager, EMC Consulting Services

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SCOPE

An electromagnetic emissions test has been performed on the Savi Technology, Inc. model Savi Reader 410R pursuant to Subpart C of Part 15 of FCC Rules for intentional radiators. Conducted and radiated emissions data has been collected, reduced, and analyzed within this report in accordance with measurement guidelines set forth in ANSI C63.4-1992 as outlined in Elliott Laboratories test procedures.

The intentional radiator above has been tested in a simulated typical installation to demonstrate compliance with the relevant FCC performance and procedural standards.

Final system data was gathered in a mode that tended to maximize emissions by varying orientation of EUT, orientation of power and I/O cabling, antenna search height, and antenna polarization.

Every practical effort was made to perform an impartial test using appropriate test equipment of known calibration. All pertinent factors have been applied to reach the determination of compliance.

The test results recorded herein are based on a single type test of the Savi Technology, Inc. model Savi Reader 410R and therefore apply only to the tested sample. The sample was selected and prepared by Eugene Schlindweinof Savi Technology, Inc.

OBJECTIVE

The primary objective of the manufacturer is compliance with Subpart C of Part 15 of FCC Rules for the radiated and conducted emissions of intentional radiators. Certification of these devices is required as a prerequisite to marketing as defined in Part 2 the FCC Rules.

Certification is a procedure where the manufacturer or a contracted laboratory makes measurements and submits the test data and technical information to the FCC. The FCC issues a grant of equipment authorization upon successful completion of their review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units subsequently manufactured.

STATEMENT OF COMPLIANCE

The tested sample of Savi Technology, Inc. model Savi Reader 410R complied with the requirements of Subpart C of Part 15 of the FCC Rules for low power intentional radiators.

Maintenance of FCC compliance is the responsibility of the manufacturer. Any modification of the product which may result in increased emissions should be checked to ensure compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

EMISSION TEST RESULTS

The following emissions tests were performed on the Savi Technology, Inc. model Savi Reader 410R. The actual test results are contained in an exhibit of this report.

LIMITS OF CONDUCTED INTERFERENCE VOLTAGE

The EUT tested complied with the limits detailed in FCC Rules Part 15 Section 15.207.

The following measurement was extracted from the data recorded during the conducted emissions scan and represents the highest amplitude emission relative to the specification limit. The actual test data and any correction factors are contained in an exhibit of this report.

0.45 – 30.00 MHz, 120V, 60Hz

Frequency	Level	Power	FCC Part 15.207		Detector	Comments
MHz	dBuV	Lead	Limit	Margin	QP/Ave	
11.064	39.5	Line	48.0	-8.5	QP	

LIMITS OF RADIATED INTERFERENCE FIELD STRENGTH –15.231 (a)

The EUT tested complied with the limits detailed in FCC Rules Part 15 Section 15.231 (a) and 15.209 in the case of emissions falling within the frequency bands specified in Section 15.205 when transmitting the control and wake-up signals.

The following measurement was extracted from the data recorded during the radiated electric field emissions scan and represents the highest amplitude emission relative to the specification limit. The actual test data and any correction factors are contained in an exhibit of this report.

Fundamental Emission: 433.9 MHz (Wake-Up Signal)

Frequency	Level	Pol	FCC Part 15.107		Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
433.937	73.3	V	54.0	-7.5	Avg	0	1.0	

Spurious Emissions: 30 – 4330 MHz (Wake-Up Signal)

Frequency	Level	Pol	FCC Part 15.107		Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
3905.385	51.3	V	54.0	-2.7	Avg	137	1.0	

No measurements were made on the control signal. This signal is identical in peak signal level to the data signal, which is subject to the more stringent limits of 15.231(e). In addition, the control signal is a shorter pulse and, therefore, the average value of the control signal emissions would be lower than the average value of the data signal. As the data signal met the 15.231(e) limits the control signal automatically meets the 15.231(a) limits.

LIMITS OF RADIATED INTERFERENCE FIELD STRENGTH –15.231 (e)

The EUT tested complied with the limits detailed in FCC Rules Part 15 Section 15.231 (e) and 15.209 in the case of emissions falling within the frequency bands specified in Section 15.205 and all emissions above 1GHz below when transmitting the data signal.

The following measurement was extracted from the data recorded during the radiated electric field emissions scan and represents the highest amplitude emission relative to the specification limit. The actual test data and any correction factors are contained in an exhibit of this report.

Fundamental Emission: 433.9 MHz (Data Signal)

Frequency MHz	Level dBuV/m	Pol v/h	FCC Part 15.231(e) Limit	Margin	Detector Pk/QP/Avg	Azimuth degrees	Height meters	Comments
433.936	61.2	V	72.9	-11.7	Avg	121	1.4	

Spurious Emissions: 30 – 4330 MHz (Data Signal)

Frequency MHz	Level dBuV/m	Pol v/h	FCC Part 15.231(e) Limit	Margin	Detector Pk/QP/Avg	Azimuth degrees	Height meters	Comments
3905.865	41.7	V	54.0	-12.3	Avg	133	1.0	

LIMITS OF BANDWIDTH

The proposed changes to the device do not affect the bandwidth measurements reported to the FCC in the original submittal for the device.

MEASUREMENT UNCERTAINTIES

ISO Guide 25 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level and were calculated in accordance with NAMAS document NIS 81.

Measurement Type	Frequency Range (MHz)	Calculated Uncertainty (dB)
Conducted Emissions	0.15 to 30	± 2.4
Radiated Emissions	30 to 1000	± 3.2

EQUIPMENT UNDER TEST (EUT) DETAILS

GENERAL

The Savi Technology, Inc. model Savi Reader 410R is an asset tag reader, which is designed to interface with the SaviTag 410 by sending control signals and receiving data (recognition codes) from the TAGs. In addition, it can also transmit data. For control signals the transmitter will be subject to the requirements of 15.231(a) and for data signals it will be subject to the requirements of 15.231(e), both of which govern pulsed transmissions.

The transmitter and receiver circuitry in the device tested is common to all of the SaviReader 410R(-T)-XXX family of readers. The differences between the various members of this product family are in the digital interface (RS232 and/or RS485), the use of an LED and LonWorks as detailed in the product list (refer to Theory of Operations Exhibit). The unit tested (SR-410R-006) contains all options and was considered representative of the worst case configuration of the product family.

The sample was received on February 2, 2000 and tested on February 2, 2000. The EUT consisted of the following component(s):

Manufacturer/Model/Description	Serial Number	FCC ID Number
Savi Tech. SR-410R-016 Tag Reader	101	KL7-410R-V1

INPUT POWER

The EUT input is rated at 120/240, 50/60 Hz. The EUT contained the following input power components during emissions testing:

Description	Manufacturer	Model
Power Supply	Savi Tech.	810-0081-010

PRINTED WIRING BOARDS

The EUT contained the following printed wiring boards during emissions testing:

Manufacturer/Description	Assembly #	Rev.	Serial #	Crystals (MHz)
Lon work Module	810-01295-001	B	2749904	10
Savi Tech. Network Interface	810-02425-001	A	068732	3.684
Savi Tech. Interrogator 3.0	810-01290-001	A	068747	16
Savi Tech. RF Comm (x2)	810-01285-001	A	897, 905	433.92(Tx)

SUBASSEMBLIES

The EUT did not contain subassembly modules during emissions testing.

ENCLOSURE

The EUT enclosure is primarily constructed of fabricated polymeric material steel. It has a diameter of 30.5 cm and is 14 cm high.

EMI SUPPRESSION DEVICES

The EUT contained the following EMI suppression devices during emissions testing:

Description	Manufacturer	Part Number
Ferrite	Ferronics	12-340

MODIFICATIONS

The EUT did not require modifications during testing in order to comply with the emission specifications.

SUPPORT EQUIPMENT

No support equipment was used during emissions testing.

EXTERNAL I/O CABLING

The I/O cabling configuration during emissions testing was as follows:

Cable Description	Length (m)	From Unit/Port	To Unit/Port
Unshielded	30.0	EUT (RS-485)	Not Terminated
Unshielded	30.0	EUT (RS-485)	Not Terminated

Note: The serial port was not connected during testing. The manufacturer stated that this port is used purely for maintenance and configuration purposes and is not used under normal operating conditions.

TEST SOFTWARE

For all radiated emissions measurements of the fundamental and spurious emissions from the transmitter, the device was configured to transmit the wake-up, data signal continuously from both transmitter/antenna combinations.

For all radiated emissions measurements from the receiver and digital circuitry, the device was configured to receive continuously at 433.985 MHz.

PROPOSED MODIFICATION DETAILS

GENERAL

This section details the modifications to the Savi Technology, Inc. model Savi Reader 410R being proposed. All performance and construction deviations from the characteristics originally reported to the FCC are addressed

Enclosure:
The original enclosure was constructed of aluminum sheet metal. The new enclosure is made of polymeric material.

Output Power:
The output powers of signals have been reduced using firmware (see below).

RF Board:
No changes other than output power that has been reduced using firmware from 72.2 dBµV/m to 58.7 dBµV/m for Data Signal, 80.3 dBµV/m to 72.2 dBµV/m for "Wake-up" Control Signal, and 79.2 dBµV/m to 57.1 dBµV/m for Control Signal. The voltage level is supplied to the final stage using a programmable voltage source on the RF board.

Digital Board:
No modification was made to Digital Board.

TEST SITE

GENERAL INFORMATION

Final test measurements were taken on February 2, 2000 at the Elliott Laboratories Open Area Test Site #3 located at 684 West Maude Avenue, Sunnyvale, California. The test site contains separate areas for radiated and conducted emissions testing. Pursuant to section 2.948 of the Rules, construction, calibration, and equipment data has been filed with the Commission.

The FCC recommends that ambient noise at the test site be at least 6 dB below the allowable limits. Ambient levels are below this requirement with the exception of predictable local TV, radio, and mobile communications traffic. The test site contains separate areas for radiated and conducted emissions testing. Considerable engineering effort has been expended to ensure that the facilities conform to all pertinent FCC requirements.

CONDUCTED EMISSIONS CONSIDERATIONS

Conducted emissions testing is performed in conformance with ANSI C63.4-1992. Measurements are made with the EUT connected to the public power network through a nominal standardized RF impedance, provided by a line impedance stabilization network, known as a LISN. A LISN is inserted in series with each current-carrying conductor in the EUT power cord.

RADIATED EMISSIONS CONSIDERATIONS

The FCC has determined that radiation measurements made in a shielded enclosure are not suitable for determining levels of radiated emissions. Radiated measurements are performed in an open field environment. The test site is maintained free of conductive objects within the CISPR defined elliptical area incorporated in ANSI C63.4 guidelines.

MEASUREMENT INSTRUMENTATION

RECEIVER SYSTEM

An EMI receiver as specified in CISPR 16-1 is used for emissions measurements. The receivers used can measure over the frequency range of 9 kHz up to 2000 MHz. These receivers allow both ease of measurement and high accuracy to be achieved. The receivers have Peak, Average, and CISPR (Quasi-peak) detectors built into their design so no external adapters are necessary. The receiver automatically sets the required bandwidth for the CISPR detector used during measurements.

For measurements above the frequency range of the receivers, a spectrum analyzer is utilized because it provides visibility of the entire spectrum along with the precision and versatility required to support engineering analysis. Average measurements above 1000MHz are performed on the spectrum analyzer using the linear-average method with a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz.

INSTRUMENT CONTROL COMPUTER

The receivers utilize either a Rohde and Schwarz EZM Spectrum Monitor/Controller or contain an internal Spectrum Monitor/Controller to view and convert the receiver measurements to the field strength at an antenna or voltage developed at the LISN measurement port, which is then compared directly with the appropriate specification limit. This provides faster, more accurate readings by performing the conversions described under Sample Calculations within the Test Procedures section of this report. Results are printed in a graphic and/or tabular format, as appropriate. A personal computer is used to record all measurements made with the receivers.

The Spectrum Monitor provides a visual display of the signal being measured. In addition, the controller or a personal computer run automated data collection programs which control the receivers. This provides added accuracy since all site correction factors, such as cable loss and antenna factors are added automatically.

LINE IMPEDANCE STABILIZATION NETWORK (LISN)

Line conducted measurements utilize a fifty microhenry Line Impedance Stabilization Network as the monitoring point. The LISN used also contains a 250 uH CISPR adapter. This network provides for calibrated radio frequency noise measurements by the design of the internal low pass and high pass filters on the EUT and measurement ports, respectively.

FILTERS/ATTENUATORS

External filters and precision attenuators are often connected between the receiving antenna or LISN and the receiver. This eliminates saturation effects and non-linear operation due to high amplitude transient events.

ANTENNAS

A biconical antenna is used to cover the range from 30 MHz to 300 MHz and a log periodic antenna is utilized from 300 MHz to 1000 MHz. Narrowband tuned dipole antennas are used over the entire 30 to 1000 MHz range for precision measurements of field strength. Above 1000 MHz, a horn antenna is used. The antenna calibration factors are included in site factors, which are programmed into the test receivers.

ANTENNA MAST AND EQUIPMENT TURNTABLE

The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height.

ANSI C63.4 specifies that the test height above ground for table mounted devices shall be 80 centimeters. Floor mounted equipment shall be placed on the ground plane if the device is normally used on a conductive floor or separated from the ground plane by insulating material from 3 to 12 mm if the device is normally used on a non-conductive floor. During radiated measurements, the EUT is positioned on a motorized turntable in conformance with this requirement.

INSTRUMENT CALIBRATION

All test equipment is regularly checked to ensure that performance is maintained in accordance with the manufacturer's specifications. All antennas are calibrated at regular intervals with respect to tuned half-wave dipoles. An exhibit of this report contains the list of test equipment used and calibration information.

TEST PROCEDURES

EUT AND CABLE PLACEMENT

The FCC requires that interconnecting cables be connected to the available ports of the unit and that the placement of the unit and the attached cables simulate the worst case orientation that can be expected from a typical installation, so far as practicable. To this end, the position of the unit and associated cabling is varied within the guidelines of ANSI C63.4, and the worst case orientation is used for final measurements.

CONDUCTED EMISSIONS

Conducted emissions are measured at the plug end of the power cord supplied with the EUT. Excess power cord length is wrapped in a bundle between 30 and 40 centimeters in length near the center of the cord. Preliminary measurements are made to determine the highest amplitude emission relative to the specification limit for all the modes of operation. Placement of system components and varying of cable positions are performed in each mode. A final peak mode scan is then performed in the position and mode for which the highest emission was noted on all current carrying conductors of the power cord.

RADIATED EMISSIONS

Radiated emissions measurements are performed in two phases as well. A preliminary scan of emissions is conducted in which all significant EUT frequencies are identified with the system in a nominal configuration. At least two scans are performed from 30 MHz up to the frequency required by the regulation specified on page 1. One or more of these is with the antenna polarized vertically while the one or more of these are with the antenna polarized horizontally. During the preliminary scans, the EUT is rotated through 360˚, the antenna height is varied and cable positions are varied to determine the highest emission relative to the limit.

A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

Final maximization is a phase in which the highest amplitude emissions identified in the spectral search are viewed while the EUT azimuth angle is varied from 0 to 360 degrees relative to the receiving antenna. The azimuth which results in the highest emission is then maintained while varying the antenna height from one to four meters. The result is the identification of the highest amplitude for each of the highest peaks. Each recorded level is corrected in the receiver using appropriate factors for cables, connectors, antennas, and preamplifier gain. Emissions which have values close to the specification limit may also be measured with a tuned dipole antenna to determine compliance.

SPECIFICATION LIMITS AND SAMPLE CALCULATIONS

The limits for conducted emissions are given in units of microvolts, and the limits for radiated emissions are given in units of microvolts per meter at a specified test distance. Data is measured in the logarithmic form of decibels relative to one microvolt, or dB microvolts (dBuV). For radiated emissions, the measured data is converted to the field strength at the antenna in dB microvolts per meter (dBuV/m). The results are then converted to the linear forms of uV and uV/m for comparison to published specifications.

For reference, converting the specification limits from linear to decibel form is accomplished by taking the base ten logarithm, then multiplying by 20. These limits in both linear and logarithmic form are as follows:

CONDUCTED EMISSIONS SPECIFICATION LIMITS, SECTION 15.207

Frequency Range (MHz)	Limit (uV)	Limit (dBuV)
0.450 to 30.000	250	48

RADIATED EMISSIONS SPECIFICATION LIMITS, SECTION 15.231 (a)

For a 433.9 MHz fundamental signal the limits in 15.231 (a) are:

Frequency Range (MHz)	Limit (uV/m @ 3m)	Limit (dBuV/m @ 3m)
Fundamental	10,965	80.8
Spurious	1096.5	60.8

The general limits apply in restricted bands.

RADIATED EMISSIONS SPECIFICATION LIMITS, SECTION 15.231 (e)

For a 433.9 MHz fundamental signal the limits in 15.231 (e) are:

Frequency Range (MHz)	Limit (uV/m @ 3m)	Limit (dBuV/m @ 3m)
Fundamental	4,415.7	72.9
Spurious	441.6	52.9

Above 1 GHz, the general limits of 15.209 permit higher emissions and are, therefore, applicable. The general limits apply in restricted bands below 1GHz

RADIATED EMISSIONS SPECIFICATION LIMITS, SECTION 15.209

Frequency Range (MHz)	Limit (uV/m @ 3m)	Limit (dBuV/m @ 3m)
30 to 88	100	40
88 to 216	150	43.5
216 to 960	200	46.0
Above 960	500	54.0

SAMPLE CALCULATIONS - CONDUCTED EMISSIONS

Receiver readings are compared directly to the conducted emissions specification limit (decibel form) as follows:

$$R_r - B = C$$

and

$$C - S = M$$

where:

R_r = Receiver Reading in dBuV

B = Broadband Correction Factor*

C = Corrected Reading in dBuV

S = Specification Limit in dBuV

M = Margin to Specification in +/- dB

* Broadband Level- Per ANSI C63.4, 13 dB may be subtracted from the quasi-peak level if it is determined that the emission is broadband in nature. If the signal level in the average mode is six dB or more below the signal level in the peak mode, the emission is classified as broadband.

SAMPLE CALCULATIONS - RADIATED EMISSIONS

Receiver readings are compared directly to the specification limit (decibel form). The receiver internally corrects for cable loss, preamplifier gain, and antenna factor. The calculations are in the reverse direction of the actual signal flow, thus cable loss is added and the amplifier gain is subtracted. The Antenna Factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements. A distance factor, when used for electric field measurements, is calculated by using the following formula:

$$F_d = 20*LOG_{10} (D_m/D_s)$$

where:

F_d = Distance Factor in dB

D_m = Measurement Distance in meters

D_s = Specification Distance in meters

Measurement Distance is the distance at which the measurements were taken and Specification Distance is the distance at which the specification limits are based. The antenna factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

The margin of a given emission peak relative to the limit is calculated as follows:

$$R_c = R_r + F_d$$

and

$$M = R_c - L_s$$

where:

R_r = Receiver Reading in dBuV/m

F_d = Distance Factor in dB

R_c = Corrected Reading in dBuV/m

L_s = Specification Limit in dBuV/m

M = Margin in dB Relative to Spec

EXHIBIT 1: Test Equipment Calibration Data

Test Equipment List - SVOATS#3

February 17, 2000

Manufacturer/Description		Model	Asset #	Interval	Last Cal	Cal Due
☒ Elliott Laboratories	300-1000 MHz Log Periodic	EL300.1000	55	11	11/3/99	10/3/2000
☒ Elliott Laboratories	Biconical Antenna, 30-300 MHz	EL30.300	54	12	12/21/1999	12/21/2000
☒ Elliott Laboratories	FCC / CISPR LISN	LISN-4 OATS	362	12	6/10/99	6/10/2000
☒ EMCO	D. Ridge Horn Antenna, 1-18GHz	3115	786	12	1/8/2000	1/8/2001
☒ Filtek	High Pass Filter	HP12/1000-5B	957	12	4/17/99	4/17/2000
☒ Hewlett Packard	EMC Spectrum Analyzer, Opt. 026	8593EM	1141	12	12/22/1999	12/22/2000
☒ Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	785	12	12/2/1999	12/2/2000
☒ Rohde & Schwarz	Test Receiver, 0.009-30 MHz	ESH3	215, (F197)	12	2/17/99	2/17/2000
☒ Rohde & Schwarz	Test Receiver, 20-1300MHz	ESVP	273	12	9/9/99	9/9/2000
☒ Rohde & Schwarz	Pulse Limiter	ESH3Z2	812	12	12/08/99	12/08/2000

File Number: T35984

Date: 2-17-2000

Engr: Mehran M Birgani

All calibration of equipment is traceable to a national standard of measurement such as NIST.

EXHIBIT 2:Test Data Log Sheets

ELECTROMAGNETIC EMISSIONS

TEST LOG SHEETS

AND

MEASUREMENT DATA

T 35370 14 Pages

Client:	Savi Technology	Date:	2/17/00	Test Eng:	Mehran M Birgani
Product:	SaviReader 410R	File:	T35984	Proj. Eng:	Mark Briggs
Objective:	Final Qualification	Site:	SVOATS #3	Contact:	Gene Schlindwein
Spec:	FCC Subparts B and C	Page:	1 of 6	Approved:	
Revision	1.0				

Ambient Conditions		
Temperature:	9	°C
Humidity:	79	% RH

Test Objective

The objective of this test session is to perform final qualification testing the EUT defined below relative to the specification defined above.

Test Summary

Run #1 - Measurement of Local Oscillator and Harmonics.
(Receiver and Digital Device)

PASS Results: FCC Class B -15.5 dB QP @ 423.231 MHz Vertical

Run #2 - Unmaximized Preliminary Radiated Emissions Scan, 30 – 1000 MHz
(Receiver and Digital Device)

PASS Results: FCC Class A -4.2 dB QP @ 80.044 MHz Vertical

Run #3 - Maximized Radiated Emissions from Run #2

PASS Results: FCC Class A -4.0 dB QP @ 80.044 MHz Vertical

Run #4 - Measurement of Fundamental Emission Field Strength
("Wake-Up" Control Signal).

PASS Results: §15.231(a) -7.5 dB Avg. @ 433.937 MHz Horizontal

Run #5 - Maximized Radiated Spurious Emissions Scan, 866 – 4330 MHz
("Wake-Up" Control Signal)

PASS* Results: §15.231(a) -2.7 dB Avg. @ 3905.385 MHz Vertical
(Note: limits in §15.209 were used for emissions falling in restricted bands)

* The difference between the level of one or more of the emissions from the system under test and the specification limit is within the measurement uncertainty.

Run #6 - Measurement of Fundamental Emission Field Strength
(Pulsed Data Signal)

PASS Results: §15.231(e) -11.7 dB Avg. @ 433.985MHz Vertical

Test Summary (continued)

Run #7 - Maximized Radiated Spurious Emissions Scan, 866 – 4330 MHz (Pulsed Data Signal)

PASS Results: §15.231(e) -12.3 dB Avg. @ 3905.865MHz Vertical

(Note: limits in §15.209 were used for emissions falling in restricted bands).

Run #8 - Conducted Emissions, 0.45 – 30MHz, 120 V / 60 Hz (Receiver)

PASS Results: FCC Part 15.107 -8.5 dB QP @ 11.064 MHz Line

Run #9 - Conducted Emissions, 0.45 – 30MHz, 120 V / 60 Hz (Transmitter#1)

PASS Results: FCC Part 15.207 -7.4 dB QP @ 11.062 MHz Line

Equipment Under Test (EUT) General Description

The EUT is an asset tag reader, which is designed to interface with the SaviTag 410 by sending control signals and receiving data (recognition codes) from the TAGs. In addition, it can also transmit data. For control signals the transmitter will be subject to the requirements of 15.231(a) and for data signals it will be subject to the requirements of 15.231(e), both of which govern pulsed transmissions.

The transmitter and receiver circuitry in the device tested is common to all of the SaviReader 410R(-T)-XXX family of readers. The differences between the various members of this product family are in the digital interface (RS232 and/or RS485), the use of an LED and LonWorks as detailed in the product list (refer to Theory of Operations Exhibit). The unit tested (SR-410R-006) contains all options and was considered representative of the worst case configuration of the product family.

Normally, the EUT will be attached to a pole or similar structure. For the purposes of EMC testing the EUT was treated as tabletop equipment and placed to simulate the orientation of the device in its intended use.

Equipment Under Test (EUT)

Manufacturer/Model/Description	Serial Number	FCC ID Number
Savi Tech. SR-410R-016 Tag Reader	101	KL7-410R-V1

Power Supply and Line Filters

The manufacturer provided the following information:

Description	Manufacturer	Model
Power Supply	Savi Tech.	810-0081-010

Printed Wiring Boards in EUT

The manufacturer provided the following information:

Manufacturer/Description	Assembly #	Rev.	Serial Number	Crystals (MHz)
Lon work Module	810-01295-001	B	2749904	10
Savi Tech. Network Interface	810-02425-001	A	068732	3.684
Savi Tech. Interrogator 3.0	810-01290-001	A	068747	16
Savi Tech. RF Comm (x2)	810-01285-001	A	897, 905	433.92(Tx)

Subassemblies in EUT

The manufacturer provided the following information:

Manufacturer/Description	Assembly Number	Rev.	Serial Number
None	-	-	-

EUT Enclosure(s)

The EUT enclosure is primarily constructed of fabricated polymeric material steel. It has a diameter of 30.5 cm and is 14 cm high.

EMI Suppression Devices (filters, gaskets, etc.)

The manufacturer provided the following information:

Description	Manufacturer	Part Number
Ferrite	Ferronics	12-340

Changes to Previously Certified Device

The EUT had been modified from the device originally certified and has the following modifications:

1) Enclosure:

The original enclosure was constructed of aluminum sheet metal. The new enclosure is made of polymeric material.

2) Output Power:

The output powers of signals have been reduced using firmware (see below).

3) RF Board:

No changes other than output power that has been reduced using firmware from 72.2 dBµV/m to 58.7 dBµV/m for Data Signal, 80.3 dBµV/m to 72.2 dBµV/m for "Wake-up" Control Signal, and 79.2 dBµV/m to 57.1 dBµV/m for Control Signal. The voltage level is supplied to the final stage using a programmable voltage source on the RF board.

4) Digital Board:

No modification was made to Digital Board.

Modifications

No modification was made to the EUT during testing.

Local Support Equipment

Manufacturer/Model/Description	Serial Number	FCC ID Number
None	-	-

Remote Support Equipment

Manufacturer/Model/Description	Serial Number	FCC ID Number
None	-	-

Interface Cabling

Cable Description	Length (m)	From Unit/Port	To Unit/Port
Unshielded	30.0	EUT (RS-485)	Not Terminated
Unshielded	30.0	EUT (RS-485)	Not Terminated

Note: The serial port was not connected during testing. The manufacturer stated that this port is used purely for maintenance and configuration purposes and is not used under normal operating conditions.

Antenna

The antenna system for the EUT is contained within the enclosure of the device. There are two sizes of antenna - measurements were made on each antenna

Test Software

For all radiated emissions measurements of the fundamental and spurious emissions from the transmitter, the device was configured to transmit the wake-up, data signal continuously from both transmitter/antenna combinations.

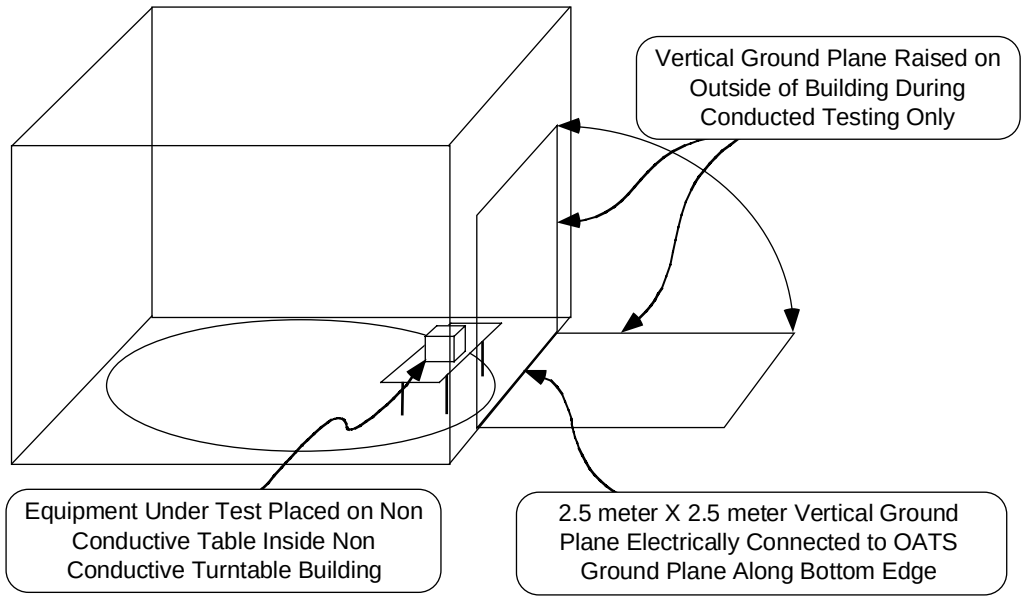
For all radiated emissions measurements from the receiver and digital circuitry, the device was configured to receive continuously at 433.985 MHz.

Client:	Savi Technology	Date:	2/17/00	Test Eng:	Mehran M Birgani
Product:	SaviReader 410R	File:	T35984	Proj. Eng:	Mark Briggs
Objective:	Final Qualification	Site:	SVOATS #3	Contact:	Gene Schlindwein
Spec:	FCC Subparts B and C	Page:	6 of 6	Approved:	
Revision	1.0				

General Test Conditions

During radiated testing, the EUT was connected to 120 V, 60 Hz power input. The EUT and all local support equipment were located on the turntable for radiated testing and conducted testing.

During conducted emissions testing, the EUT was connected to 120 V, 60 Hz power input as noted. A 2.5 x 2.5 meter ground plane was raised to a vertical position 40 cm from the EUT as shown below:



Test Data Tables

See attached data

Emissions Test Data

Client:	Savi Technologies	Date:	02/17/2000	Test Engr:	Mehran M Birgani
Product:	SaviReader 410R	File:	T35984	Proj. Engr:	Mark Briggs
Objective	Final Qualification	Site:	SVOATS #3	Contact:	Gene Schlindwein
Spec:	FCC Part 15 Subparts B and C	Distance:	See Data Log	Approved:	

Ambient Conditions
Temperature: 9 °C
Humidity: 79 %

Run #1: Preliminary Radiated Emissions, Receiver LO at 423.231 MHz and Harmonics.

*Measured at 3m with FCC Class B limits.

Frequency	Level	Pol	FCC 15.109		Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
423.231	30.5	V	46.0	-15.5	QP	272	1.1	First Harmonic of Receiver
423.231	30.1	H	46.0	-15.9	QP	290	1.9	First Harmonic of Receiver
846.494	29.2	H	46.0	-16.8	QP	146	1.1	Second Harmonic of Receiver
846.495	27.0	V	46.0	-19.0	QP	158	1.0	Second Harmonic of Receiver

Run #2: Preliminary Radiated Emissions, Digital Device, 30-1000 MHz

*Measured at 10m with FCC Class A limits.

Frequency	Level	Pol	FCC 15.109		Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
80.044	34.9	V	39.1	-4.2	QP	252	1.4	
164.995	33.0	V	43.5	-10.5	QP	215	1.0	
76.041	27.8	V	39.1	-11.3	QP	233	1.2	
68.035	27.3	V	39.1	-11.8	QP	233	1.2	
64.996	26.7	V	39.1	-12.4	QP	215	1.0	
140.000	30.3	V	43.5	-13.2	QP	199	1.0	
52.024	24.6	V	39.1	-14.5	QP	233	1.0	
60.034	23.3	V	39.1	-15.8	QP	310	1.2	
80.044	23.1	H	39.1	-16.0	QP	300	1.8	
140.000	24.0	H	43.5	-19.5	QP	284	4.0	
108.058	23.1	V	43.5	-20.4	QP	260	1.0	
164.995	21.3	H	43.5	-22.2	QP	284	4.0	
76.041	16.6	H	39.1	-22.5	QP	247	1.8	
116.064	20.8	V	43.5	-22.7	QP	264	1.0	

Run #3: Maximized Readings from Run #2, Sorted by Margin.

*Measured at 10m with FCC Class A limits.

Frequency	Level	Pol	FCC 15.109		Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
80.044	35.1	V	39.1	-4.0	QP	255	1.3	
164.995	33.0	V	43.5	-10.5	QP	215	1.0	
76.041	27.8	V	39.1	-11.3	QP	233	1.2	
68.035	27.3	V	39.1	-11.8	QP	233	1.2	
64.996	26.7	V	39.1	-12.4	QP	215	1.0	
140.000	30.3	V	43.5	-13.2	QP	199	1.0	

Elliott

Emissions Test Data

Client:	Savi Technologies	Date:	02/17/2000	Test Engr:	Mehran M Birgani
Product:	SaviReader 410R	File:	T35984	Proj. Engr:	Mark Briggs
Objective	Final Qualification	Site:	SVOATS #3	Contact:	Gene Schlindwein
Spec:	FCC Part 15 Subparts B and C	Distance:	See Data Log	Approved:	

Run #4: Maximized Radiated Emissions, Fundamental Frequency
(Device operating under 15.231(a) - Wake-Up Control Signal)

*Measured at 3m

Frequency	Level	Polarity	FCC 15.231(a)		Detector	Azimuth	Height	Comments
MHz	dBuV	H/V	Limit	Margin	Pk/QP/Avg	degrees	meters	
433.937	73.3	H	80.8	-7.5	Avg	0	1.0	120kHz bandwidth
433.937	73.1	V	80.8	-7.7	Avg	114	1.3	120kHz bandwidth
433.937	75.0	H	100.8	-25.8	Pk	0	1.0	120kHz bandwidth
433.937	73.2	V	100.8	-27.6	Pk	114	1.3	120kHz bandwidth

Note 1:	Average readings measured using analyzer - pulse width is 2.5 seconds, no average correction factor.

Run #5: Maximized Radiated Emissions, 866 MHz - 4333 MHz, Spurious Emissions
(Device operating under 15.231(a) - Wake-Up Control Signal)

*Measured at 3m against FCC 15.231(a) limits (15.209 in restricted bands)

Frequency	Level	Pol	FCC 15.231(a)		Detector	Azimuth	Height	Comments
MHz	dBuV/m	H/V	Limit	Margin	Pk/QP/Avg	degrees	meters	
3905.385	51.3	V	54.0	-2.7	Avg	137	1.0	1MHz bandwidth. In restricted band
3905.385	51.0	H	54.0	-3.0	Avg	205	1.1	1MHz bandwidth. In restricted band
2603.616	48.1	H	60.8	-12.7	Avg	220	1.0	1MHz bandwidth
2169.925	46.8	V	60.8	-14.0	Avg	249	1.1	1MHz bandwidth
3905.385	59.8	V	74.0	-14.2	Pk	137	1.0	1MHz bandwidth. In restricted band
3905.385	59.5	H	74.0	-14.5	Pk	205	1.1	1MHz bandwidth. In restricted band
2169.925	42.5	H	60.8	-18.3	Avg	228	1.1	1MHz bandwidth
1301.808	34.5	H	54.0	-19.5	Avg	160	1.0	1MHz bandwidth. In restricted band
2603.616	55.2	H	80.8	-25.6	Pk	220	1.0	1MHz bandwidth
2169.925	54.8	V	80.8	-26.0	Pk	249	1.1	1MHz bandwidth
1301.808	45.1	H	74.0	-28.9	Pk	160	1.0	1MHz bandwidth. In restricted band
2169.925	51.8	H	80.8	-29.0	Pk	228	1.1	1MHz bandwidth
867.874	30.2	V	60.8	-30.6	Avg	114	1.3	120kHz bandwidth
867.874	27.0	H	60.8	-33.8	Avg	0	1.0	120kHz bandwidth
867.874	38.9	H	80.8	-41.9	Pk	0	1.0	120kHz bandwidth
867.874	38.6	V	80.8	-42.2	Pk	114	1.3	120kHz bandwidth

Note 1:	Average readings measured using analyzer - pulse width is 2.5 seconds, no average correction factor.
Note 2:	In restricted bands, the limit is FCC15.209 limit, otherwise average limit is 60.8dBuV/m

Client:	Savi Technologies	Date:	02/17/2000	Test Engr:	Mehran M Birgani
Product:	SaviReader 410R	File:	T35984	Proj. Engr:	Mark Briggs
Objective	Final Qualification	Site:	SVOATS #3	Contact:	Gene Schlindwein
Spec:	FCC Part 15 Subparts B and C	Distance:	See Data Log	Approved:	

Run #6: Maximized Radiated Emissions, Fundamental Frequency
(Device operating under 15.231(e) - DATA Signal)

*Measured at 3m

Frequency	Level	Polarity	FCC 15.231(e)		Detector	Azimuth	Height	Comments
MHz	dBuV	H/V	Limit	Margin	Pk/QP/Avg	degrees	meters	
433.936	61.2	V	72.9	-11.7	Avg	121	1.4	120kHz bandwidth
433.936	61.2	H	72.9	-11.7	Avg	0	1.0	120kHz bandwidth
433.936	79.9	V	92.9	-13.0	Pk	121	1.4	120kHz bandwidth
433.936	79.7	H	92.9	-13.2	Pk	0	1.0	120kHz bandwidth

Note 1:	Average readings calculated from peak readngs using correction factor of -18.4dB, pulse width =12mS

Run #7: Maximized Radiated Emissions, 866 MHz - 4333 MHz, Spurious Emissions
(Device operating under 15.231(e) - DATA Signals)

*Measured at 3m

Note: Output of Control Signal and Data Signal are identical, Since limit of Data System is more stringent than Control Signal, also correction factor for average limits for Control Signal is -1.6 dB more than Data Signal. Therefor, by passing Data Signal Control Signal passes as well.

Frequency	Level	Pol	FCC 15.231(e)		Detector	Azimuth	Height	Comments
MHz	dBuV/m	H/V	Limit	Margin	Pk/QP/Avg	degrees	meters	
3905.865	41.7	V	54.0	-12.3	Avg	133	1.0	1MHz bandwidth. In restricted band
3905.865	60.1	V	74.0	-13.9	Pk	133	1.0	1MHz bandwidth. In restricted band
2603.616	38.0	H	54.0	-16.0	Avg	223	1.0	1MHz bandwidth
2603.616	56.4	H	74.0	-17.6	Pk	223	1.0	1MHz bandwidth
2603.616	36.3	V	54.0	-17.7	Avg	197	1.0	1MHz bandwidth
2603.616	54.7	V	74.0	-19.3	Pk	197	1.0	1MHz bandwidth
2169.680	33.7	V	54.0	-20.3	Avg	195	1.2	1MHz bandwidth
3905.865	33.7	H	54.0	-20.3	Avg	216	1.1	1MHz bandwidth. In restricted band
2169.680	52.1	V	74.0	-21.9	Pk	195	1.2	1MHz bandwidth
3905.865	52.1	H	74.0	-21.9	Pk	216	1.1	1MHz bandwidth. In restricted band
1301.808	27.4	V	54.0	-26.6	Avg	180	1.0	1MHz bandwidth. In restricted band
1301.808	45.8	V	74.0	-28.2	Pk	180	1.0	1MHz bandwidth. In restricted band
867.970	20.2	V	52.9	-32.7	Avg	121	1.4	120kHz bandwidth
867.970	20.0	H	52.9	-32.9	Avg	0	1.0	120kHz bandwidth
867.970	38.6	V	72.9	-34.3	Pk	121	1.4	120kHz bandwidth
867.970	38.4	H	72.9	-34.5	Pk	0	1.0	120kHz bandwidth

Note 1:	Average readings calculated from peak readngs using correction factor of -18.4dB, pulse width =12mS
Note 2:	Above 1GHz the FCC15.209 limit is used since it permits higher radiation than the 15.231(e) limit.

Client:	Savi Technologies	Date:	02/17/2000	Test Engr:	Mehran M Birgani
Product:	SaviReader 410R	File:	T35984	Proj. Engr:	Mark Briggs
Objective	Final Qualification	Site:	SVOATS #3	Contact:	Gene Schlindwein
Spec:	FCC Part 15 Subparts B and C	Distance:	See Data Log	Approved:	

Run #8: Conducted Emissions, 120V/60Hz, Receiver

At 120V/60Hz against FCC Class B limits.

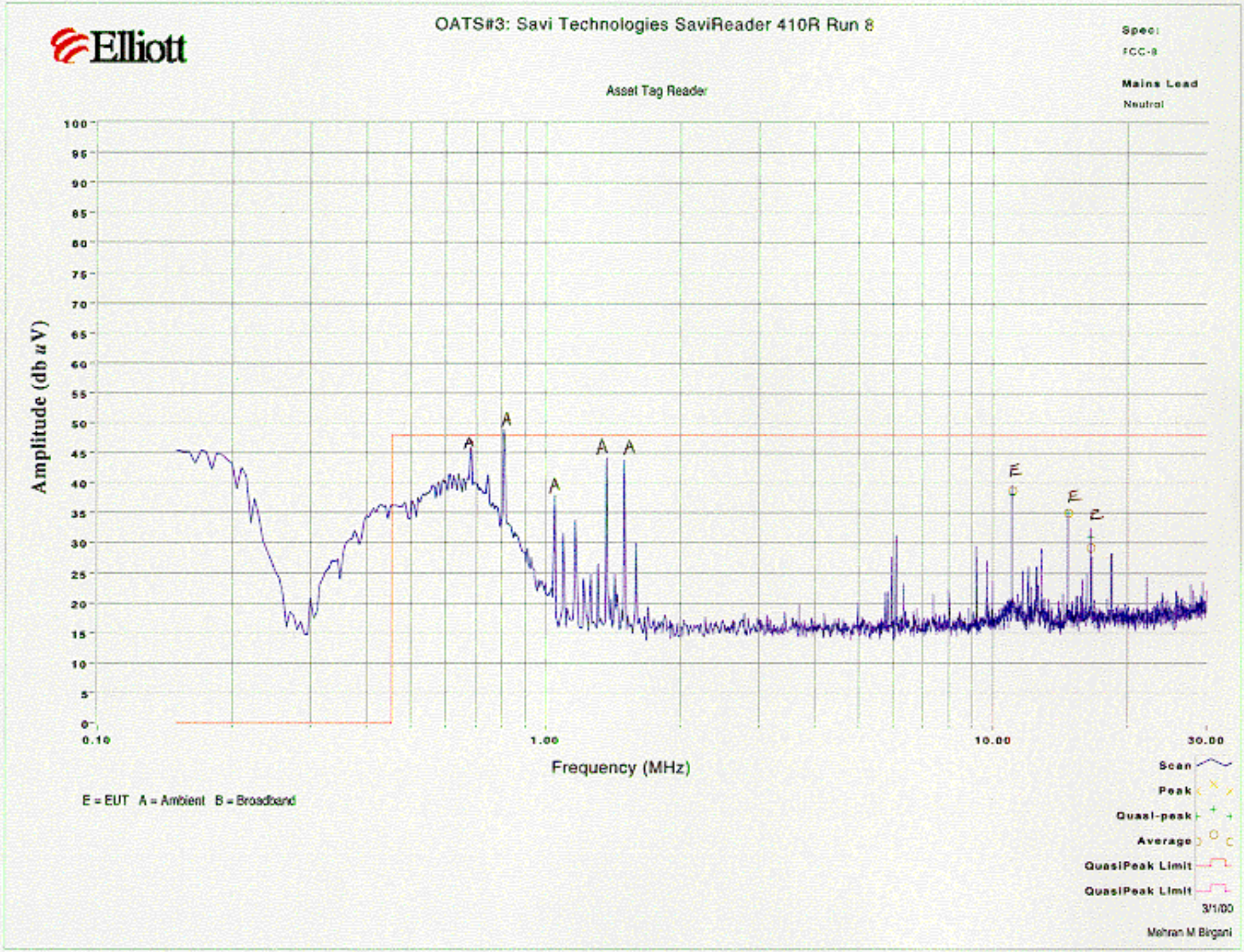
Frequency	Level	Power	FCC Part 15.107		Detector	Comments
MHz	dBuV	Lead	Limit	Margin	QP/Ave	
11.064	39.5	Line	48.0	-8.5	QP	
11.060	38.0	Neutral	48.0	-10.0	QP	
14.749	36.0	Line	48.0	-12.0	QP	
14.749	35.1	Neutral	48.0	-12.9	QP	
16.592	31.0	Neutral	48.0	-17.0	QP	
0.613	21.9	Line	48.0	-26.1	QP	Note 1

Note 1:	Broadband corrcetion factor of -13db applied to the QP reading as the avergae reading was 6dB lower than the QP reading.

Run #9: Conducted Emissions, 120V/60Hz, Transmitter #1

At 120V/60Hz against FCC Class B limits.

Frequency	Level	Power	FCC Part 15.207		Detector	Comments
MHz	dBuV	Lead	Limit	Margin	QP/Ave	
11.062	40.6	Line	48.0	-7.4	QP	
11.064	38.3	Neutral	48.0	-9.7	QP	
14.748	35.9	Line	48.0	-12.1	QP	
14.750	34.3	Neutral	48.0	-13.7	QP	
16.591	33.4	Line	48.0	-14.6	QP	
16.592	31.0	Neutral	48.0	-17.0	QP	


OATS#3: Savi Technologies SaviReader 410R Run 8
Elliott
Asset Tag Reader
Spec:
FCC-B
Mains Lead
Neutral
Amplitude (db uV)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0.10
1.00
10.00
30.00
Frequency (MHz)
A
E
E = EUT A = Ambient B = Broadband
Scan
Peak
Quasi-peak
Average
QuasiPeak Limit
QuasiPeak Limit
3/1/00
Mehran M Birgani

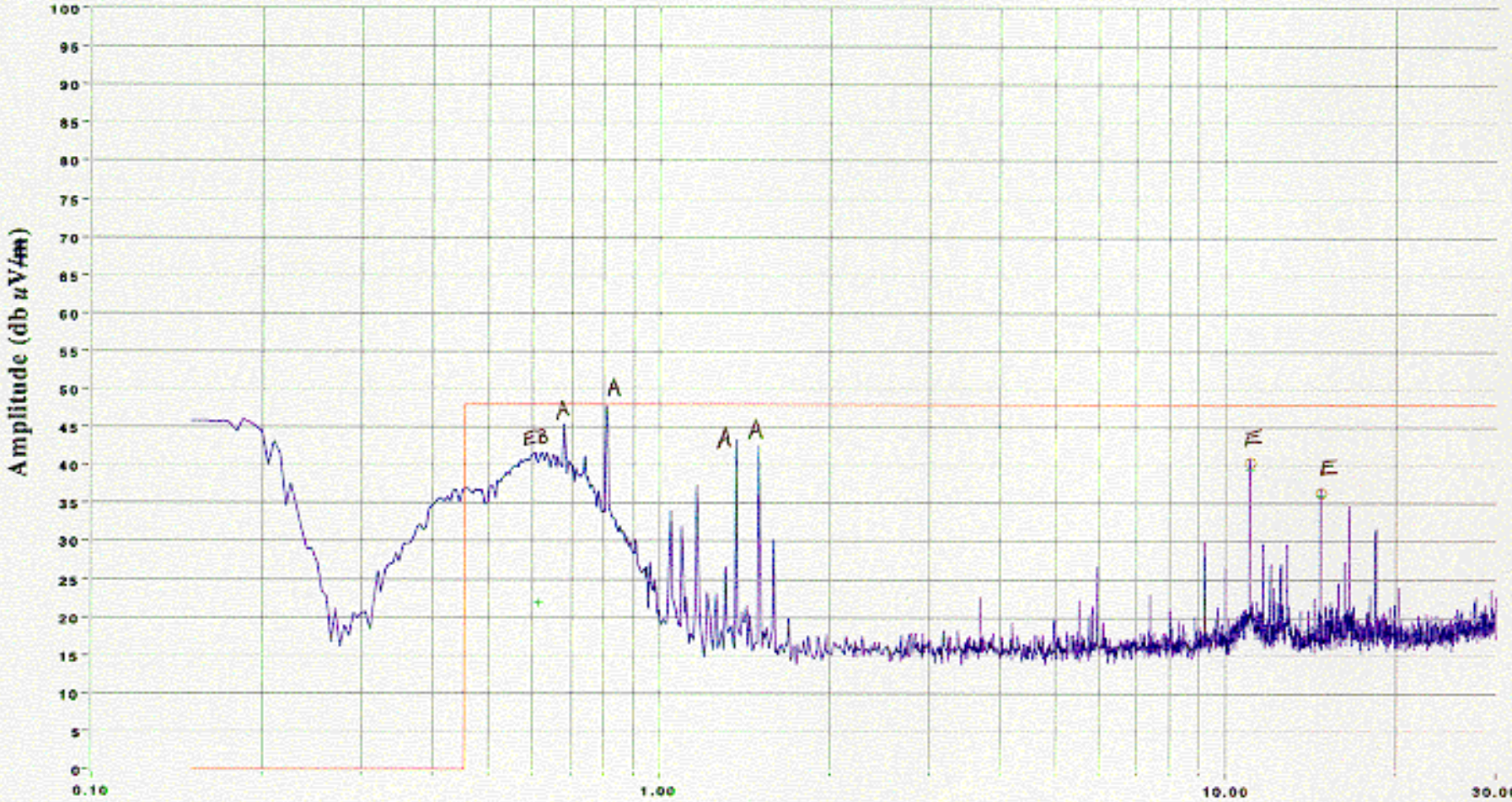
Elliott

OATS#3: Savi Technologies SaviReader 410R Run 8

Spec:
FCC-B

Asset Tag Reader

Mains Lead
Line 1

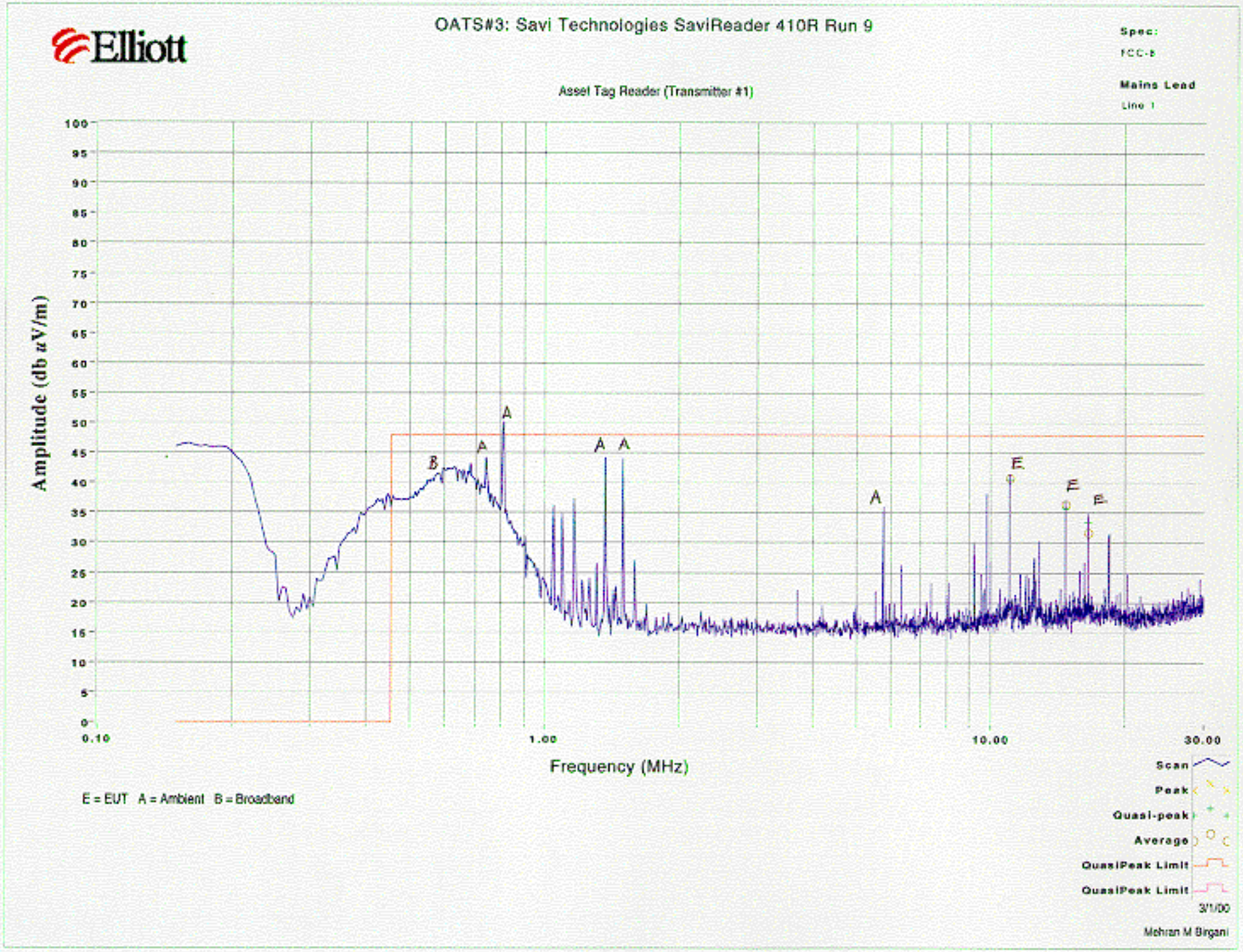


E = EUT A = Ambient B = Broadband

Scan
Peak
Quasi-peak
Average
QuasiPeak Limit
QuasiPeak Limit

3/1/00

Mehran M Birgani


OATS#3: Savi Technologies SaviReader 410R Run 9
Elliott
Spec:
FCC-B
Mains Lead
Line 1
Asset Tag Reader (Transmitter #1)
Amplitude (db uV/m)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0.10
1.00
10.00
30.00
Frequency (MHz)
E = EUT A = Ambient B = Broadband
Scan
Peak
Quasi-peak
Average
QuasiPeak Limit
QuasiPeak Limit
3/1/00
Mehran M Birgani

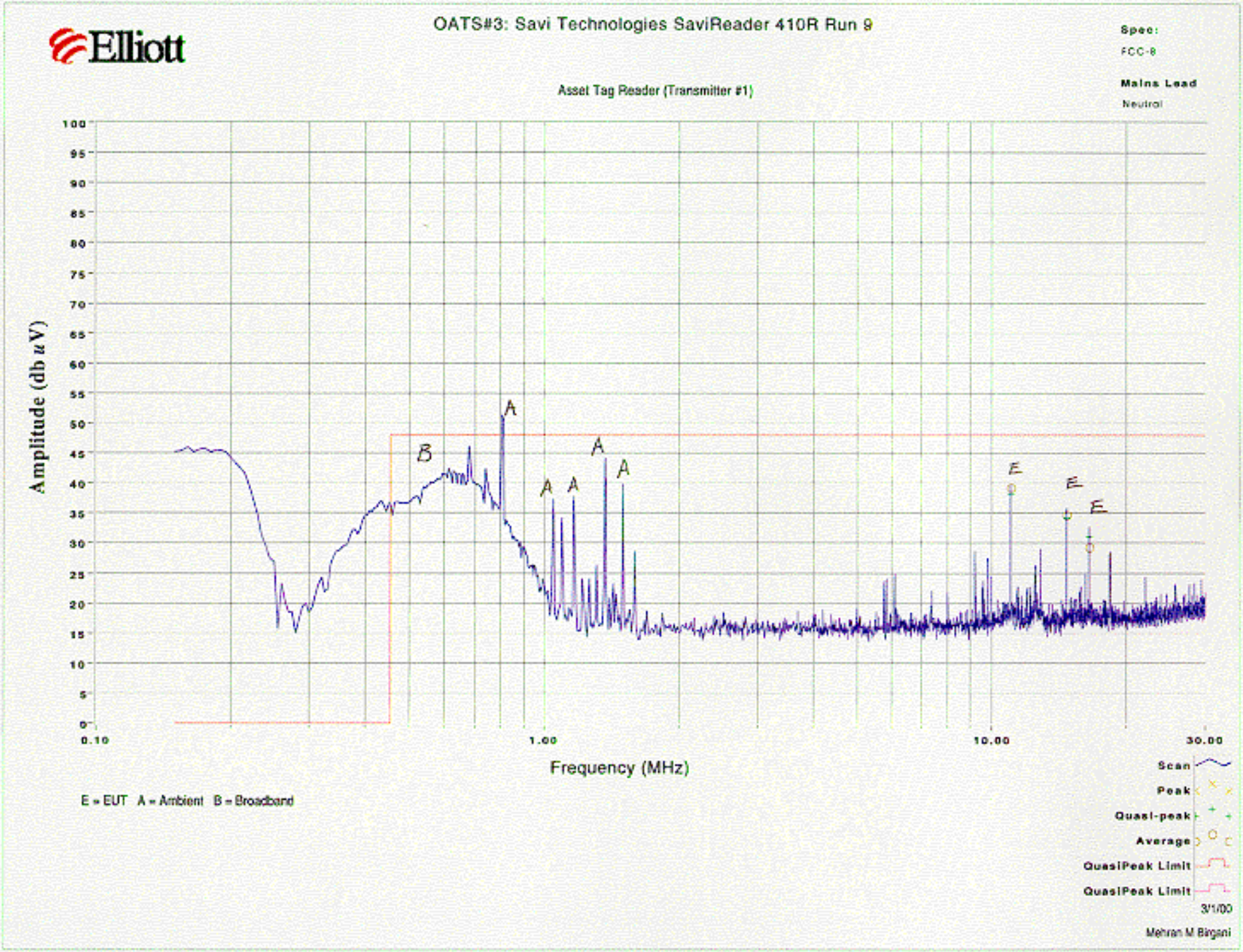

OATS#3: Savi Technologies SaviReader 410R Run 9
Spec:
FCC-B
Mains Lead
Neutral
Asset Tag Reader (Transmitter #1)
Amplitude (db uV)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0.10
1.00
10.00
30.00
Frequency (MHz)
B
A
A
A
A
A
E
E
E
E = EUT A = Ambient B = Broadband
Scan
Peak
Quasi-peak
Average
QuasiPeak Limit
QuasiPeak Limit
3/1/00
Mehran M Birgani

EXHIBIT 3: Radiated Emissions Test Configuration Photographs

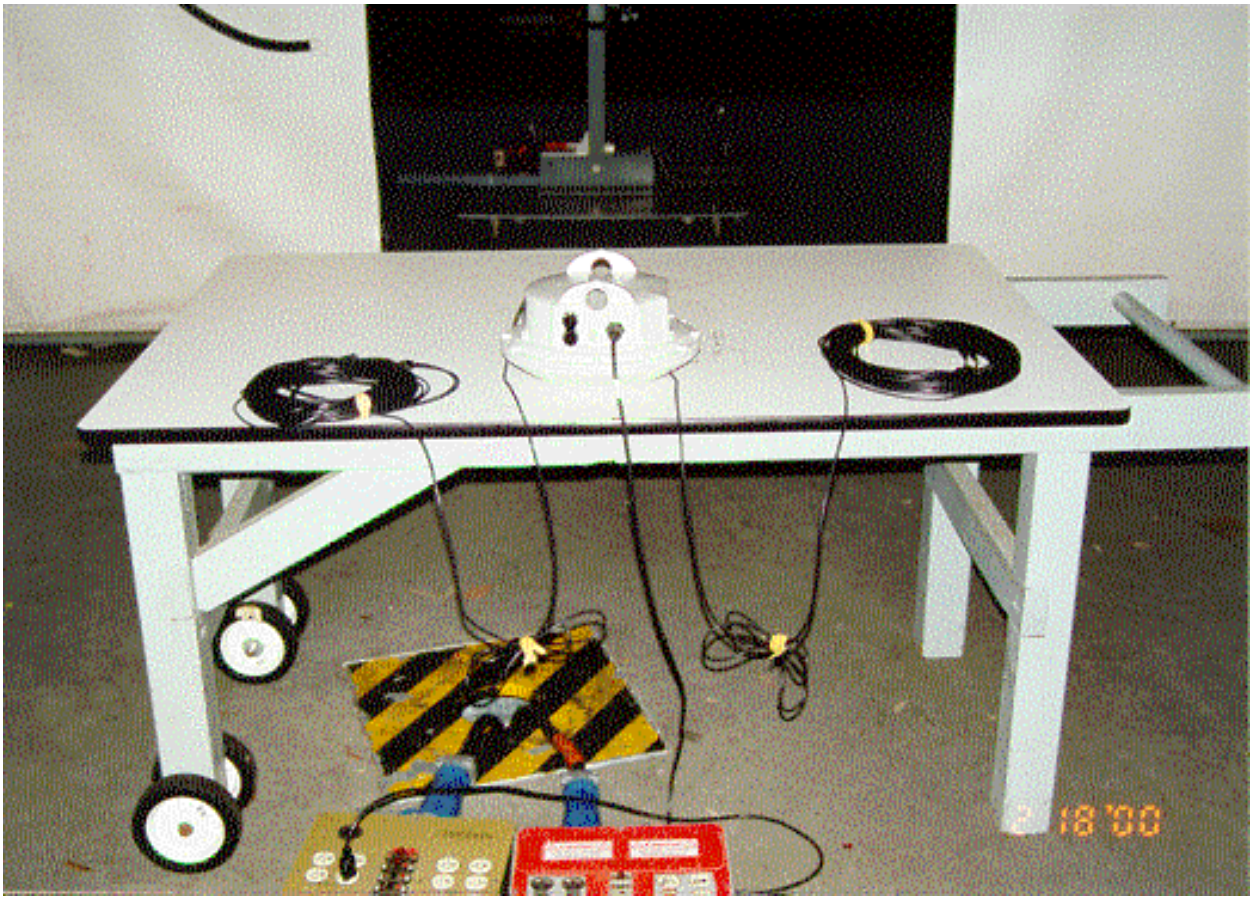


EXHIBIT 3: Radiated Emissions Test Configuration Photographs

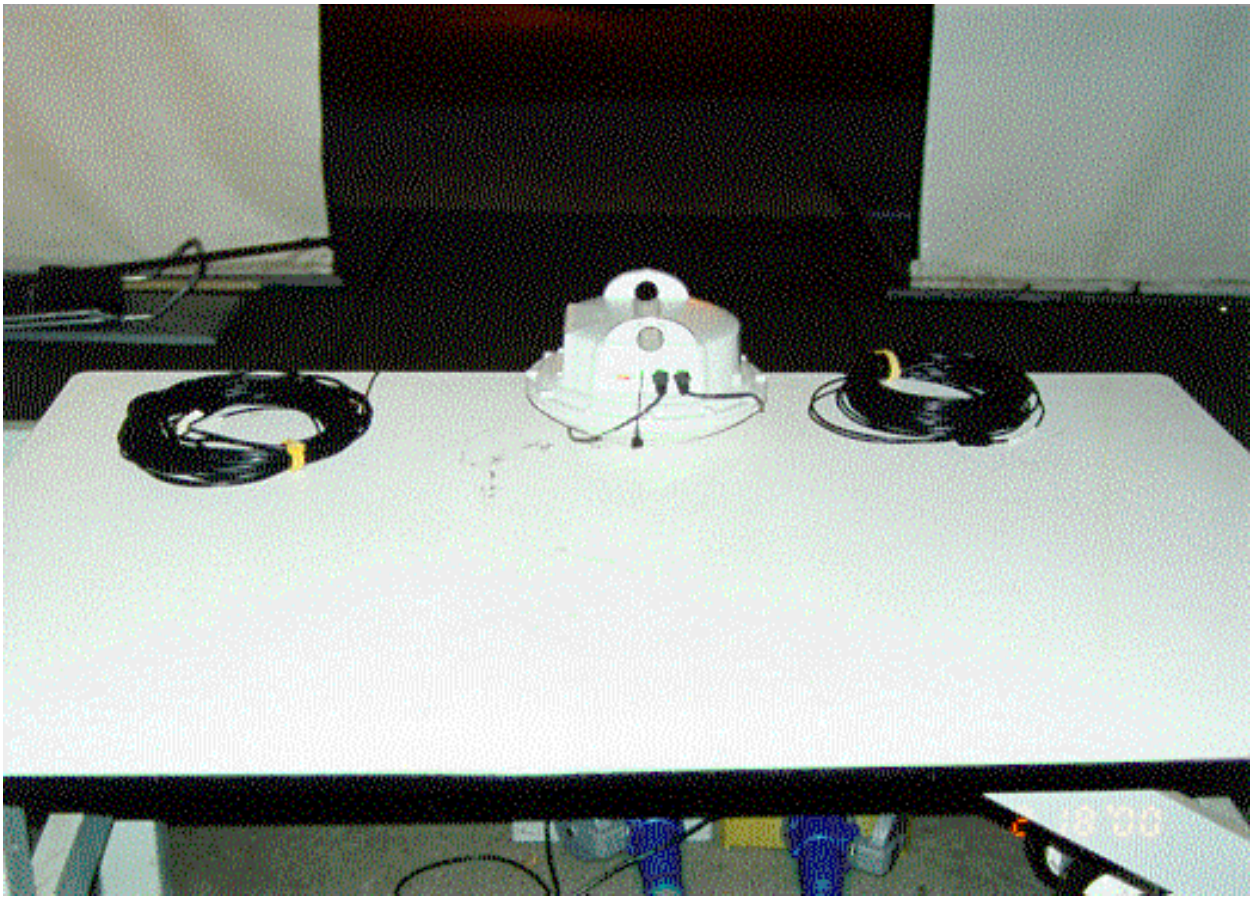


EXHIBIT 4: Conducted Emissions Test Configuration Photographs

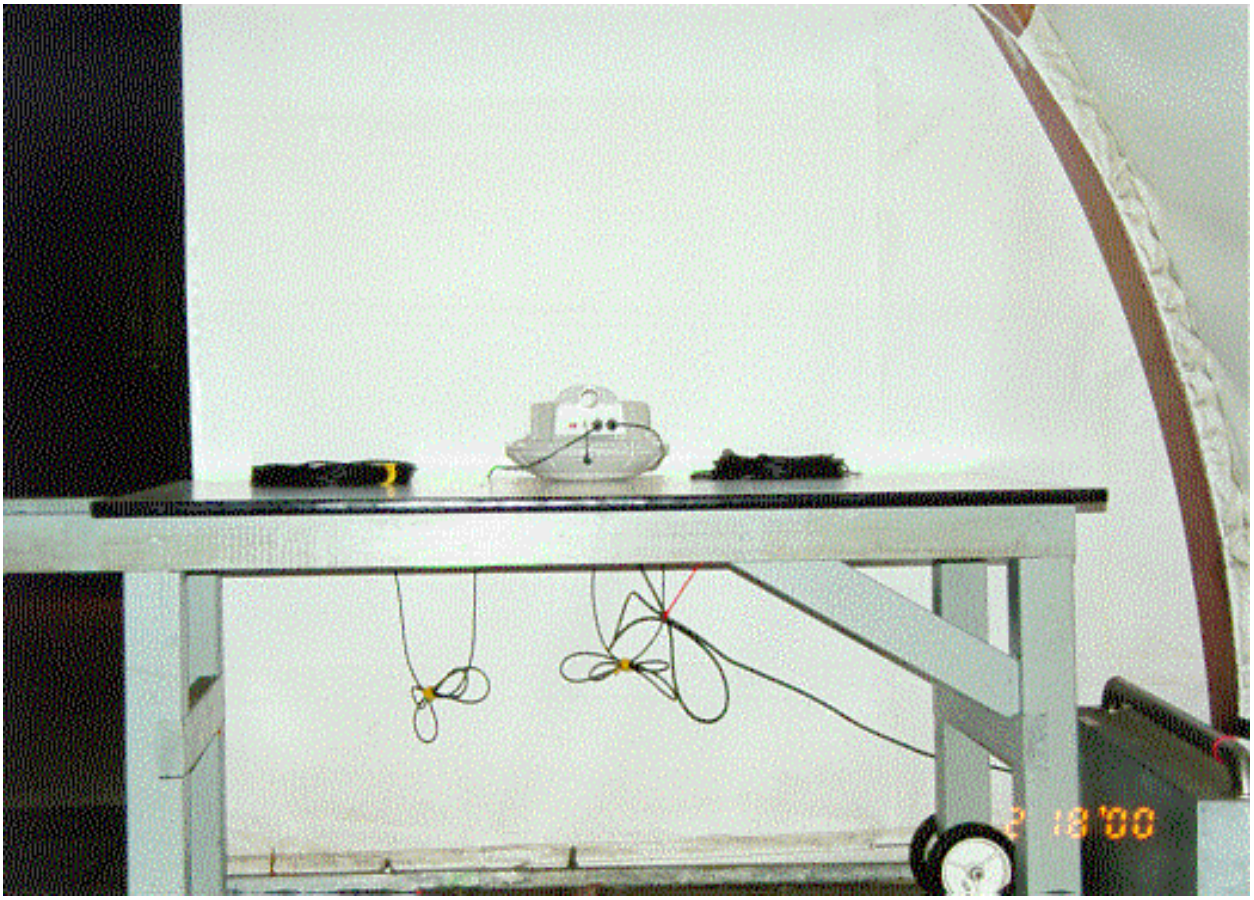


EXHIBIT 4: Conducted Emissions Test Configuration Photographs

EXHIBIT 5: Proposed FCC ID Label & Label Location

Did not change from original application

EXHIBIT 6:Detailed Photographs of Savi Technology, Inc. Model Savi Reader 410R Construction

6 Pages

EXHIBIT 7: Operator's Manual for Savi Technology, Inc. Model Savi Reader 410R

Did not change from original application

EXHIBIT 8: Block Diagram of Savi Technology, Inc. Model Savi Reader 410R

Did not change from original application

EXHIBIT 9: Schematic Diagrams for Savi Technology, Inc. Model Savi Reader 410R

Did not change from original application

EXHIBIT 10: Theory of Operation for Savi Technology, Inc. Model Savi Reader 410R

Did not change from original application