Nortel BWA Type Acceptance Radio Transceiver Test Report

Product Description:	28 GHz Base Station (BTR) and Customer Premise (CTR) Radio Transceivers
Model:	BTR2800 and CTR 2800
Nortel BWA File #	N9UBTRCTR2800

CHARLIE BISHOP PI ENGINEER **DATE**

ROMAN WROCZYNSKI PI MANAGER **DATE**

WINNIPEG,

DECLARATION BY Nortel Networks BWA

The tests were performed from Feb 5 through Mar 20,1999 at the Nortel Networks BWA's EMC Laboratory in Winnipeg.

The following personnel collaborated to this project:

Mitch Hebert, Tech.
Charlie Bishop, PI Engineer

Testing was performed and supervised by the undersigned. The test supervisor attests to the accuracy of the test data recorded in this report.

Performed by:	Date
Supervised by:	Date

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Total number of pages: 65.

The results presented in this report refer only to the product(s) described in section 1.

All equipment and instrumentation used during this test have been verified and/or calibrated. All calibration certificates are traceable to the National Research Council of Canada (CNRC) and/or to the American National Institute of Standards and Technology (NIST) standards and can be provided on request.

Nortel BWA is registered ISO 9002:1998, certificate # 766.2.

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1. INTRODUCTION

Object

This test report is submitted to the FCC for type acceptance of the Nortel Networks BWA Reunion Radios operating in the LMDS Bands 27.5 to 28.35 GHz and 29.1 to 29.25 GHz. Nortel Networks BWA radios is not compliant to the specification stated in FCC part 101.111 (a) (2) (ii) within +/- 250% allocated operating channel frequency.

Nortel Networks BWA Reunion is non-compliant to the stated specifications referenced above, as our radios are designed to provide wide-band multi-carrier point-to-multi-point subscriber services in an efficient and cost effective manner. The present rules for LMDS in these bands do not consider the transmission characteristics of a wide-band multi-carrier through a single transmitter design. Nortel Networks BWA is currently seeking type approval on this product, and has appended a waiver justification for the performance non-compliance with our type approval application.

Equipment Under Test Description

The Nortel Networks BWA 28 GHz radio product is of wide band design. The power amplifiers and the LNA are designed to provide gain over the entire 28.20 to 29.25 GHz band. The BTR and CTR are of a single conversion design. A single DRO serve both the transmit and receive path. The BTR and CTR provide a maximum power output of 1 and 0.5 watt respectively for a single un-modulated tone. Thus the power limitation requirement of FCC part 101 section 101.113 is satisfied. The following table identifies the EUT:

Model #	Description	Manufacturer	Part #
BTR2800	Base Transceiver	Nortel BWA	NTVG14AG
CTR2800	Customer Transceiver	Nortel BWA	NTVG16AG

Model #	Order Code	uW Tx (GHz)	uW Rx (GHz)	RF Rx (MHz)	RF Tx (MHz)	BW	Separation
BTR2800	NTVG14AG	29.1-29.25	28.2-28.35	250-400	500-650	150	900
CTR2800	NTVG16AG	28.2-28.35	29.1-29.25	250-400	500-650	150	900

General

Tests were performed on a production sample(s) of the BTR and CTR, according to standards and directives indicated on the table in paragraph 1.1. All measurements were performed in accordance to the measurement procedures outlined in these standards or detailed in this report.Results

The following table summarizes the EUT test results of the testing described in this report:

Standard	Test Description	Para. No.	Results
FCC part 101 section 101.111 (a) (4)	Spectral Mask		Non compliant
FCC part 2, section 2.997;	Conducted Emissions except mask region	2	Compliant
FCC part 2, Section 2.997,	Radiated Emissions except mask region	3	Compliant
TSB10-F – June 1994	Adjacent Channel Test	4.2.1	Compliant
TSB10-F – June 1994	Co-Channel Test	ANNEX B	Complaint
FCC part 101, sec 101.113	Transmit Power Limitation	C2	Compliant
FCC part 101, sec 101.113	Antenna azimuth limitation	C3	Compliant
FCC part 2, Section 2.995 (a) (1), (b) and FCC part 101 section 101.107	Frequency Stability Over Temperature	4	Compliant

Test Facilities Description

The Nortel Network BWA EMC facility is a shielded 3m room The room is provided with input voltage of 120 and 240 V ac, which is filtered through Corcom filters before entry. Due to lab construction, the radiated measurements were performed in an open lab environment. A reference sweep was taken to demonstrate the ambient conditions.

Test Equipment

The following is a list of test equipment used to perform all tests described in this report.

Equipment	Manufacturer	Model	Serial or Asset #	Cal due (Y/M/D)
Spectrum Analyzer	Hewlett Packard	HP 8665E	02940	09/99
Spectrum Analyzer	Hewlett Packard	HP 8663E	3611A05001	08/99
Synthesized Sig. Gen.	Anritsu	69369A	981807	06/99

Power Meter Power Sensor	Anritsu Anritsu	ML2438A MA2475A	97400074	06/99 06/99
Mixer Assembly 40 to 60 GHz	Millitech/Nortel BWA	MHB-19-RD3A0	MS-118086	7/99

Equipment	Manufacturer	Model	Serial or Asset #	Cal due (Y/M/D)
Mixer Assembly 60 to 90 GHZ	Millitech/Nortel BWA	MHB-12-RD3A0	MS-118101	7/99
Mixer Assembly 90 to 140 GHz	Millitech/Nortel BWA	MHB-08-RD3A0	MS-118090	7/99
Power Supply	Hewlett Packard	6544A	US36390168	-----
Power Supply	Hewlett Packard	6554A	US36340233	-----
Frequency Counter	XL microwave	3460	980338143	03/99
Antenna Bilog 30 to 1000 MHz	Shaffner-Chase	CBL6111B	2261	08/99
Horn Antenna 1 to 18 GHz	EMCO	3115	9711-5345	11/99
Horn Antenna 14 to 40 GHz	Shaffner-Chase	BBHA 9170	9046	3/99

2. CONDUCTED EMISSIONS

Tested by: Charlie Bishop and Mitch Hebert

Date: Mar 9 through Mar 15,1998

Test was performed to validate the requirements specified in FCC part 2, section 2.997; FCC part 101 Section 101.111

Test Conditions

Temperature 22 to 25C,
Primary Voltage BTR -48 V and for CTR +18 V dc

Minimum Specifications

Since there is no specification for this range, specification in FCC part 101, section 101.111 for DEMS devices operating in the 24.25 to 25.25GHz band will be used.

Test Results

The EUT does not comply with the specification referenced in the previous paragraph. The radios do comply with either of the proposed emissions profile in the Nortel Networks BWA request for waiver.

Measurement Data

See on Appendix A for test results and setup photographs.

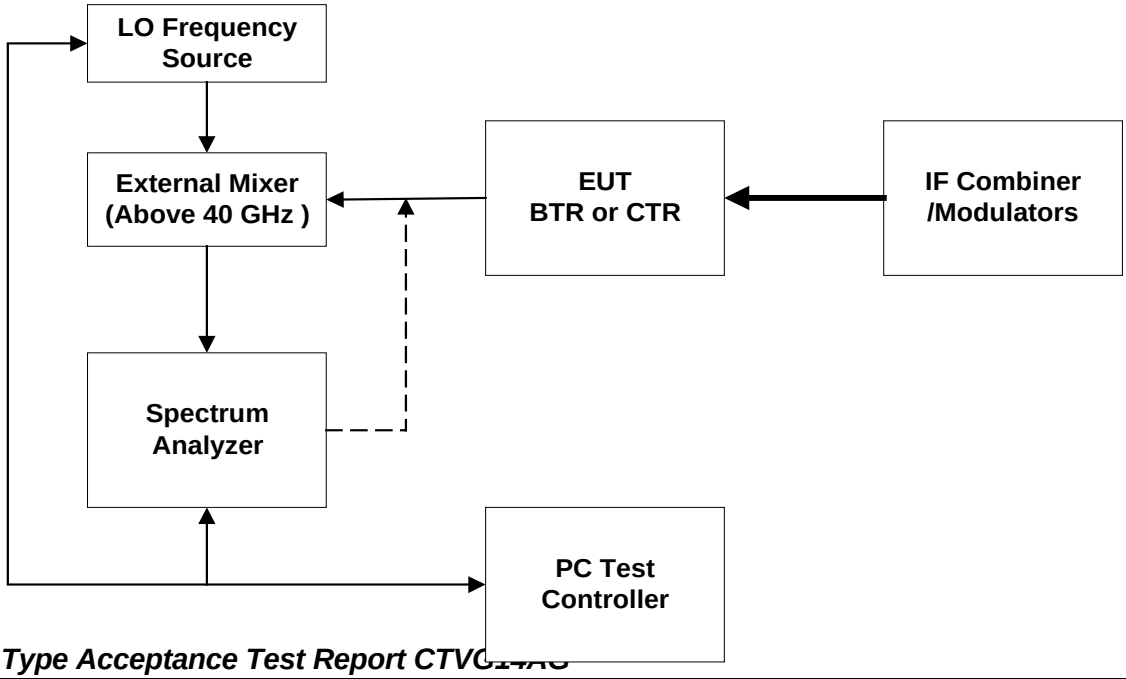
Test Method

Nortel processing equipment stimulated the EUT (BTR and CTR) with digitally modulated 16 QAM signal. The modulator output signals are then combined, through a passive combiner, and fed into the input to the BTR and/or CTR. The output is examined directly by a spectrum analyzer for up to frequencies of 40GHz. External mixers are used for frequencies greater than 40GHz. A synthesized frequency generator stimulates the external mixer's local oscillator input. The spectrum analyzer, synthesized generator and all calculations are administered by a Labview software application on a PC.

Test System Test Configuration

Figure 1.0 presents a simplified block diagram of the conducted emissions test set-up. For measurements above 40GHz, a PC controlled a synthesized generator programming the LO frequency input to the external mixer, so that the difference frequency between what is measured and the LO frequency is 100MHz. Below 40GHz, the output of the EUT was directly connected to the input of the spectrum analyzer.

A reference passband response is recorded, of four 16 QAM modulated carriers, occupied bandwidth of 40MHz for the BTR and two for the CTR occupying 20MHz. The measured reference is used to determine the out of band emissions, by measuring the relative differences between the reference and the measured emission.



1. RADIATED EMISSIONS

Tested by:	Charlie Bishop and Mitch Hebert
Date:	Mar 9 through Mar 15, 1998

Test was performed to validate the requirements specified in FCC part 2, section 2.997; and FCC part 101 Section 101.111.

Test Conditions

Temperature	20-25C,
Primary Voltage	BTR -48 V dc and for CTR +18 V dc

Specifications

Since there is no specification for this range, specification in FCC part 2, section 2.997, and FCC part 101, section 101.111 for DEMS devices operating in the 24.25 to 25.25GHz band.

Test Results

The EUT does not comply with the specification referenced in the previous paragraph. The radios do comply with either of the proposed emissions profile in the Nortel Networks BWA request for waiver.

Measurement Data

See on Appendix B for test results and setup photographs.

Test Method

Nortel processing equipment stimulated the EUT (BTR and CTR) with digitally modulated 16 QAM signal. The modulator output signals are then combined, through a passive combiner, and fed into the input to the BTR and/or CTR. The output is examined directly by a spectrum analyzer for up to frequencies of 40GHz. External mixers are used for frequencies greater than 40GHz. A synthesized frequency generator stimulates the external mixer's local oscillator input. The spectrum analyzer, synthesized generator and all calculations are administered by a Labview software application on a PC.

Test System Configuration

Figure 2.0 presents a simplified block diagram of the radiated emissions test set-up. For measurements above 40GHz, the antennae is positioned 30cm from the EUT; a PC controlled a synthesized generator programming the LO frequency input to the external mixer, so that the difference frequency between what is measured and the LO frequency is 100 MHz. External mixers are connected to Millitech horn antennae, covering the band 40 to 60GHz, 60 to 90GHz and 90 to 140GHz. Below 40 GHz, the antennae is positioned 1m from the EUT; the input to the spectrum analyzer was connected to various antenna a Chase 30 to 1000MHz bilog, EMCO 1 to 18GHz horn, and Chase 14 to 40GHz horn.

A reference passband response is recorded, of four 64 QAM modulated carriers, occupied bandwidth of 40 MHz for the BTR and two for the CTR occupying 20 MHz. The test antennae and the EUT antenna are positioned at a given distance, to produce a maximum amplitude response of the passband. The antennae are held in this position during the entire testing of up to 110 GHz. The measured reference is used to determine the out of band emissions, by measuring the relative differences between it and the measured emission.

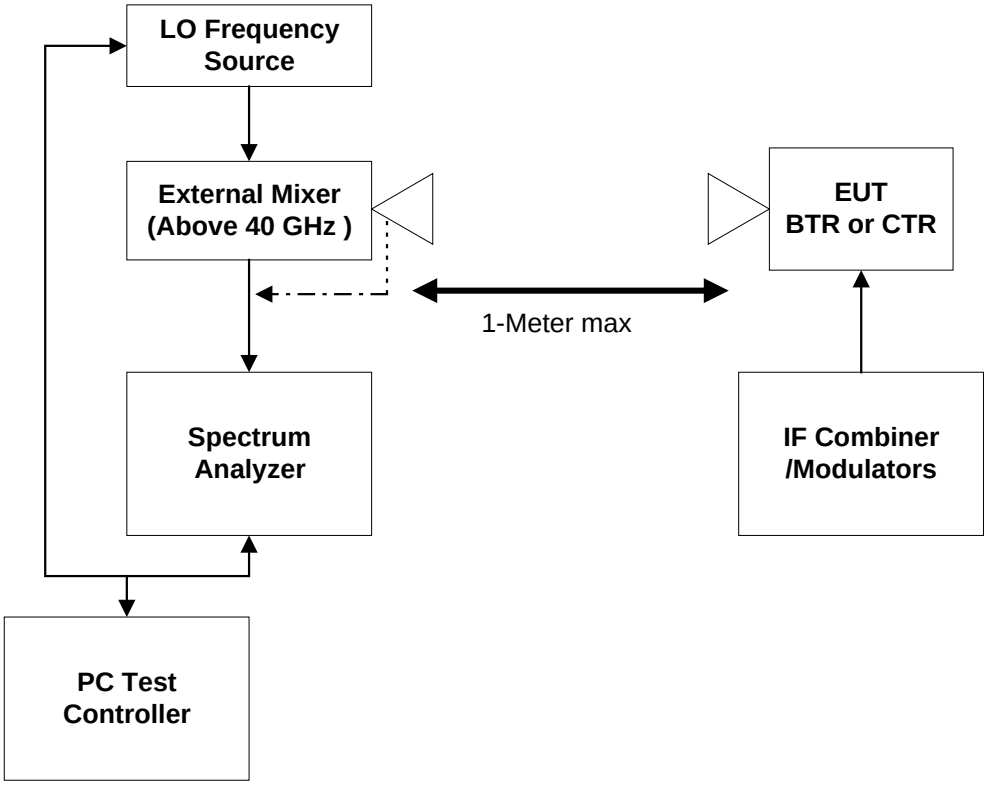


Figure 2.0: Test Setup Configuration for Radiated Emissions

4. TEMPERATURE STABILITY TESTS

Tested by:	Charlie Bishop and Mitch Hebert
Date:	Mar 8, 1998

Test was performed to the validate the requirement of part 101, section

Test Conditions

Temperature	-40C to +50C,
Primary Voltage	BTR -48 V dc and for CTR +18 Vdc

Specifications

Requirement specified in FCC part 101, section 101.107, frequency tolerance of ±0.03%

Test Results

The BTR and CTR complies with the specifications stated in specification paragraph

Measurement Data

See on Appendix C for test setup and photographs.

Test Method

Tests were performed on a BTR and CTR, these units were placed into a temperature chamber, and the temperature profile used for temperature is referenced in FCC part 2, section. A base line frequency measurement is made at first ambient temperature. With the power not applied to the EUT, the temperature is then decreased by the programmed interval (10C) and allowed to “soak” for a period time specified by the user.(20min) This time allows the internal component temperature to stabilize. Once the plateau has been achieved, the power is applied to the EUT and the frequency is measured to 6 significant digits.

Test System Configuration

Figure 3.0 presents a simplified block diagram of the temperature stability test set-up. The PC controls the temperature profile of the temperature chamber. The specified temperature profile is –40°C to +50°C.

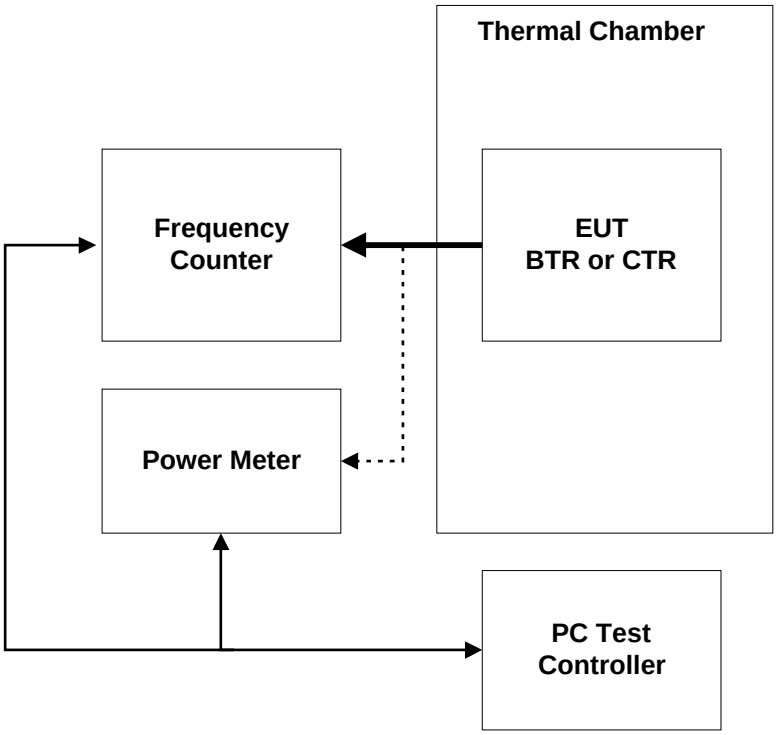


Figure 3.0: Test Setup Configuration for Temperature Stability Tests

5. CO/ADJACENT CHANNEL TEST

Tested by:	Charlie Bishop and Mitch Hebert
Date:	Mar 19,1998

Test Conditions

Temperature	25C,
Primary Voltage	BTR -48 V and for CTR +18 V dc

Minimum Specifications

Following along the European standards, the protection criteria for 16QAM shall be at least 10.5dB for adjacent channel and 22.5dB for co-channel. The BER should at no time be greater than 10^{-6}

Measurement Data

See on Appendix D for test results and setup photographs.

Adjacent Channel Test Method

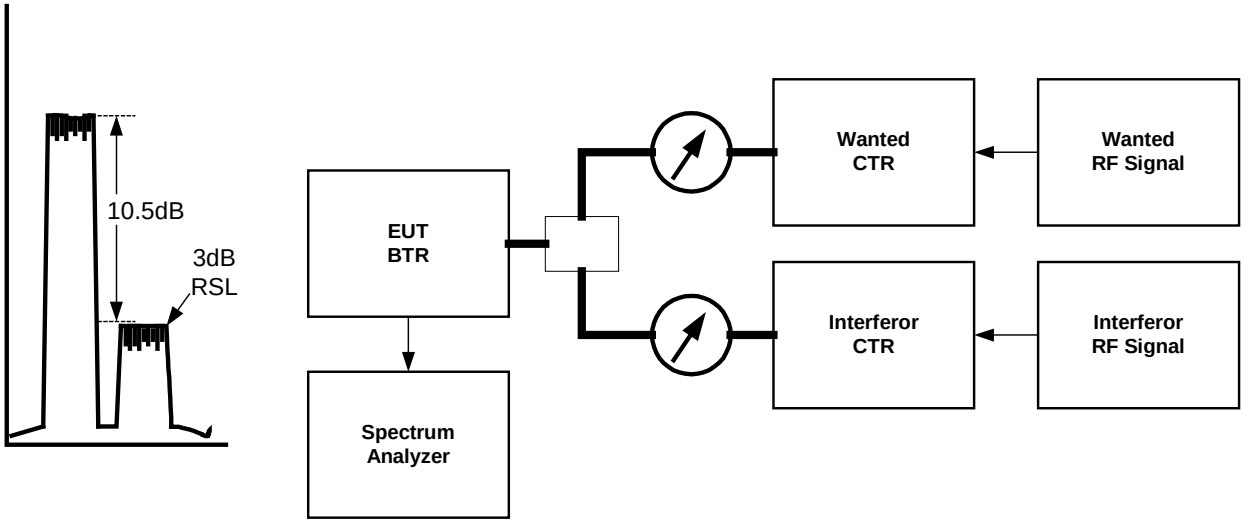
Nortel translation equipment (CTR) is stimulated with digitally modulated 16 QAM signals. The two signals (wanted and interferor) are combined and fed into the EUT (BTR). The wanted CTR output is adjusted such that a quality QAM signal is present. The inline vane attenuator is adjusted until a raw MPEG BER of 10^{-6} is achieved. The level is then adjusted up by 3dB. The interferor signal is then adjusted such that the power density of the carrier is 10.5dB above the wanted signal. The BER is recorded.

Co Channel Test Method

Nortel translation equipment (CTR) is stimulated with digitally modulated 16 QAM signals. The two signals (wanted and interferor) are combined and fed into the EUT (BTR). The wanted CTR output is adjusted such that a quality QAM signal is present, this value is then noted and then the signal is disabled The interferor signal is then adjusted such that the power density of the carrier is 20.9 dB below the wanted signal. The wanted signal is then reapplied and the BER is recorded.

Test System Test Configuration

The figure below represents a simplified block diagram of the adjacent and co-channel interference test set-up.

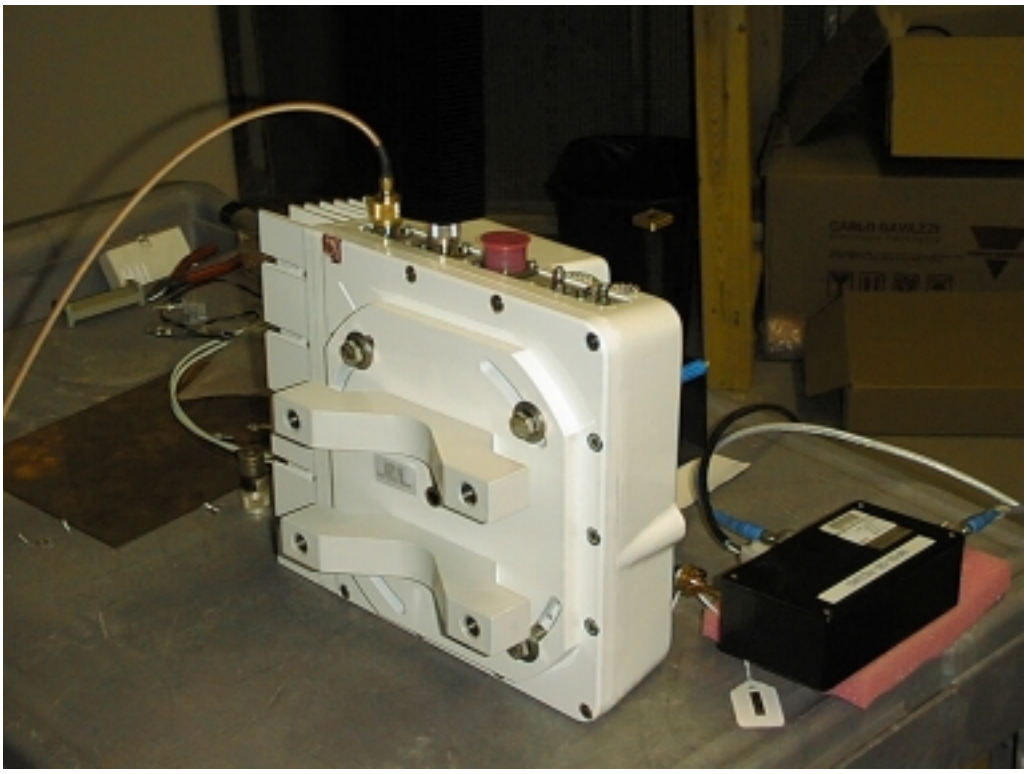


APPENDIX A

Conducted Emissions Measurement Results

CONDUCTED EMISSIONS MEASUREMENT RESULTS

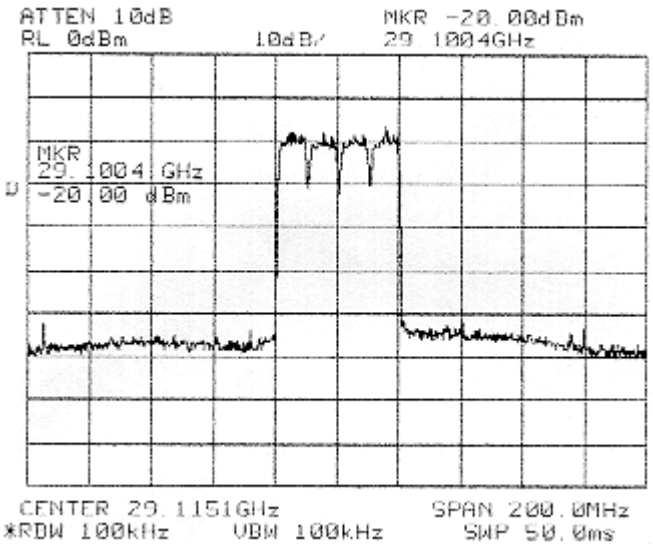
Computer setup and instrumentation in the PI laboratory

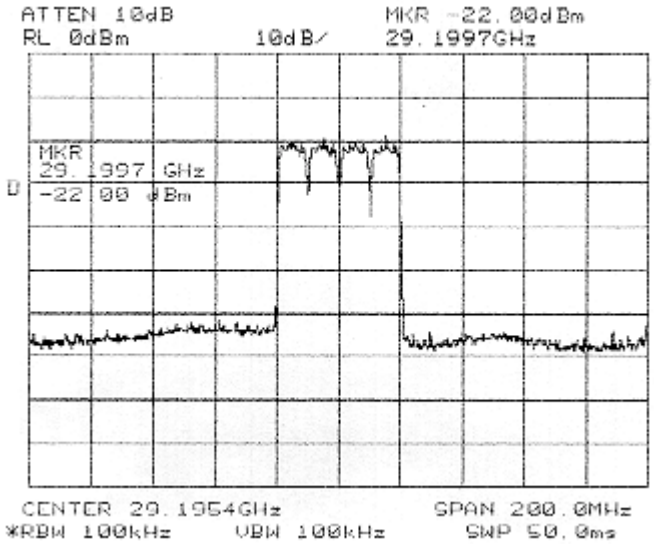


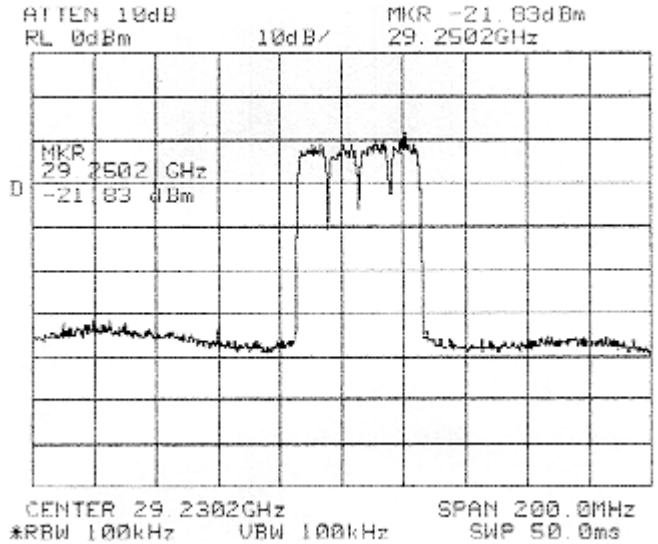
Connection to the BTR using the wave-guide connection

BTR 2800, 4 carrier QAM 64 modulated - In-band carriers

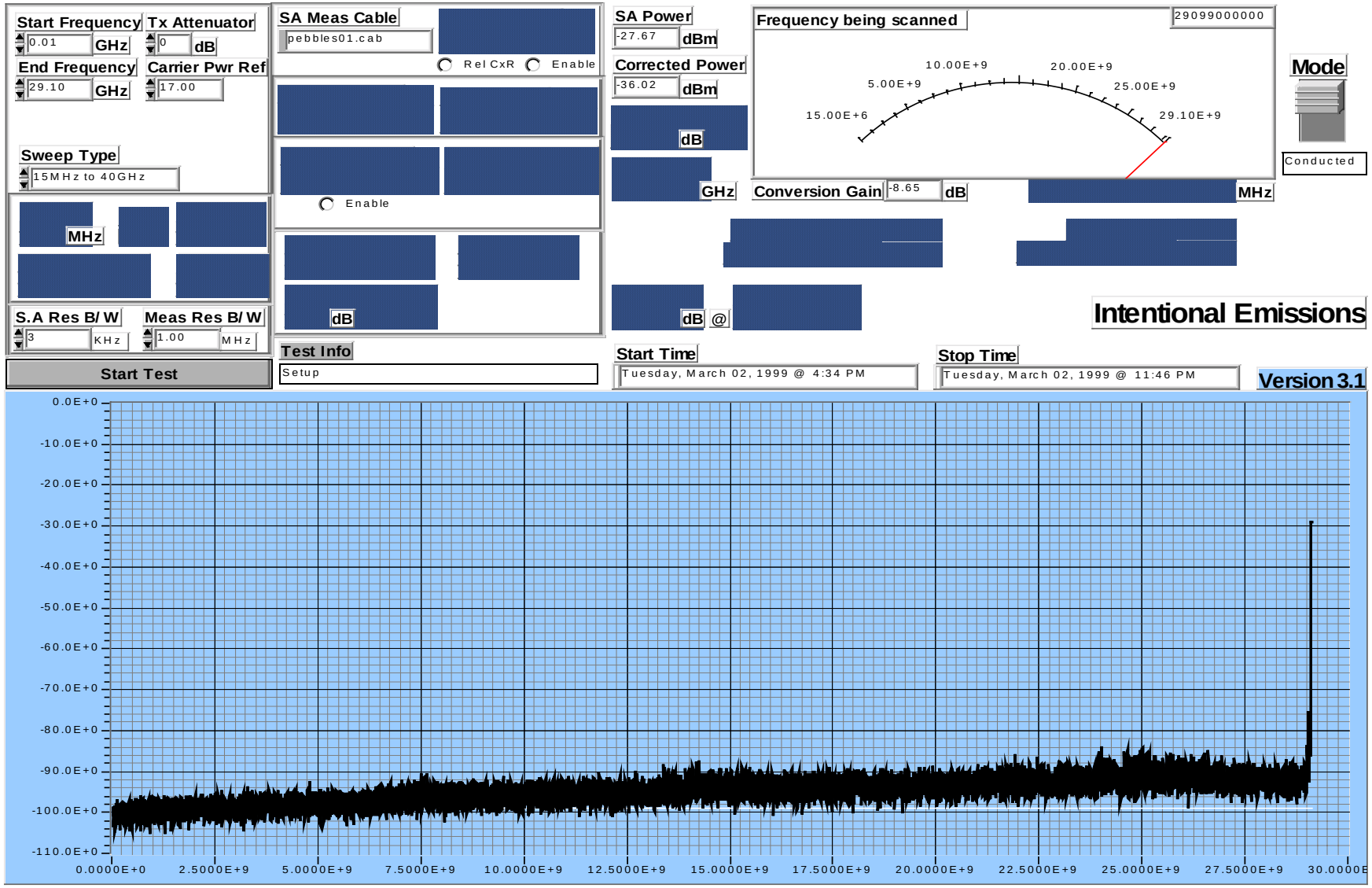
The emission showing amplitude and angle-modulated (D) with two or more channels (7) which could contain data or telephony (W). The signal has a maximum occupied bandwidth of 40MHz. (40M0). Equipment Type 40M0D7W The following pictures show 4 – 10MHz carriers across the minimum, maximum and middle of the 150MHz band at a channel power of 20dBm.



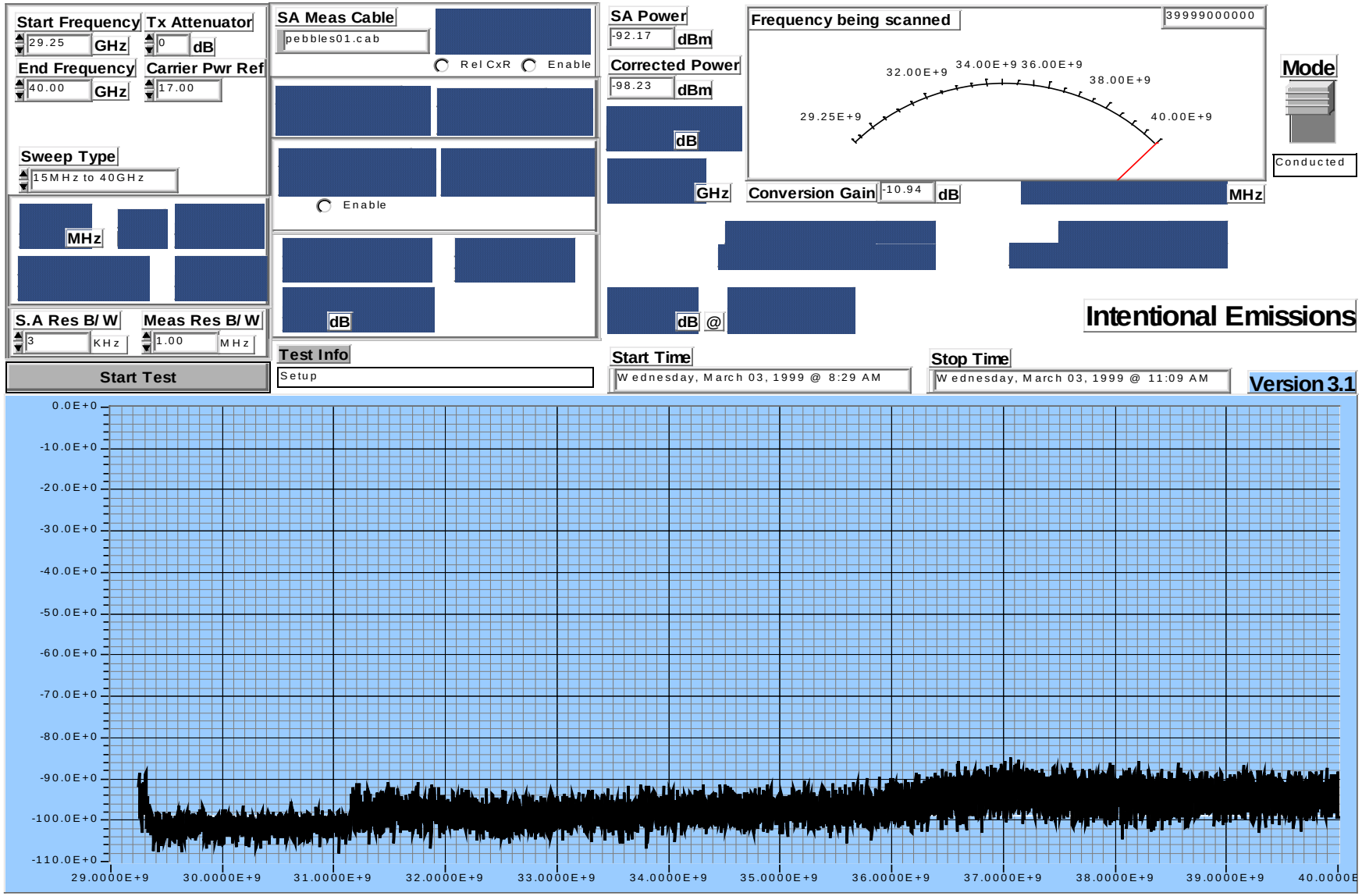




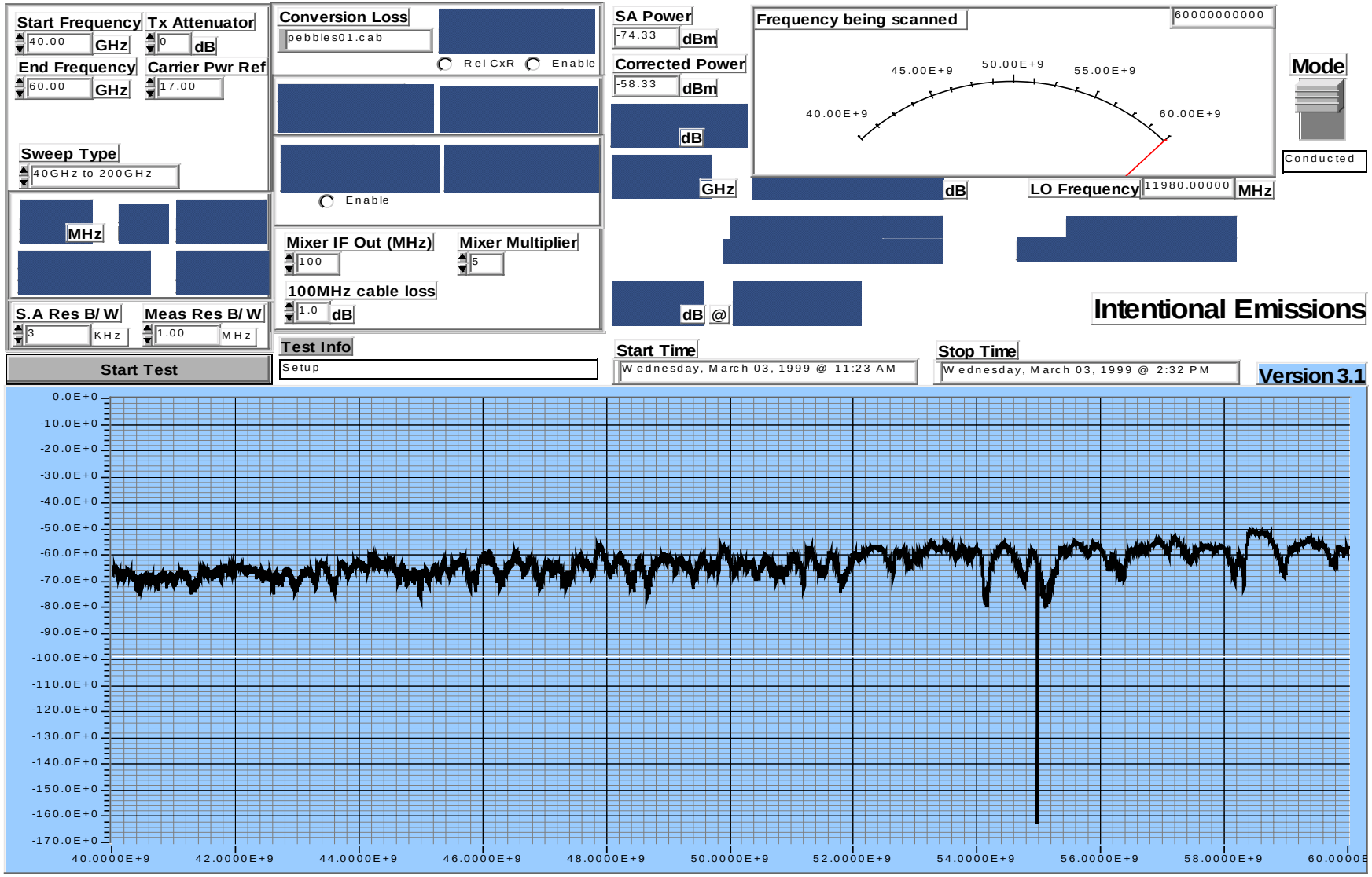
BTR 2800, 4 carrier QAM 64 modulated. – 30MHz to edge of carriers



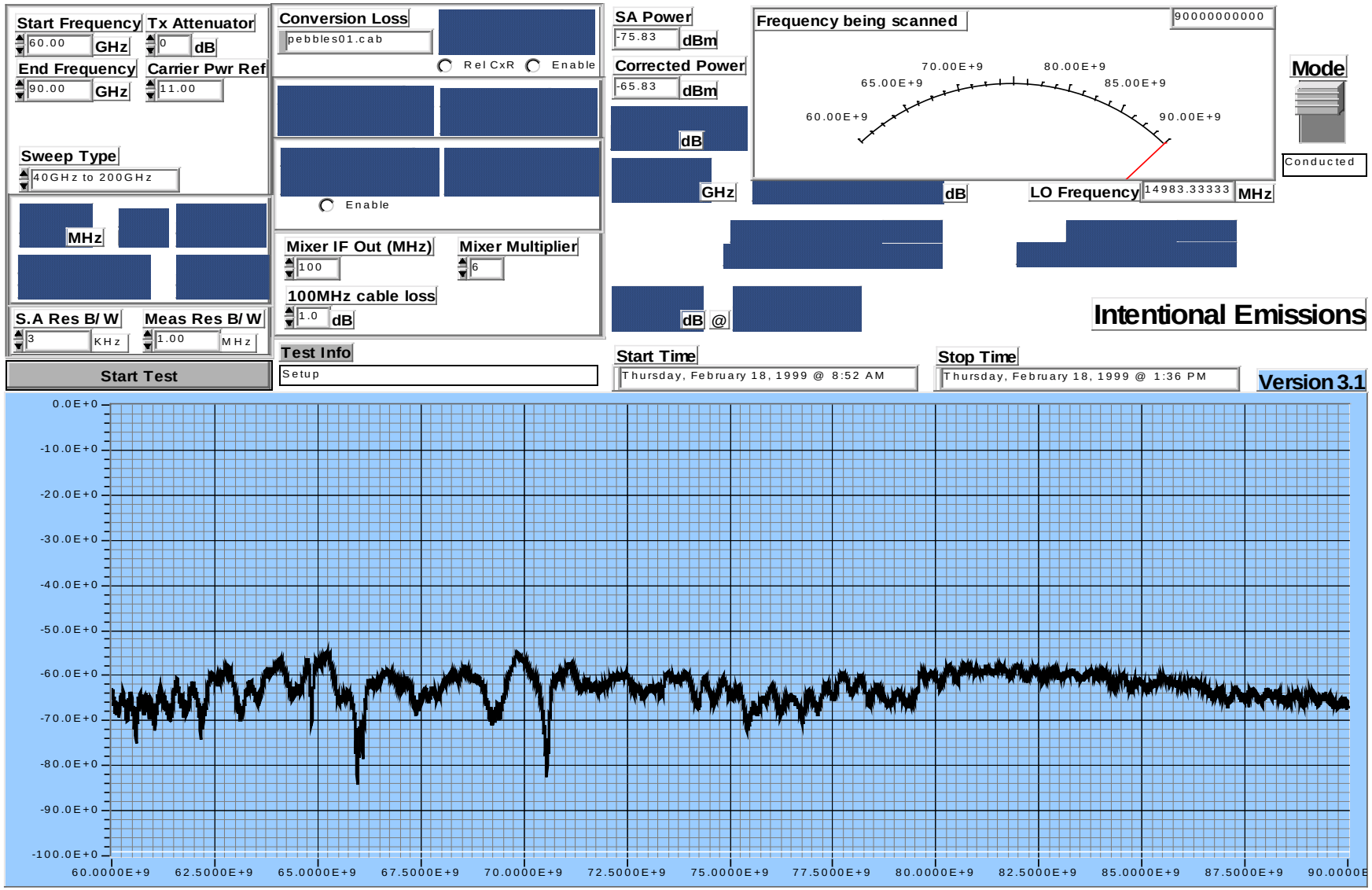
BTR 2800, 4 carrier QAM 64 modulated. – edge of carriers to 40GHz



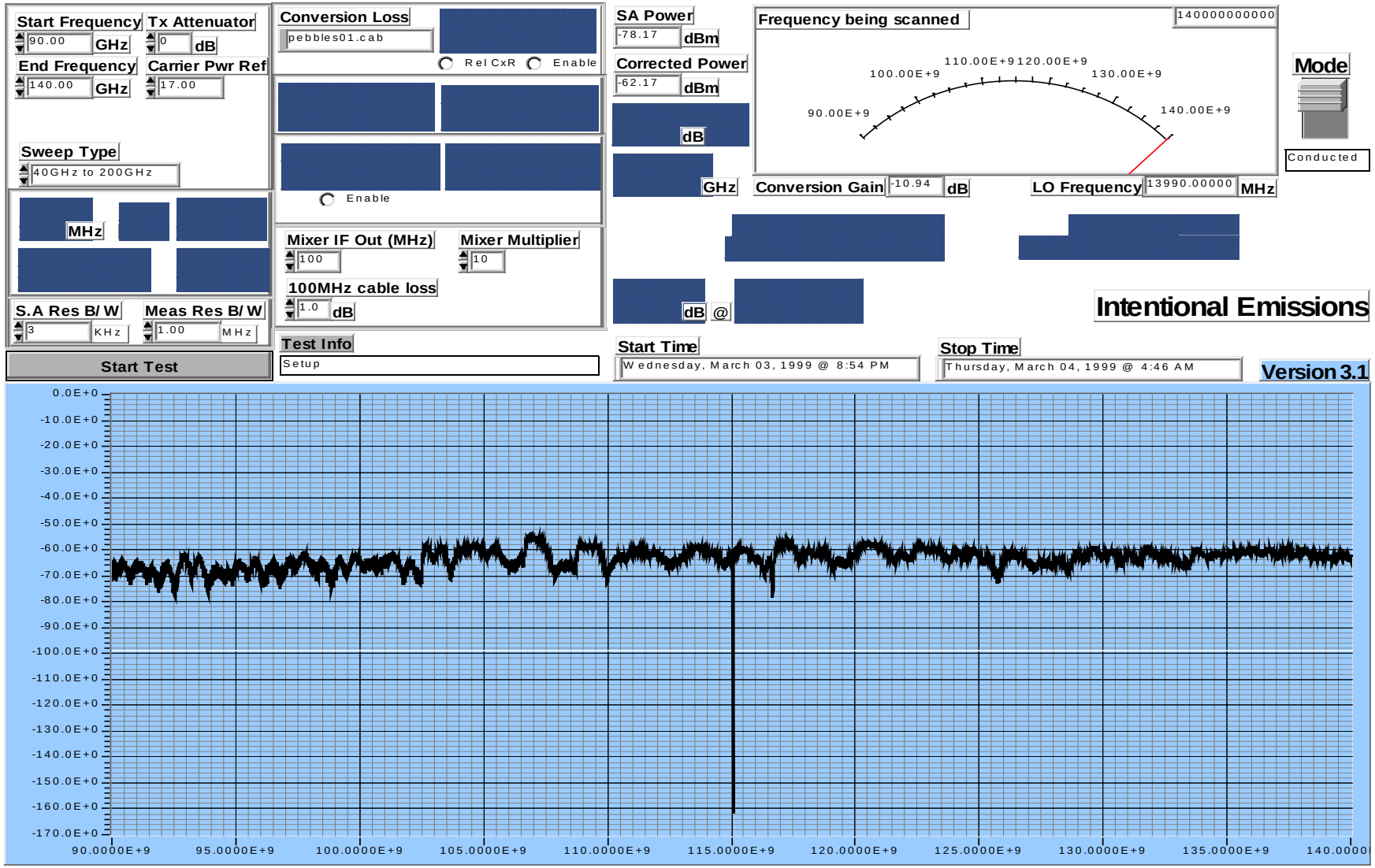
BTR 2800, 4 carrier QAM 64 modulated. – 40 to 60GHz



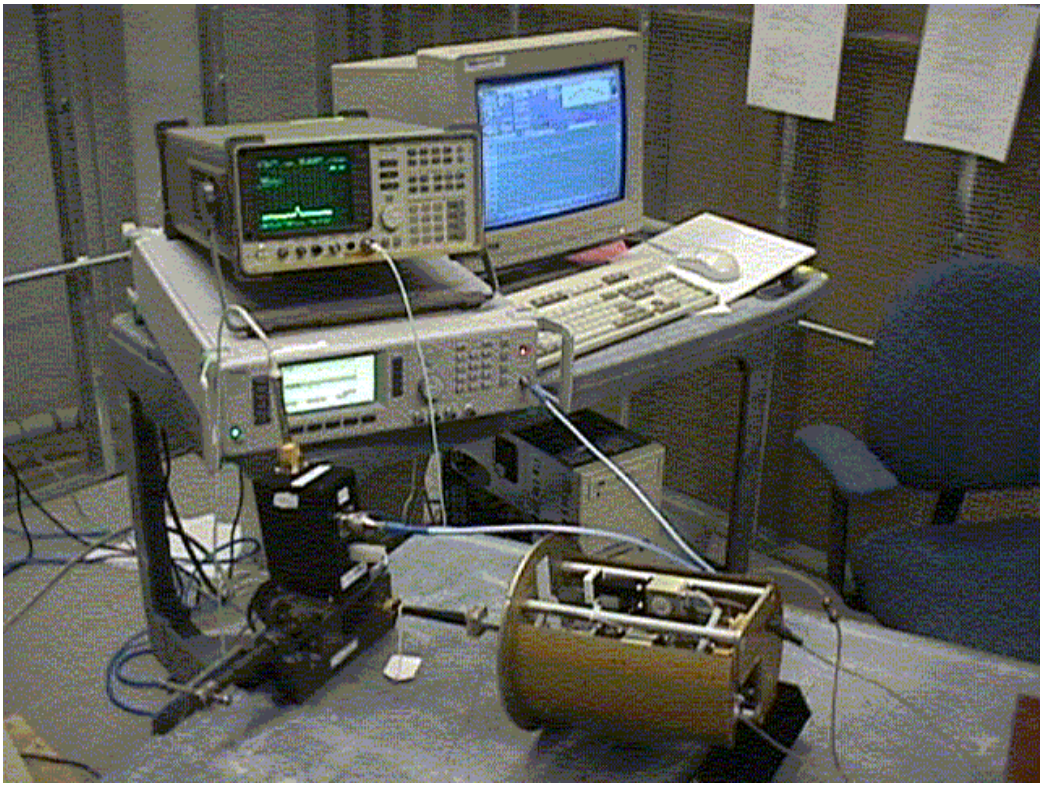
BTR 2800, 4 carrier QAM 64 modulated. – 60 to 90GHz

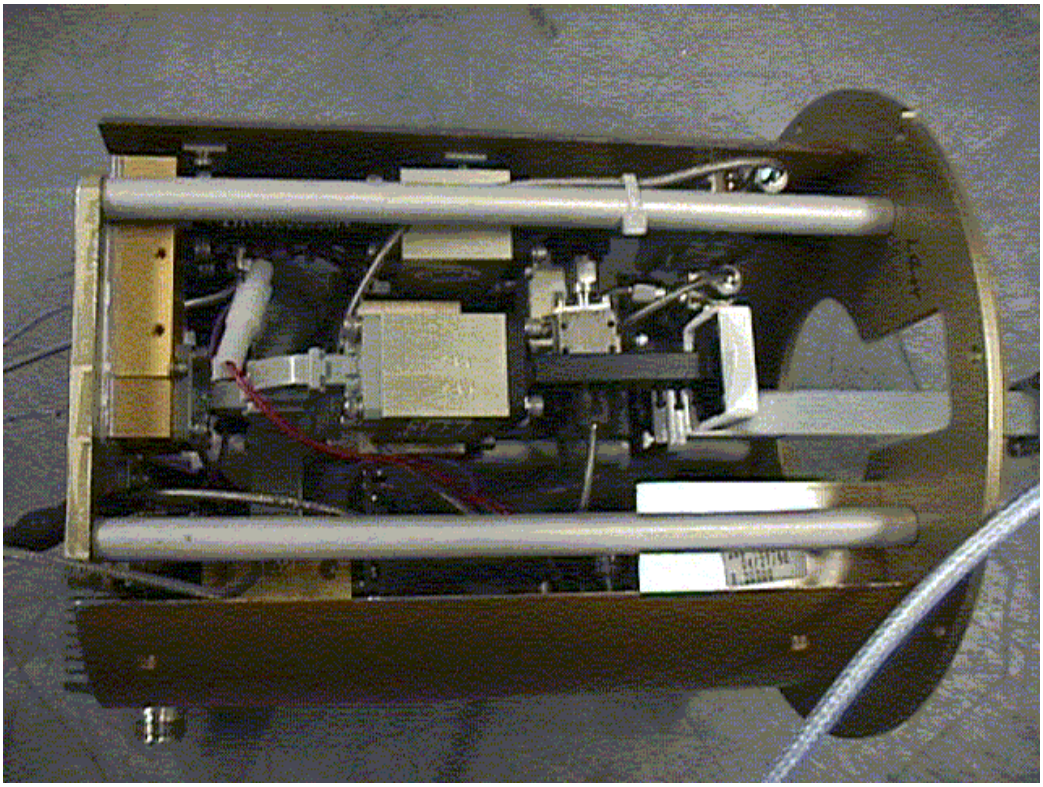


BTR 2800, 4 carrier QAM 64 modulated. – 90 to 140GHz



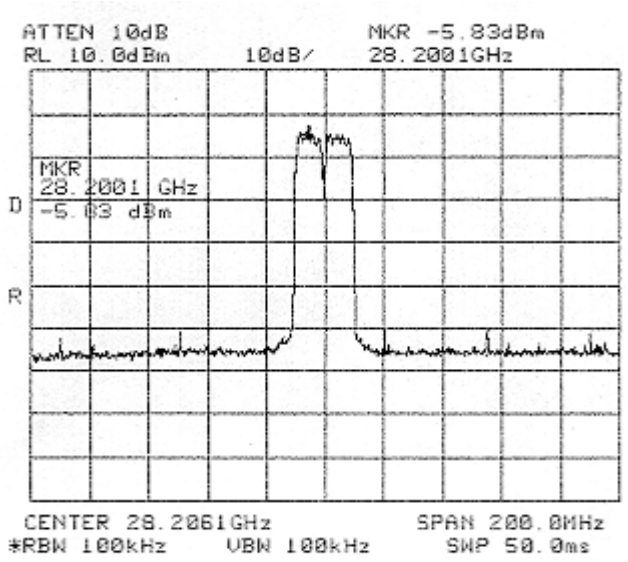
CTR connected in the laboratory for conducted measurements

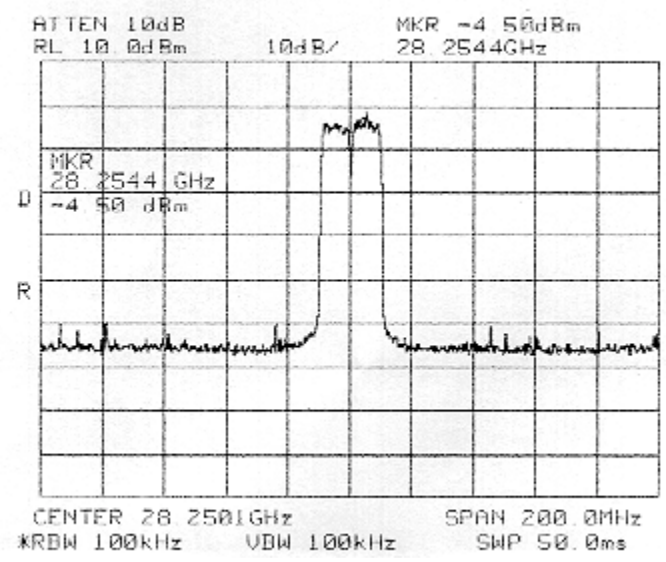


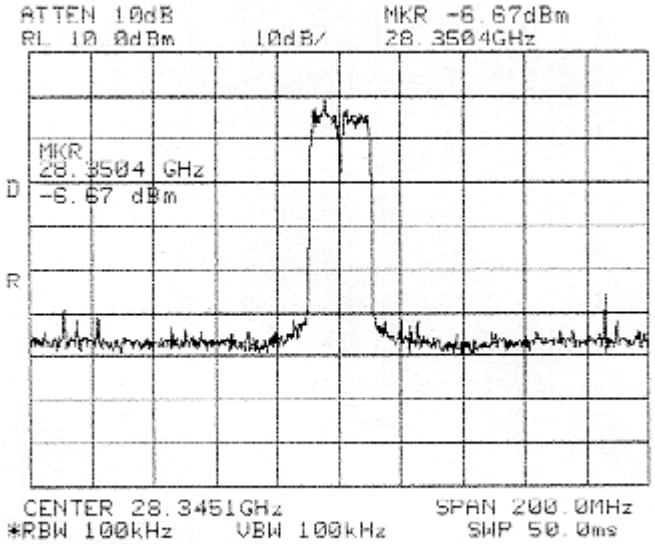


CTR with the case removed

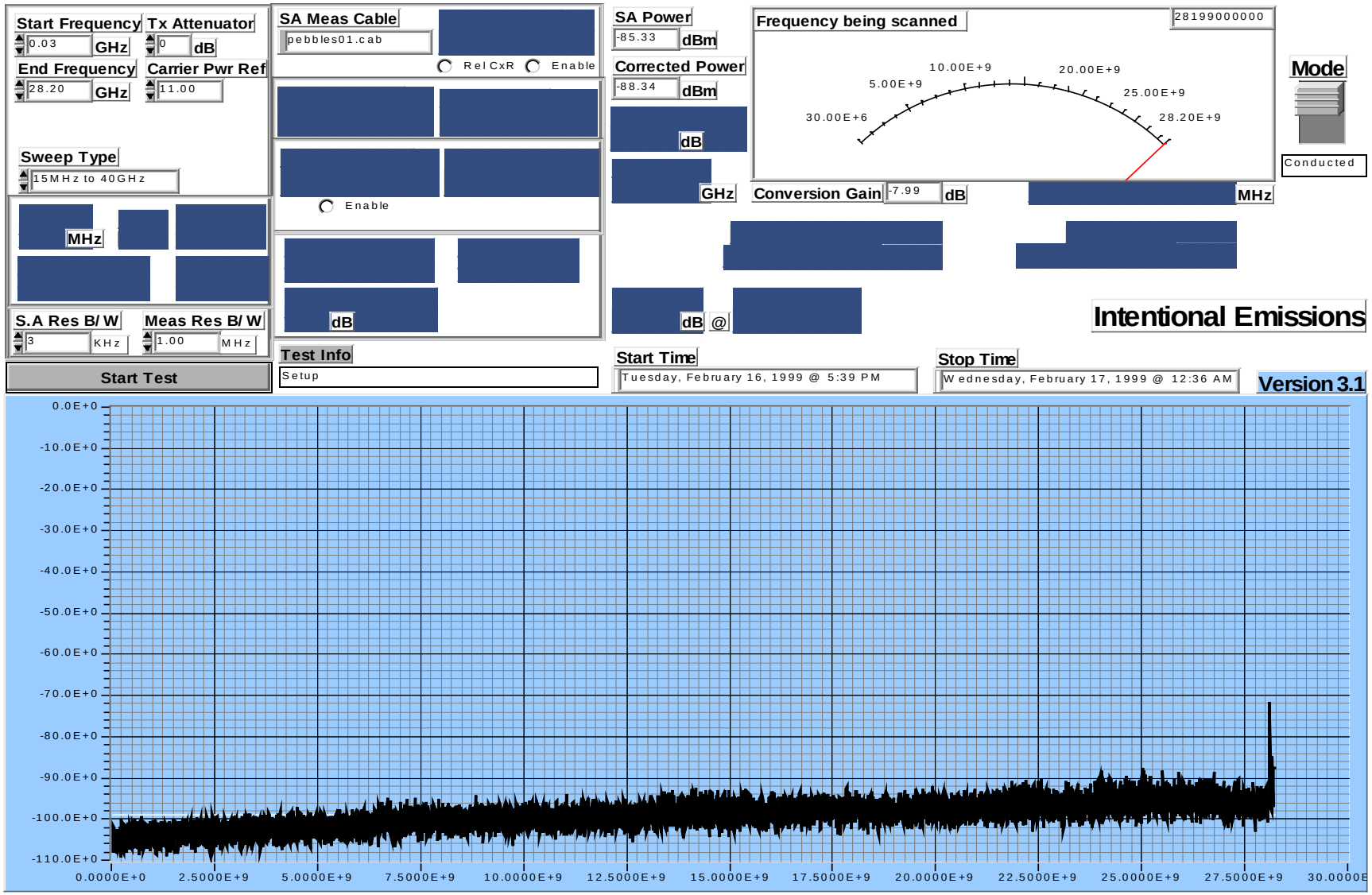
The following pictures show 2 – 10MHz carriers across the minimum, maximum and middle of the 150MHz band at a channel power of 16dBm.



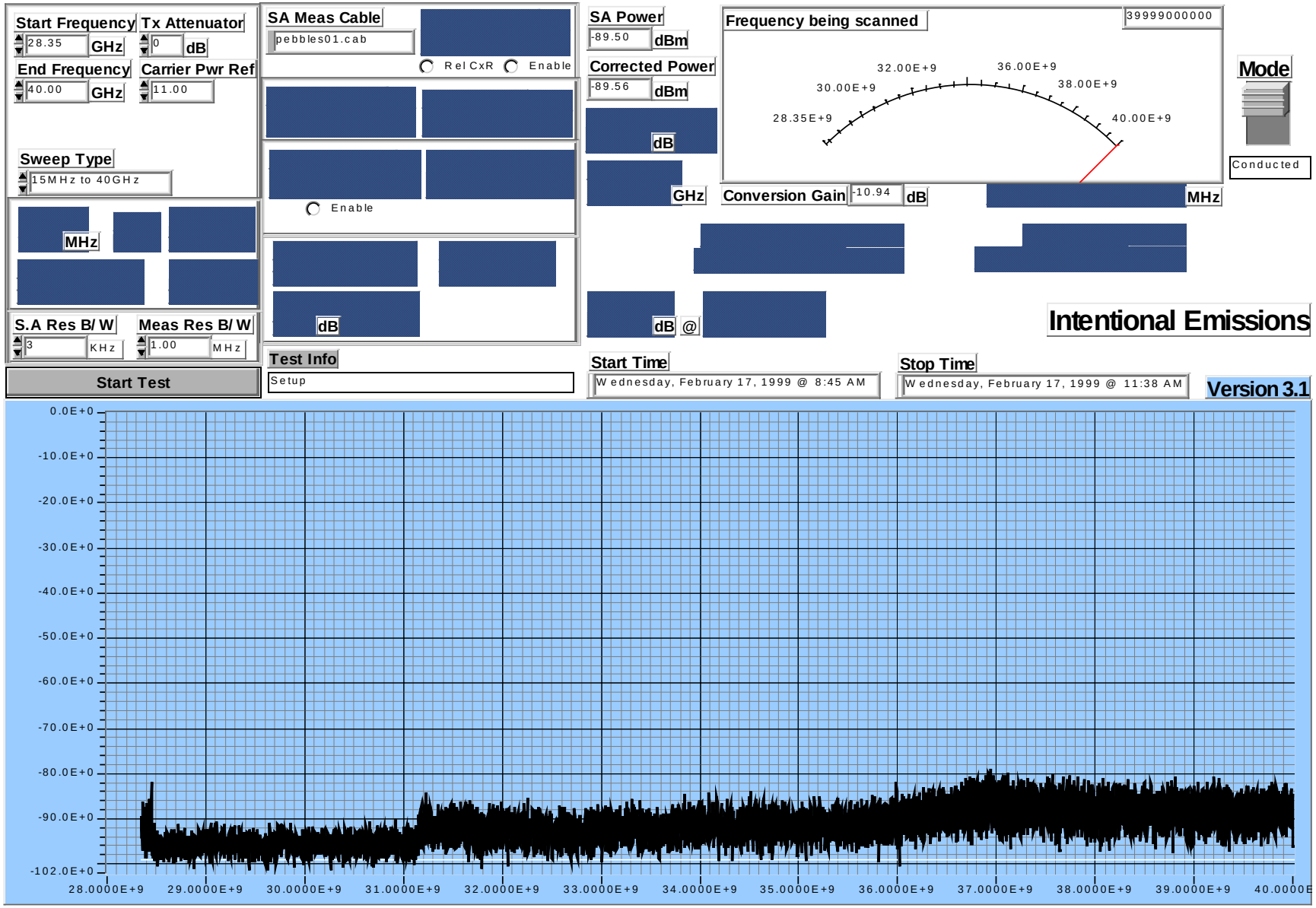




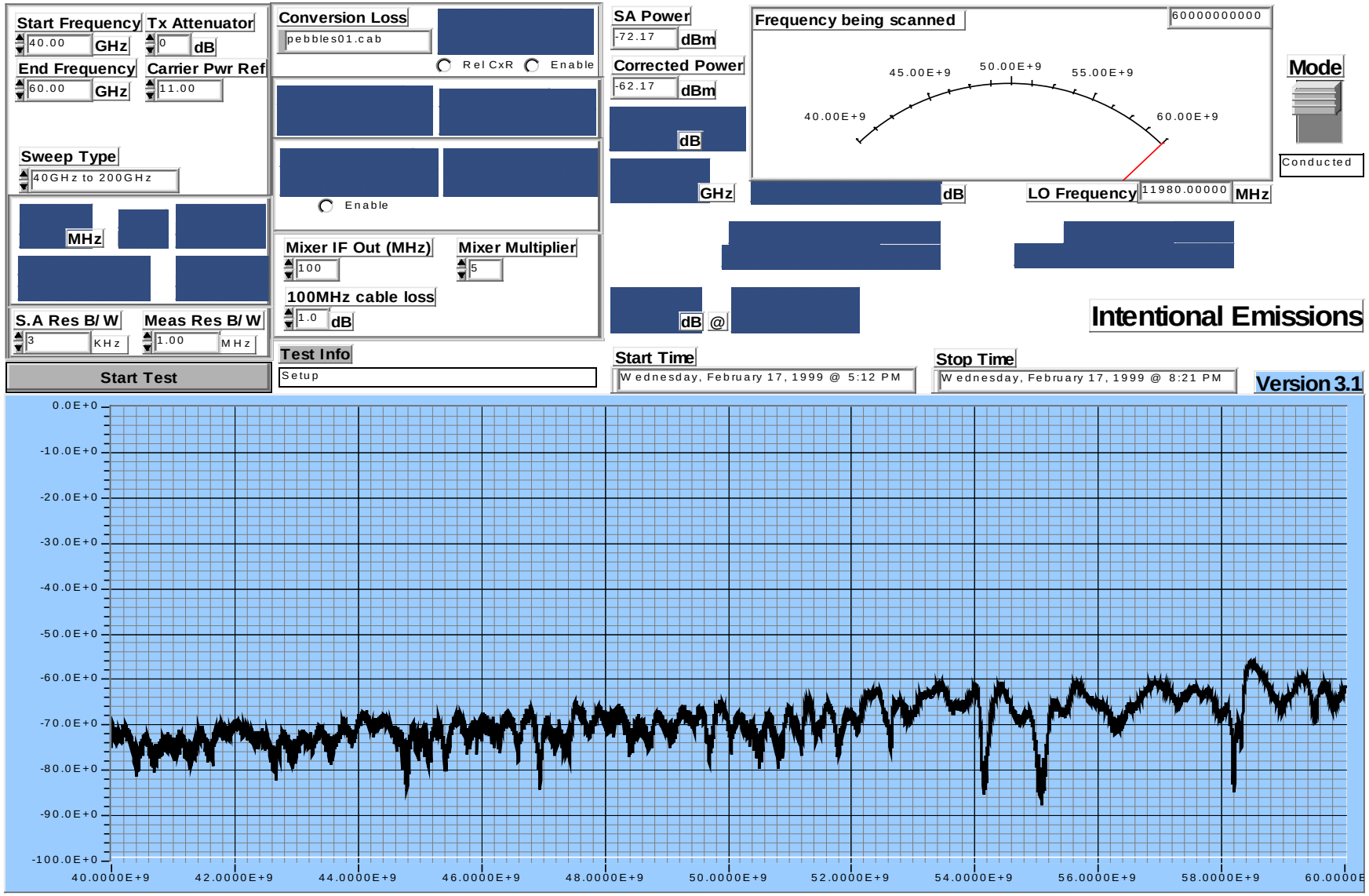
CTR 2800, 2 carrier QAM 64 modulated. – 30MHz to edge of carriers



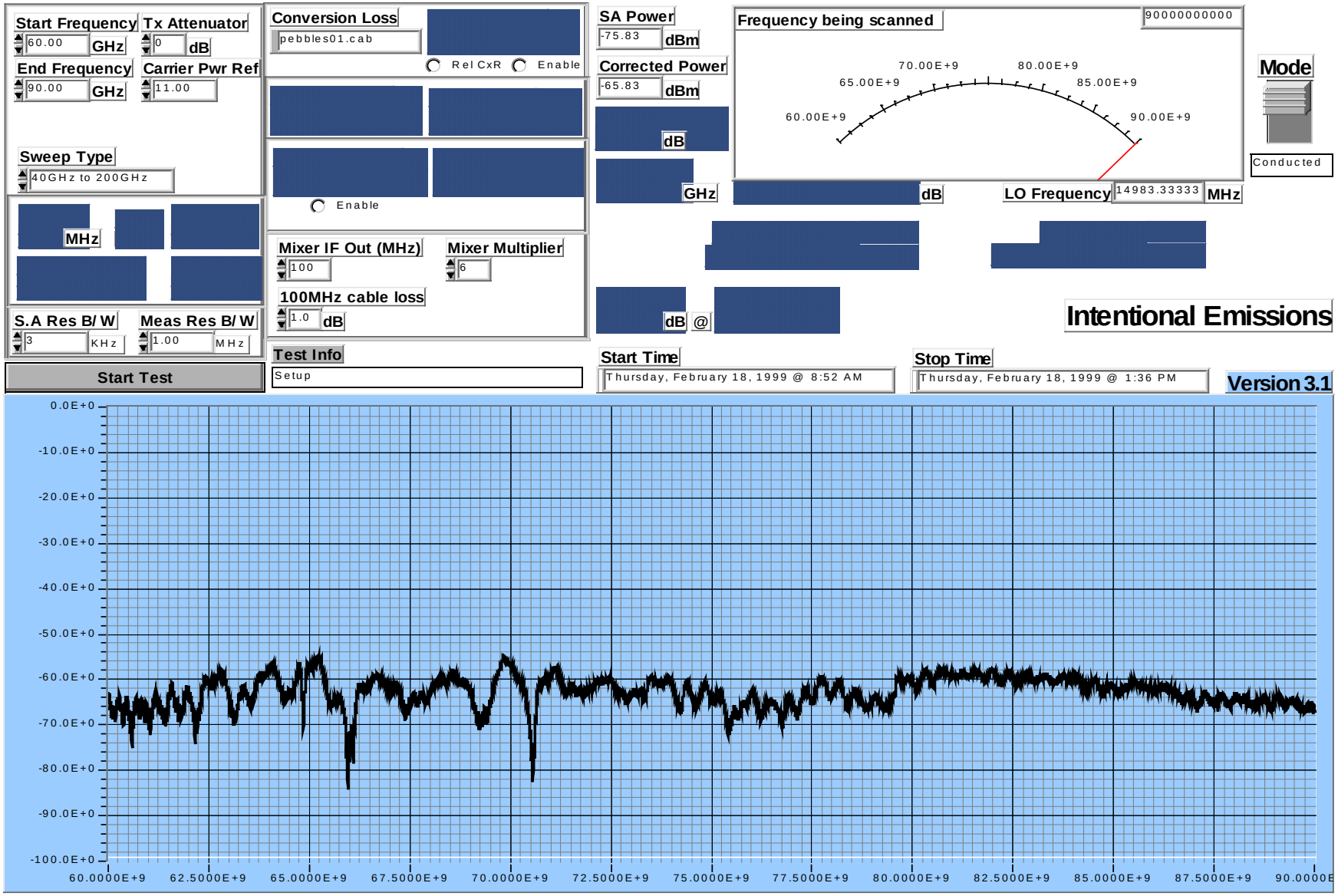
CTR 2800, 2 carrier QAM 64 modulated. – edge of carriers to 40GHz



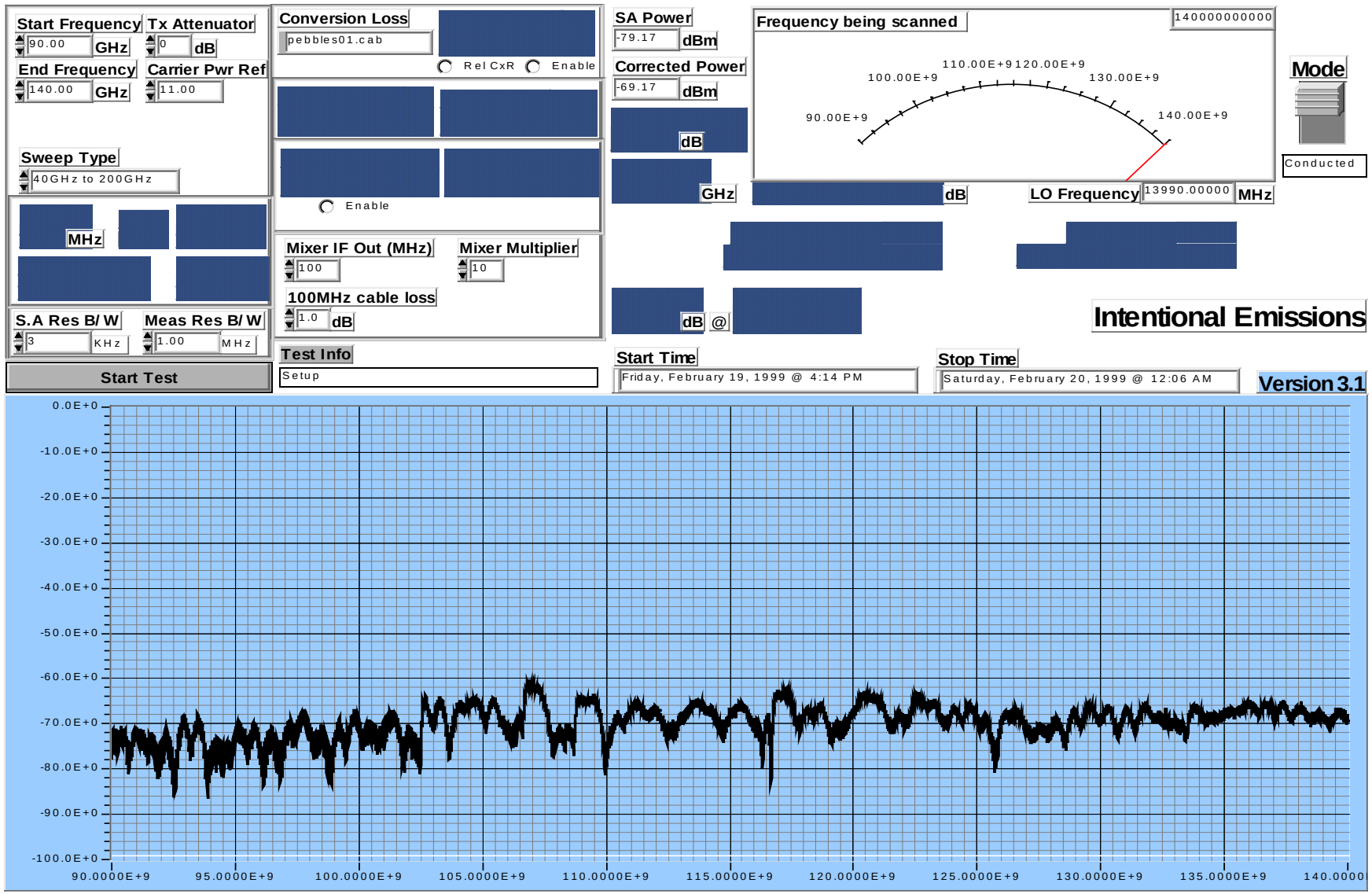
CTR 2800, 2 carrier QAM 64 modulated. – 40-60GHz



CTR 2800, 2 carrier QAM 64 modulated. –60-90GHz



CTR 2800, 2 carrier QAM 64 modulated. –90-110GHz

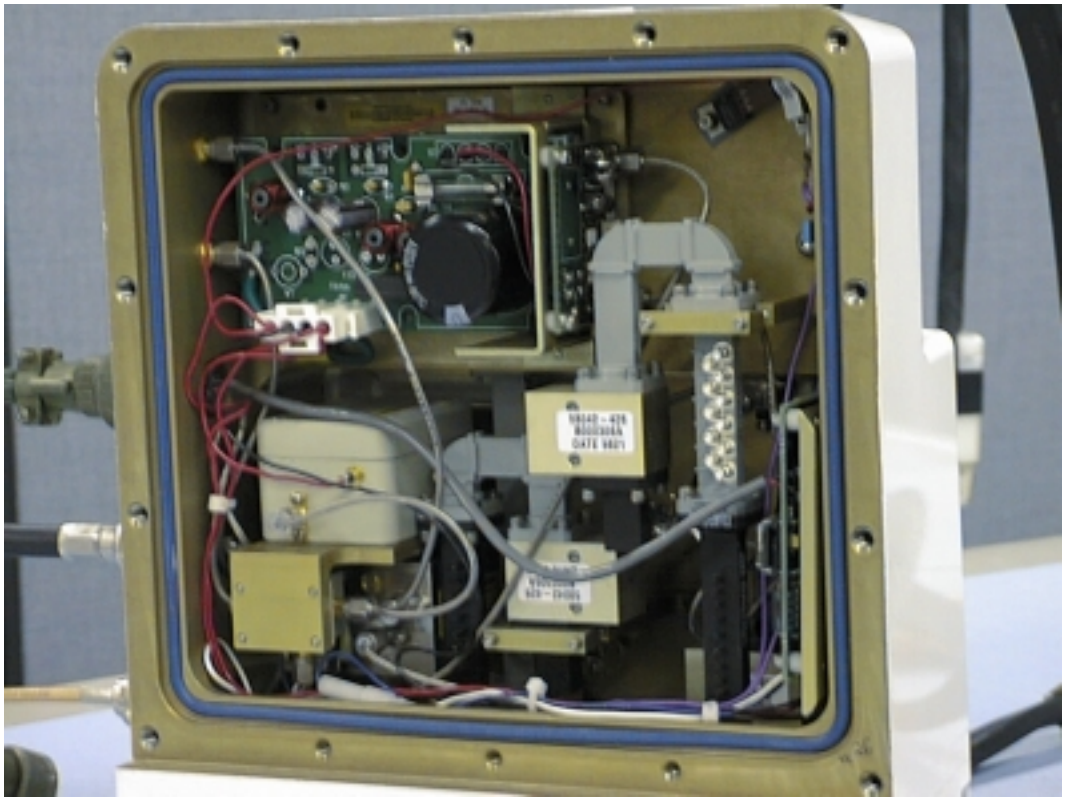


APPENDIX B

Radiated Emissions Measurement Results

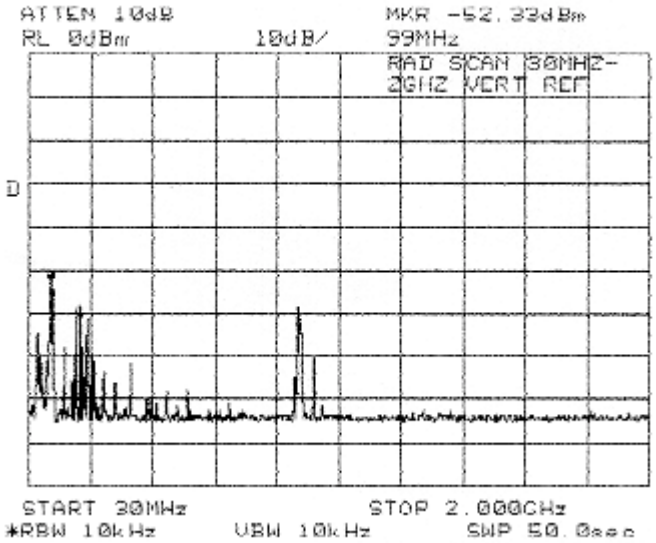
RADIATED EMISSIONS MEASUREMENT RESULTS

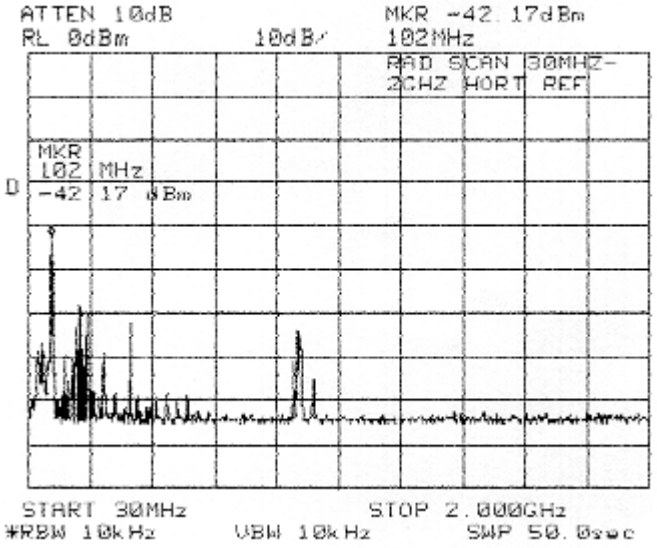
Radiated test using the 40-60GHz horn**.**



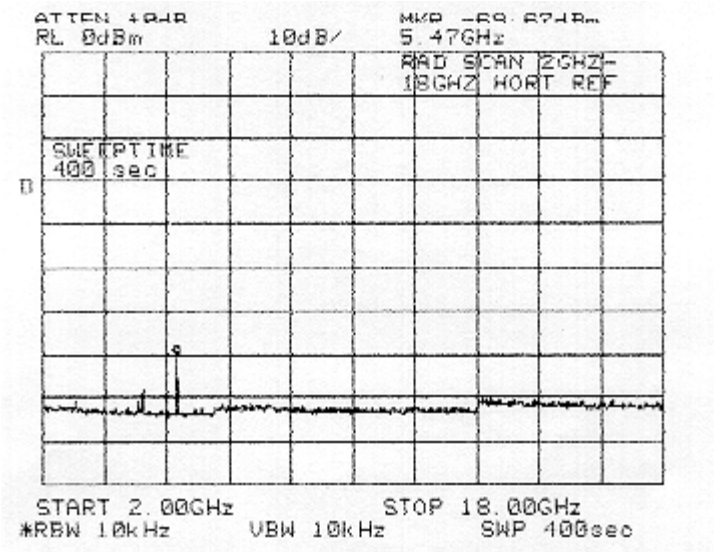
BTR with the back cover removed

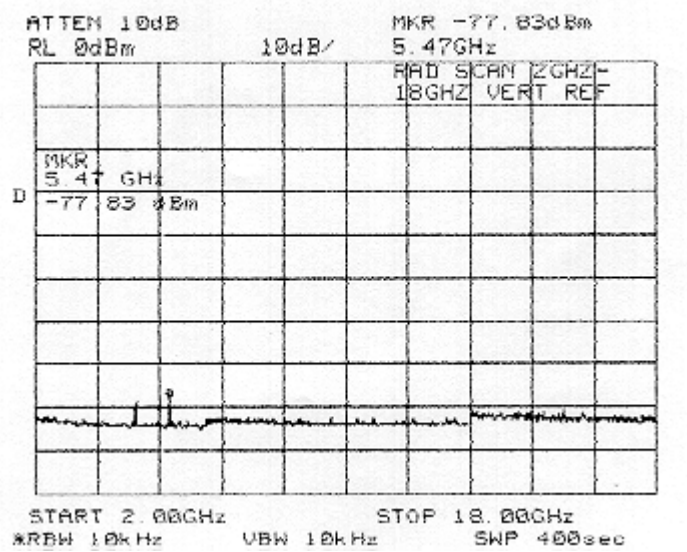
BTR 2800, 4 carrier QAM 64 modulated. – 30MHz to 2GHz



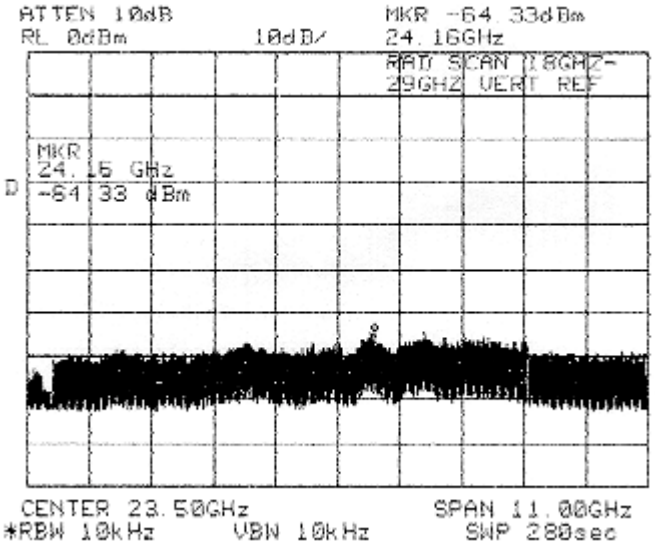


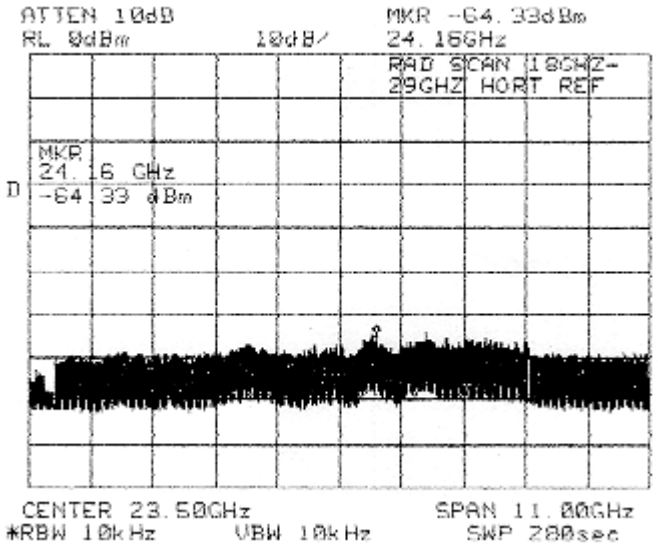
BTR 2800, 4 carrier QAM 64 modulated. – 2GHz to 18GHz



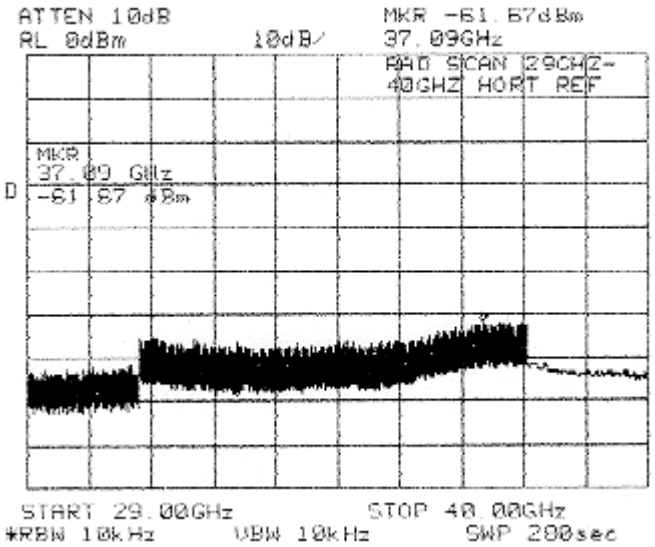


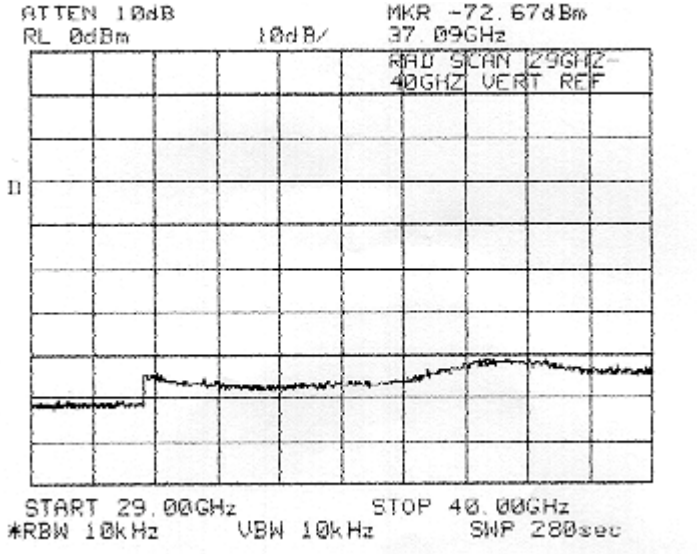
BTR 2800, 4 carrier QAM 64 modulated. – 18 to 29 GHz



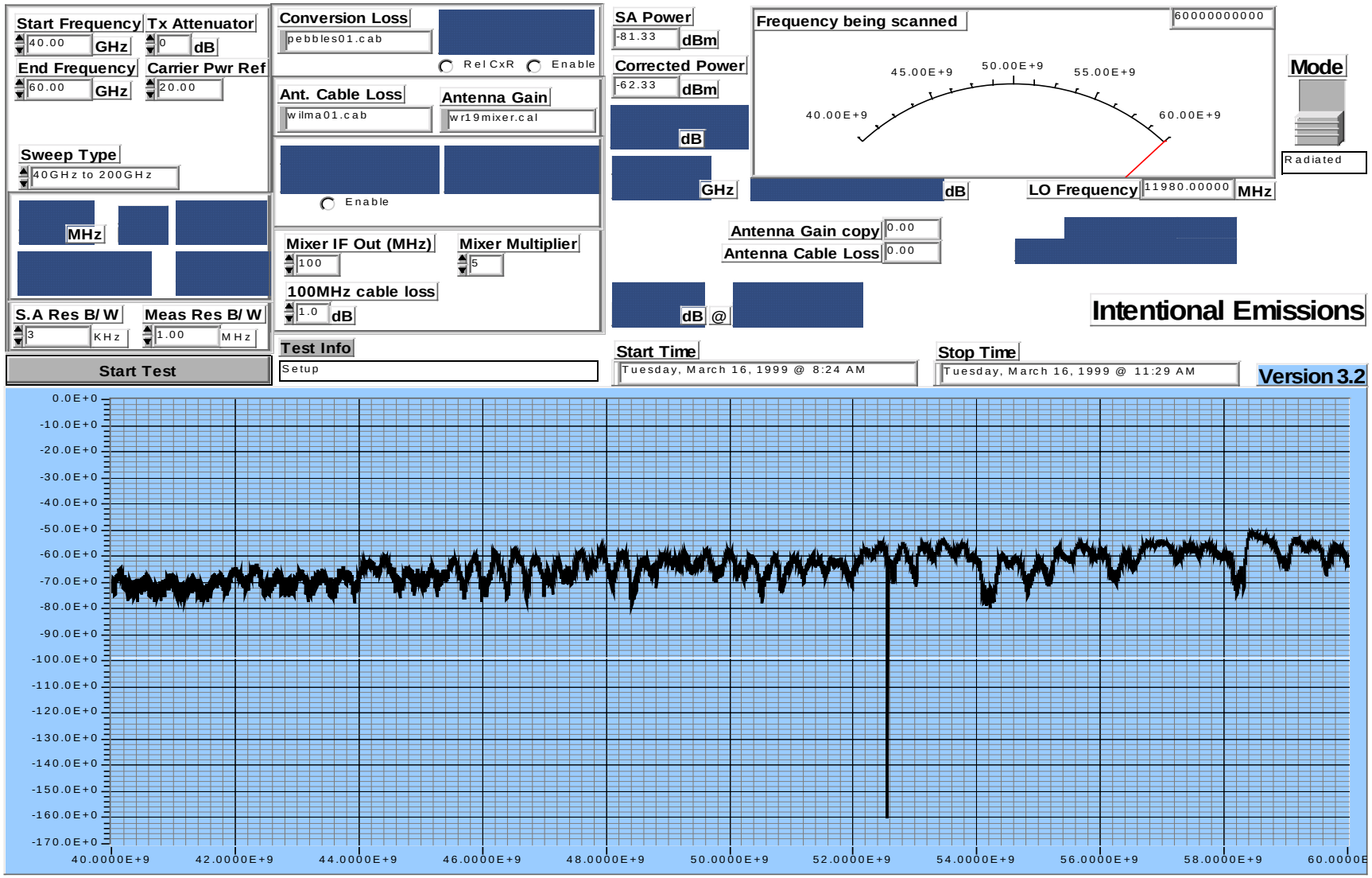


BTR 2800, 4 carrier QAM 64 modulated. – 29.5GHz to 40GHz

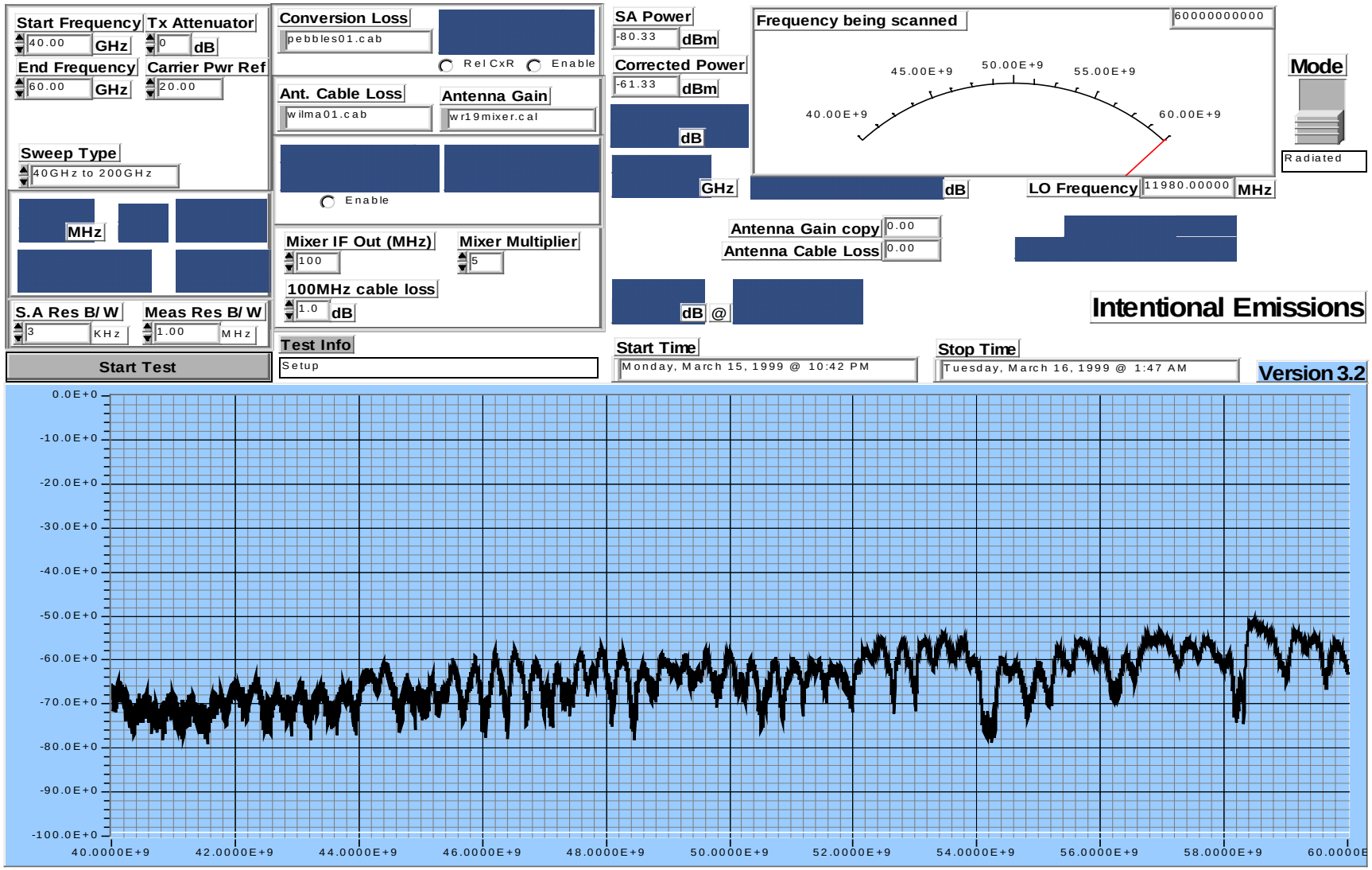




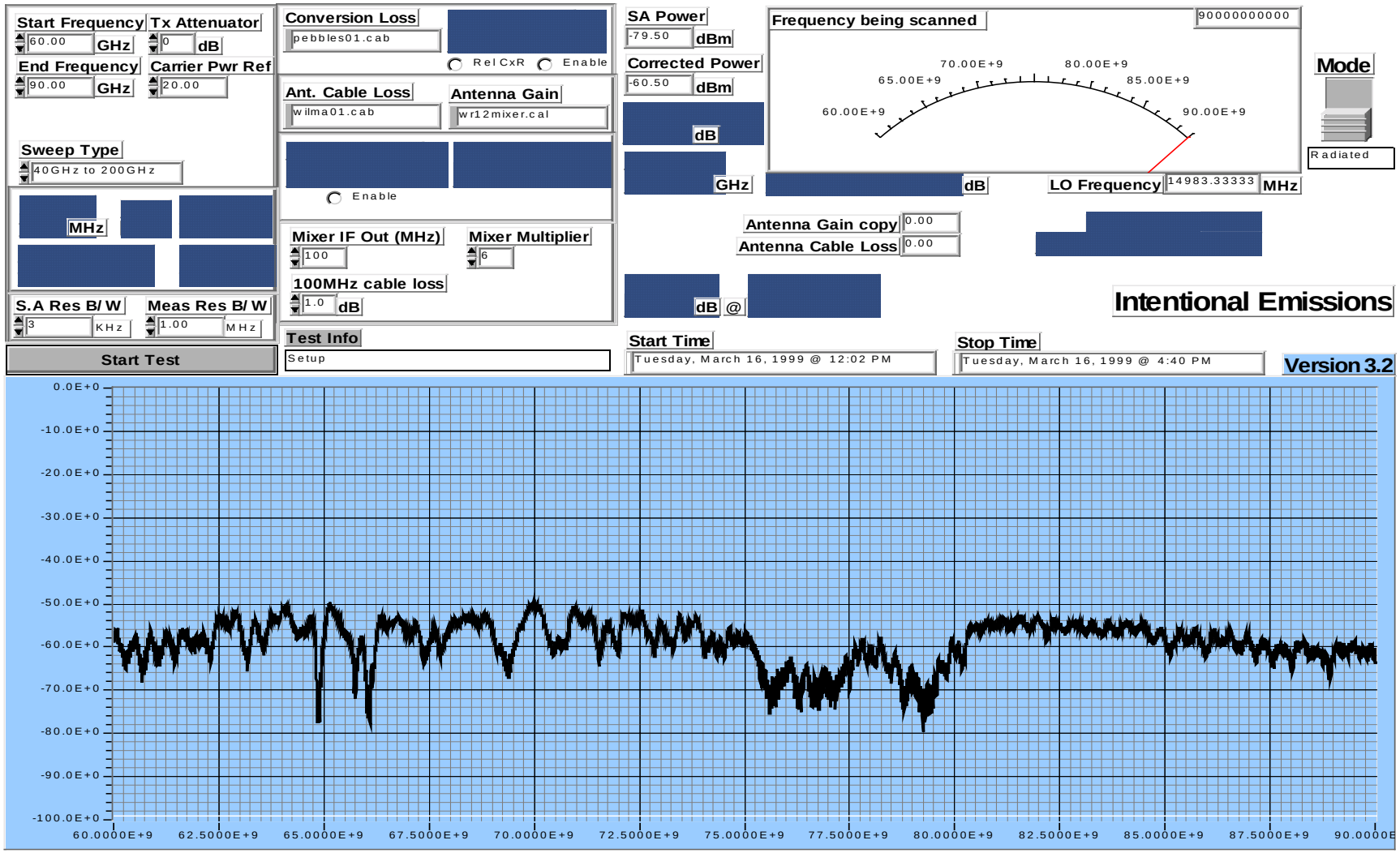
BTR 2800, 4 carrier QAM 64 modulated. –40GHz-60GHz - Horizontal



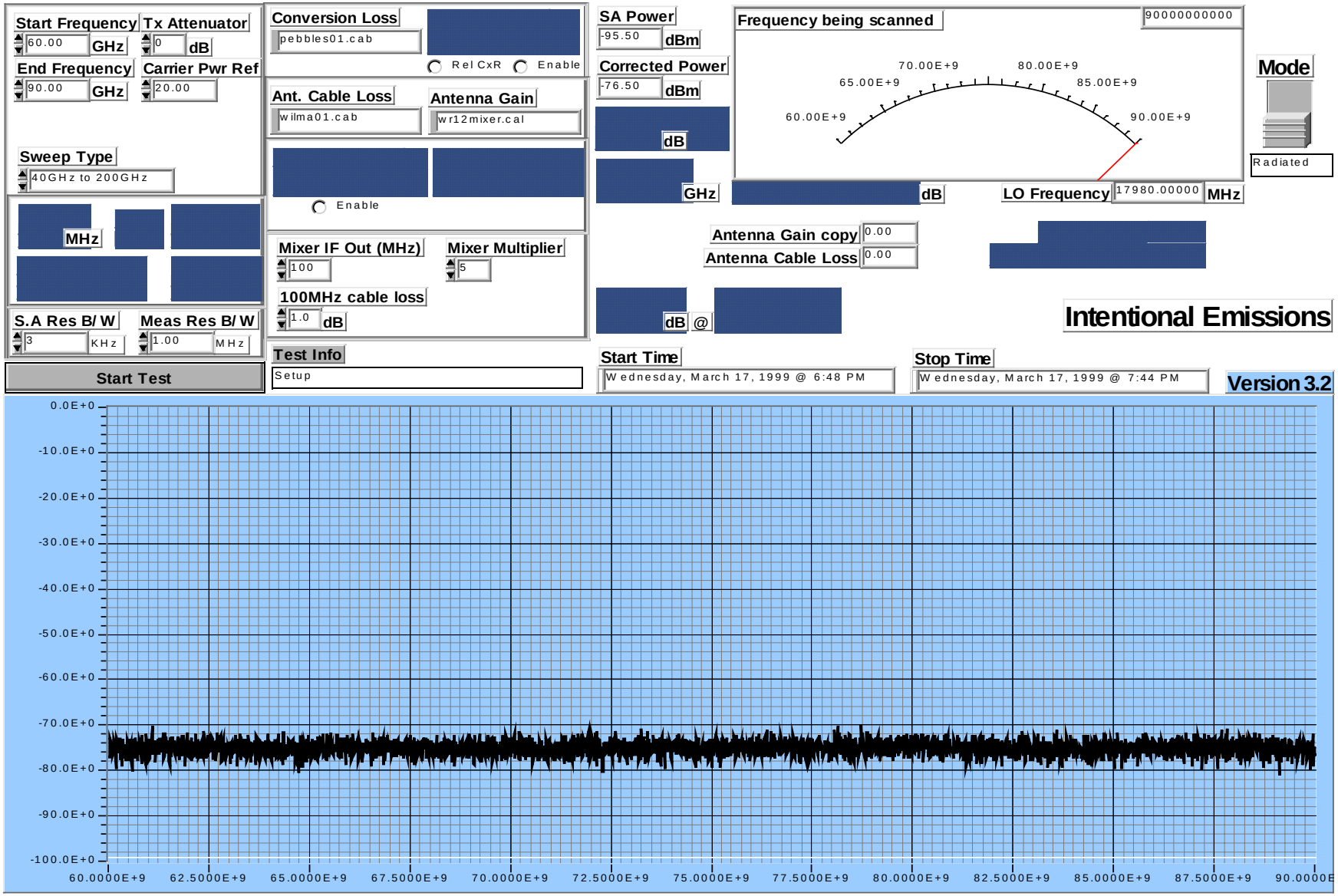
BTR 2800, 4 carrier QAM 64 modulated. –40GHz-60GHz - Vertical



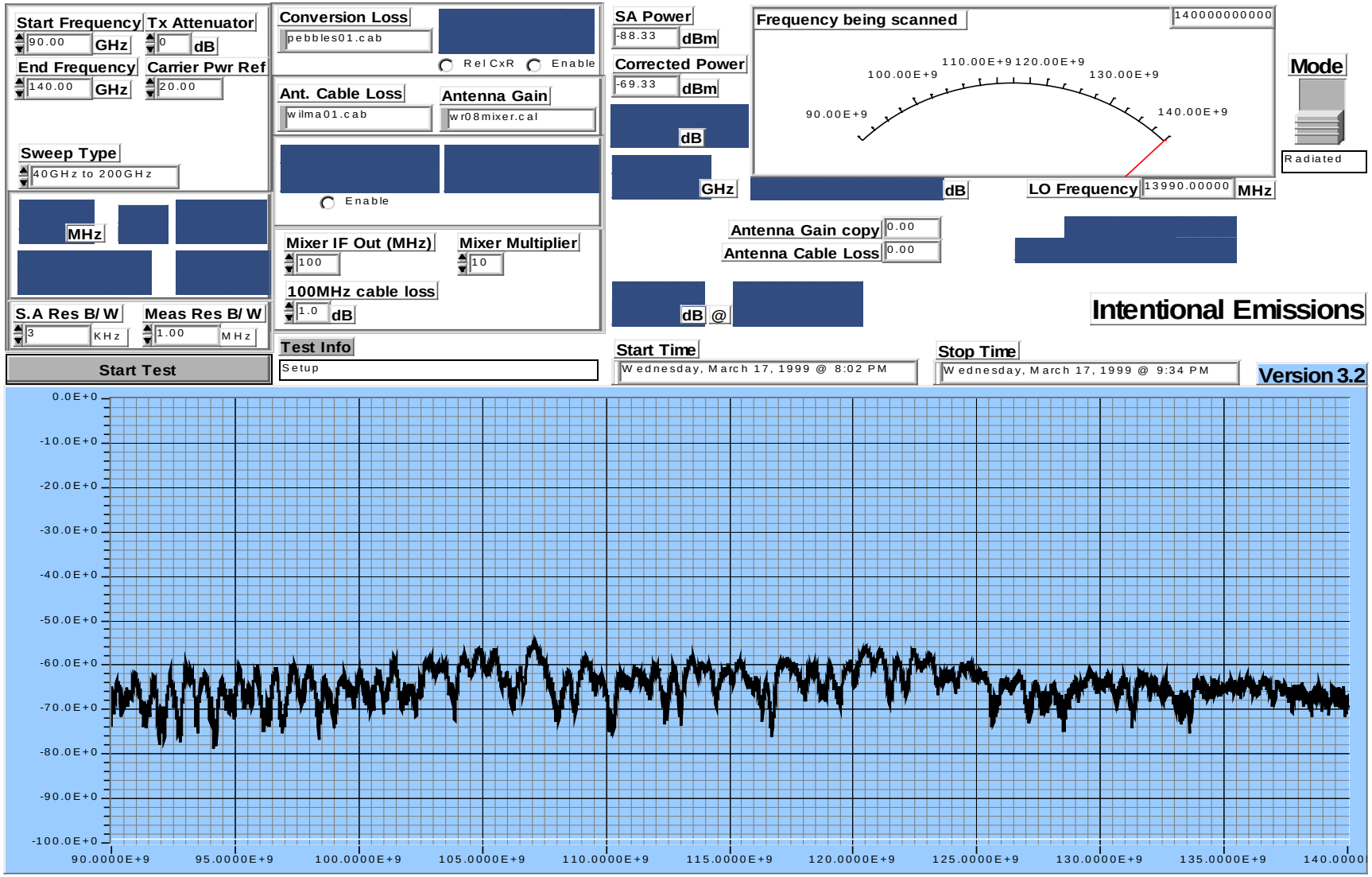
BTR 2800, 4 carrier QAM 64 modulated. –60GHz-90GHz - Horizontal



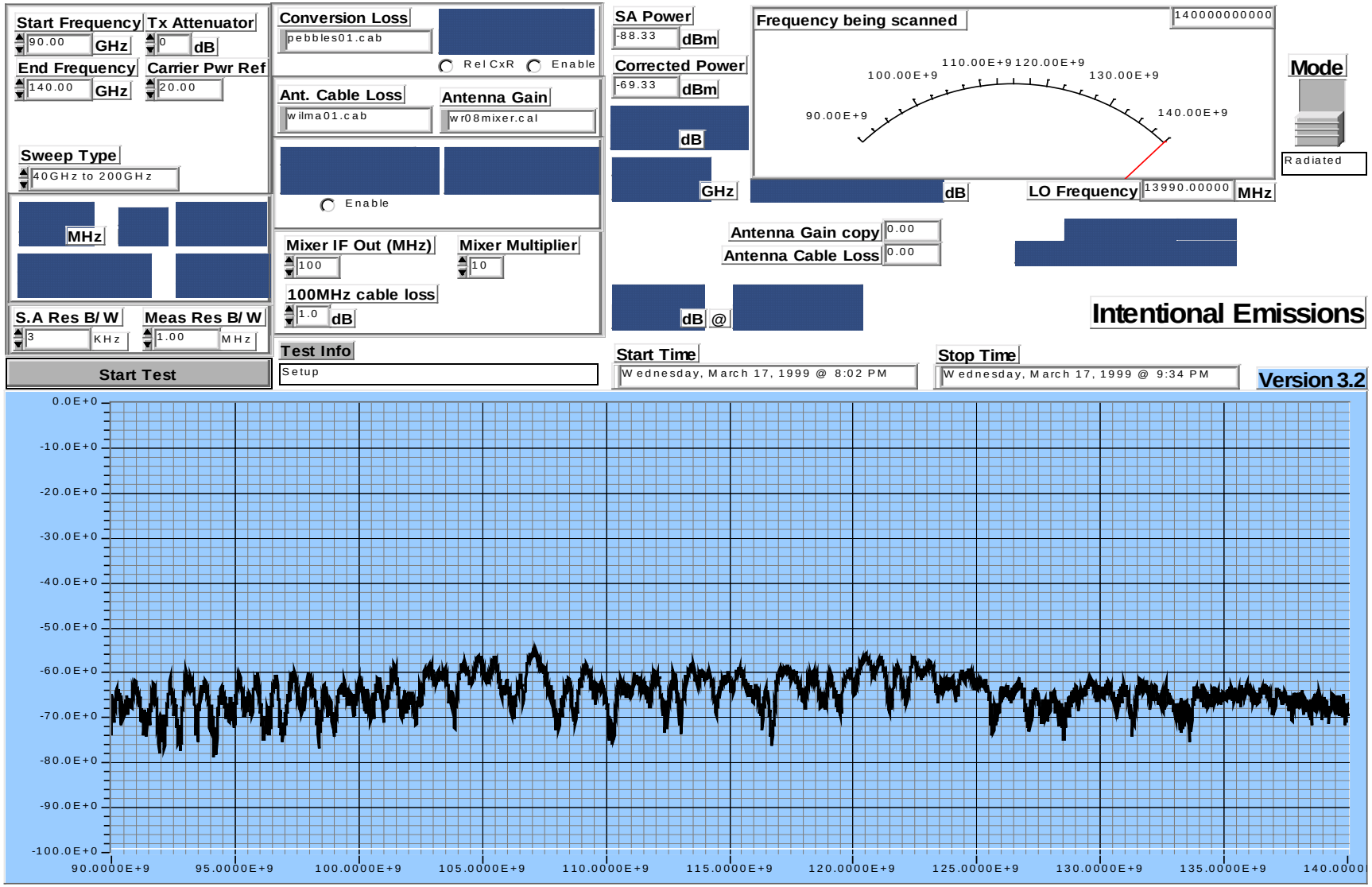
BTR 2800, 4 carrier QAM 64 modulated. –60GHz-90GHz – Vertical



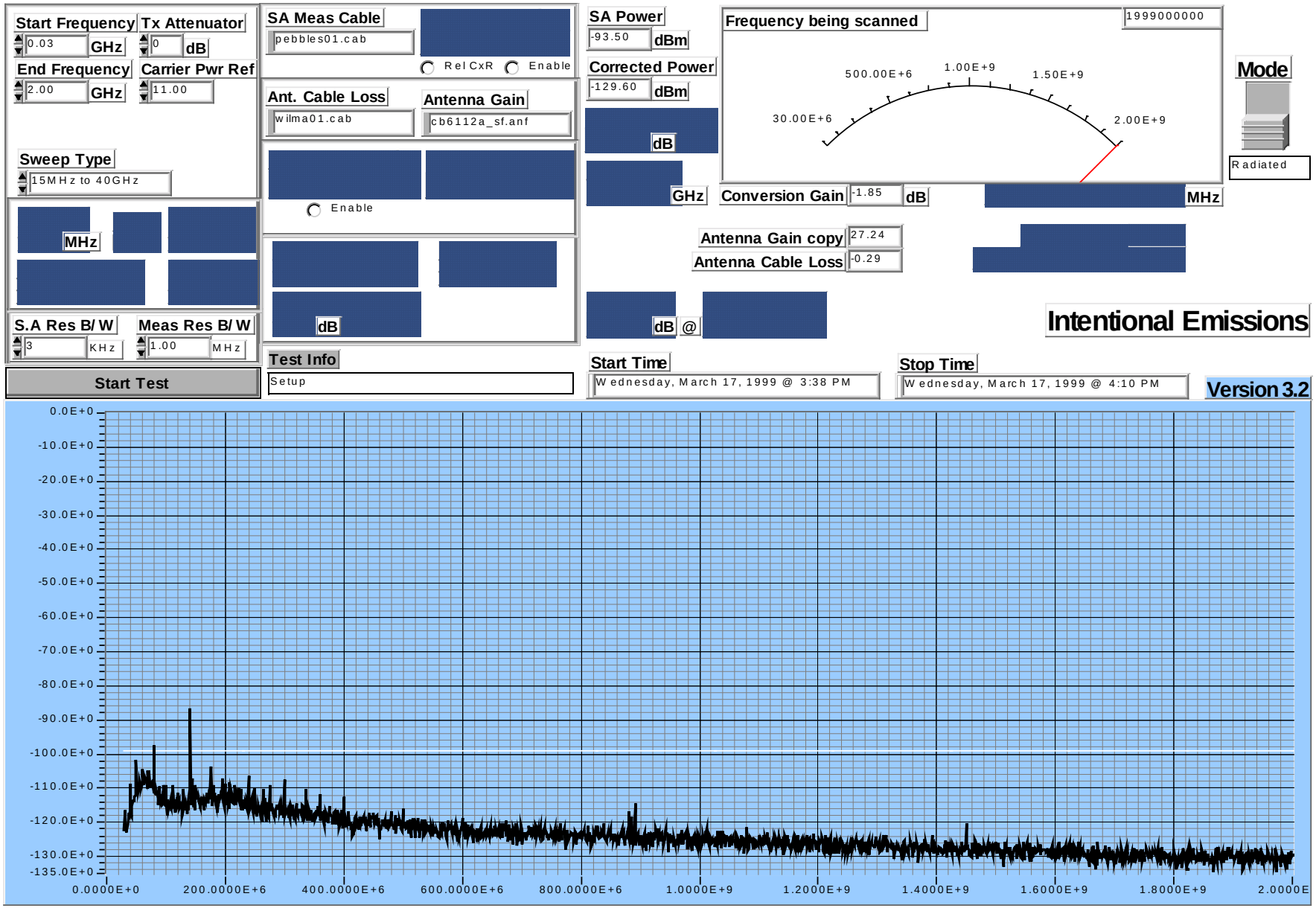
BTR 2800, 4 carrier QAM 64 modulated. –90GHz-140GHz – Horizontal



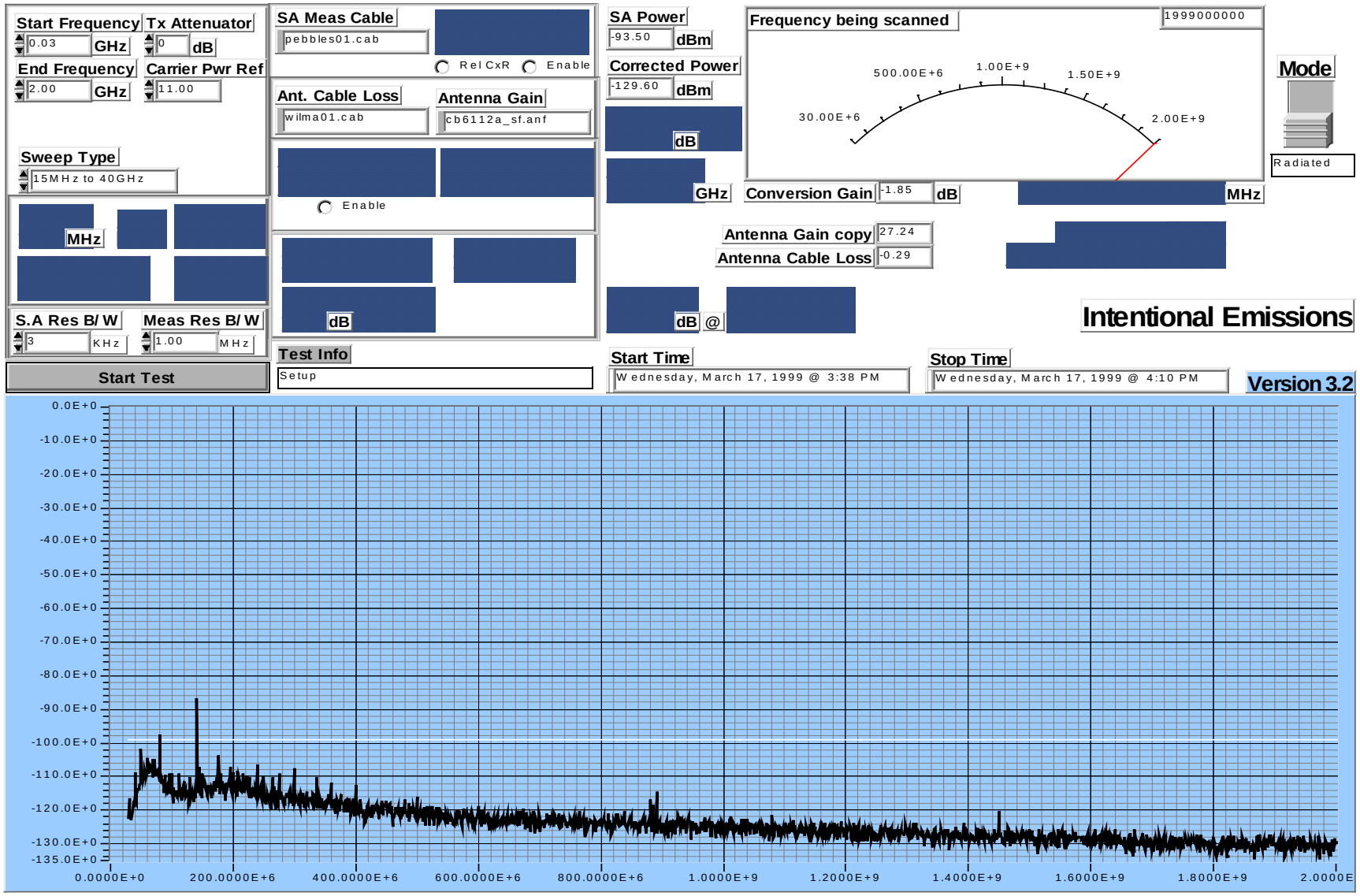
BTR 2800, 4 carrier QAM 64 modulated. –90GHz-140GHz – Vertical



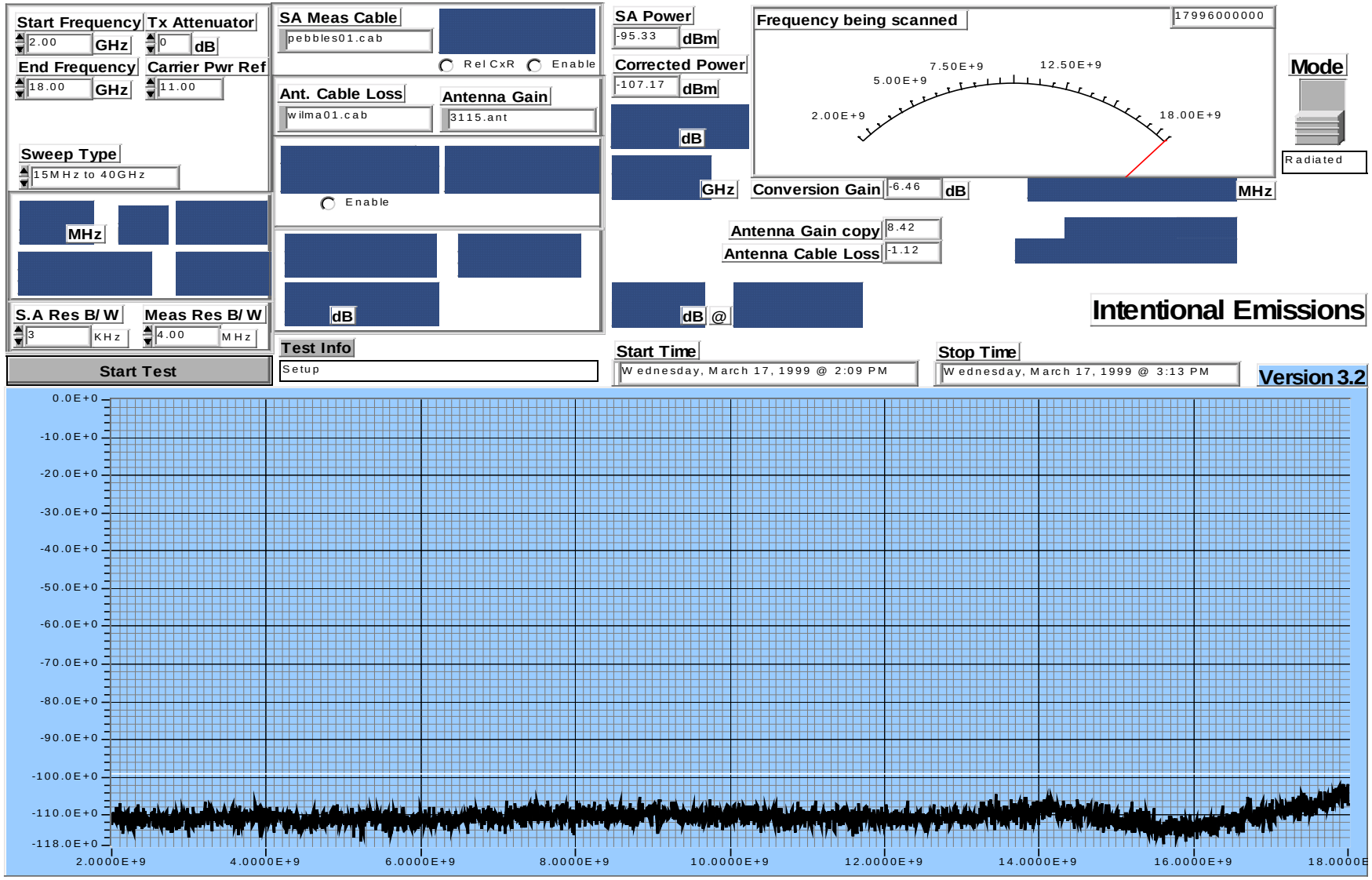
CTR 2800, 2 carrier QAM 64 modulated. – 30MHz to 2GHz – Horizontal



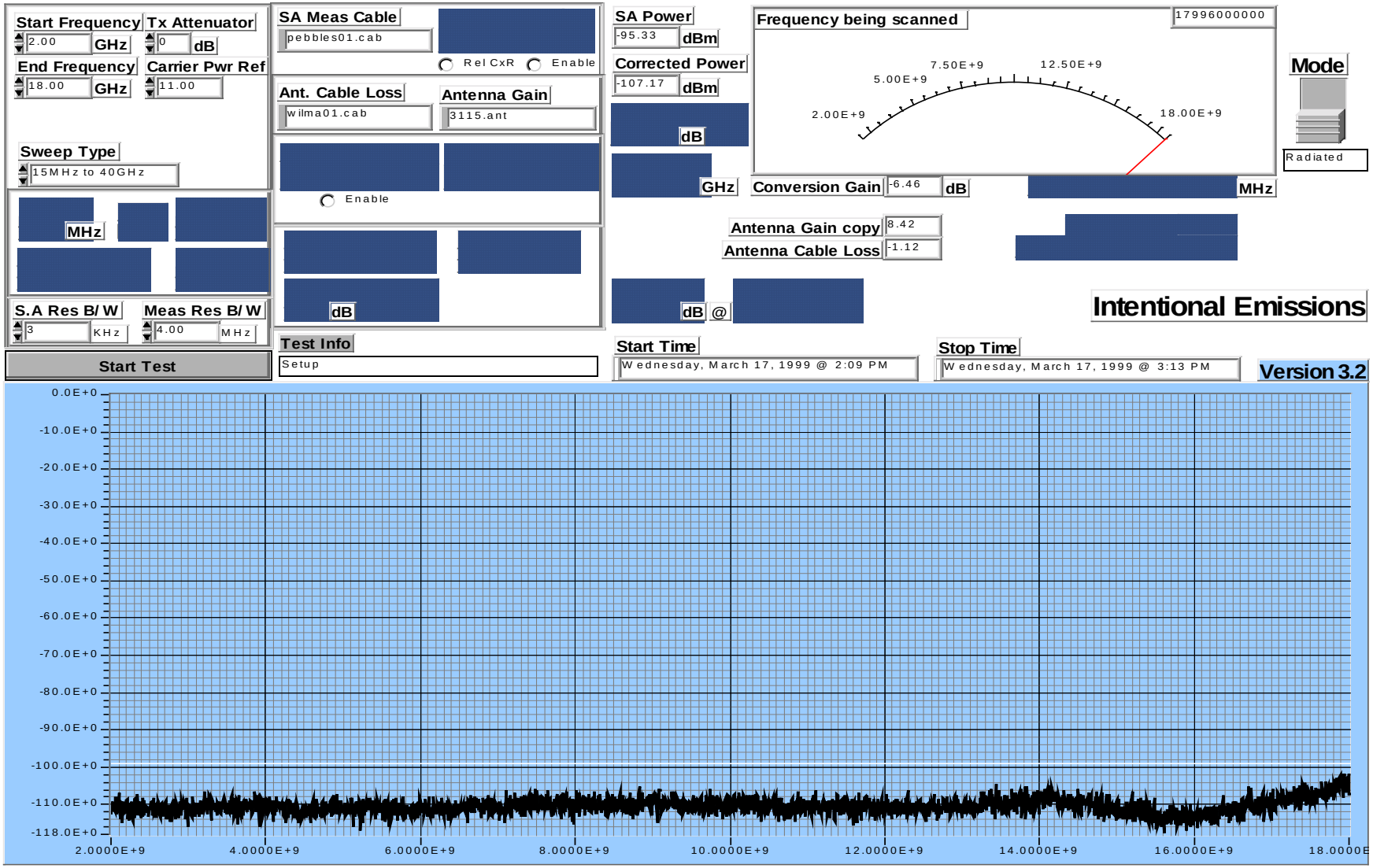
CTR 2800, 2 carrier QAM 64 modulated. – 30MHz to 2GHz – Vertical



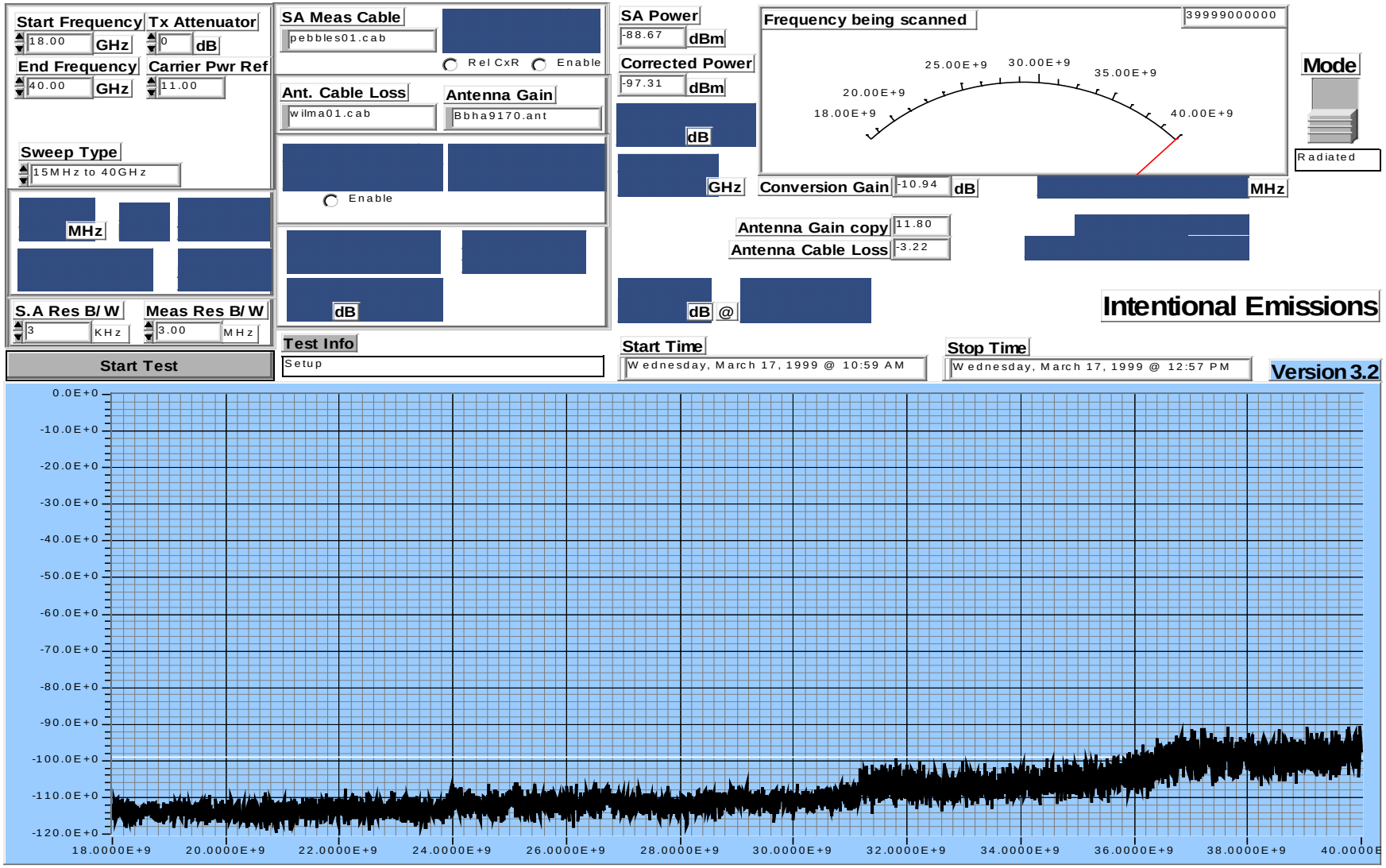
CTR 2800, 2 carrier QAM 64 modulated. – 1GHz to 18GHz - Horizontal



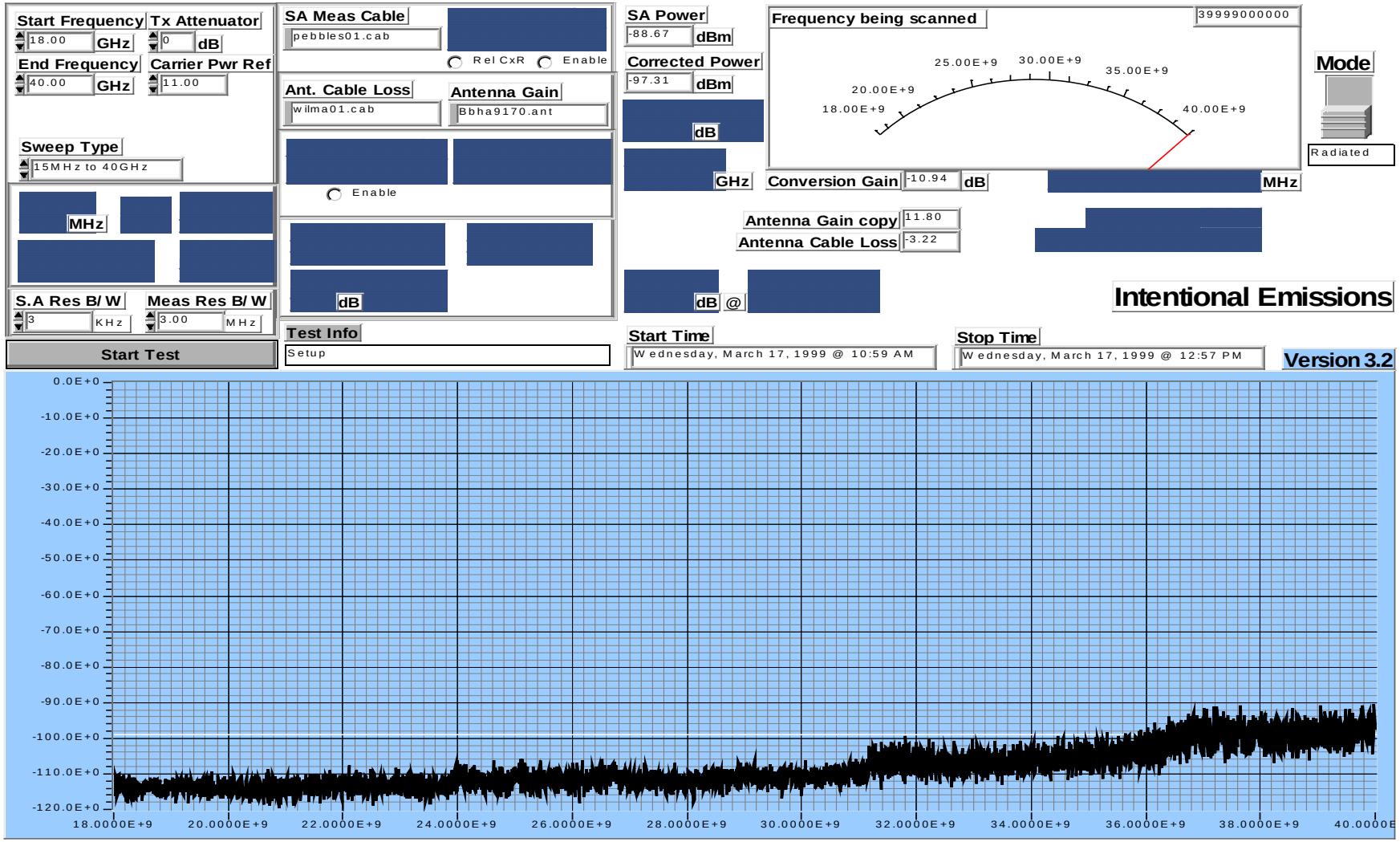
CTR 2800, 2 carrier QAM 64 modulated. – 1GHz to 18GHz - Vertical



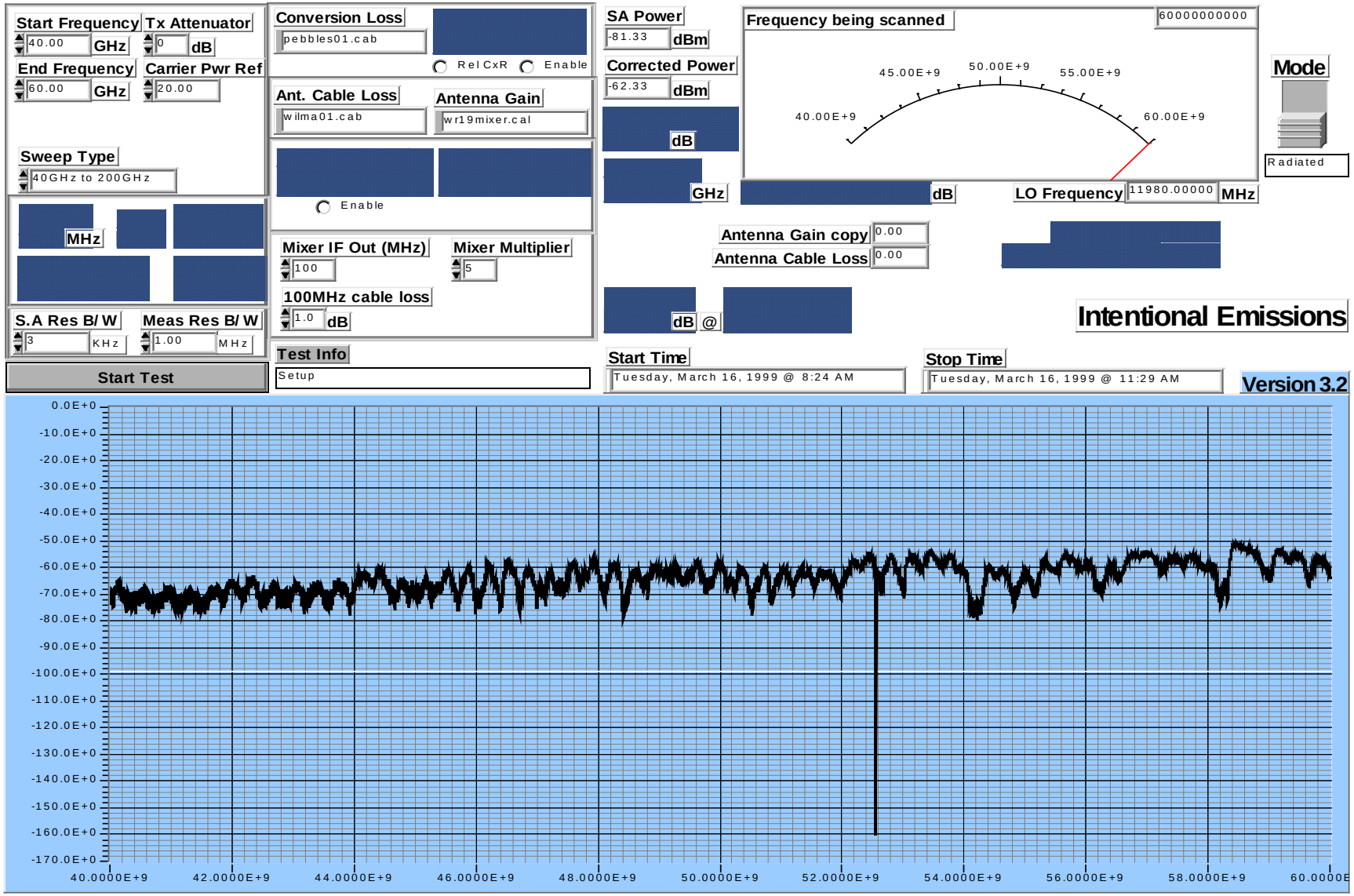
CTR 2800, 2 carrier QAM 64 modulated. –18GHz to 40GHz - Horizontal



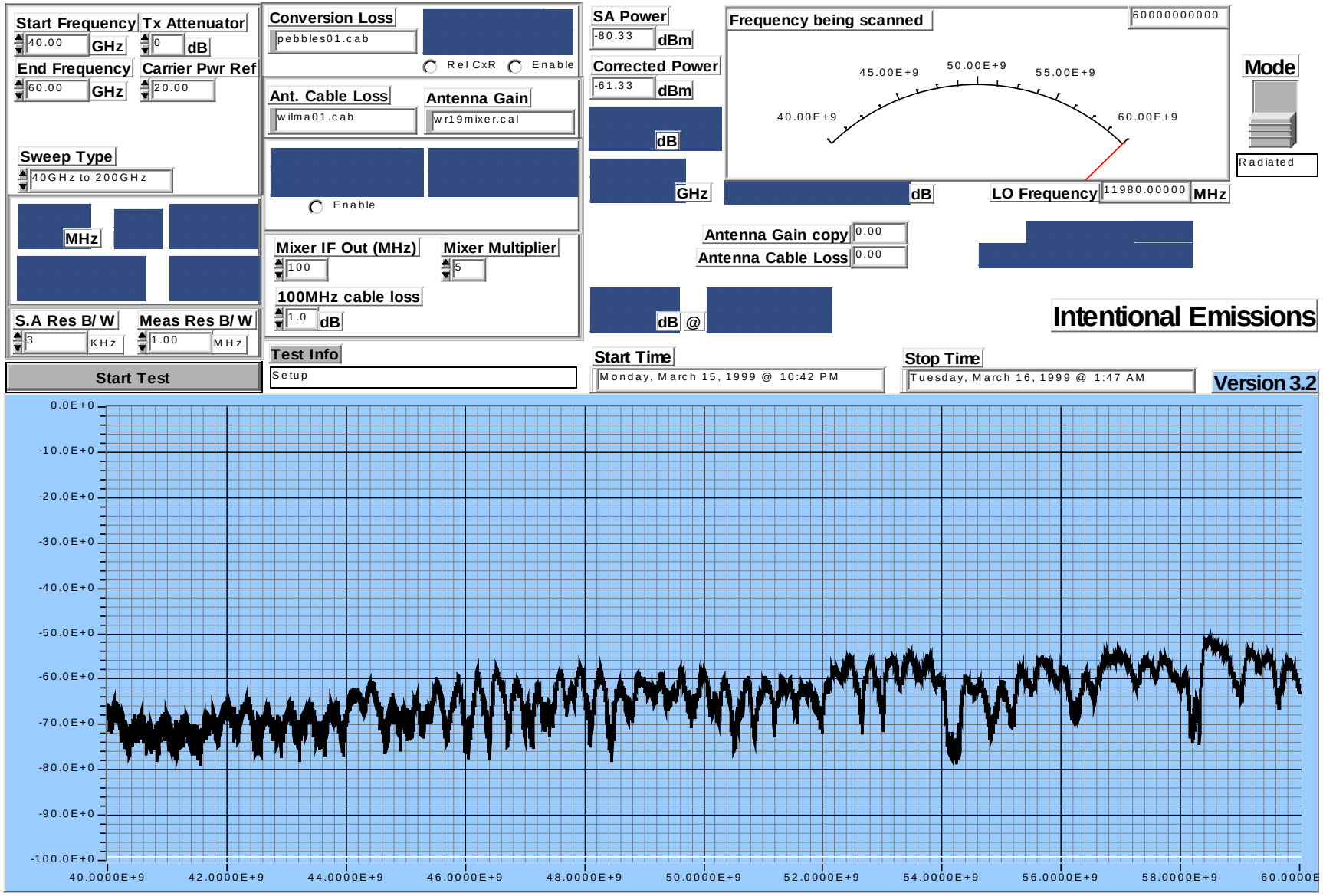
CTR 2800, 2 carrier QAM 64 modulated. –18GHz to 40GHz - Vertical



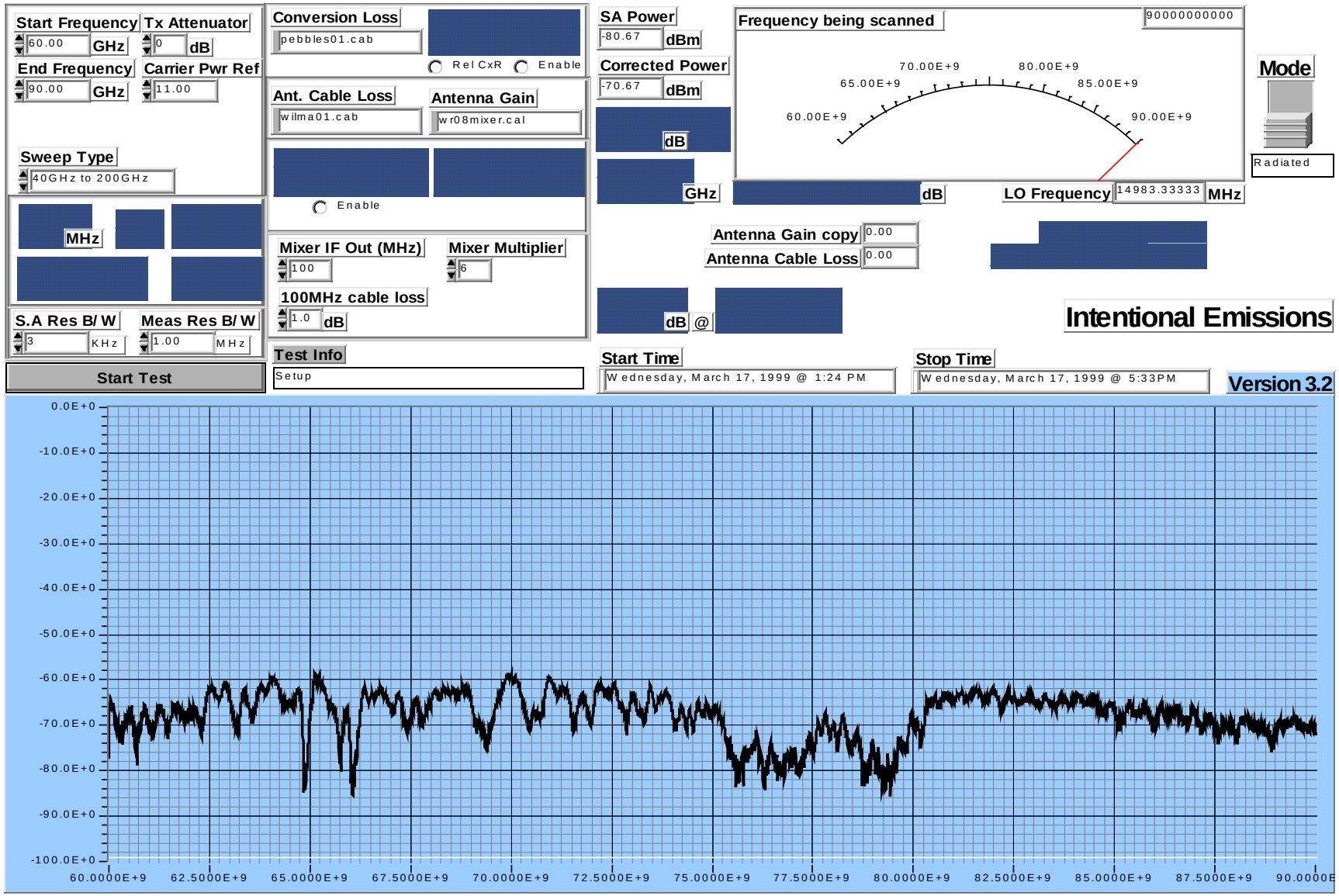
CTR 2800, 2 carrier QAM 64 modulated. –40GHz to 60GHz - Horizontal



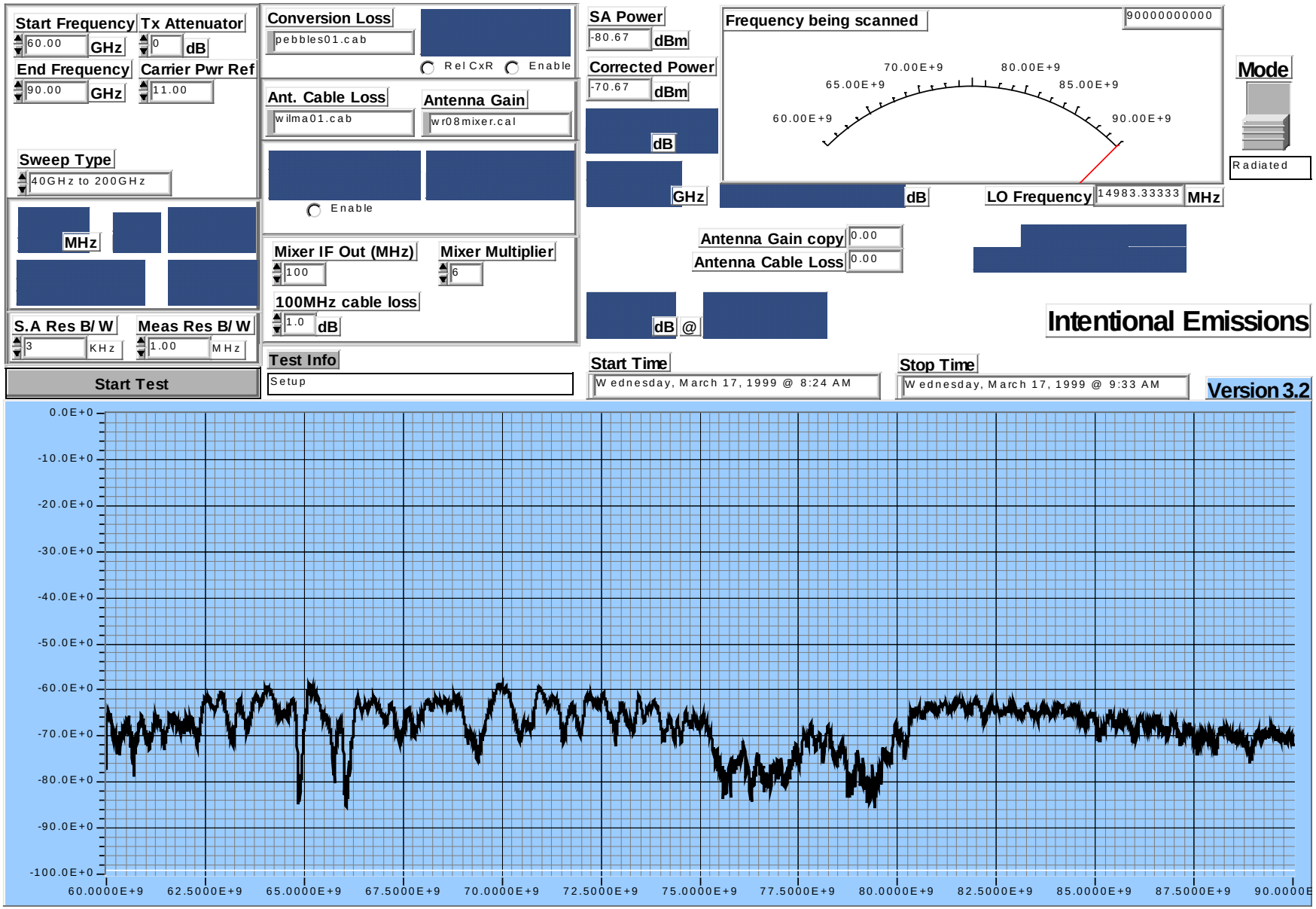
CTR 2800, 2 carrier QAM 64 modulated. –40GHz to 60GHz - Vertical



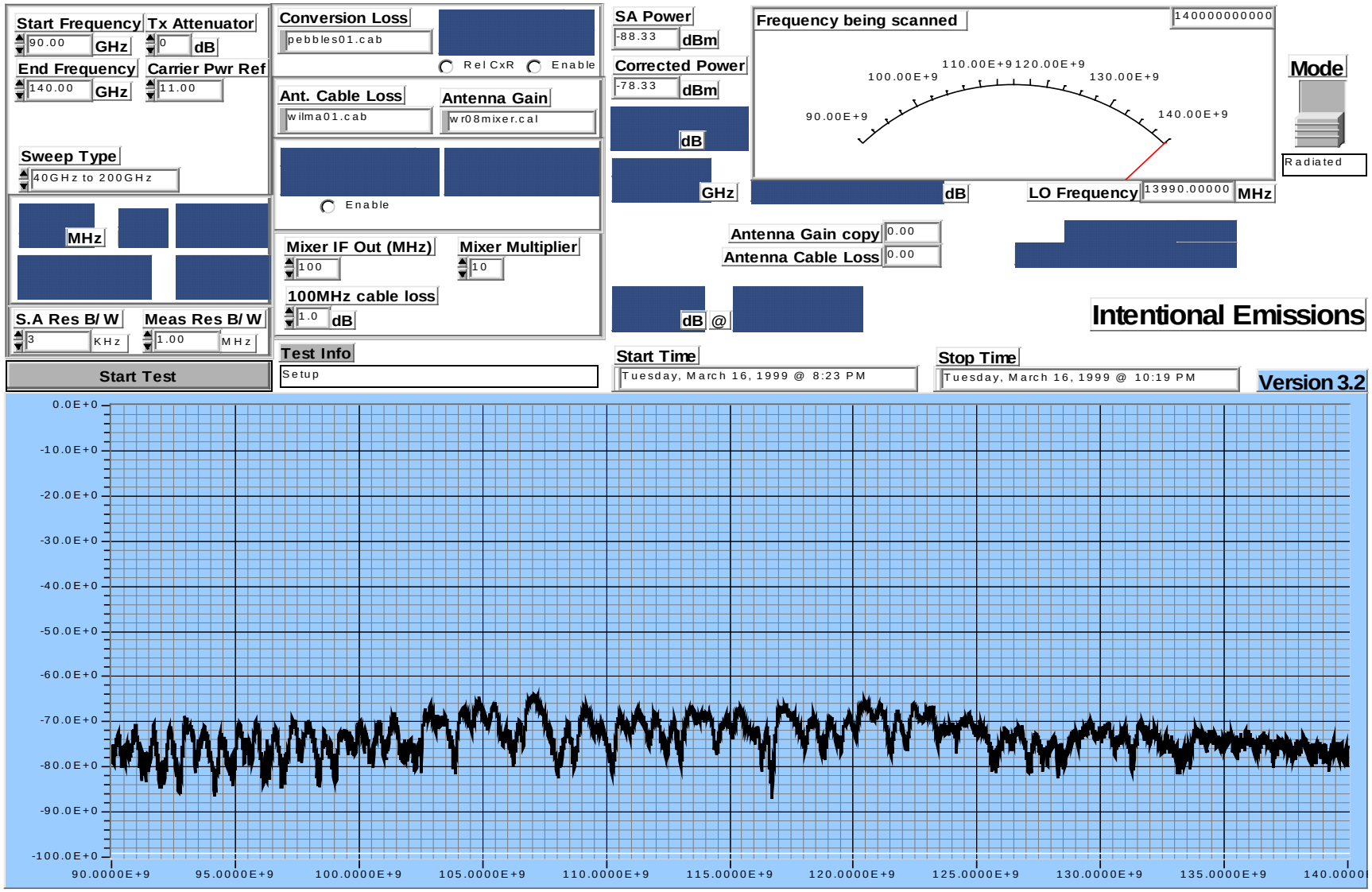
CTR 2800, 2 carrier QAM 64 modulated. –60GHz to 90GHz - Horizontal



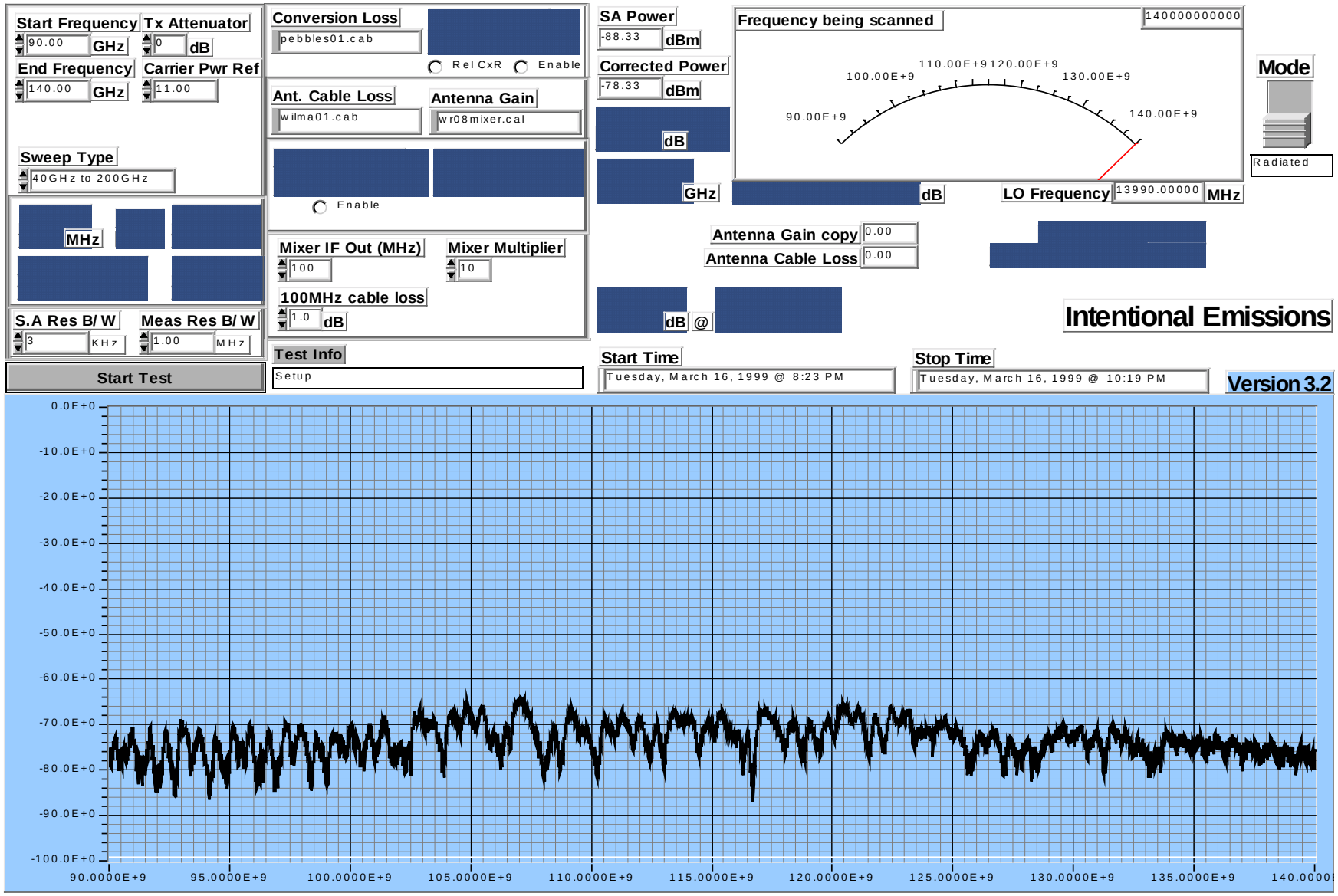
CTR 2800, 2 carrier QAM 64 modulated. –60GHz to 90GHz - Vertical



CTR 2800, 2 carrier QAM 64 modulated. –90GHz to 140GHz - Horizontal



CTR 2800, 2 carrier QAM 64 modulated. –90GHz to 140GHz - Vertical

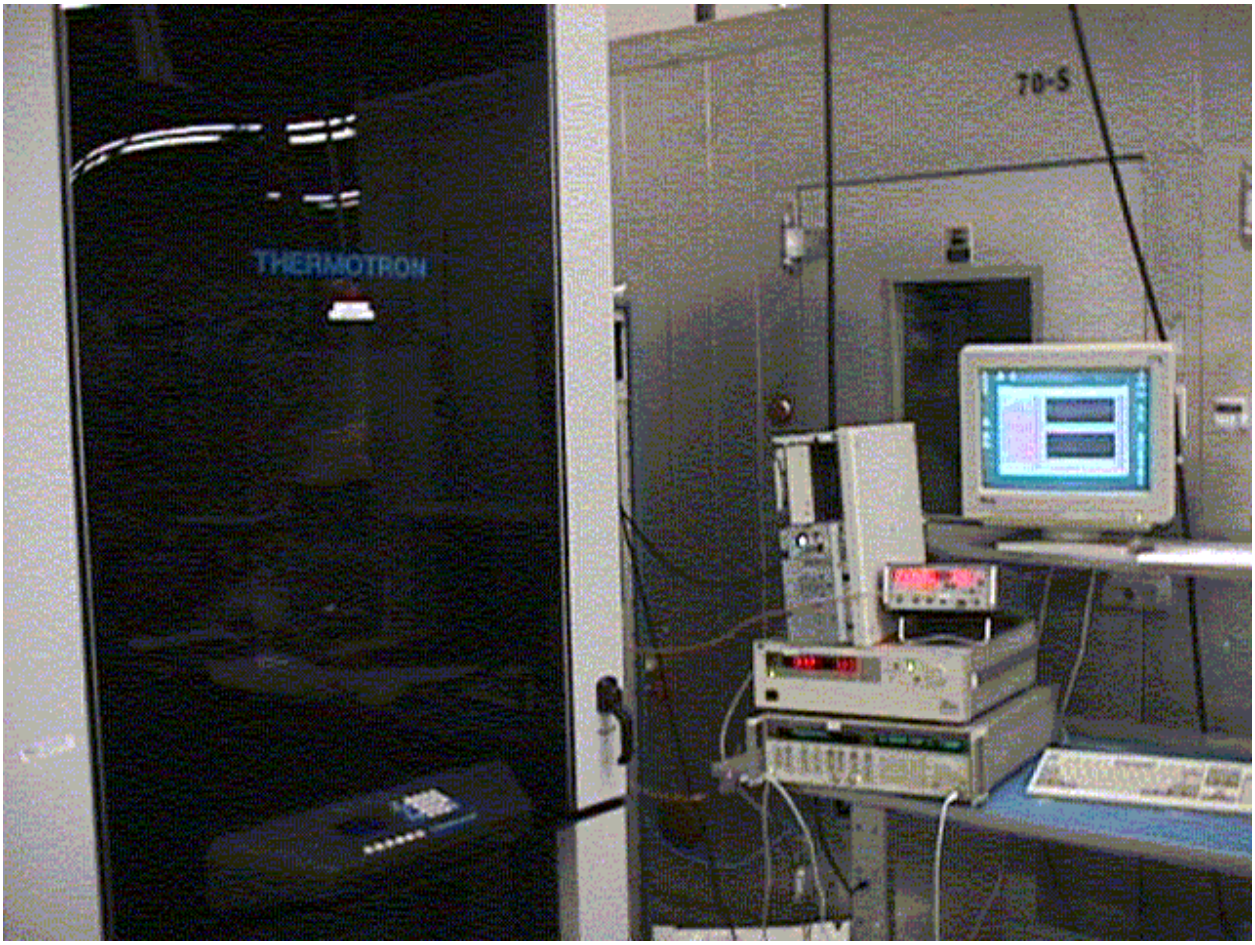


APPENDIX C

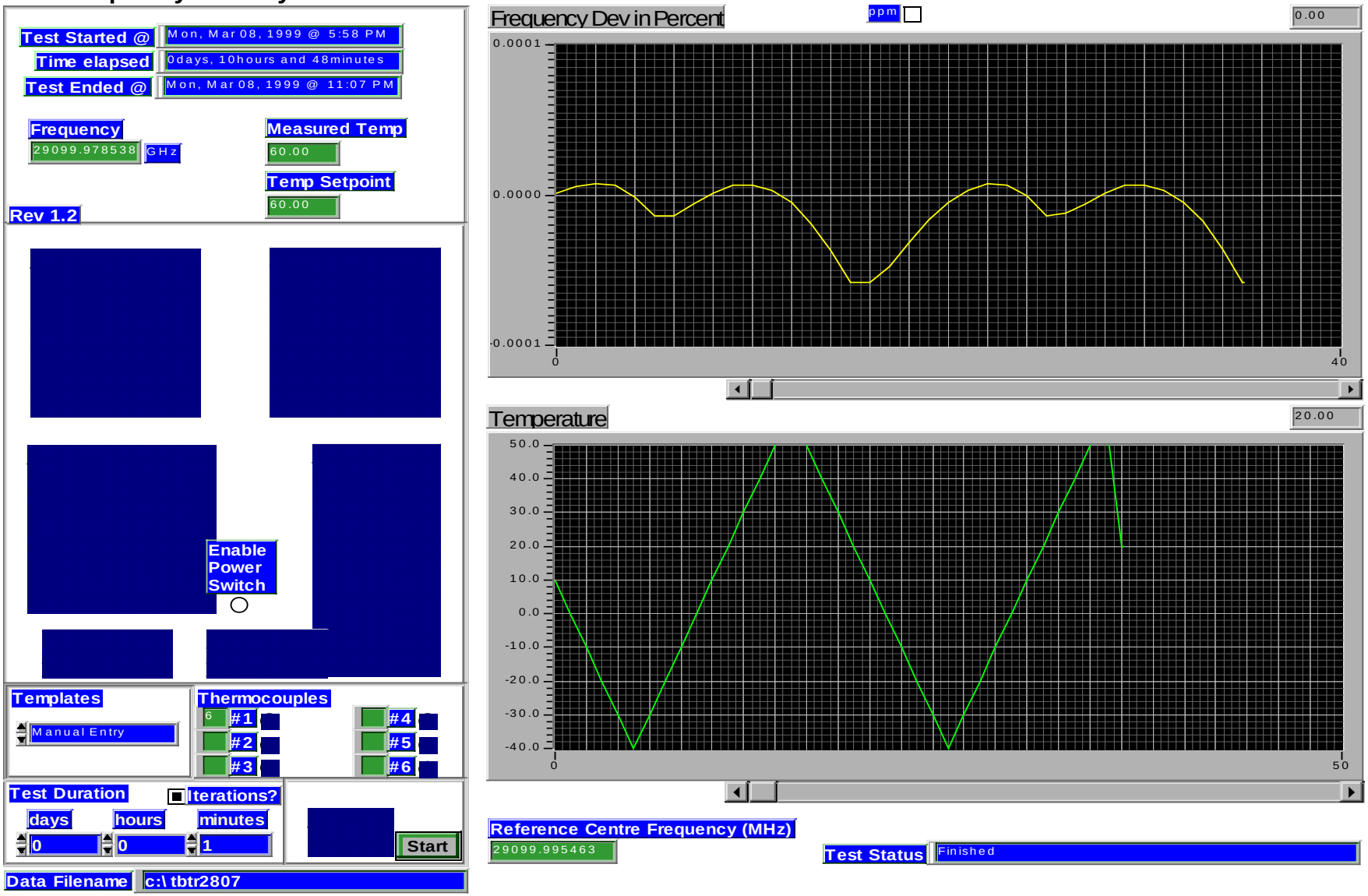
Temperature Stability Measurements Results

TEMPERATURE STABILITY MEASUREMENTS RESULTS

Frequency Stability Test Setup

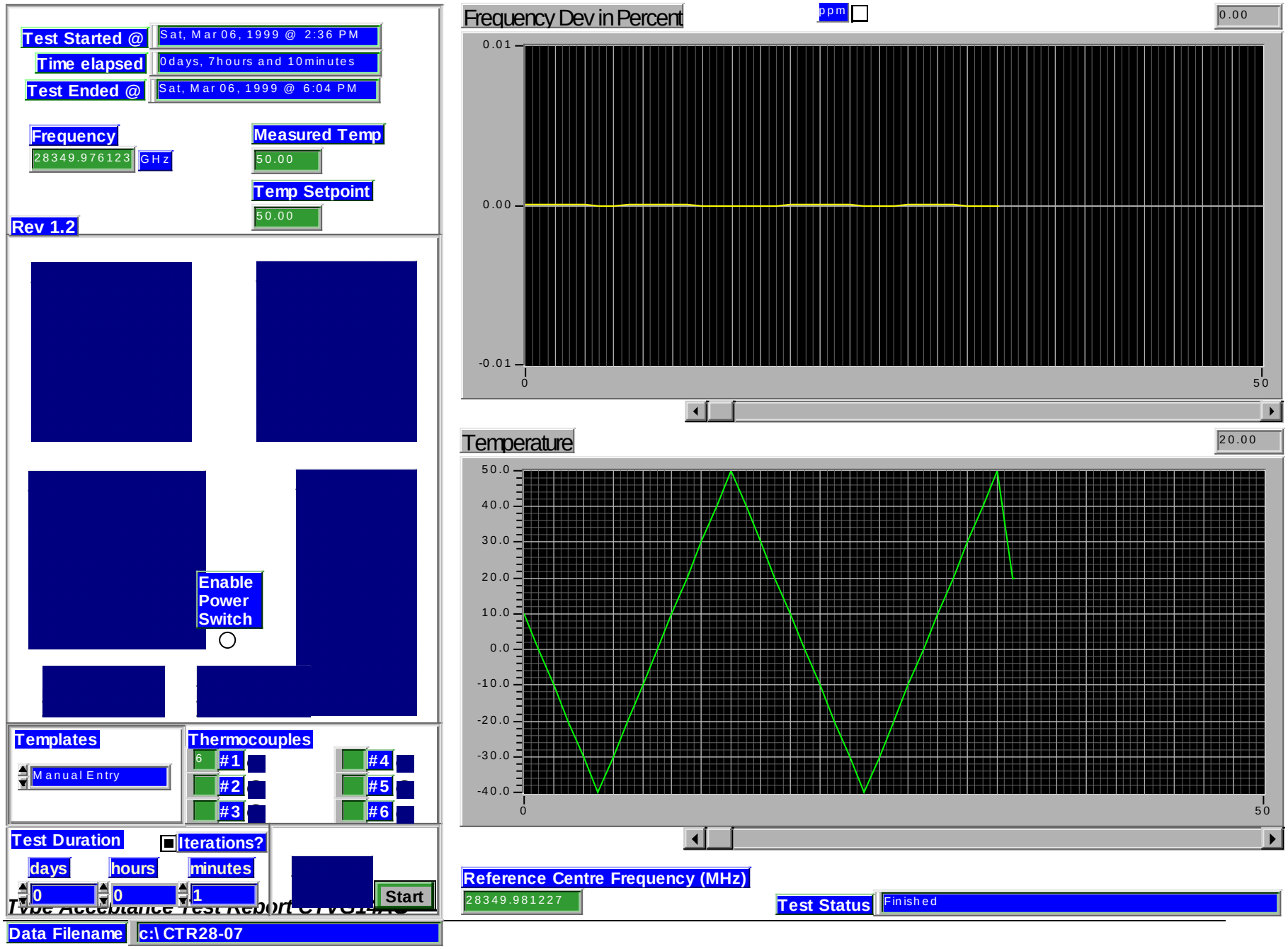


BTR Frequency Stability



Date and Time			Frequency	Temp	Deviation
Mon	Mar08	1999 @ 6:16PM	29099.995747	10.0	0.000001
Mon	Mar08	1999 @ 6:36PM	29099.997153	0.0	0.000006
Mon	Mar08	1999 @ 6:54PM	29099.997590	-10.0	0.000007
Mon	Mar08	1999 @ 7:13PM	29099.997346	-20.0	0.000006
Mon	Mar08	1999 @ 7:32PM	29099.995199	-30.0	-0.000001
Mon	Mar08	1999 @ 7:51PM	29099.991453	-40.0	-0.000014
Mon	Mar08	1999 @ 8:10PM	29099.991398	-30.0	-0.000014
Mon	Mar08	1999 @ 8:27PM	29099.993856	-20.0	-0.000006
Mon	Mar08	1999 @ 8:44PM	29099.995924	-10.0	0.000002
Mon	Mar08	1999 @ 9:00PM	29099.997276	0.0	0.000006
Mon	Mar08	1999 @ 9:17PM	29099.997357	10.0	0.000007
Mon	Mar08	1999 @ 9:34PM	29099.996241	20.0	0.000003
Mon	Mar08	1999 @ 9:51PM	29099.993925	30.0	-0.000005
Mon	Mar08	1999 @ 10:09PM	29099.989839	40.0	-0.000019
Mon	Mar08	1999 @ 10:28PM	29099.984737	50.0	-0.000037
Mon	Mar08	1999 @ 10:48PM	29099.978462	60.0	-0.000058
Mon	Mar08	1999 @ 11:07PM	29099.978409	50.0	-0.000059
Mon	Mar08	1999 @ 11:24PM	29099.981585	40.0	-0.000048
Mon	Mar08	1999 @ 11:41PM	29099.986225	30.0	-0.000032
Tue	Mar09	1999 @ 12:00AM	29099.990573	20.0	-0.000017
Tue	Mar09	1999 @ 12:19AM	29099.993987	10.0	-0.000005
Tue	Mar09	1999 @ 12:38AM	29099.996469	0.0	0.000003
Tue	Mar09	1999 @ 12:55AM	29099.997603	-10.0	0.000007
Tue	Mar09	1999 @ 1:16AM	29099.997368	-20.0	0.000007
Tue	Mar09	1999 @ 1:34AM	29099.995438	-30.0	0.000000
Tue	Mar09	1999 @ 1:53AM	29099.991581	-40.0	-0.000013
Tue	Mar09	1999 @ 2:11AM	29099.992010	-30.0	-0.000012
Tue	Mar09	1999 @ 2:28AM	29099.993853	-20.0	-0.000006
Tue	Mar09	1999 @ 2:45AM	29099.995944	-10.0	0.000002
Tue	Mar09	1999 @ 3:01AM	29099.997295	0.0	0.000006
Tue	Mar09	1999 @ 3:18AM	29099.997420	10.0	0.000007
Tue	Mar09	1999 @ 3:35AM	29099.996299	20.0	0.000003
Tue	Mar09	1999 @ 3:52AM	29099.994005	30.0	-0.000005
Tue	Mar09	1999 @ 4:10AM	29099.990394	40.0	-0.000017
Tue	Mar09	1999 @ 4:27AM	29099.985010	50.0	-0.000036
Tue	Mar09	1999 @ 4:46AM	29099.978538	60.0	-0.000058

CTR Frequency Stability



Date and Time			Frequency	Temp	Deviation
Sat	Mar 06	1999 @ 2:47 PM	28349.982318	10.0	0.000004
Sat	Mar 06	1999 @ 2:59 PM	28349.983326	0.0	0.000007
Sat	Mar 06	1999 @ 3:13 PM	28349.983705	-10.0	0.000009
Sat	Mar 06	1999 @ 3:27 PM	28349.983266	-20.0	0.000007
Sat	Mar 06	1999 @ 3:41 PM	28349.982303	-30.0	0.000004
Sat	Mar 06	1999 @ 3:55 PM	28349.979945	-40.0	-0.000005
Sat	Mar 06	1999 @ 4:09 PM	28349.979937	-30.0	-0.000005
Sat	Mar 06	1999 @ 4:20 PM	28349.981277	-20.0	0.000000
Sat	Mar 06	1999 @ 4:32 PM	28349.982322	-10.0	0.000004
Sat	Mar 06	1999 @ 4:44 PM	28349.982972	0.0	0.000006
Sat	Mar 06	1999 @ 4:56 PM	28349.983086	10.0	0.000007
Sat	Mar 06	1999 @ 5:08 PM	28349.982624	20.0	0.000005
Sat	Mar 06	1999 @ 5:20 PM	28349.981028	30.0	-0.000001
Sat	Mar 06	1999 @ 5:35 PM	28349.978784	40.0	-0.000009
Sat	Mar 06	1999 @ 5:49 PM	28349.975842	50.0	-0.000019
Sat	Mar 06	1999 @ 6:04 PM	28349.976447	40.0	-0.000017
Sat	Mar 06	1999 @ 6:16 PM	28349.978139	30.0	-0.000011
Sat	Mar 06	1999 @ 6:28 PM	28349.980213	20.0	-0.000004
Sat	Mar 06	1999 @ 6:42 PM	28349.982028	10.0	0.000003
Sat	Mar 06	1999 @ 6:56 PM	28349.983258	0.0	0.000007
Sat	Mar 06	1999 @ 7:10 PM	28349.983670	-10.0	0.000009
Sat	Mar 06	1999 @ 7:24 PM	28349.983325	-20.0	0.000007
Sat	Mar 06	1999 @ 7:38 PM	28349.982134	-30.0	0.000003
Sat	Mar 06	1999 @ 7:52 PM	28349.979825	-40.0	-0.000005
Sat	Mar 06	1999 @ 8:06 PM	28349.980026	-30.0	-0.000004
Sat	Mar 06	1999 @ 8:18 PM	28349.981167	-20.0	-0.000000
Sat	Mar 06	1999 @ 8:30 PM	28349.982257	-10.0	0.000004
Sat	Mar 06	1999 @ 8:41 PM	28349.982956	0.0	0.000006
Sat	Mar 06	1999 @ 8:53 PM	28349.983092	10.0	0.000007
Sat	Mar 06	1999 @ 9:06 PM	28349.982394	20.0	0.000004
Sat	Mar 06	1999 @ 9:20 PM	28349.981157	30.0	-0.000000
Sat	Mar 06	1999 @ 9:32 PM	28349.978976	40.0	-0.000008
Sat	Mar 06	1999 @ 9:47 PM	28349.976123	50.0	-0.000018

APPENDIX E

Channel Interference Measurements Results

CHANNEL INTERFERENCE MEASUREMENTS RESULTS

Results can be found in Addendum A.