Washington Laboratories, Ltd.

www.wll.com

7560 Lindbergh Drive . Gaithersburg, MD 20879
301.216.1500 . info@wll.com

FCC Certification Test Report
For the
Applied Micro Design, Inc.
1456 FFDPA-800

FCC ID: 2AES2-1456FFDPA-800

WLL JOB# **14423-01 Rev 3**
Revised September 2, 2016

Prepared for:

Applied Micro Design, Inc.
19516 Amaranth Drive
Germantown, MD, 20874

Prepared By:

Washington Laboratories, Ltd.
7560 Lindbergh Drive
Gaithersburg, Maryland 20879

ANAB ACCREDITED ISO/IEC 17025 TESTING LABORATORY

Testing Certificate AT-1448

FCC Certification Test Report
for the
Applied Micro Design Inc.
1456 FFDPA-800
FCC ID: 2AES2-1456FFDPA-800

Revised September 2, 2016

WLL JOB# 14423-01 Rev 3

Prepared by:

James Ritter
EMC Compliance Engineer

Reviewed by:

Steven D. Koster
President

Abstract

This report has been prepared on behalf of Applied Micro Design Inc. to support the attached Application for Equipment Authorization. The test report and application are submitted for a Class B Industrial Signal Booster under Part 90.219 (2013) of the FCC Rules and Regulations of the FCC rules. The test report was constructed with guidance from KDB 935210 D05 Industrial Booster Basic Measurement v01 V01R01.

Testing was performed at Washington Laboratories, Ltd, 7560 Lindbergh Drive, Gaithersburg, MD 20879.

Washington Laboratories, Ltd. has been accepted by the FCC and approved by ACLASS under Certificate AT-1448 as an independent FCC test laboratory.

These tests are accredited and meet the requirements of ISO/IEC 17025:2005 as verified by the ANSI-ASQ National Accreditation Board/ANAB

.

Revision History	Description of Change	Date
Rev 0	Initial Release	May 9, 2016
Rev 1	Added clarification on test setup and included Part 90.219 test results statements.	June 19,2016
Rev 2	Added testing for OpenSky 4-GFSK Modulation under sections 4.1,4.3,& 4.4.	August 25, 2016
Rev 3	Corrected frequency range in table 1	September 2, 2016

Table of Contents

List of Tables

List of Figures

1 Introduction

1.1 Compliance Statement

The Applied Micro Design Inc. 1456 FFDPA-800 was tested to the requirements of Part 90.219 Private Land Mobile Radio Services Subpart I--Private Land Mobile Radio Services general technical requirements section of the FCC Rules and Regulations (10/2014). The device is a class B booster.

1.2 Test Scope

The following tests were performed using the applicable parts of the FCC rules and KDB 935210 D05 Indus Booster Basic Meas V01R01 (February 12, 2016) as guidance:

§ 90.219	General Technical Standards: Use of Signal Boosters
§ 90.210	General Technical Standards: Emission Masks

KDB 935210 DO5

Test Methods for PLMRS/PSRS Repeater/Amplifier and Industrial Booster Devices.

1.3 Contract Information

Customer:	Applied Micro Design Inc. 19516 Amaranth Drive Germantown, MD, 20874
Purchase Order Number:	26100
Quotation Number:	69252A

1.4 Test Dates

Testing was performed on the following date(s):	2/17/2016- 3/31/2016

1.5 Test and Support Personnel

Washington Laboratories, LTD	James Ritter
Customer Representative	Stan Mantel

1.6 Abbreviations

A	**A**mpere
ac	**a**lternating **c**urrent
AM	Amplitude Modulation
Amps	**Amp**ere**s**
b/s	**b**its per **s**econd
BW	**B**and**W**idth
CE	**C**onducted **E**mission
cm	**c**enti**m**eter
CW	**C**ontinuous **W**ave
dB	**d**eci**B**el
dc	**d**irect **c**urrent
EMI	**E**lectro**m**agnetic **I**nterference
EUT	**E**quipment **U**nder **T**est
FM	**F**requency **M**odulation
G	**g**iga - prefix for 10^9 multiplier
Hz	**H**ertz
IF	**I**ntermediate **F**requency
k	**k**ilo - prefix for 10^3 multiplier
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
M	**M**ega - prefix for 10^6 multiplier
m	**m**eter
μ	**m**icro - prefix for 10^{-6} multiplier
NB	**N**arrow**b**and
QP	**Q**uasi-**P**eak
RE	**R**adiated **E**missions
RF	**R**adio **F**requency
rms	**r**oot-**m**ean-**s**quare
SN	**S**erial **N**umber
S/A	**S**pectrum **A**nalyzer
V	**V**olt

2 Equipment Under Test

2.1 EUT Identification & Description

The Applied Micro Design 1456 FFDPA-800 is an 800MHz band Amplifier used in an Industrial Booster system operating Class B for an in Tunnel wireless communications for Public Safety distribution. It consists of the frequency band 851-859 MHz. This frequency range has a primary amplifier and a backup secondary amplifier. The amplifier output connects to a leaky coax antenna system. This device is only for the downlink part of the system (base station to inside tunnel). Only 1 system will be made for the City of San Francisco. The input to this amplifier is RF.

Table 1: Device Summary

ITEM	DESCRIPTION
Manufacturer:	Applied Micro Design Inc.
FCC ID:	2AES2-1456FFDPA-800
Model:	1456 FFDPA-800
FCC Rule Parts:	§90.219
Frequency Range:	851-860MHZ
Maximum Output Power:	36.45dBm
Channel Occupied Bandwidth:	12.5 kHz, 25 kHz
Maximum number of input channel	50
Type of Information:	Voice
Antenna Connector	N
Antenna Type	Leaky Coax
Power Source & Voltage:	120Vac

2.2 Test Configuration

The 1456 FFDPA-800 was configured via a laptop/server that enabled/disabled the primary and secondary amp. These amps are contained in a single enclosure and are NOT enabled simultaneously. The AGC threshold was set in this program to 3200. An RF signal was sent to the input of the amplifier

The Test setup only tests the amplifiers in this system

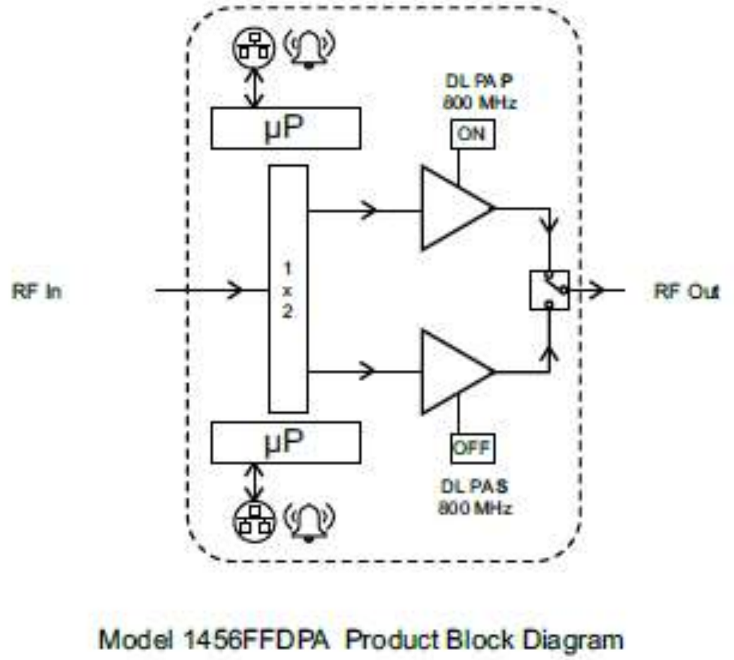


Figure 1: Simplified Top Level Block Diagram

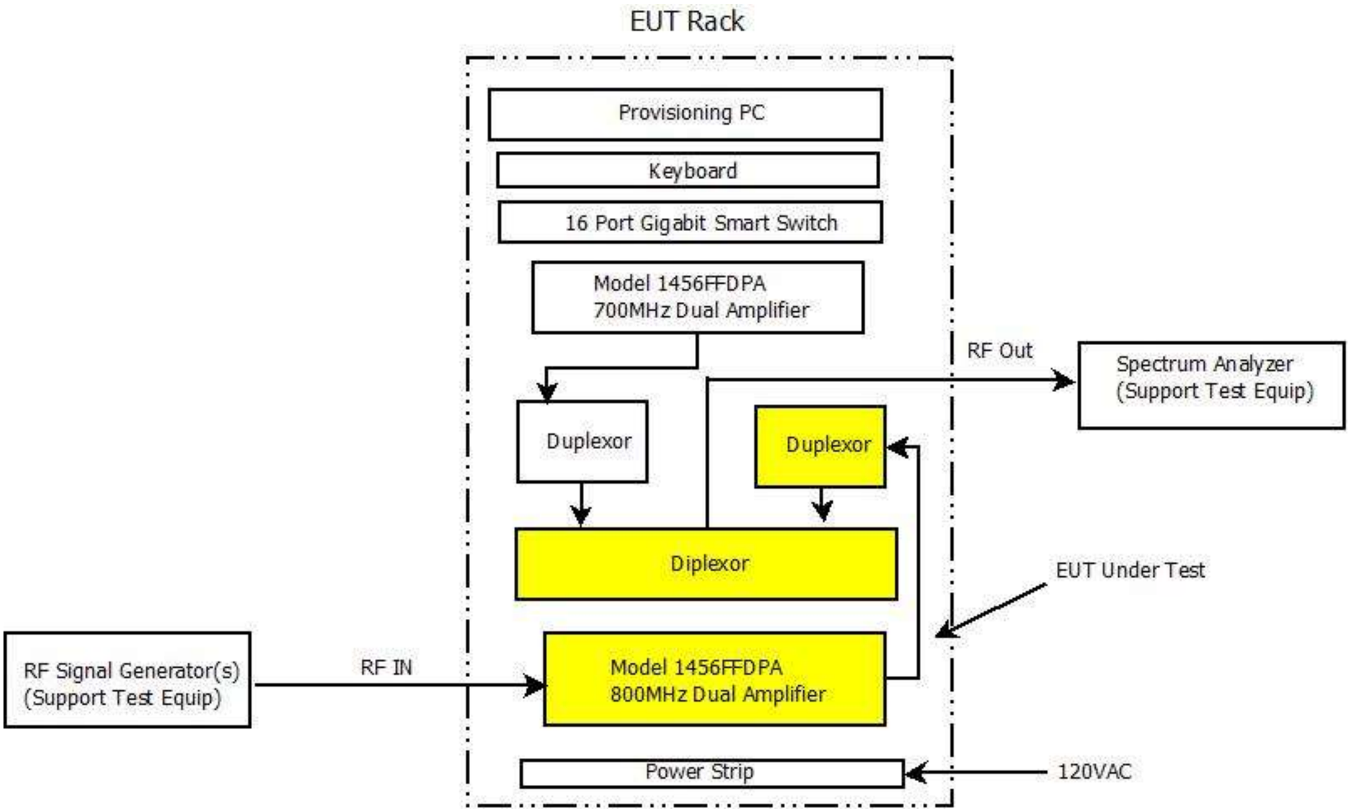


Figure 2: Test Block Diagram

2.3 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Gaithersburg, MD. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. The Industry Canada OATS numbers are 3035A-1 and 3035A-2 for Washington Laboratories, Ltd. Site 1 and Site 2, respectively. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Certificate AT-1448 as an independent FCC test laboratory.

.

2.4 Measurement Uncertainty

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 (R2002) with a type B evaluation of the standard uncertainty. Elements contributing to the standard uncertainty are combined using the method described in Equation 1 to arrive at the total standard uncertainty. The standard uncertainty is multiplied by the coverage factor to determine the expanded uncertainty which is generally accepted for use in commercial, industrial, and regulatory applications and when health and safety are concerned (see Equation 2). A coverage factor was selected to yield a 95% confidence in the uncertainty estimation.

Equation 1: Standard Uncertainty

$$u_c = \pm\sqrt{\frac{a^2}{{div_a}^2} + \frac{b^2}{{div_b}^2} + \frac{c^2}{{div_c}^2} + \ldots\ldots}$$

Where u_c = standard uncertainty

a, b, c,.. = individual uncertainty elements

$Div_{a,\,b,\,c}$ = the individual uncertainty element divisor based on the probability distribution

Divisor = 1.732 for rectangular distribution

Divisor = 2 for normal distribution

Divisor = 1.414 for trapezoid distribution

Equation 2: Expanded Uncertainty

$$U = ku_c$$

Where U = expanded uncertainty

k = coverage factor

$k \leq 2$ for 95% coverage (ANSI/NCSL Z540-2 Annex G)

u_c = standard uncertainty

The measurement uncertainty complies with the maximum allowed uncertainty from CISPR 16-4-2. Measurement uncertainty is not used to adjust the measurements to determine compliance. The expanded uncertainty values for the various scopes in the WLL accreditation are provided in

Table 2 below.

Table 2: Expanded Uncertainty List

Scope	Standard(s)	Expanded Uncertainty
Conducted Emissions	CISPR11, CISPR22, CISPR14, FCC Part 15	2.63 dB
Radiated Emissions	CISPR11, CISPR22, CISPR14, FCC Part 15	4.55 dB

3 Test Equipment

Table 3 shows a list of the test equipment used for measurements along with the calibration information.

Table 3: Test Equipment List

Test Name:	**Bench & Radiated Emissions**		
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
528	AGILENT - E4446A	3HZ - 44GHZ ANALYZER SPECTRUM	7/15/2016
276	ELECTROMETRICS - BPA-1000	PRE-AMPLIFIER RF 50KHZ-1GHZ	9/18/2016
823	AGILENT – N9010A	10HZ – 26.5GHZ ANALYZER SPECTRUM	8/23/2016
478	RHODE SCHWARZ - SMT 06	SIGNAL GENERATOR	7/22/2016
382	SUNOL SCIENCES CORPORATION - JB1	ANTENNA BICONLOG	8/31/2017
7	ARA - LPB-2520	ANTENNA BICONILOG ANTENNA	10/20/2017
4	ARA - DRG-118/A	ANTENNA DRG 1-18GHZ	10/8/2016
425	ARA - DRG-118/A	ANTENNA DRG 1-18GHZ	11/23/2017
522	HP - 8449B	PRE-AMPLIFIER 1-26.5GHZ	6/30/2016
803	R&S - SMR 40	SIGNAL GENERATOR 1 - 40GHZ	7/15/2017
75	HP - 8648C	GENERATOR RF SIGNAL	9/16/2016
--	HARRIS OPENSKY BASE GENERATOR	OPENSKY BASE STATION SET	NA

4 Test Results

4.1 EUT AGC Threshold (935210 DO5 section 4.2)

Procedure: KDB 935210 D05 Indus Booster Basic Meas V01R01: Section 4.2

Testing at and above the AGC threshold is required. The AGC threshold shall be determined by applying the procedure defined in 3.2 with the signal generator configured to produce either a test signal defined in Table 1 or a CW input signal, as appropriate. OpenSky was tested with CW and 4-GFSK modulation.

Section 3.2 states:

a) Connect a signal generator to the input of the EUT.

b) Connect a spectrum analyzer or power meter to the output of the EUT using appropriate attenuation as necessary.

c) The signal generator should initially be configured to produce either of the required test signals (i.e., broadband or narrowband).

d) Set the signal generator frequency to the center frequency of the EUT operating band.

e) While monitoring the output power of the EUT, measured using the methods of 3.5.3 or

3.5.4, increase the input level until a 1 dB increase in the input signal power no longer causes a 1 dB increase in the output signal power.

f) Record this level as the AGC threshold level.

Each amplifier was connected to a signal generator set to the low, center, and high frequencies producing a CW signal of the frequency under test. The output of the system was connected to the input of the spectrum analyzer through appropriate attenuation, with offsets set in the spectrum analyzer to compensate for the attenuation. The above procedure was followed. The results can be found in Table 4.

As there are only 2 OpenSky channels (859.1125MHz & 859.5125MHz) authorized in this system which are separated by less than 0.5MHz only one channel was tested with 4-GFSK modulation.

Table 4: AGC Threshold Level

851-854MHz Band

TX DL CERS

Amplifier	Frequency (MHz)	Measured AGC input (dBm)	Power Out (dBm)
Primary	851.125	-4	35.50
Primary	852.263	-4	35.47
Primary	853.8875	-4	35.58
Secondary	851.125	-4	35.47
Secondary	852.2625	-4	35.52
Secondary	853.8875	-4	35.58

851-860MHz Band

TX DL PERS

Amplifier	Frequency (MHz)	Measured AGC input (dBm)	Power Out (dBm)
Primary	851.25	-4	35.49
Primary	852.363	-4	35.58
Primary	857.237	-4	35.73
Secondary	851.25	-4	35.70
Secondary	852.3625	-4	35.78
Secondary	857.237	-4	35.82

Open Sky (CW Mode)

Amplifier	Frequency (MHz)	Measured AGC input (dBm)	Power Out (dBm)
Primary	859.1125	-4	35.70
Primary	859.5125	-4	35.72
Secondary	859.1125	-4	35.61
Secondary	859.5125	-4	35.57

Open Sky (4-GFSK Mode)

Amplifier	Frequency (MHz)	Measured AGC input (dBm)	Power Out (dBm)
Primary	859.1125	-3.5	36.45
Secondary	859.1125	-3.5	36.39

4.2 Out of Band Rejection (935210 DO5 section 4.3)

Section 4.3 specifies the following procedure:

a) Connect a signal generator to the input of the EUT.

b) Configure a swept CW signal with the following parameters:

c) Frequency range = ± 250 % of the manufacturer's pass band.

d) The CW amplitude will be 3 dB below the AGC threshold (see 4.2) and but not activate the AGC threshold throughout the test.

e) Dwell time = approx. 10 ms.

f) Frequency step = 50 kHz.

g) Connect a spectrum analyzer to the output of the EUT using appropriate attenuation. h) Set the resolution bandwidth of the spectrum analyzer between 1 % and 5 % of the manufacturer's pass band with the video bandwidth set to 3 × RBW. i) Set the detector to Peak and the trace to Max-Hold.

j) After the trace is completely filled, place a marker at the peak amplitude, which is designated as f0, and with two additional markers (use the marker-delta method) at the 20 dB bandwidth (i.e., at the points where the gain has fallen by 20 dB)

Table 5 provides the peak amplitude (F0) as well as center frequency of the window (Fc), the low end of the frequency band (FL), the high end of the frequency band (FH) and the overall bandwidth of the window (Bw). See Figure 2 through Figure 4 for plots of the measurements.

.

Table 5: Out of Band Rejection

Amplifier	F_0 (MHz)	F_L (MHz)	F_H (MHz)	20 dB BW (MHz)
851-860MHz Primary	860.19000	844.10000	866.42000	22.32
851-860 MHz Secondary	856.65000	844.05000	866.30000	22.25

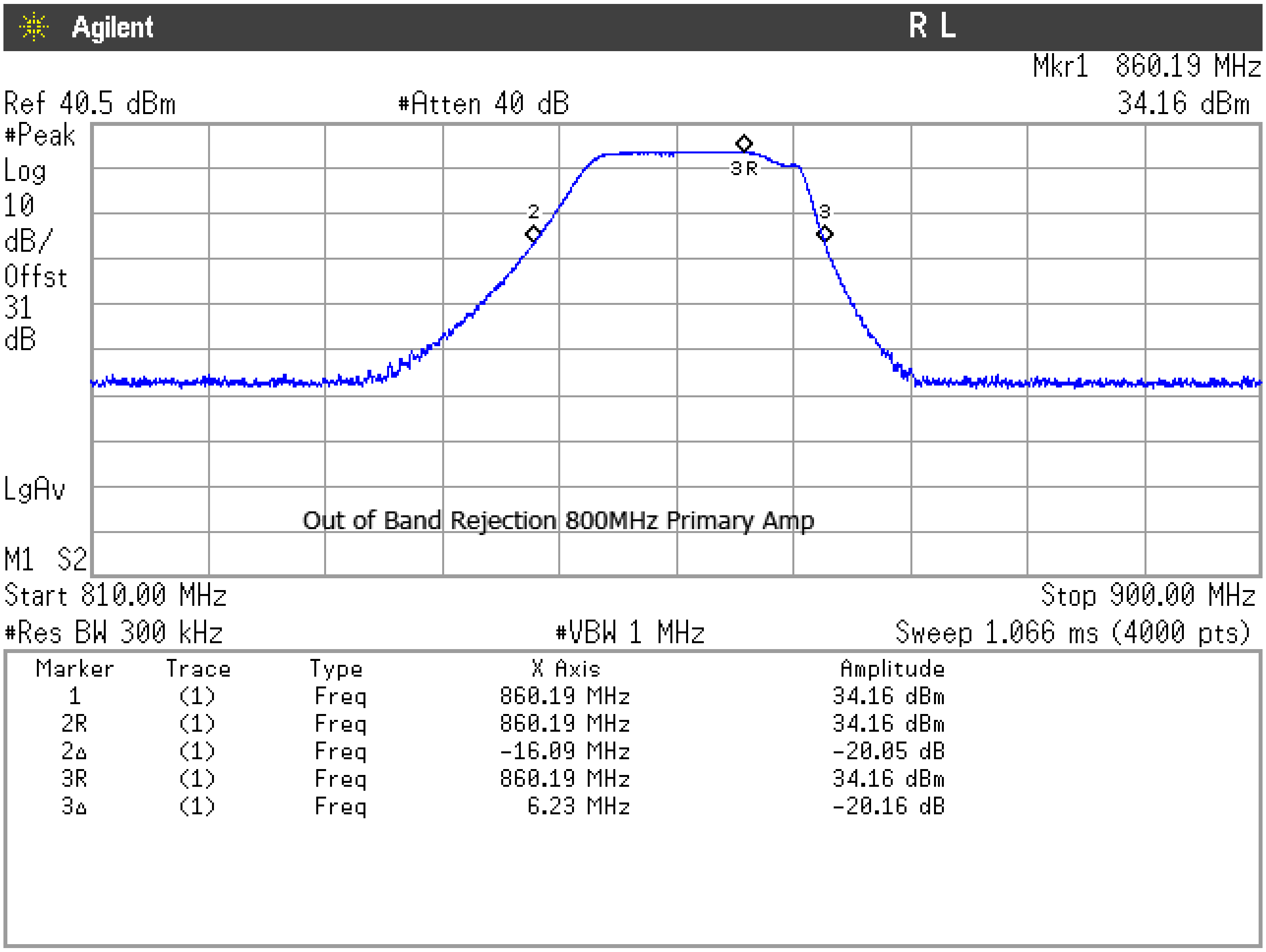
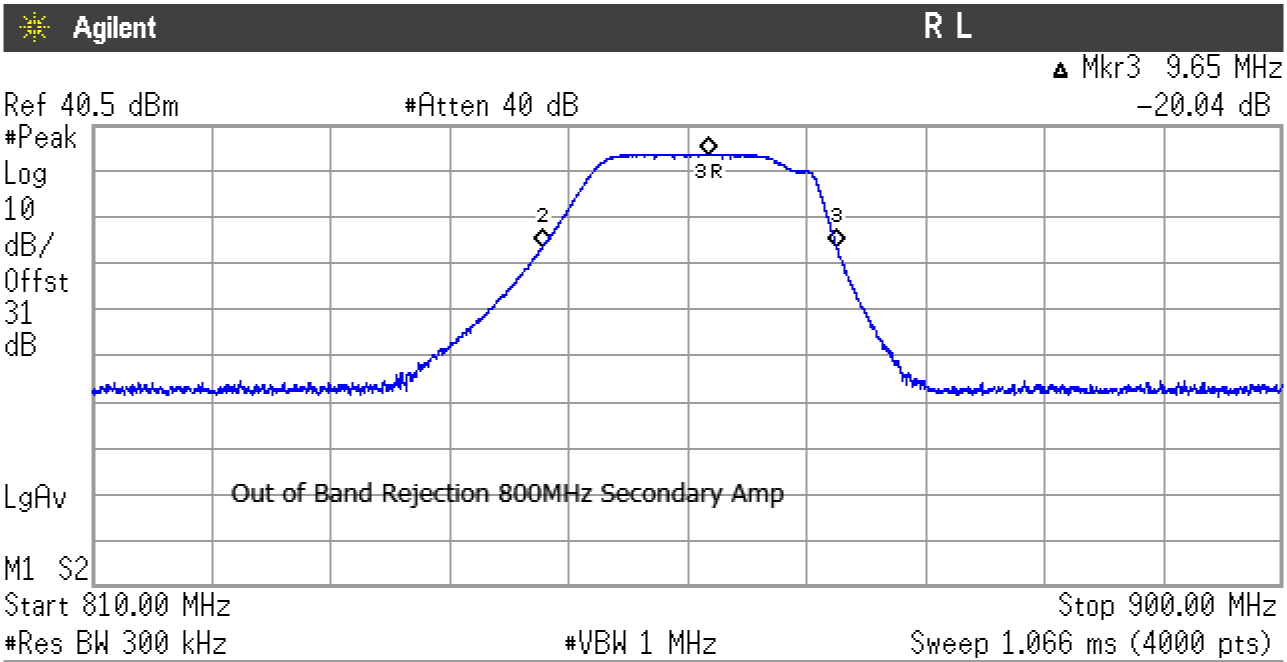


Figure 3: 851-860MHz Primary Amp Out of Band Rejection



Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	856.65 MHz	34.10 dBm
2R	(1)	Freq	856.65 MHz	34.10 dBm
2Δ	(1)	Freq	-12.60 MHz	-20.02 dB
3R	(1)	Freq	856.65 MHz	34.10 dBm
3Δ	(1)	Freq	9.65 MHz	-20.04 dB

Figure 4: 851-860MHz Secondary Amp Out of Band Rejection

4.3 EUT input-versus-output signal comparison (935210 DO5 section 4.4)

Section 4.4 Specifies that the emissions mask of the EUT output shall be measured for the following public safety signal types

Table 6: Test Signals

Emission Designator	Modulation	Occupied Bandwidth	Channel Bandwidth	Audio Frequency
16K0F3E	FM	16 kHz	25 kHz	1 kHz
11K3F3E	FM	11.3 kHz	12.5 kHz	1kHz
4K00F1E	FM	4 kHz	6.25 kHz	1 kHz
NA	CW	NA	NA	NA
NA	OPENSKY 4-GFSK	NA	25 kHz	NA

The signal generator was configured to produce a FM or digital signal with the appropriate deviation that created a signal with the occupied bandwidths listed in Table 6.

Per Part 90.210 table for Applicable Emission Masks the following emissions masks apply:

Frequency Band (MHz)	Emission mask
851-854	H
854-860	G

This device does not have an audio low pass filter

The following procedure was used:

a) Connect a signal generator to the input of the EUT.

b) Configure the signal generator to transmit the appropriate test signal associated with the public safety emission designation (see Table 1).

c) Configure the signal level to be just below the AGC threshold (see results from 4.2).

d) Connect a spectrum analyzer to the output of the EUT using appropriate attenuation as necessary.

e) Set the spectrum analyzer center frequency to the nominal EUT channel center frequency. The span range for the spectrum analyzer shall be between 2 times to 5 times the EBW (or OBW).

f) The nominal resolution bandwidth (RBW) shall 300 Hz for 16K0F3E and 100 Hz for all other emissions types.

g) Set the reference level of the spectrum analyzer to accommodate the maximum input amplitude level.

h) Set spectrum analyzer detection mode to peak, and trace mode to max hold. i) Allow the trace to fully stabilize.

j) Confirm that the signal is contained within the appropriate emissions mask.

k) Use the marker function to determine the maximum emission level and record the associated frequency as f_0.

l) Capture the emissions mask plot for inclusion in the test report (output signal spectra).

m) Measure the EUT input signal power (signal generator output signal) directly from the signal generator using power measurement guidance provided in KDB Publication 971168 (input signal spectra).

n) Compare the spectral plot of the output signal (determined in step k), to the input signal (determined in step l) to affirm they are similar.

o) Repeat steps b) to n) for all authorized operational bands and emissions types (see applicable regulatory specifications, e.g., §90.210).

p) Include all accumulated spectral plots depicting EUT input signal and EUT output signal in the test report and note any observed dissimilarities.

4.3.1 Results:

In all cases, the output matched the input with the exception of amplitude as would be expected in a booster. See Figure 5 through Figure 34for the plots that support this conclusion.

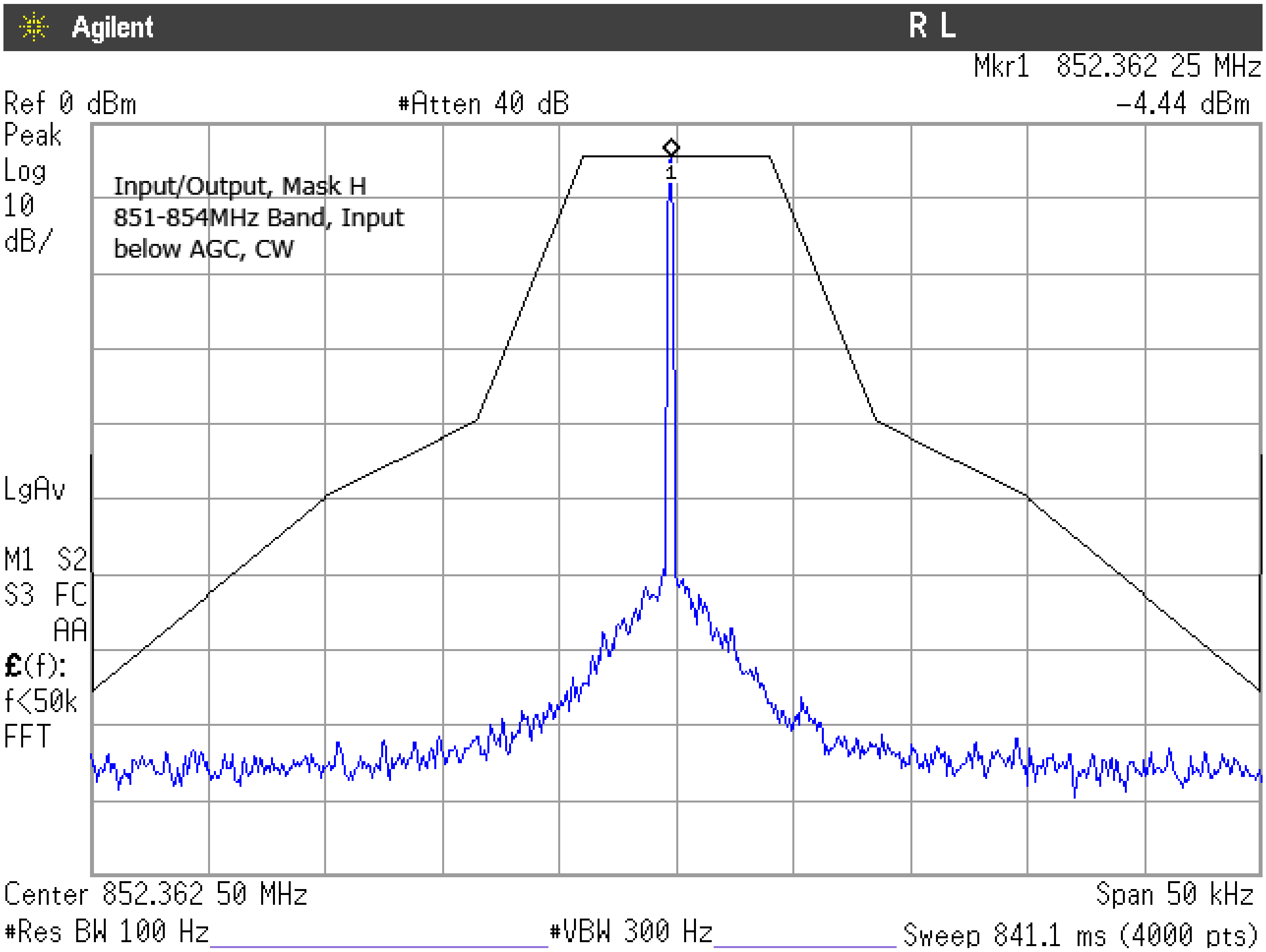


Figure 5: 851-854MHz comparison CW input, Mask H, Level under AGC

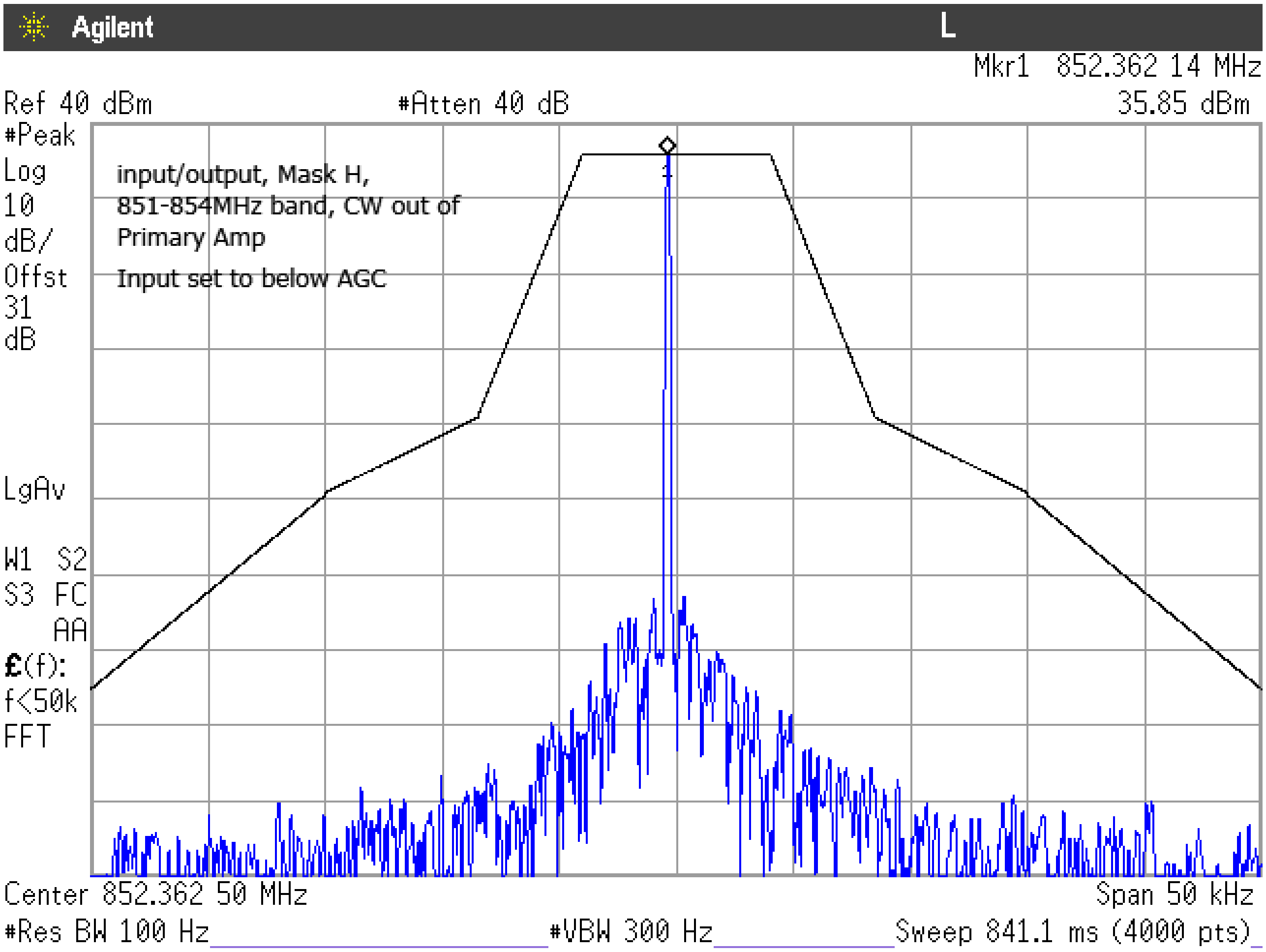


Figure 6: 851-854MHz comparison, CW Output, Mask H- Primary Amp, Under AGC

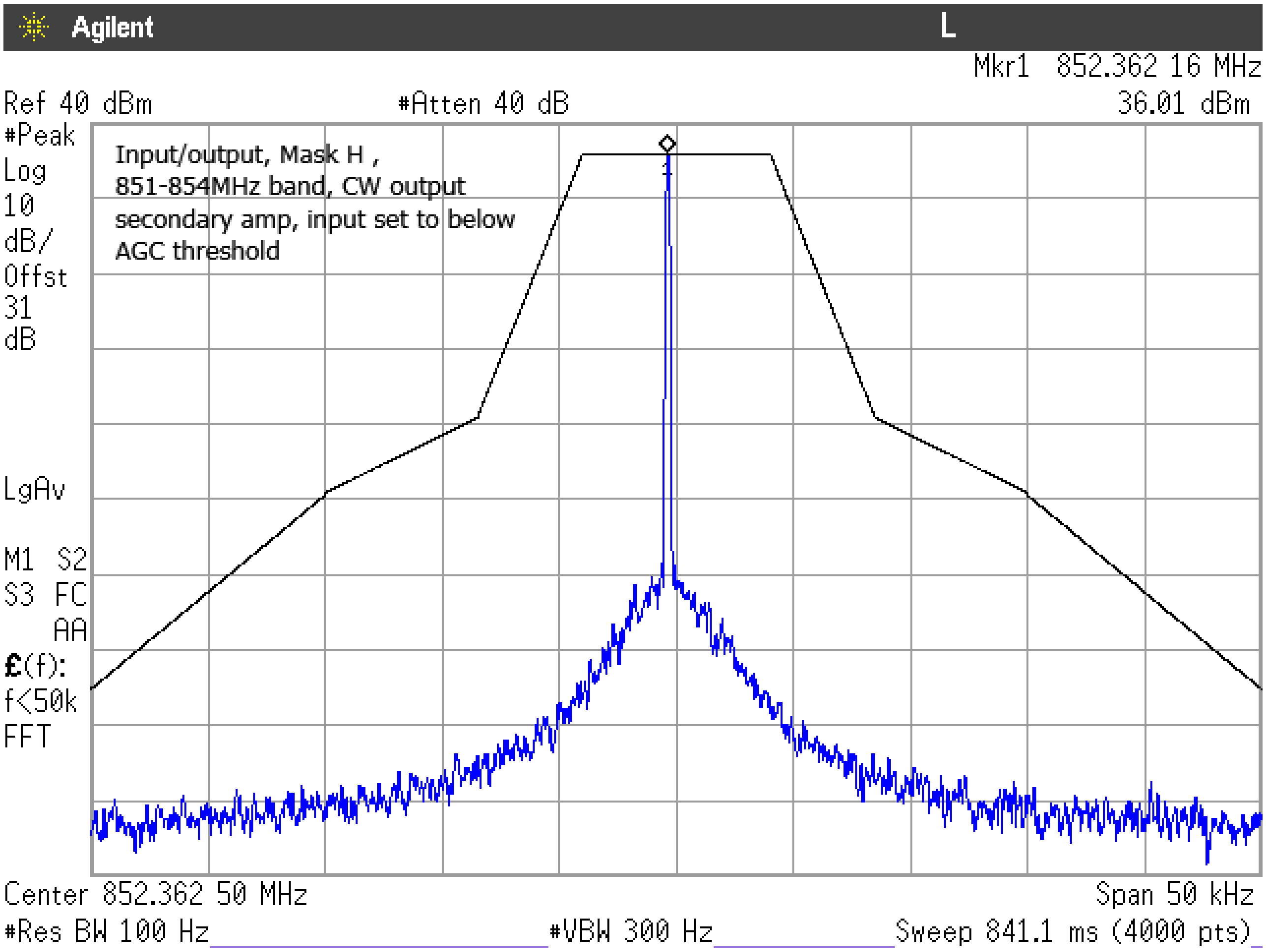


Figure 7: 851-854MHz comparison CW Output, Mask H- Secondary Amp, Under AGC

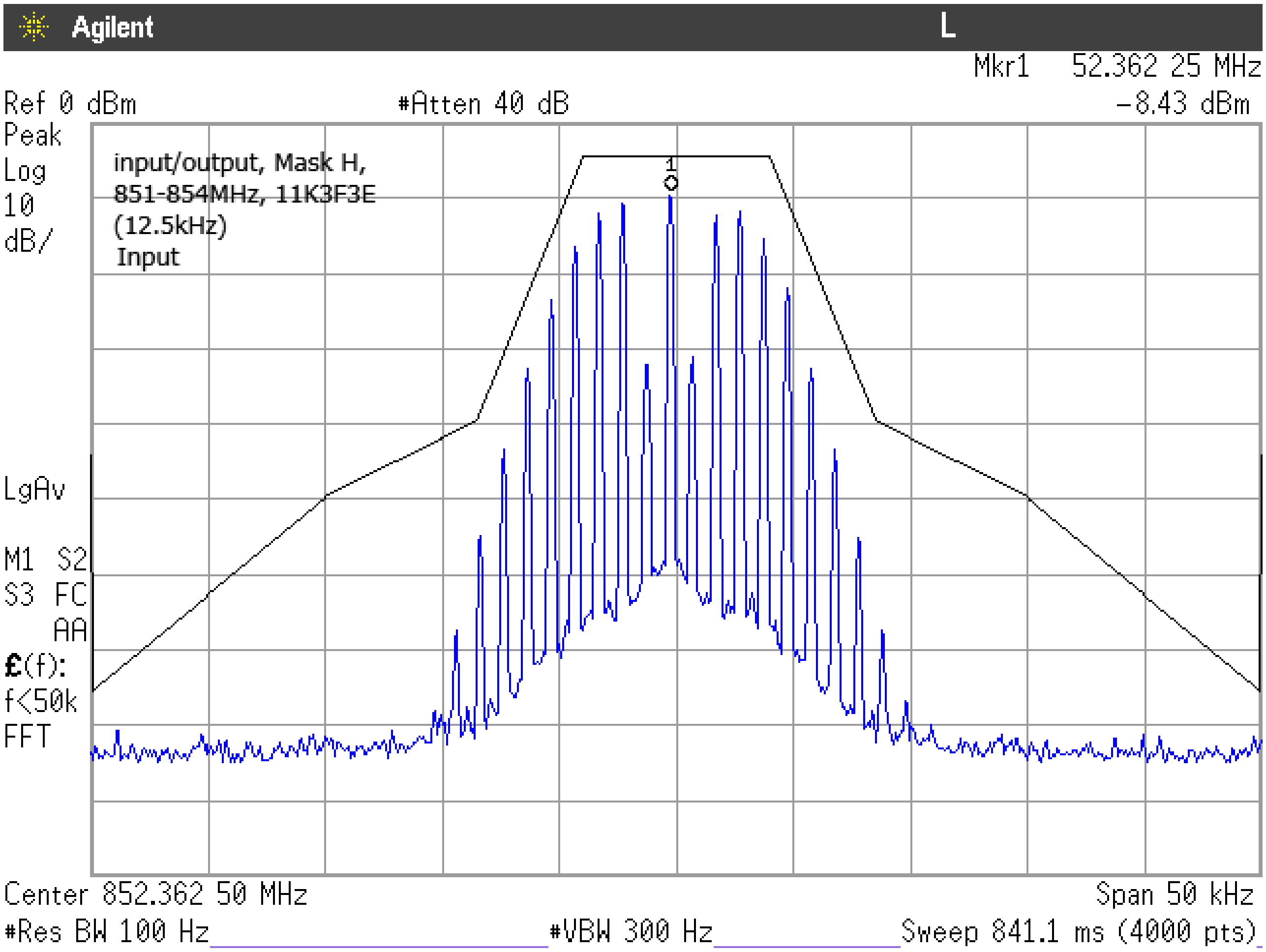


Figure 8: 851-854MHz comparison 11K3F3E input, Mask H, Level under AGC

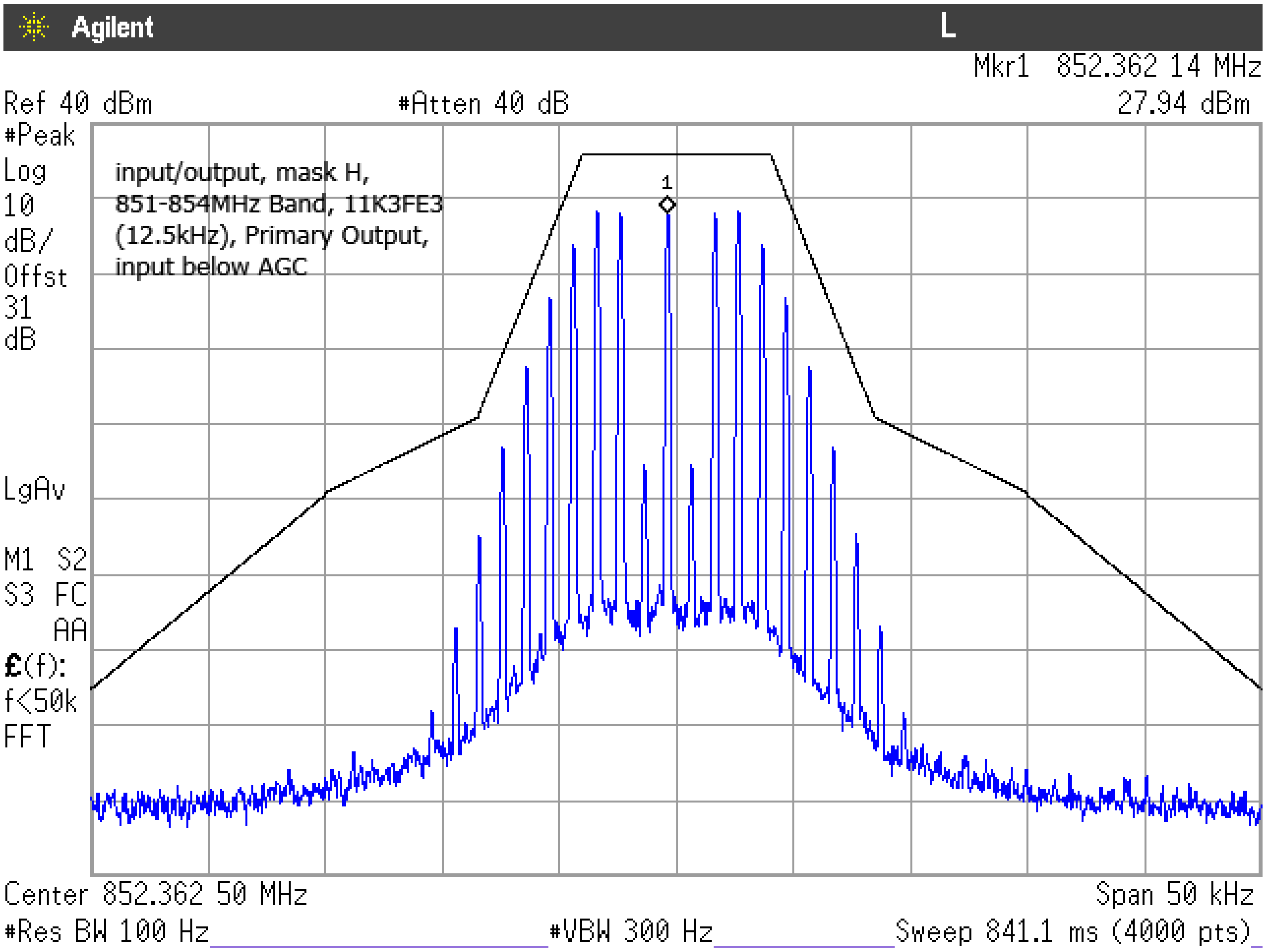


Figure 9: 851-854MHz comparison 11K3F3E Output- Primary Amp

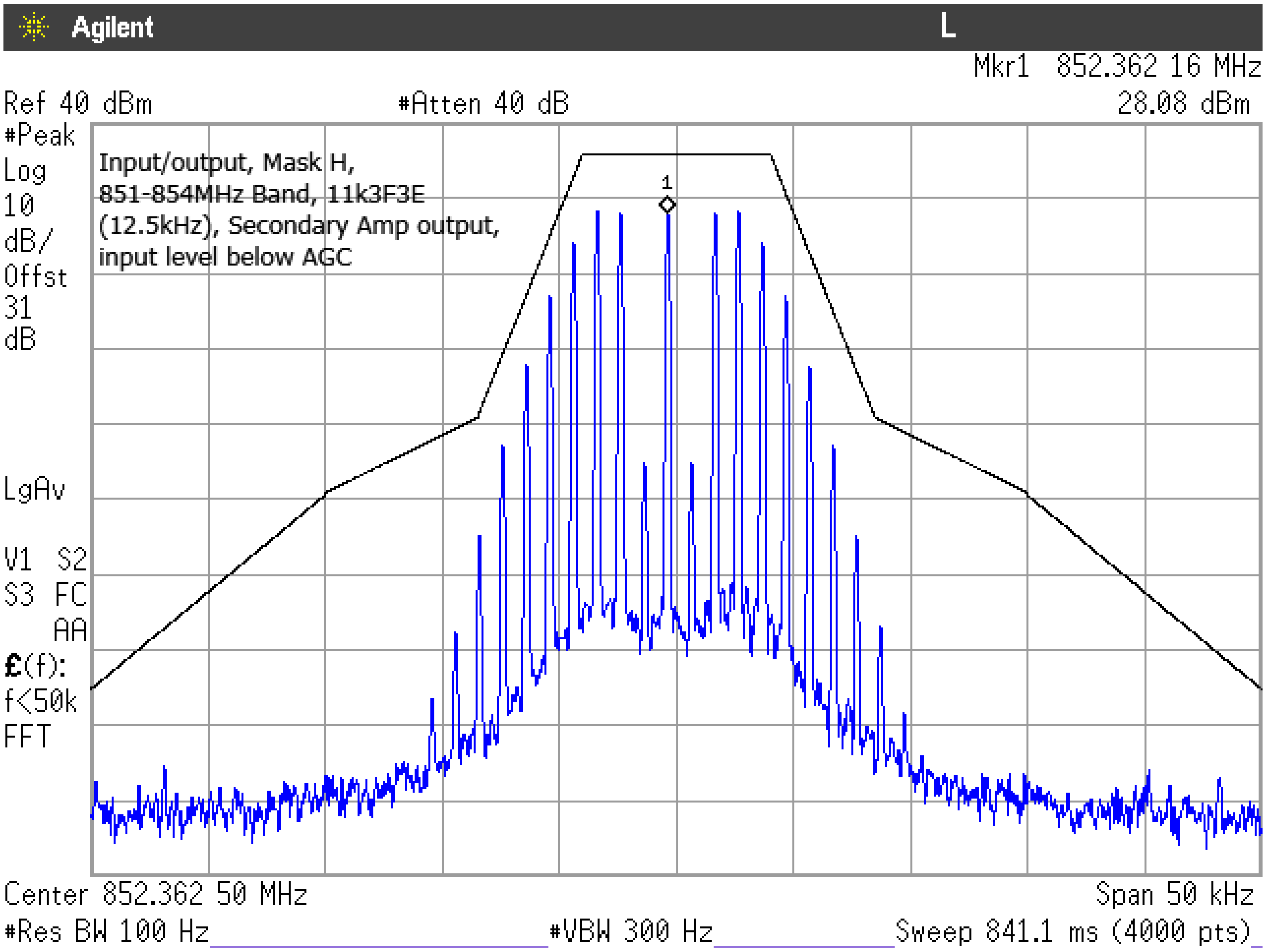


Figure 10: 851-854MHz comparison 11K3F3E Output- Secondary Amp

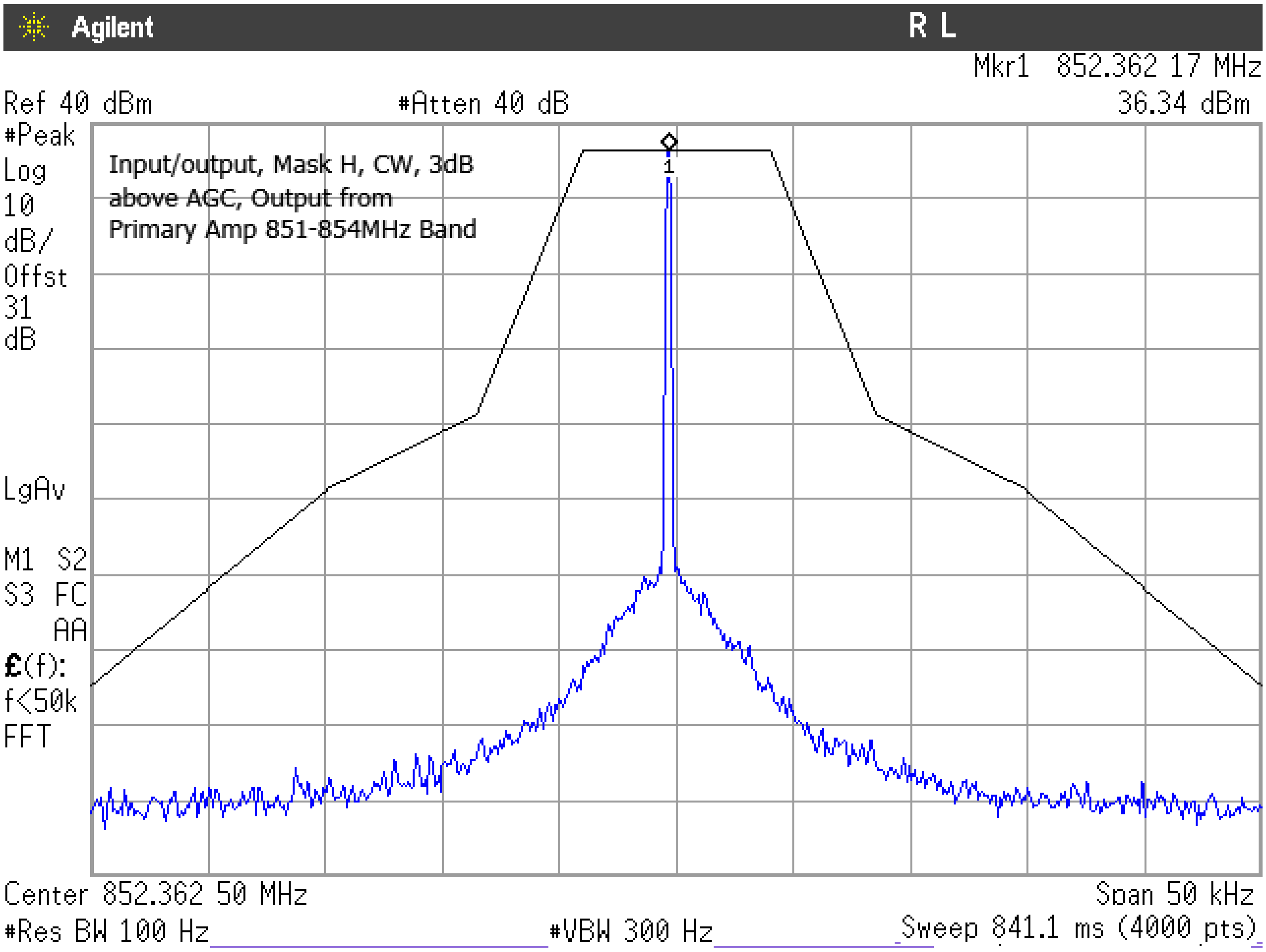


Figure 11: 851-854MHz comparison CW input, Mask H, Level 3dB over AGC

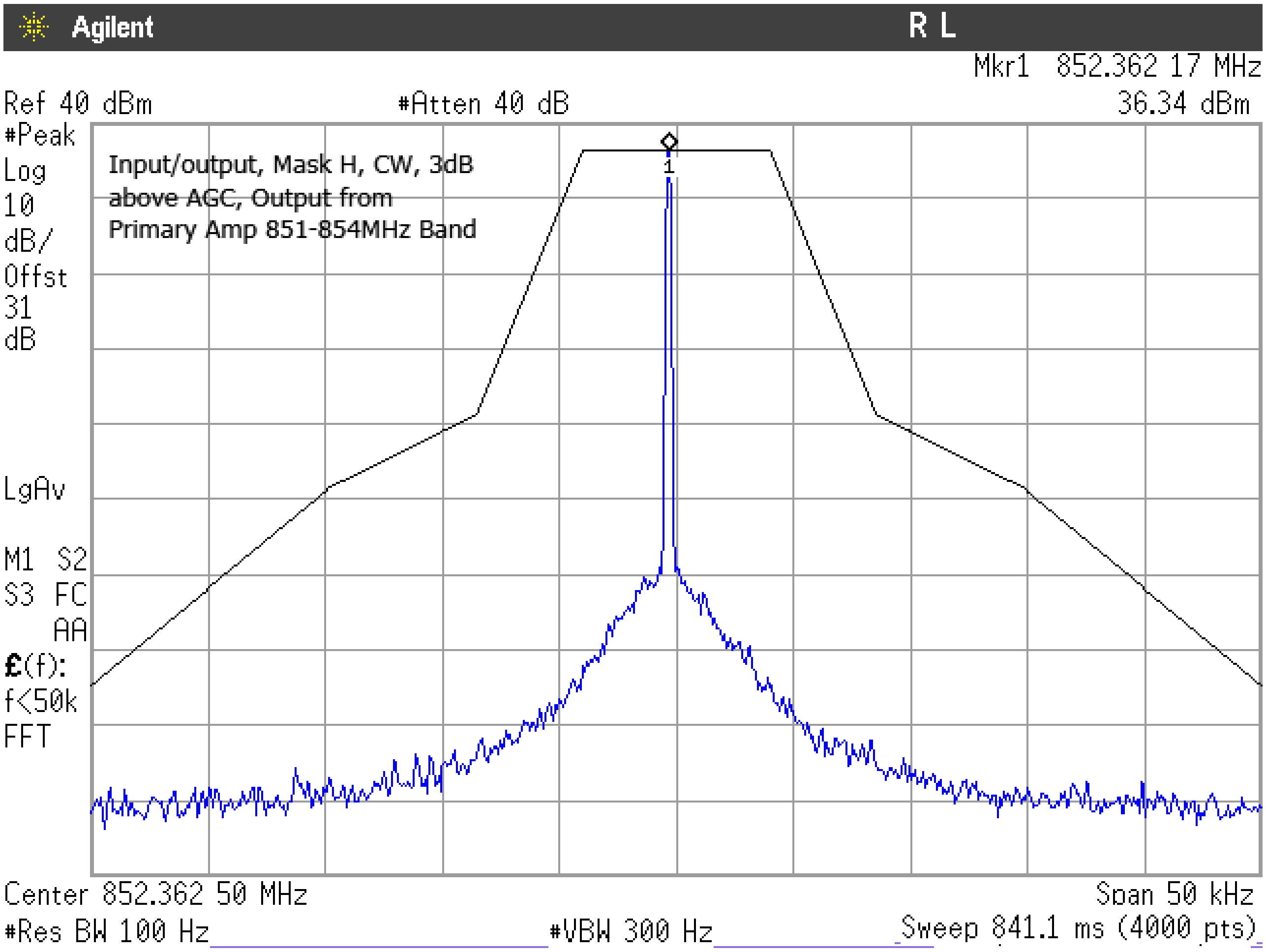


Figure 12: 851-854MHz comparison, CW Output, Mask H- Primary Amp, 3dB over AGC

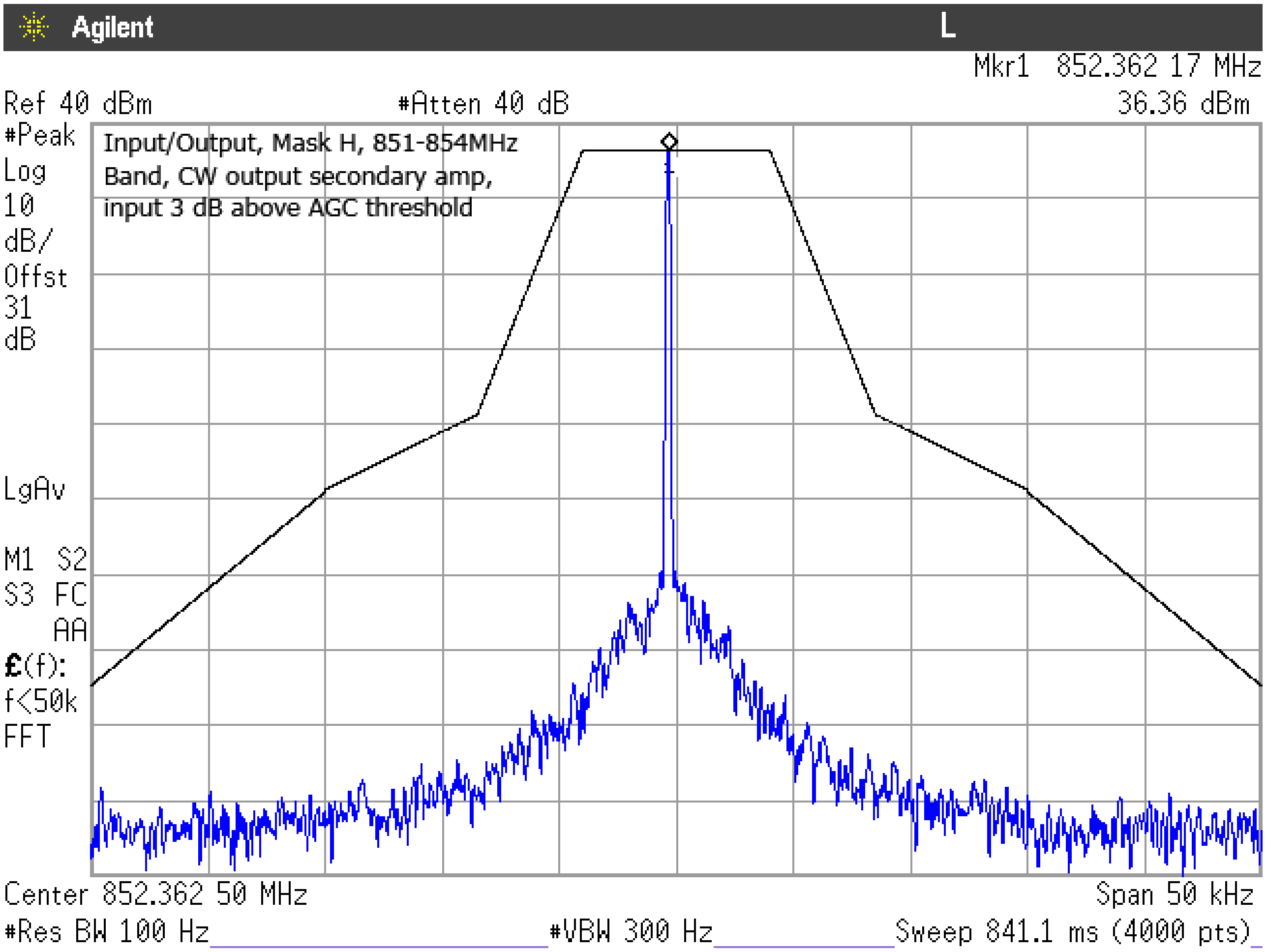


Figure 13: 851-854MHz comparison, CW Output, Mask H- Secondary Amp, 3dB over AGC

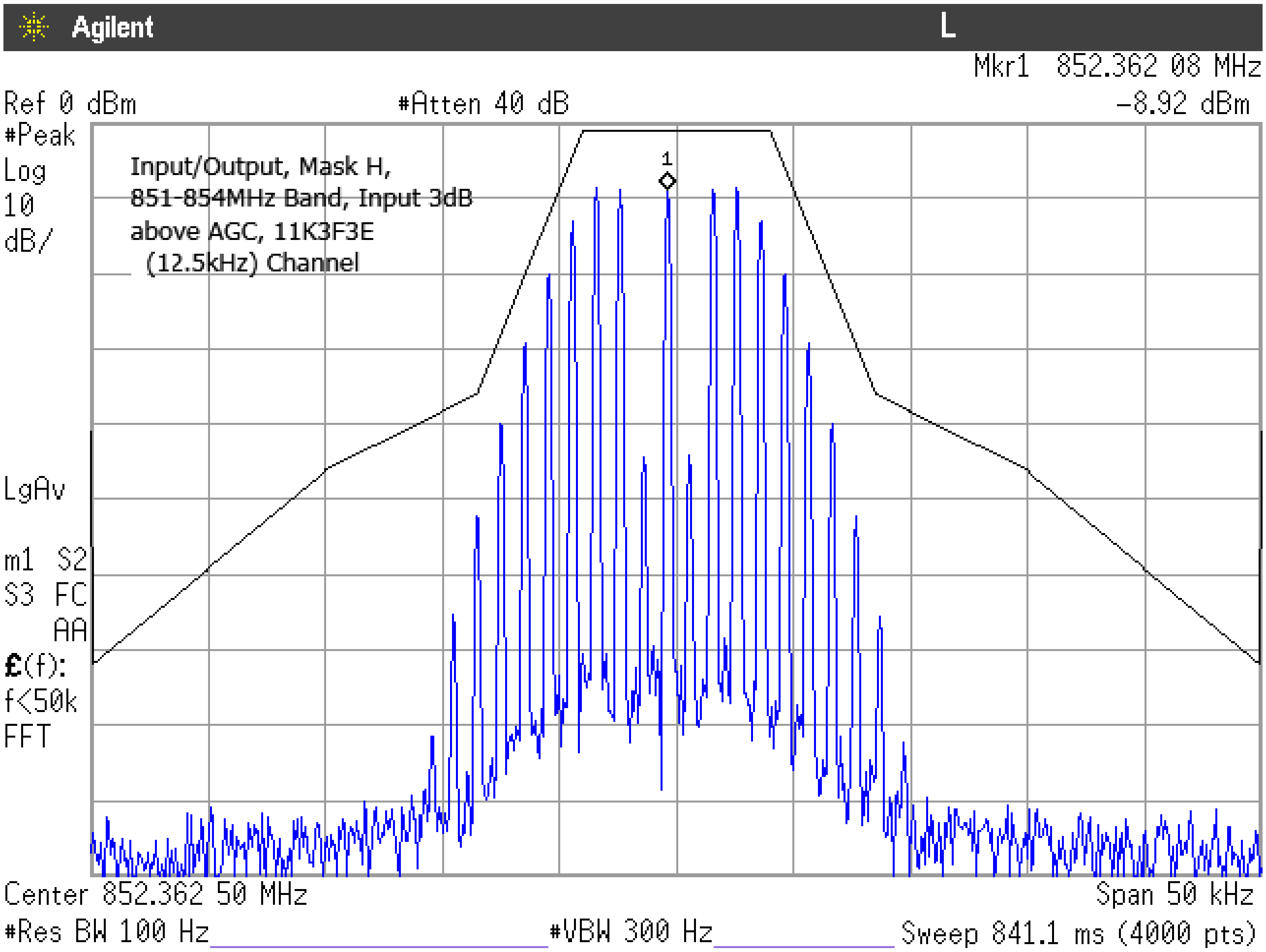


Figure 14: 851-854MHz comparison 11K3F3E input, Mask H, Level 3dB over AGC

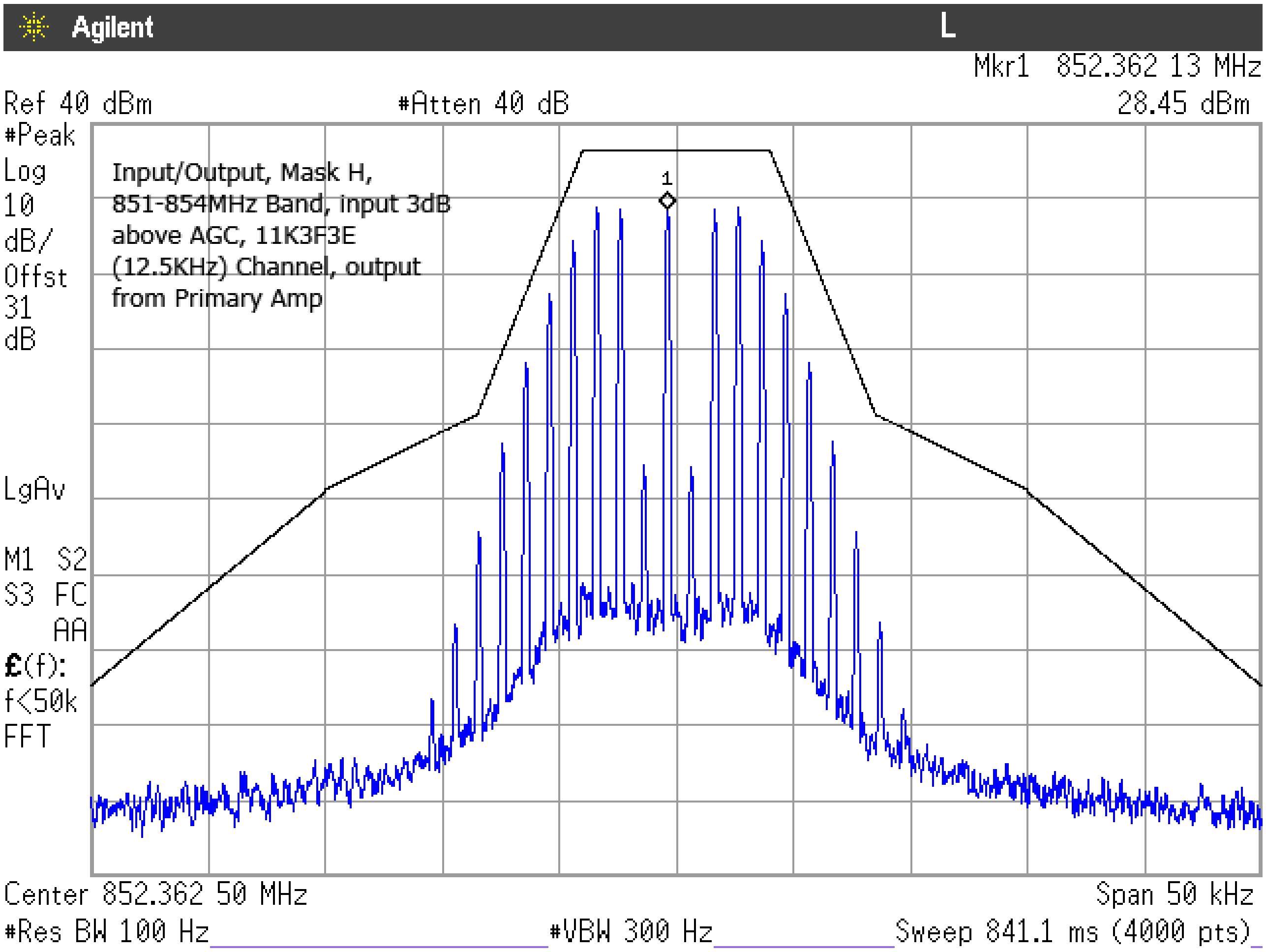


Figure 15: 851-854MHz comparison 11K3F3E Output, Mask H- Primary Amp, 3dB over AGC

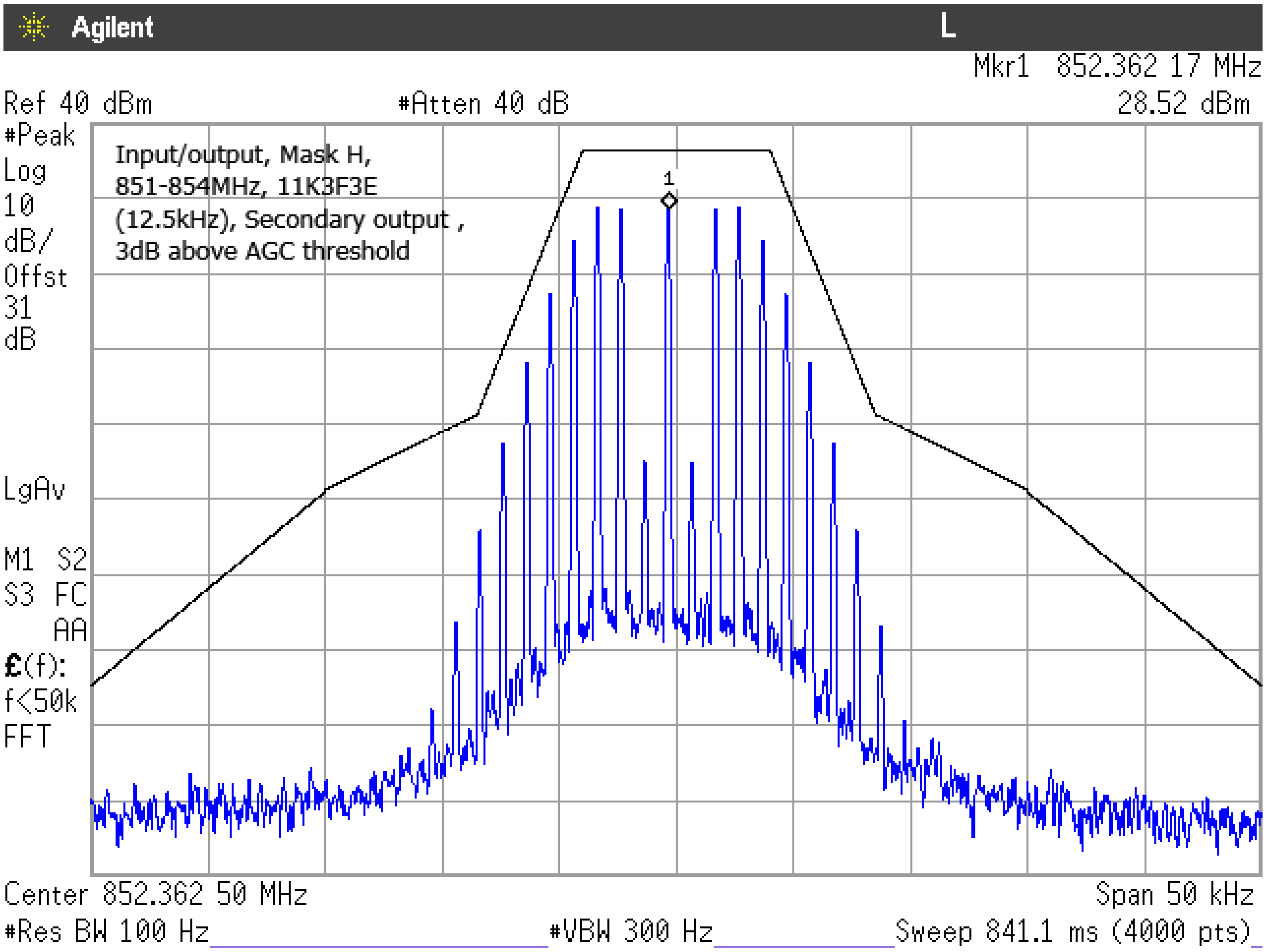


Figure 16: 851-854MHz comparison 11K3F3E Output, Mask H- Secondary Amp, 3dB over AGC

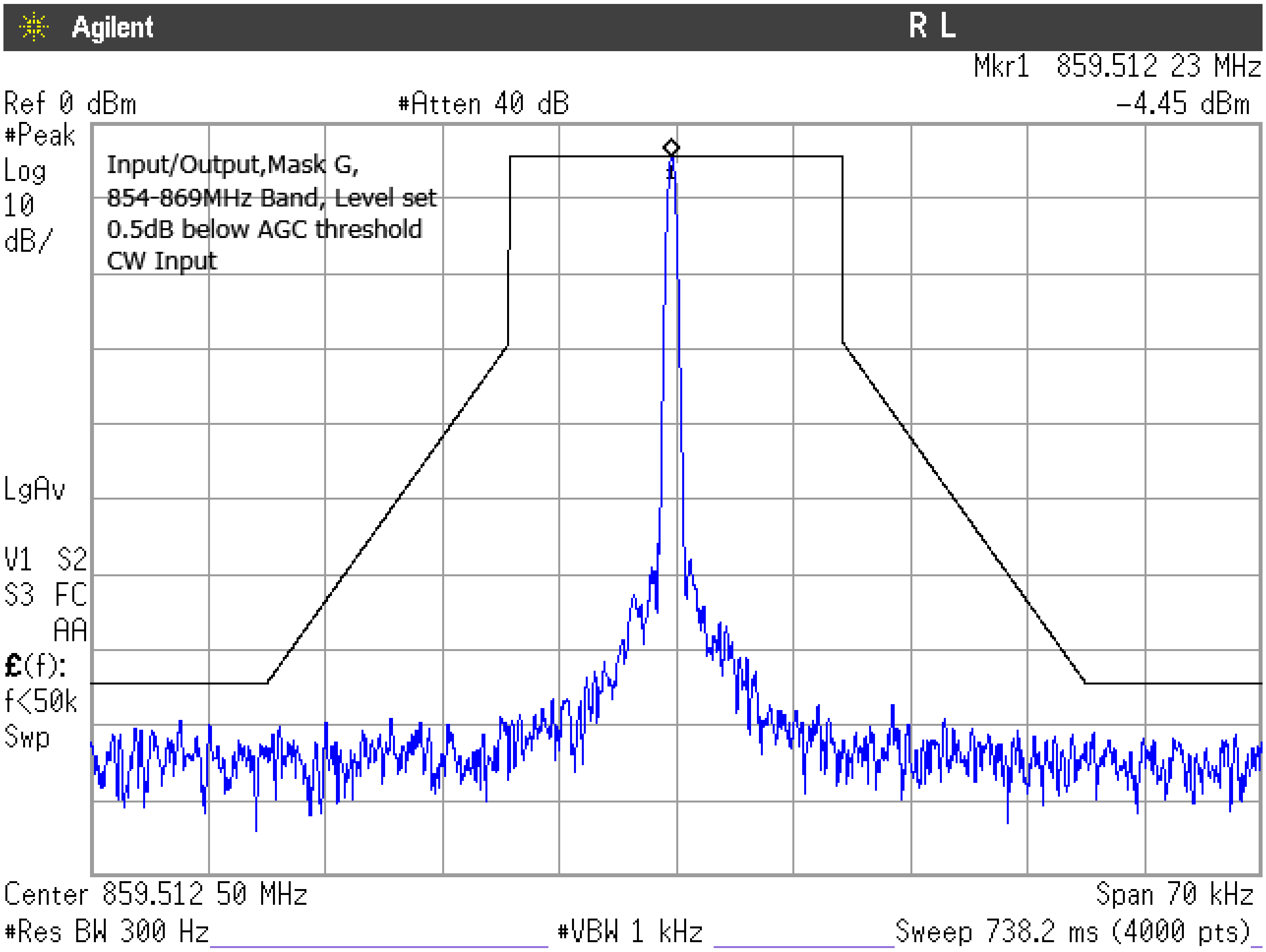


Figure 17: 854-869MHz comparison CW input, Mask G, Level under AGC

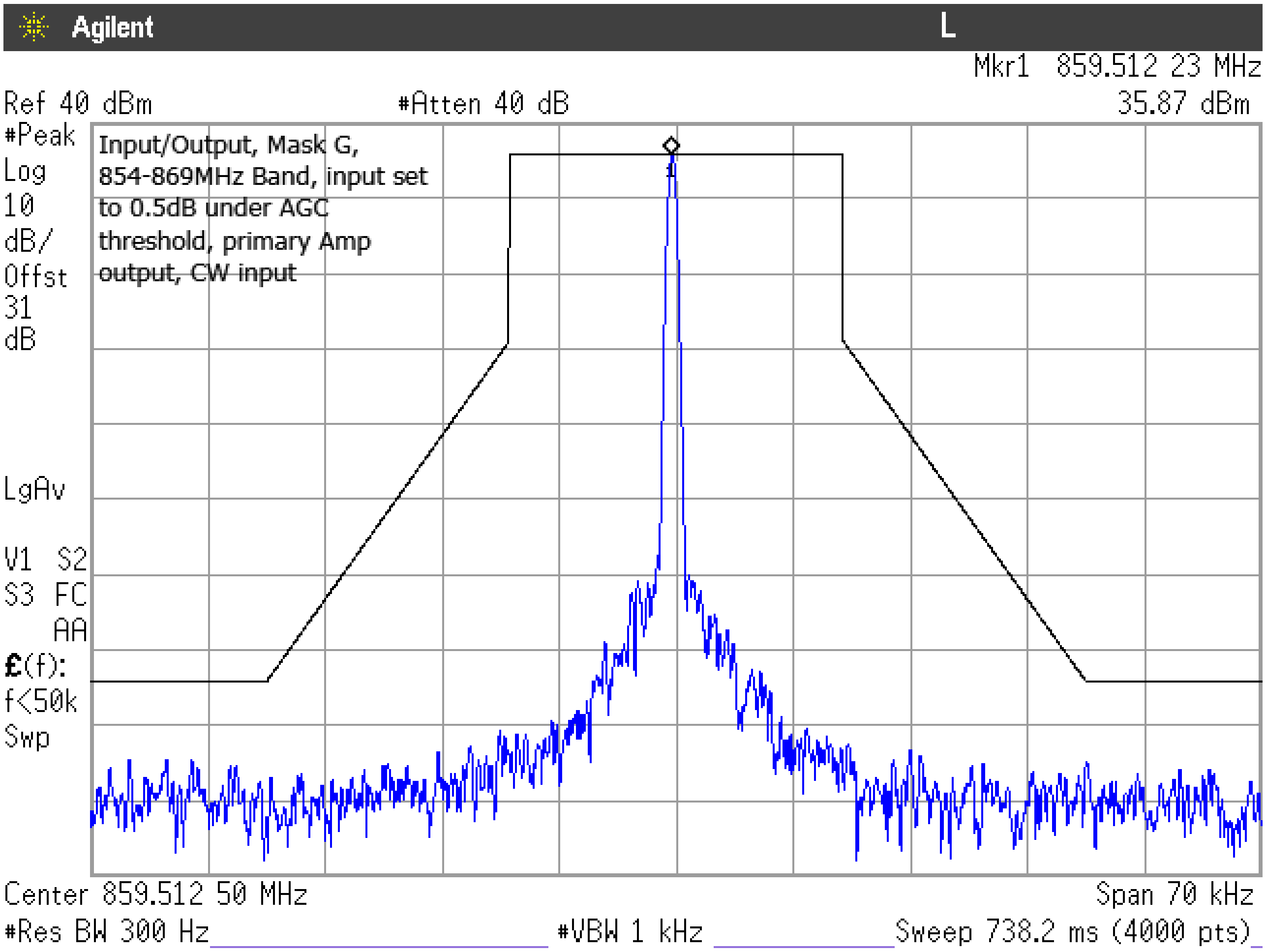


Figure 18: 854-869MHz comparison, CW Output, Mask G- Primary Amp, Under AGC

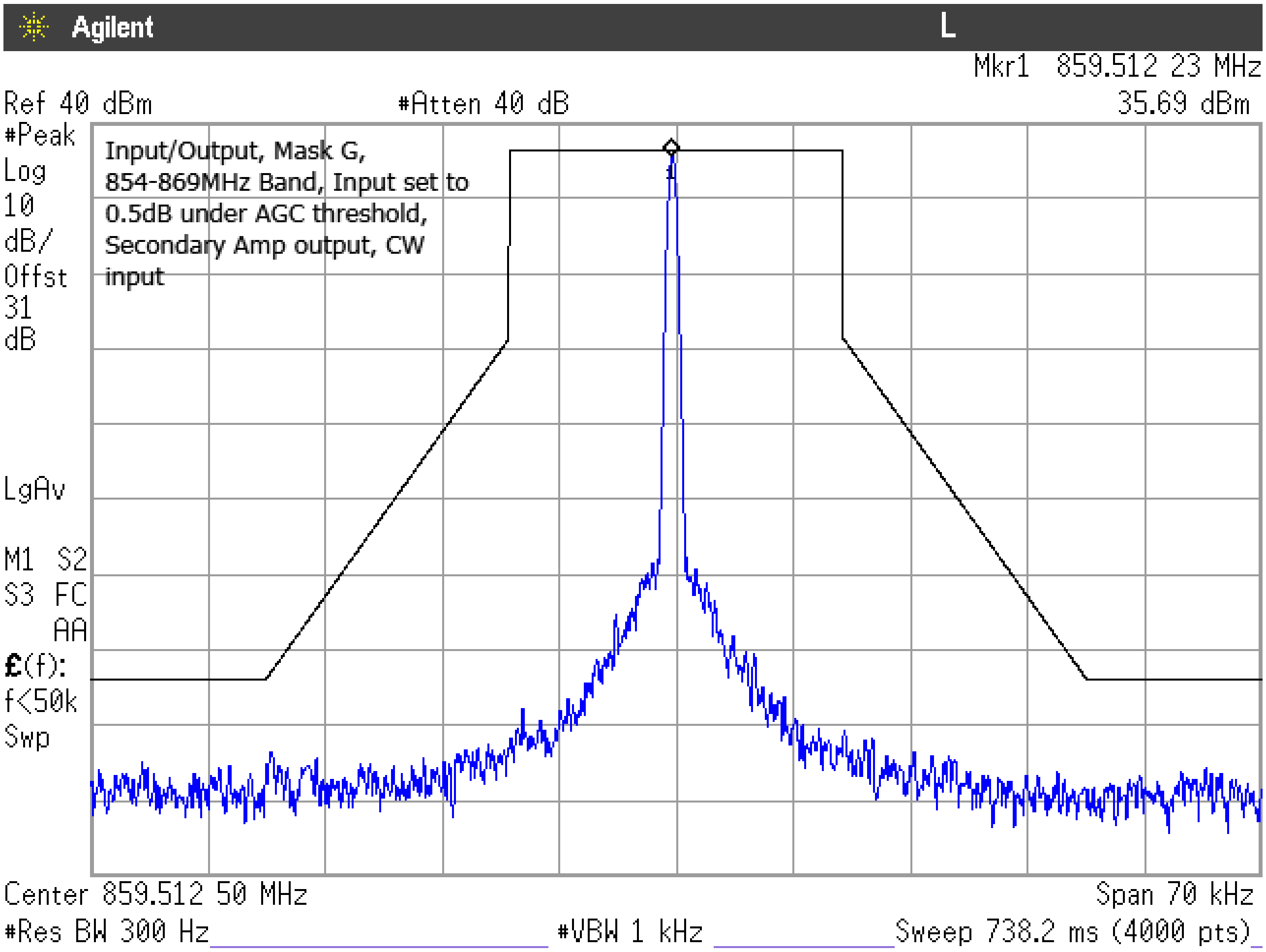


Figure 19: 854-869MHz comparison, CW Output, Mask G- Secondary Amp, Under AGC

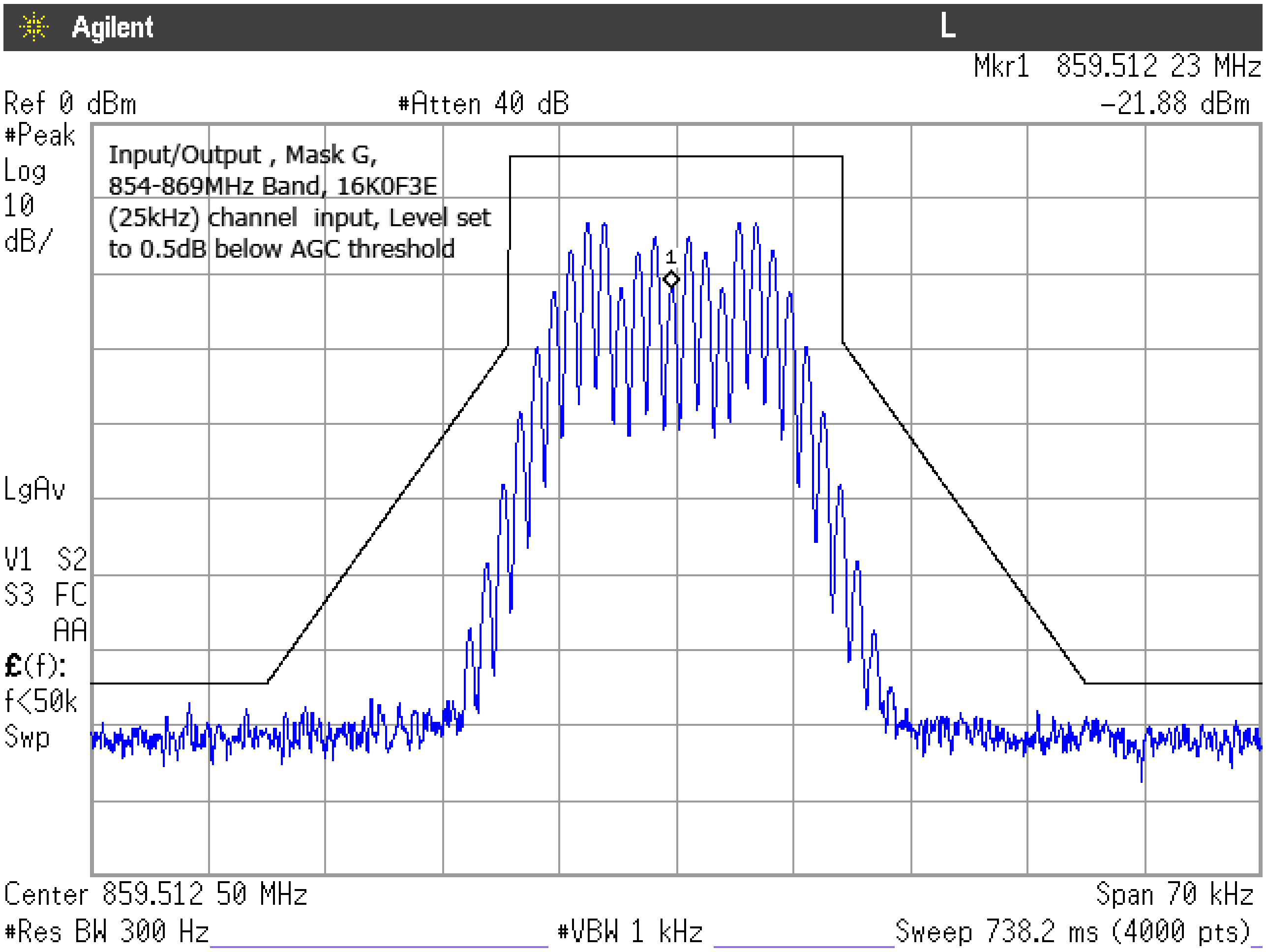


Figure 20: 854-869MHz comparison 16K0F3E input, MaskG, Level under AGC

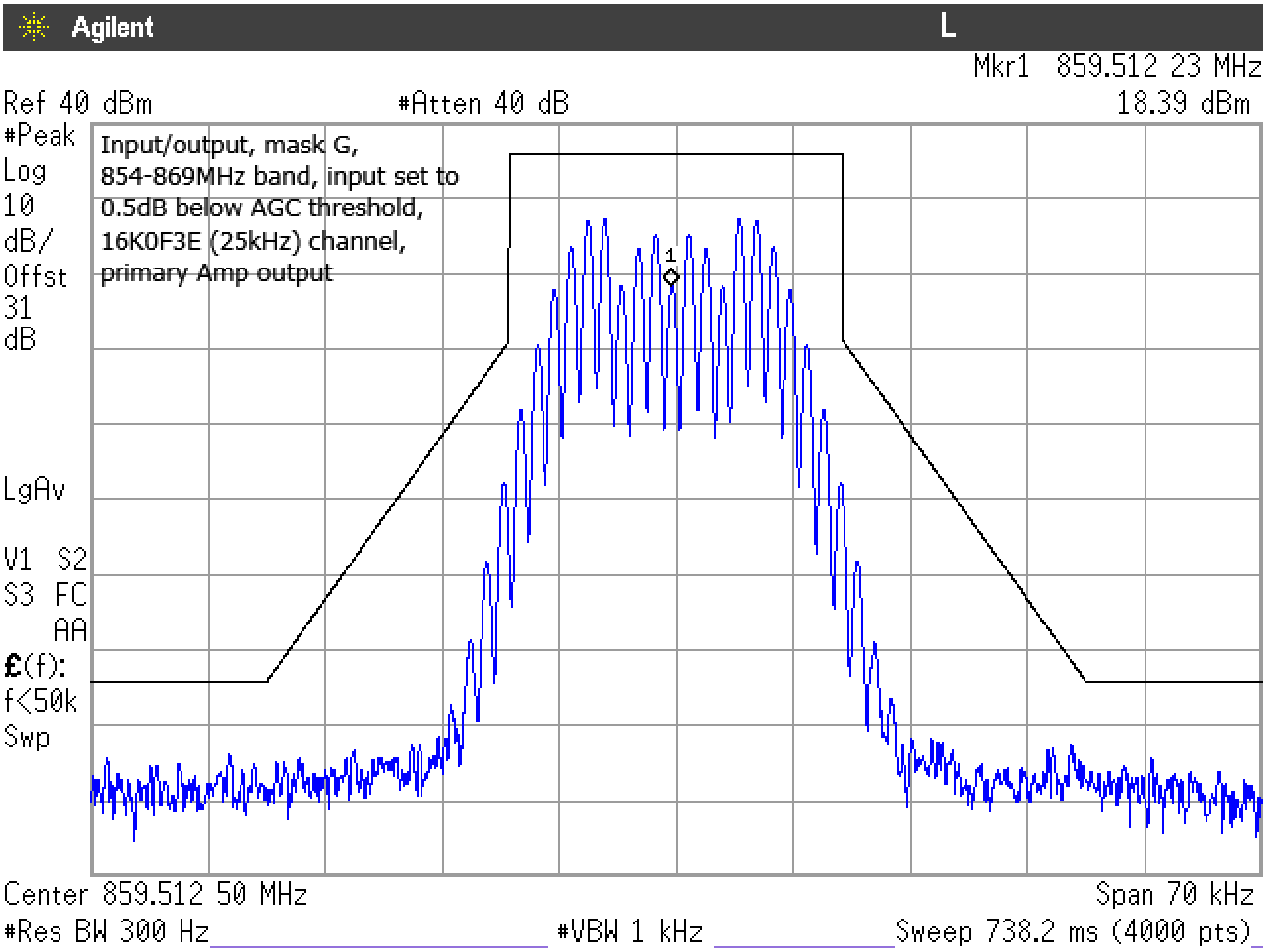


Figure 21: 854-869MHz comparison 16K0F3E input, Mask G- Primary Amp, Under AGC

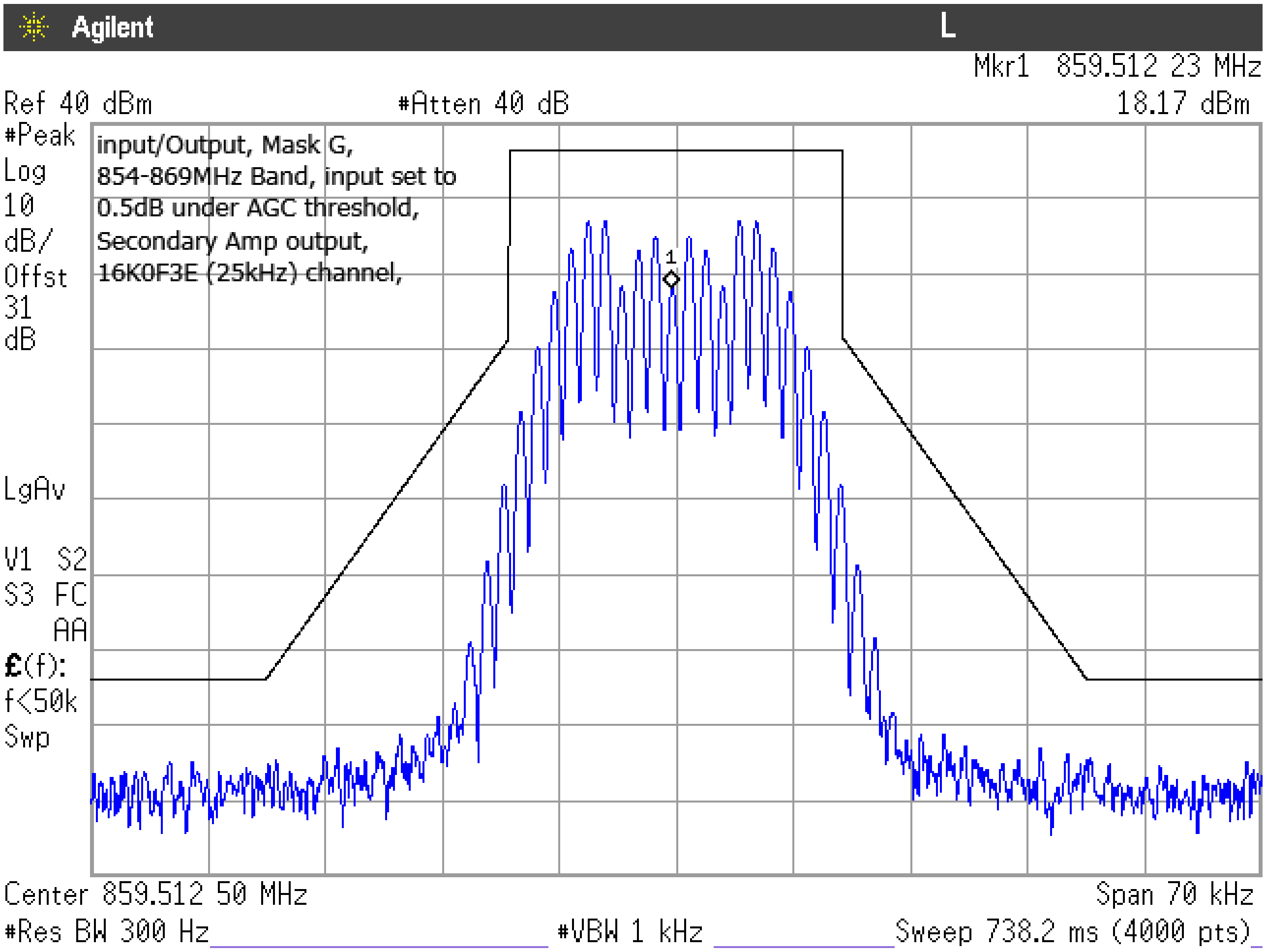


Figure 22: 854-869MHz comparison 16K0F3E input, Mask G- Primary Amp, Under AGC

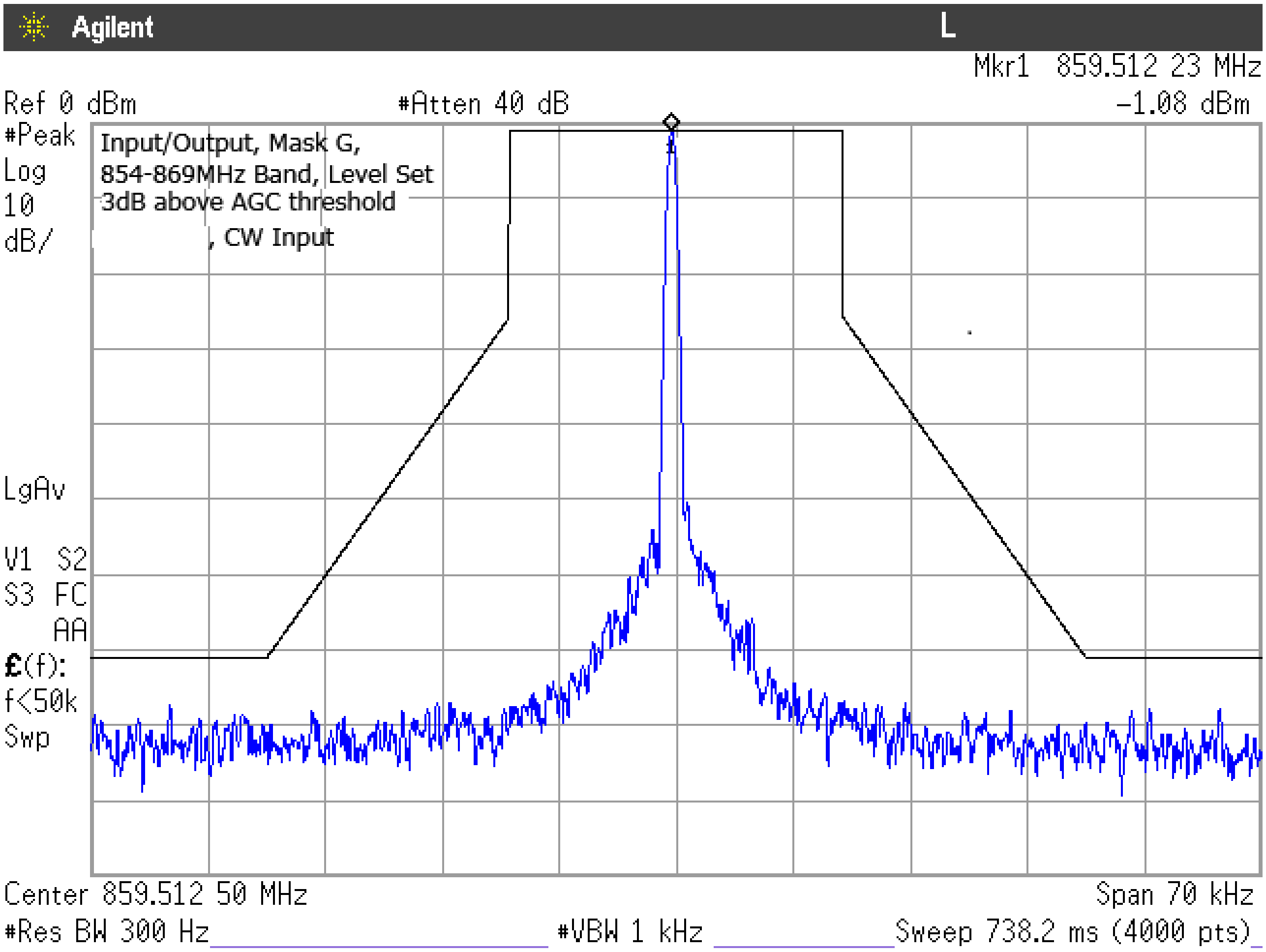


Figure 23: 854-869MHz comparison CW input, Mask G, Level 3dB over AGC

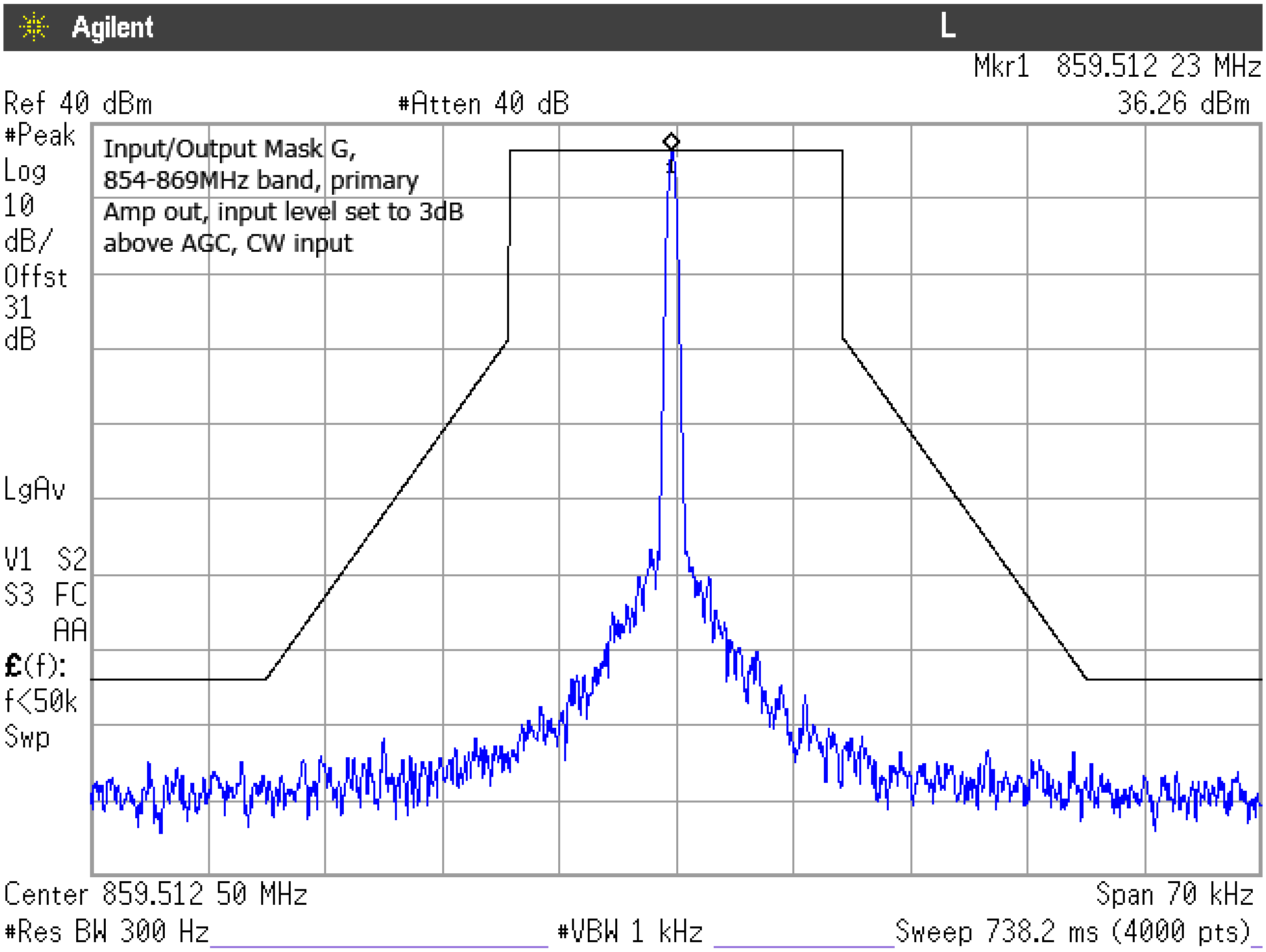


Figure 24: 854-869MHz comparison, CW Output, Mask G- Primary Amp, 3dB over AGC

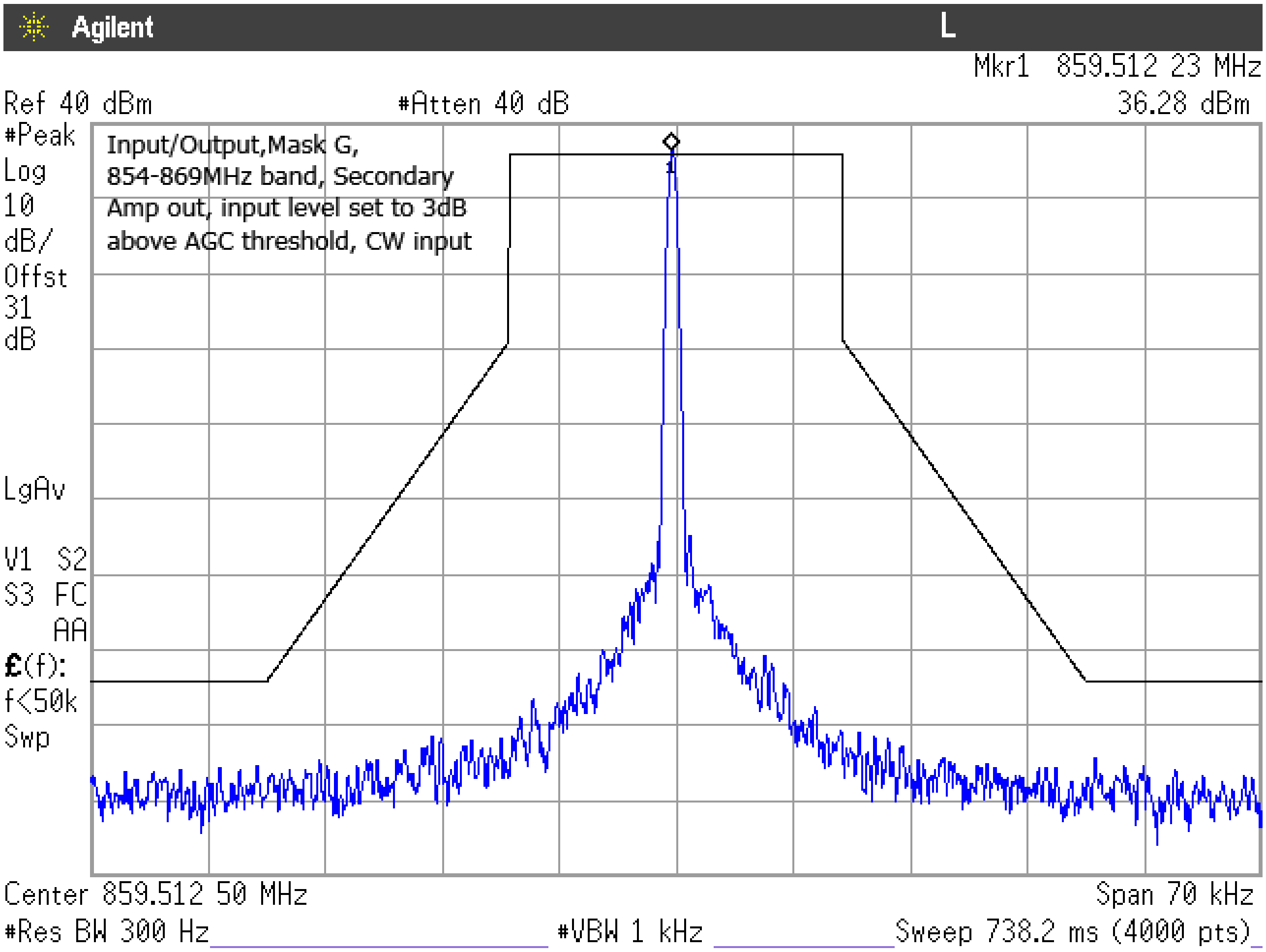


Figure 25: 854-869MHz comparison, CW Output, Mask G- Secondary Amp, 3dB over AGC

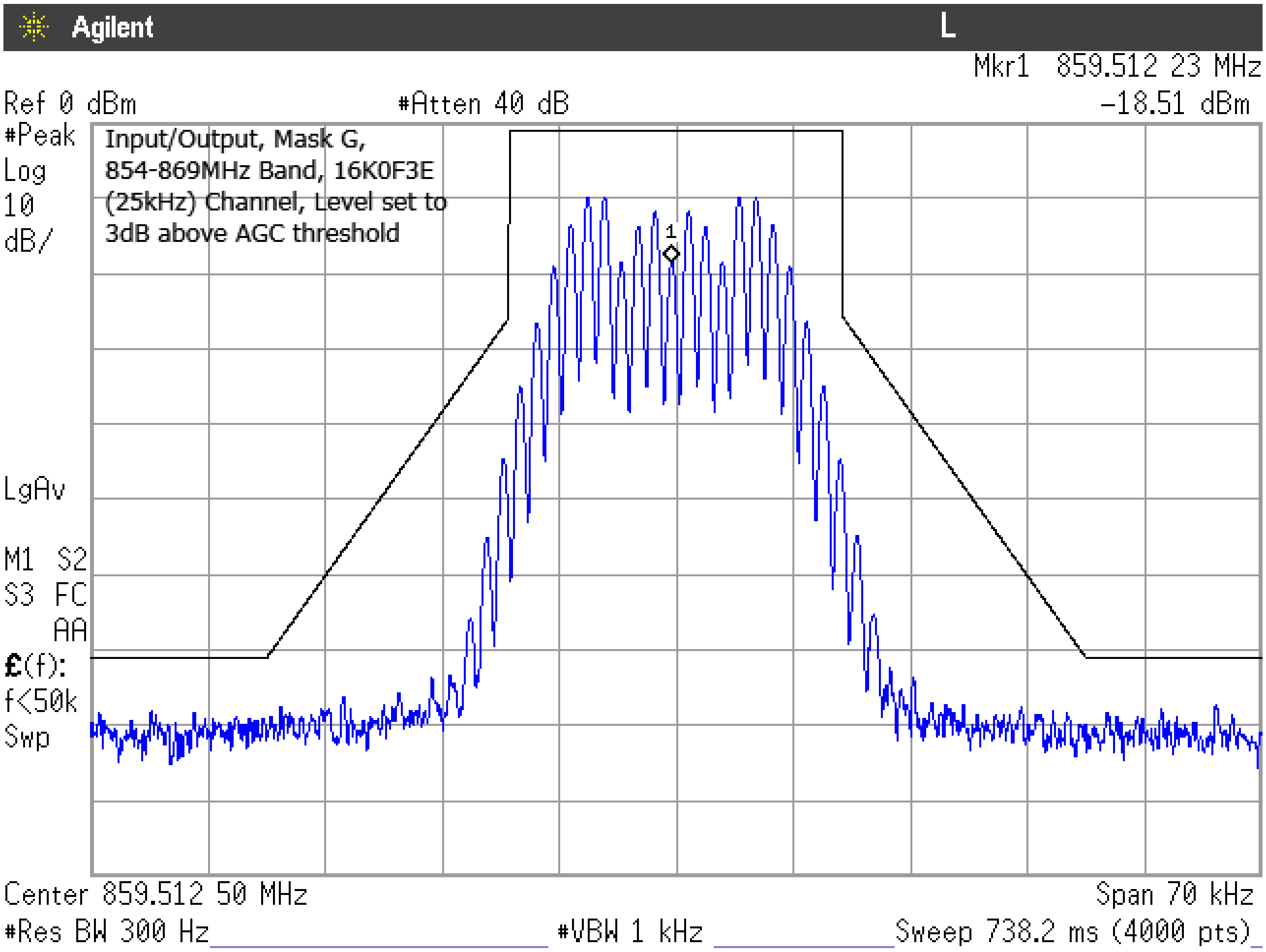


Figure 26: 854-869MHz comparison 16K0F3E input, MaskG, Level 3dB over AGC

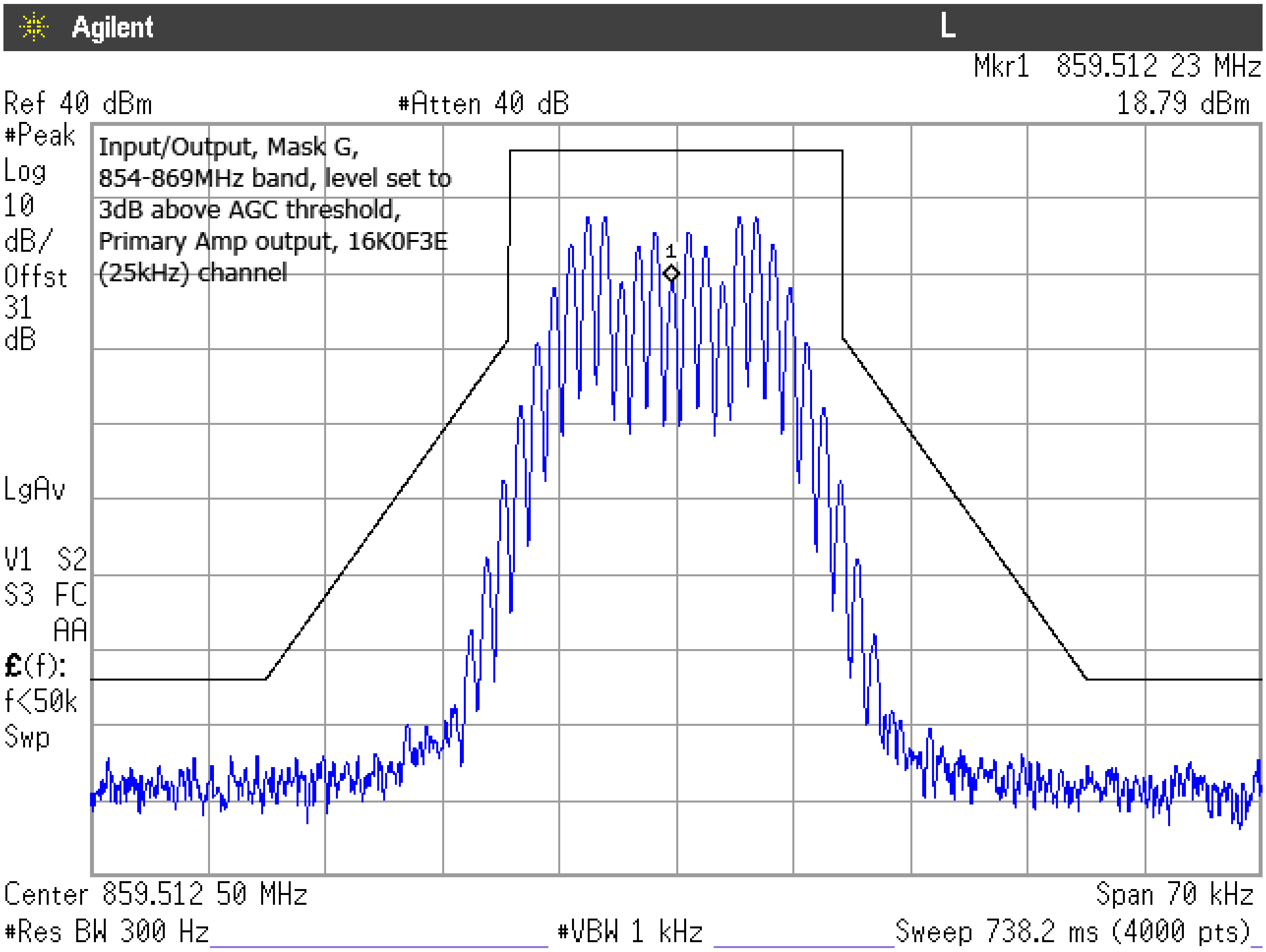


Figure 27: 854-869MHz comparison 16K0F3E output, Mask G- Primary Amp, 3dB over AGC

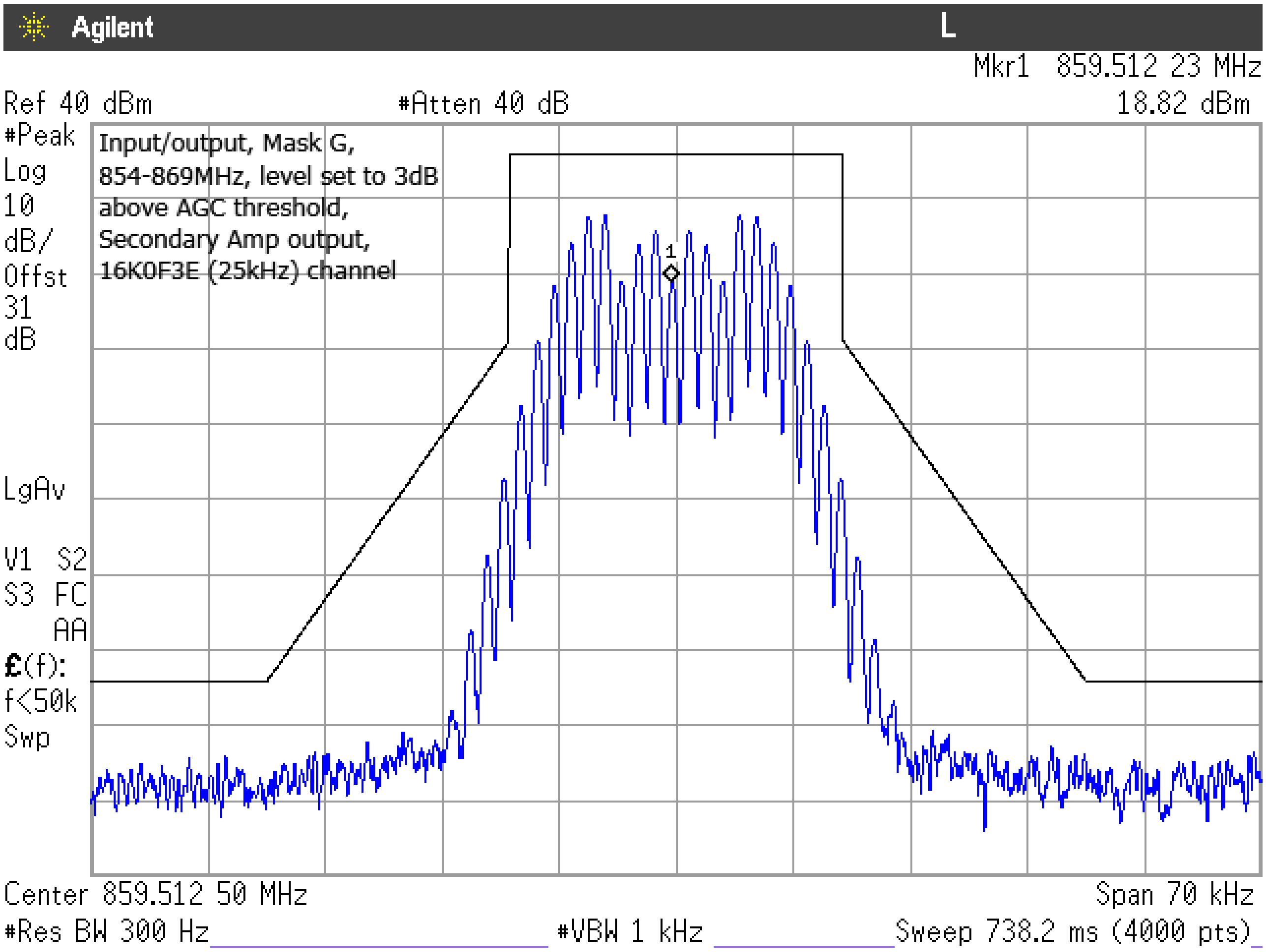


Figure 28: 854-869MHz comparison 16K0F3E output, Mask G- Primary Amp, 3dB over AGC

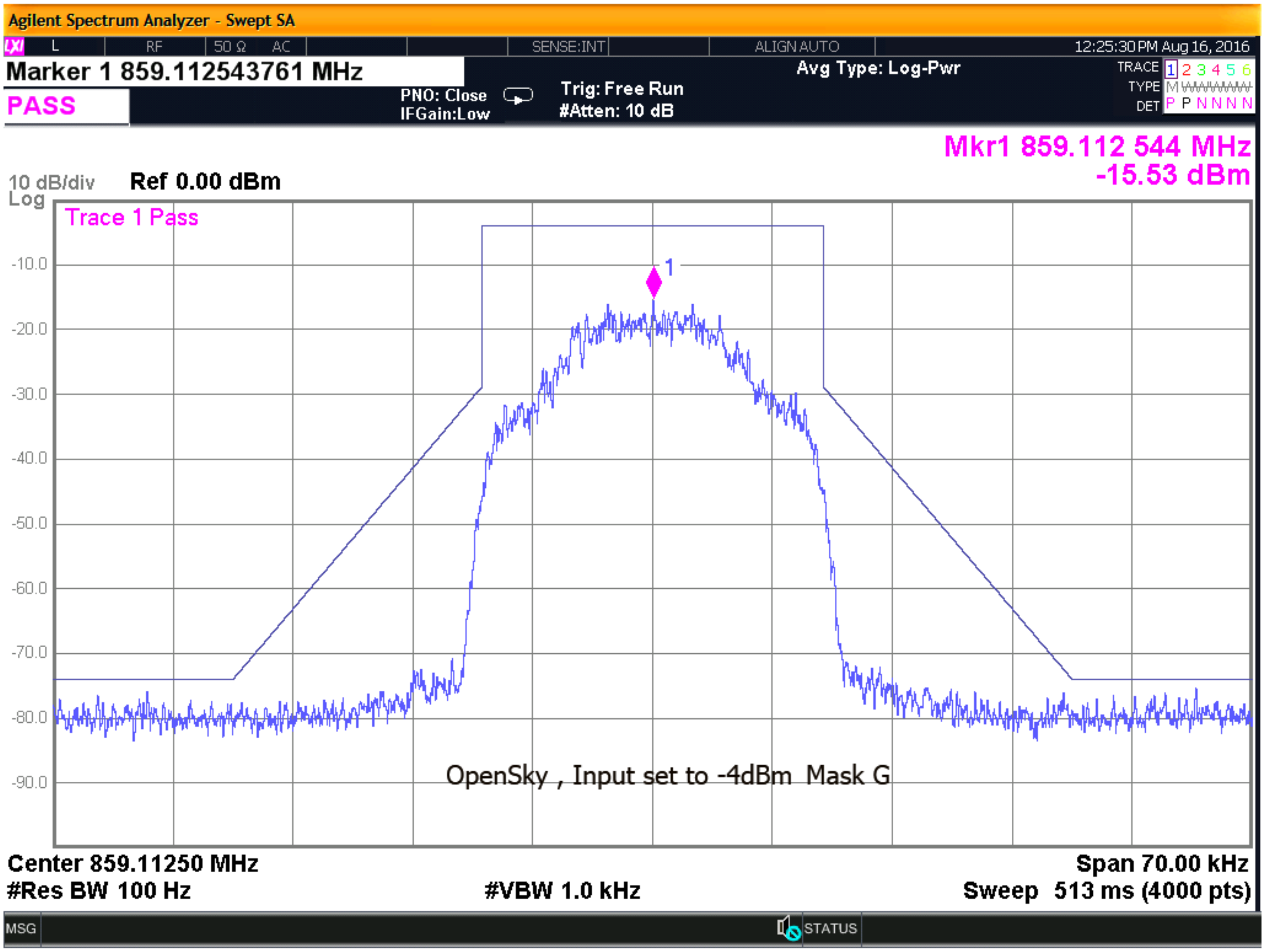


Figure 29: OpenSky 4-GFSK input, Mask G, 0.5 dB below AGC Threshold

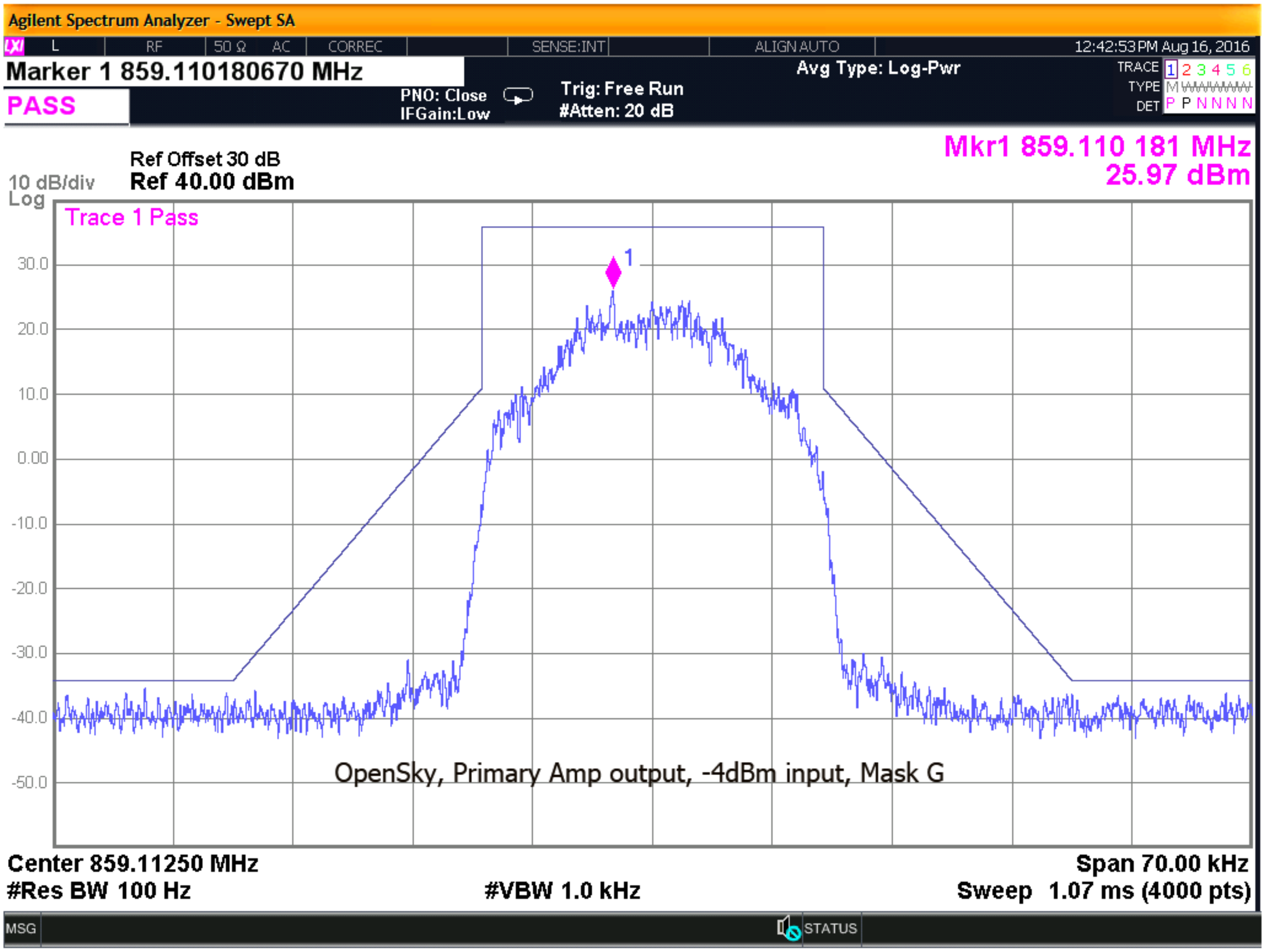


Figure 30: OpenSky 4-GFSK output, Mask G –Primary amp, 0.5 dB below AGC Threshold

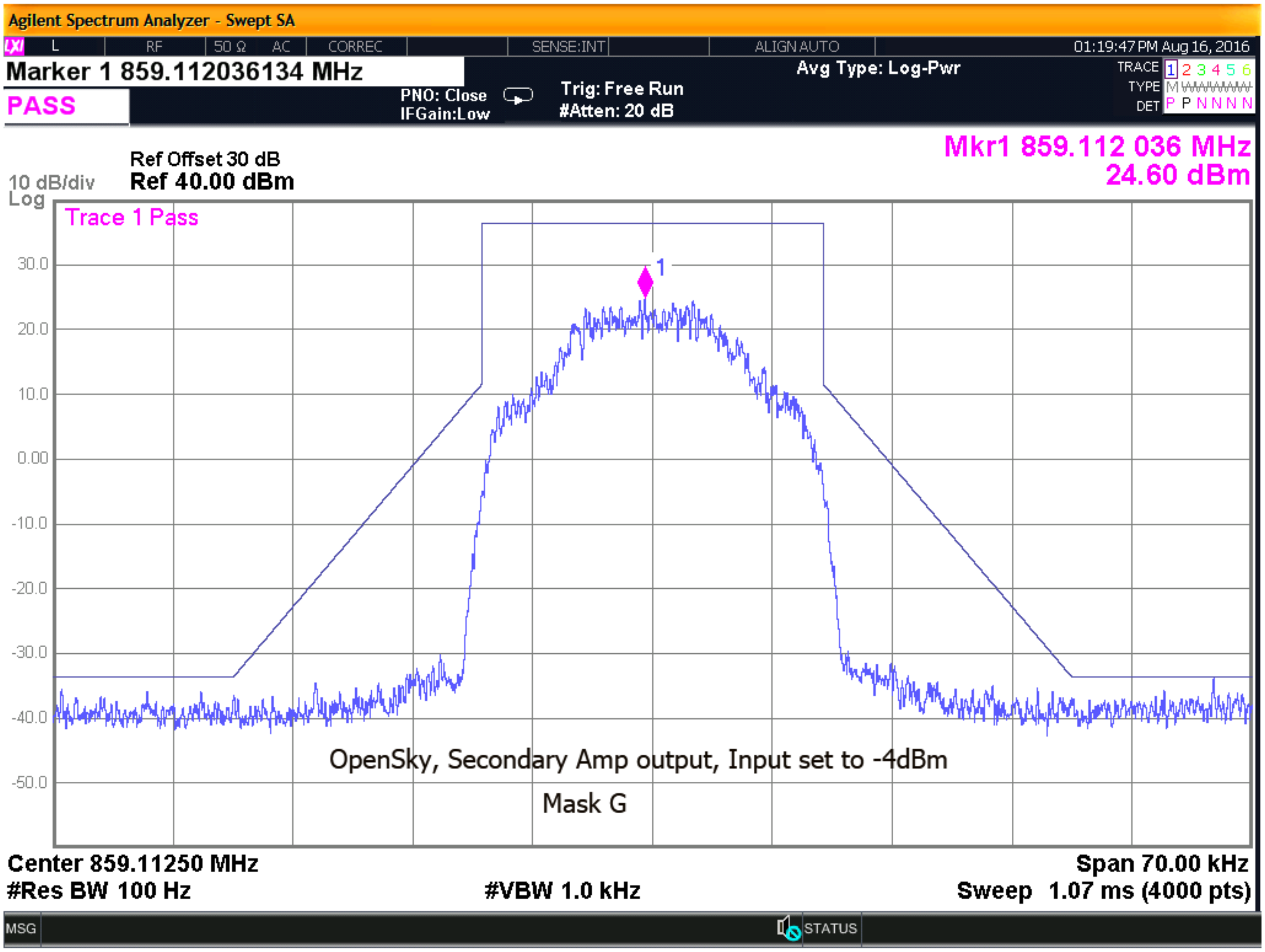


Figure 31: OpenSky 4-GFSK output, Mask G –Secondary amp, 0.5 dB below AGC Threshold

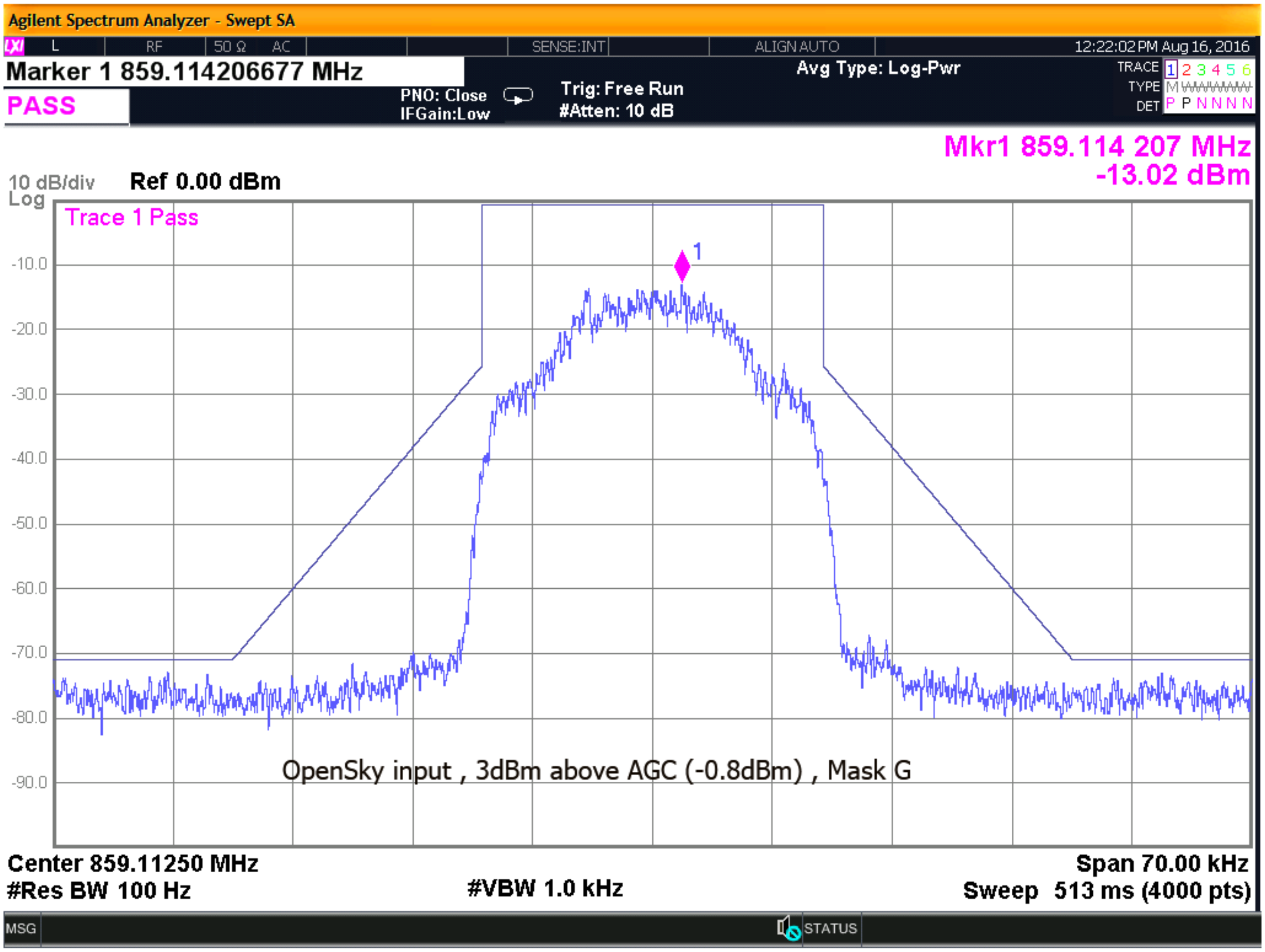


Figure 32: OpenSky 4-GFSK input, Mask G, 3 dB above AGC Threshold

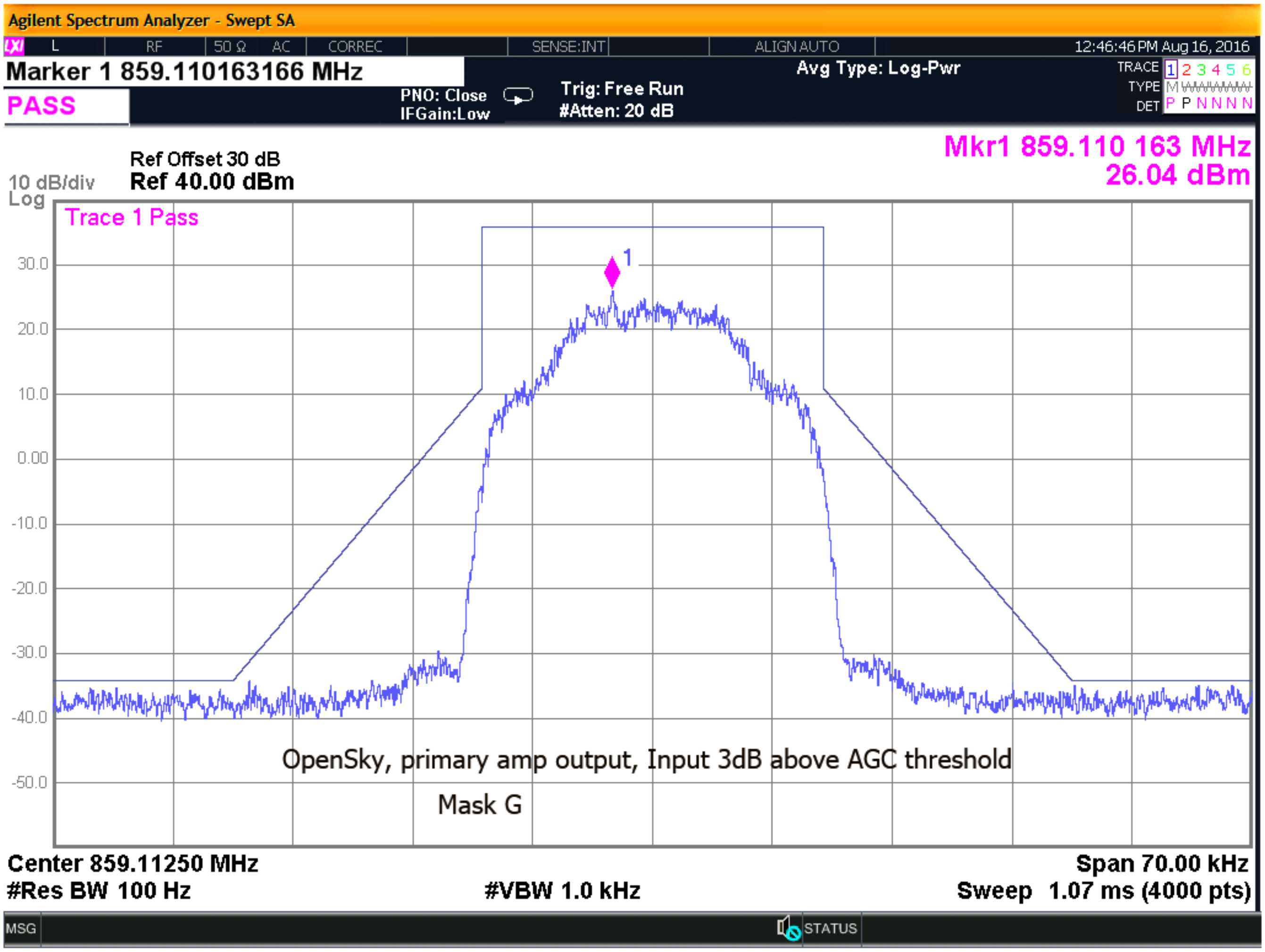


Figure 33: OpenSky 4-GFSK output, Mask G –Primary amp, 3 dB above AGC Threshold

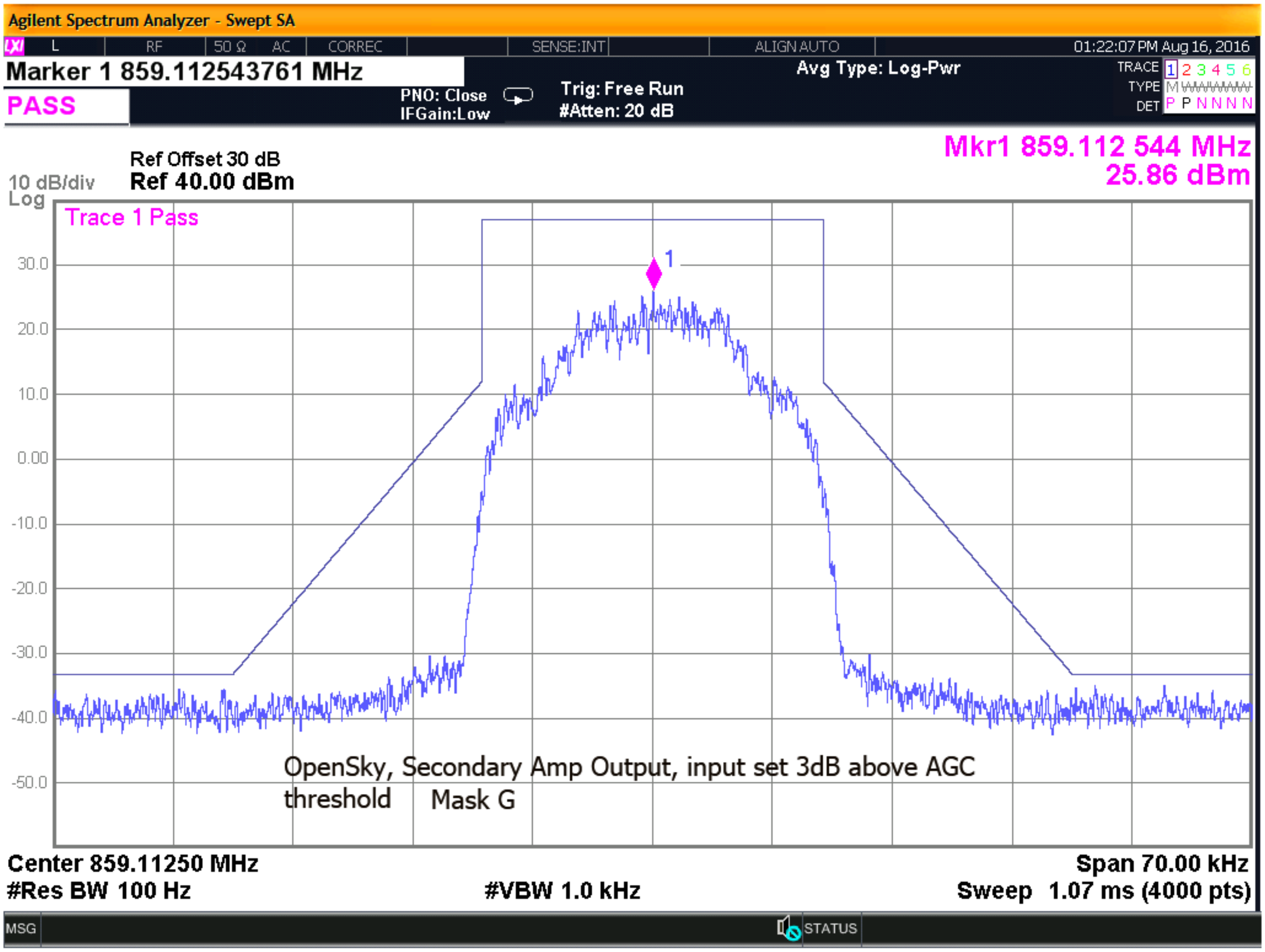


Figure 34: OpenSky 4-GFSK output, Mask G –Secondary amp, 3 dB above AGC Threshold

4.4 EUT input/output power and amplifier gain (935210 DO5 section 4.5)

Section 4.5 specifies the following measurement of mean input and output power of a PLMRS and/or PSRS amplifier, booster, or repeater, to compute the gain of the device.

> Adjust the internal gain control of the equipment under test to the maximum gain for which the equipment certification is being sought. Any attenuation settings shall be set to their minimum setting. Input power levels (uplink and downlink) should be set to maximum input ratings while confirming that the device is not capable of operating in saturation (non-linear mode) at the rated input levels, including during the performance of the input/output power measurements.

Note: The EUT has no user attenuation or gain controls.

In addition to a CW signal the Gain was also tested with a modulated 4-GFSK signal to test the digital OpenSky mode.

DO5-4.5.2 Measuring the EUT input and output power levels for determining amplifier/booster gain

The guidance of section 3.5.2 was used with the modifications listed in 4.5.2 a) through d):

DO5-3.5.2 Measuring the EUT mean input and output power

a) Connect a signal generator to the input of the EUT.

b) Configure to generate the AWGN (broadband) test signal.

c) The frequency of the signal generator shall be set to the frequency of (f0) as determined from

3.4.

d) Connect a spectrum analyzer or power meter to the output of the EUT using appropriate attenuation as necessary.

e) Set the signal generator output power to a level that produces an EUT output level that is just below the AGC threshold (see 3.2), but not more than 0.5 dB below.

f) Measure the output power of the EUT and record (see 3.5.3 or 3.5.4 for power measurement guidance).

g) Remove the EUT from the measurement setup and using the same signal generator settings, repeat the power measurement on the input signal to the EUT and record as input power.

h) Repeat the procedure with the narrowband test signal.

i) Repeat the procedure for both test signals with input signal amplitude set to 3 dB above the AGC threshold level.

j) Repeat for all frequency bands authorized for use by the EUT.

Required Modifications per Guidance:

a) Configure the signal generator for CW operation instead of AWGN,

b) Select the analyzer positive peak detector instead of the power averaging (rms) detector, c) Activate the max hold function instead of the trace average function,

d) Use in conjunction with guidance provided in 4.5.3.

DO5-4.5.3 Method 1: Power measurement with a spectrum or signal analyzer

a) Set the frequency span to at least 1 MHz.

b) Set the resolution bandwidth to 100 kHz

c) Set the video bandwidth to ≥ 3 × RBW.

d) Set the detector to PEAK and trace mode to MAX HOLD.

e) Place a marker on the peak of the signal and record the value as the maximum power.

DO5-4.5.5 Calculating the amplifier, booster, or repeater gain

After the input and output power levels have been measured as described above, the gain of the EUT can be determined from:

Gain (dB) = output power (dBm) − input power (dBm).

4.4.1 Results:

See Table 7 for tabular gain results. See Figure 35 through Figure 48 for the plots which support the tabular data.

The EUT is AGC limited and cannot operate in a non-linear saturated mode

In accordance with FCC part 90.219(e) (1) the maximum power out is less than 5Watts ERP as the conducted maximum is 36.85dBm (4.8Watts), In addition the antenna to be used is a lossy cable that will have a negative gain.

Table 7: Input/ Output Power and Amplifier Gain

CW Mode

Amplifier	Output (dBm)	Input (dBm)	Gain (dB)
851-860MHz Primary	35.640	-4.530(below AGC)	40.170
851-860 MHz Secondary	35.890	-4.500(below AGC)	40.390
851-860 Primary	36.190	-1.040(above AGC)	37.230
851-860 MHz Secondary	36.170	-1.000(above AGC)	37.170

Gain OpenSky

4-GFSK

Amplifier	Output (dBm)	Input (dBm)	Gain (dB)
800MHz Primary	35.422	-3.996	39.418
800 MHz Secondary	36.262	-3.996	40.258
800MHz Primary	36.861	-0.879	37.740
800 MHz Secondary	36.885	-0.879	37.764

..

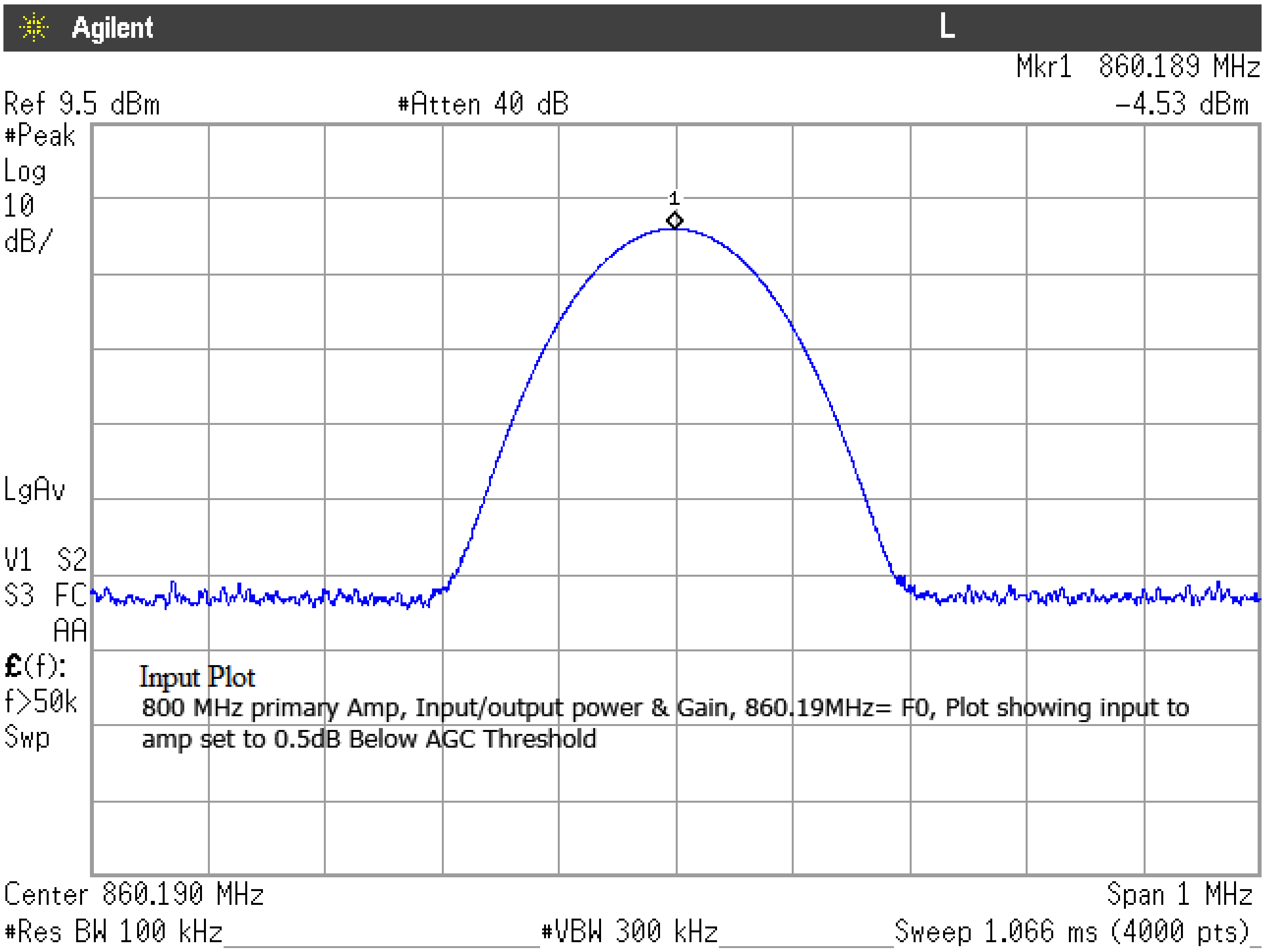


Figure 35: Power/Gain-851-860 MHz Primary Input set below AGC threshold

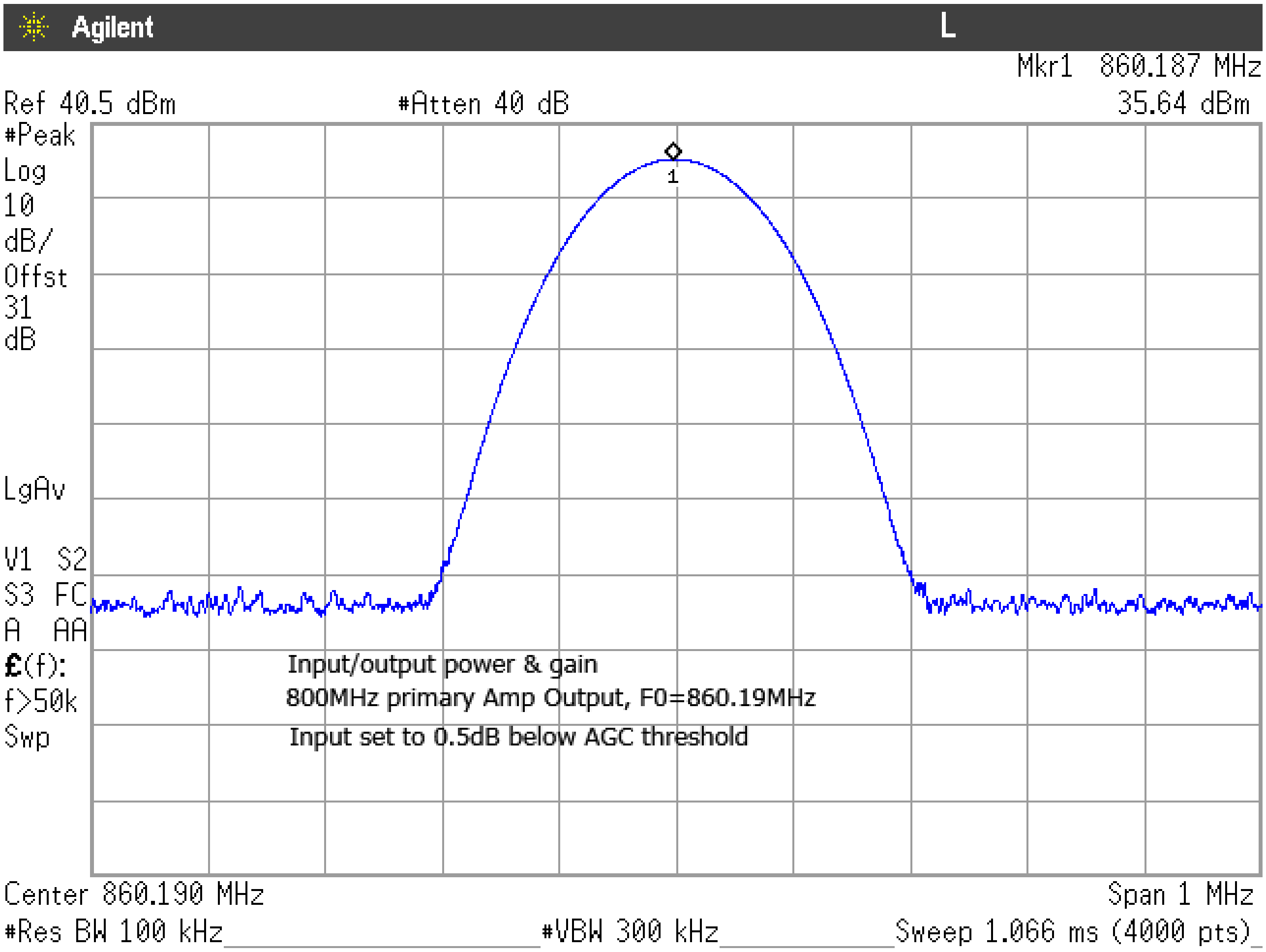


Figure 36: Power/Gain-851-860MHz Output set below AGC threshold-Primary Amp

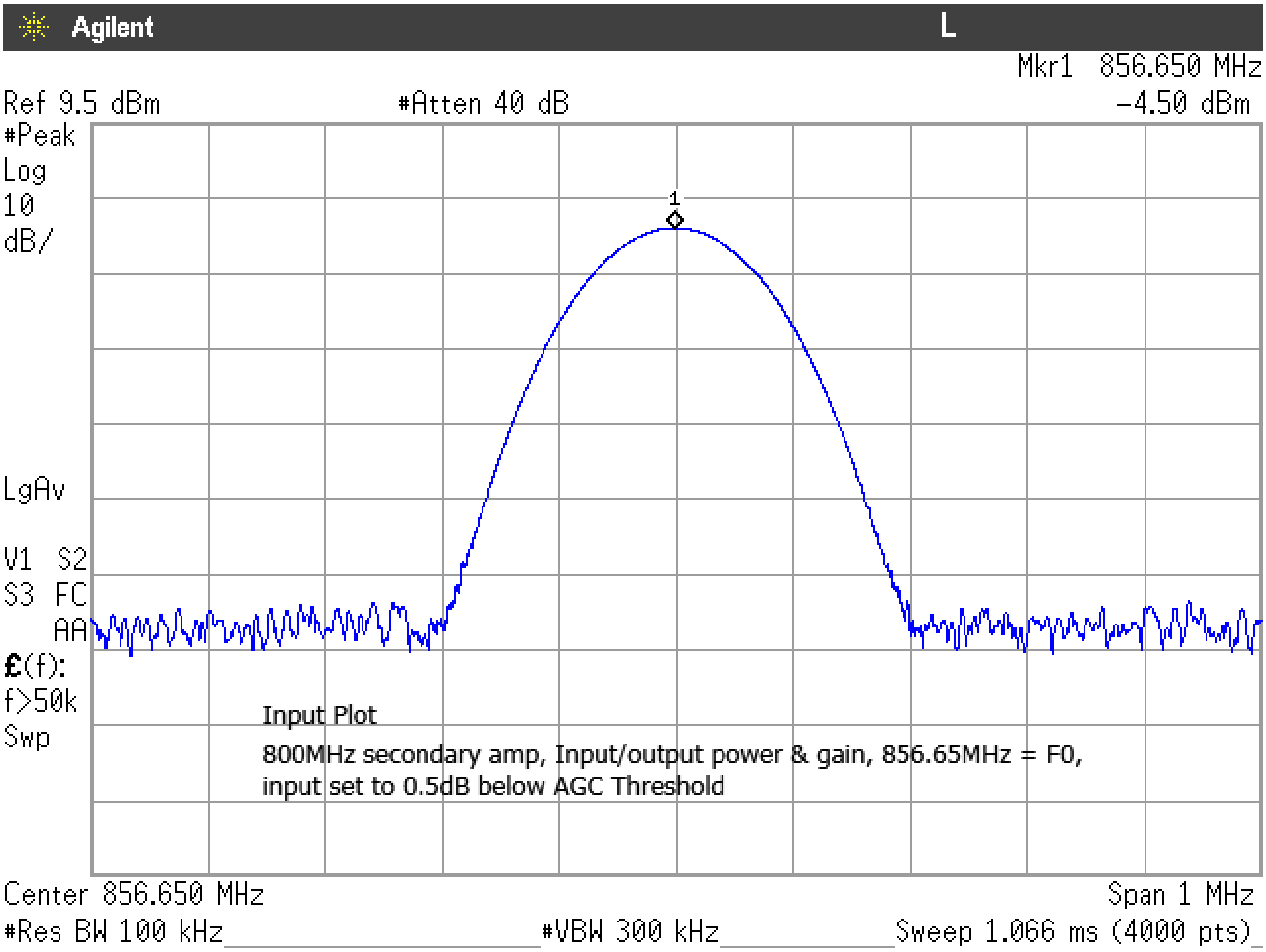


Figure 37: Power/Gain-851-860 MHz Secondary Input set below AGC threshold

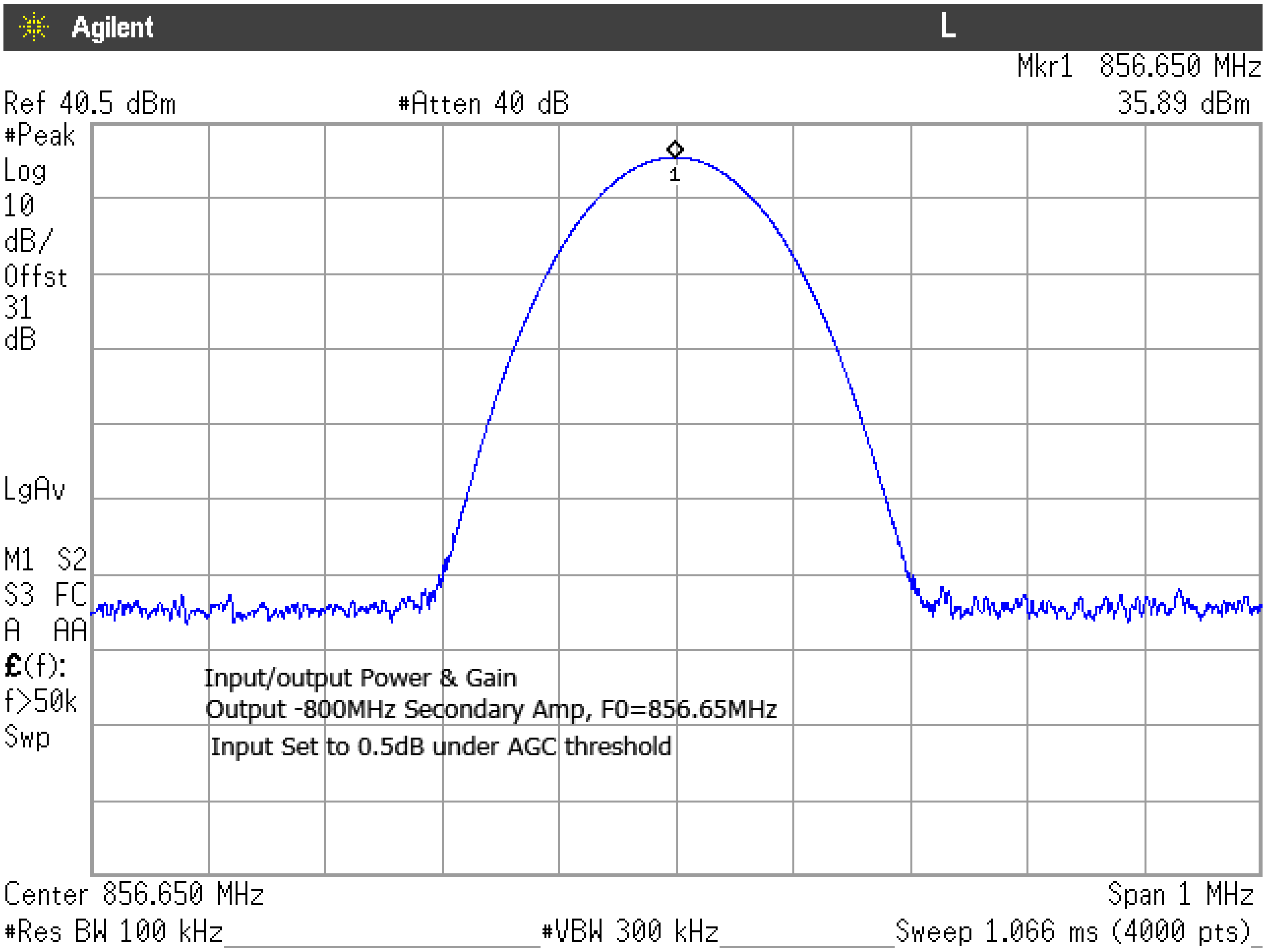


Figure 38 Power/Gain-851-860MHz Output set below AGC threshold-Secondary Amp

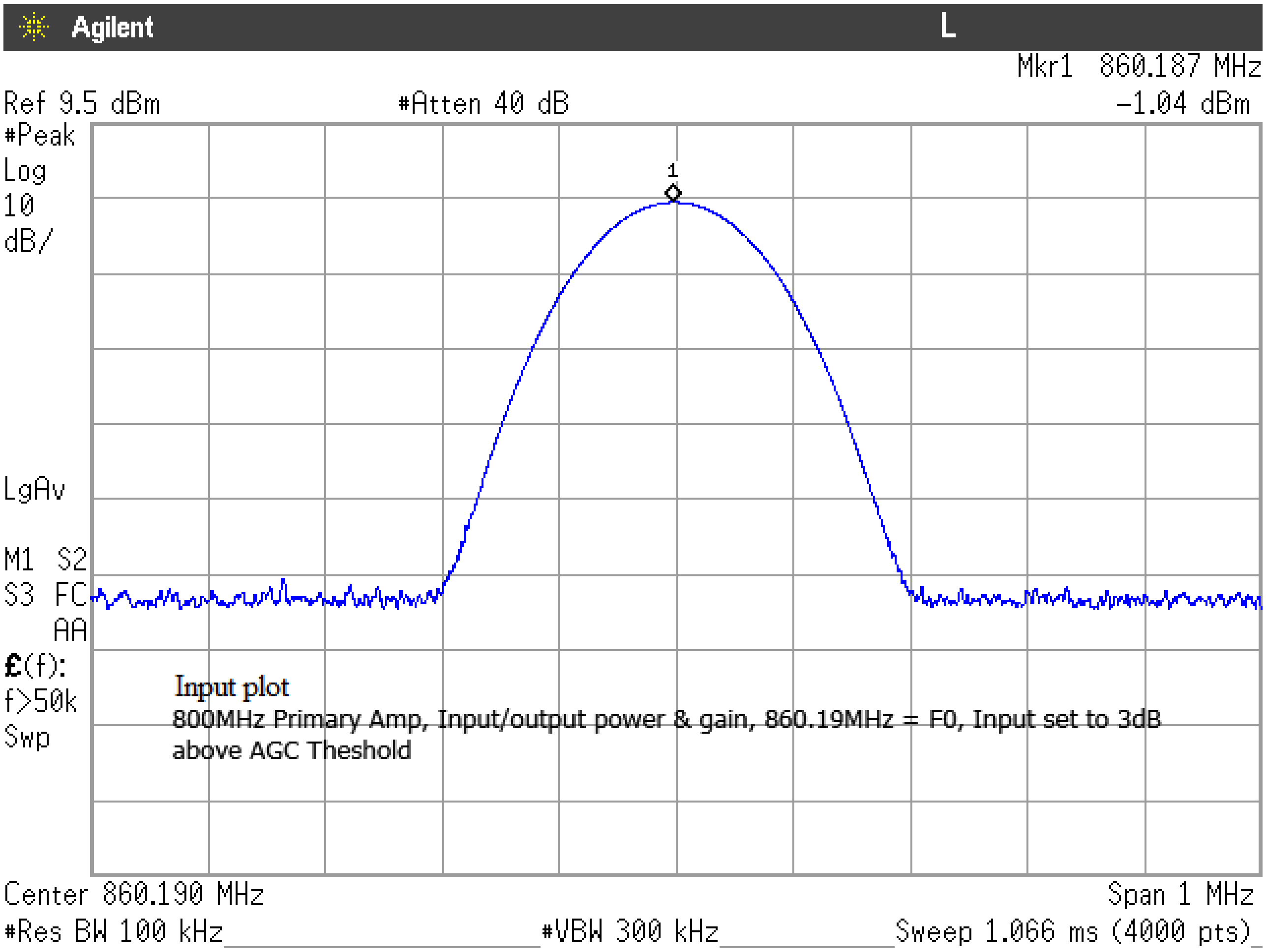


Figure 39: Power/Gain-851-860MHz Primary Input set 3dB above AGC threshold

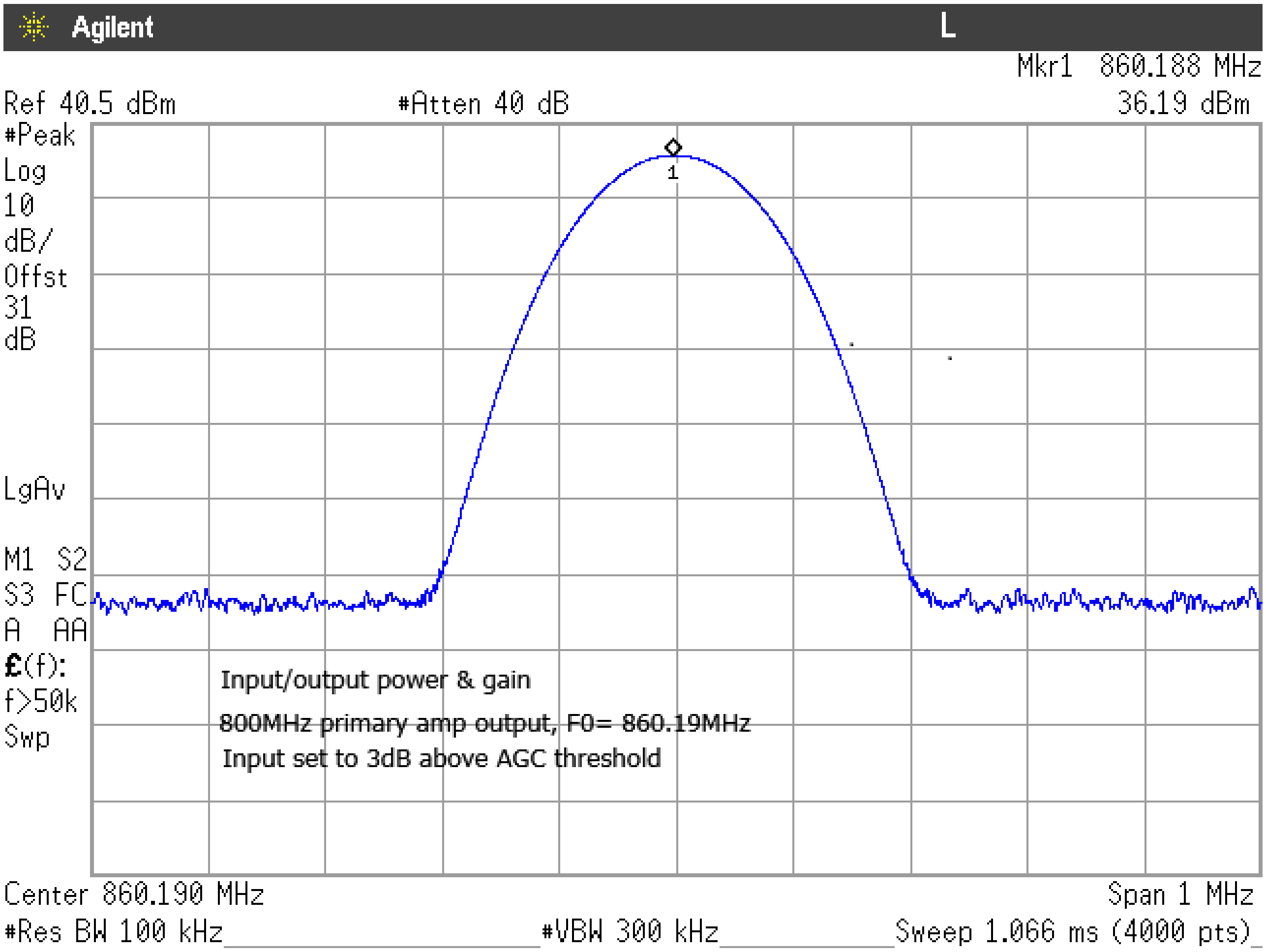


Figure 40: Power/Gain-851-860MHz Output set 3dB above threshold-Primary Amp

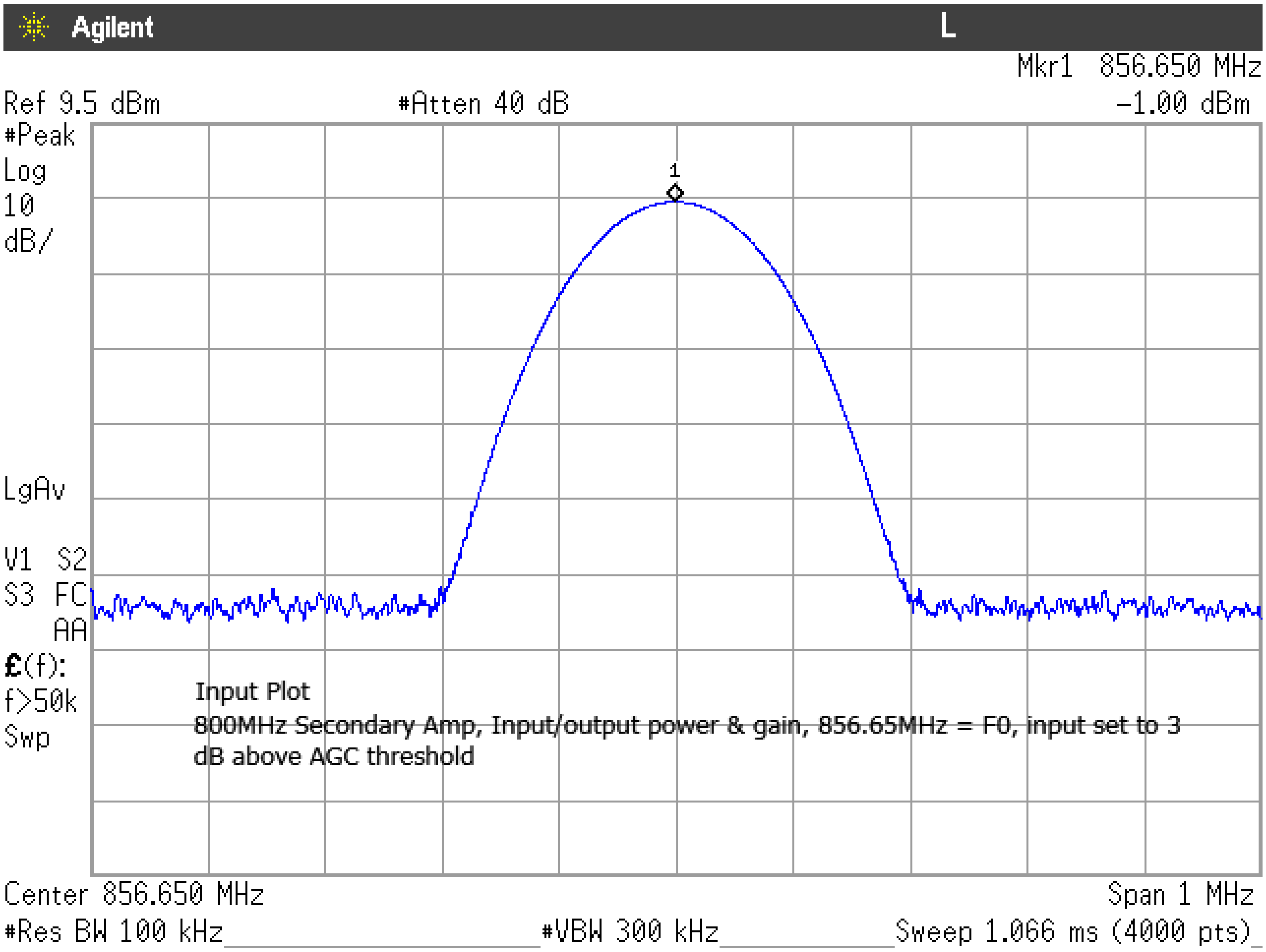


Figure 41: Power/Gain-851-860MHz Secondary Input set 3dB above AGC threshold

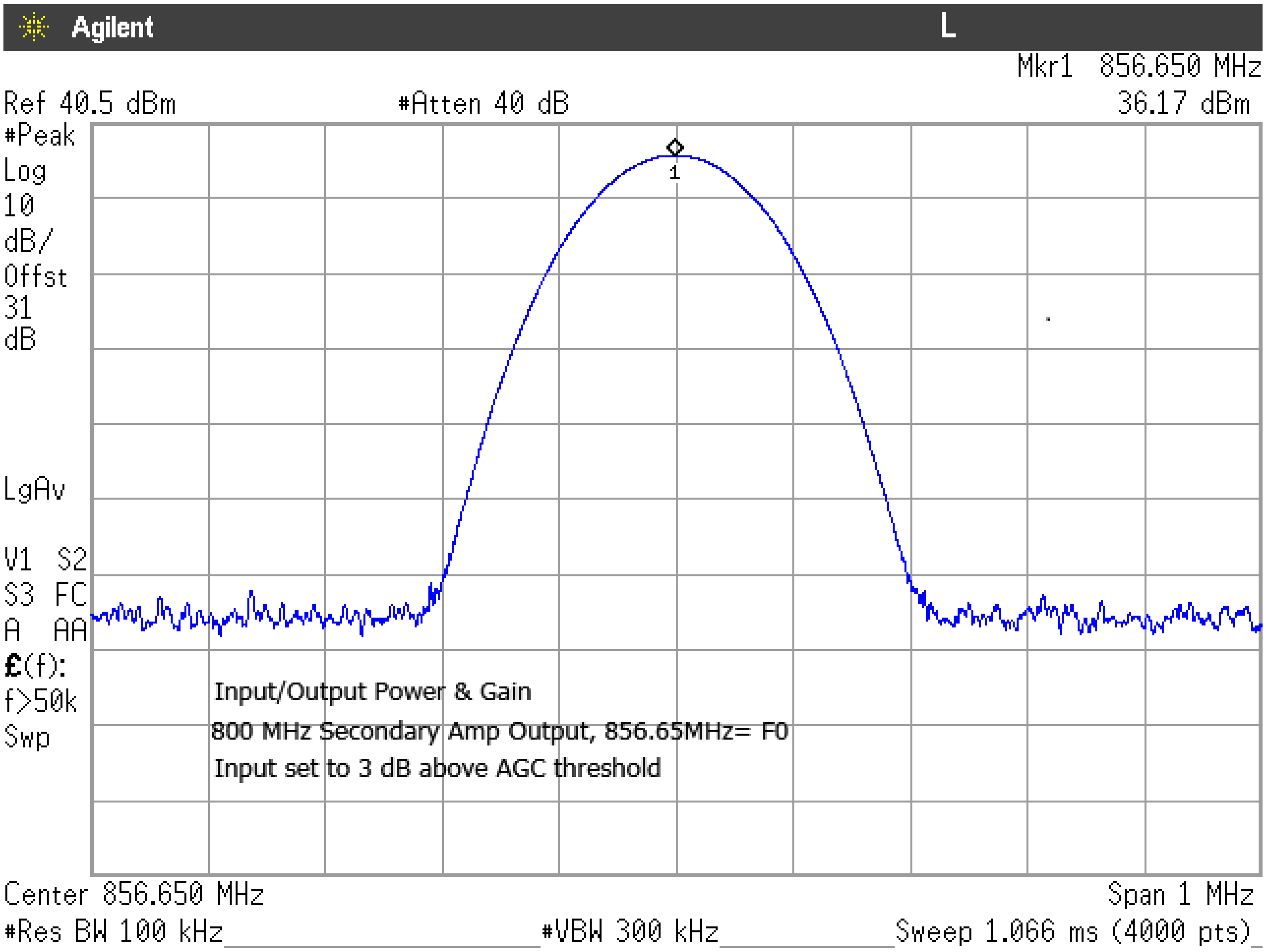


Figure 42 Power/Gain-851-860MHz Output set 3dB above threshold-Secondary Amp

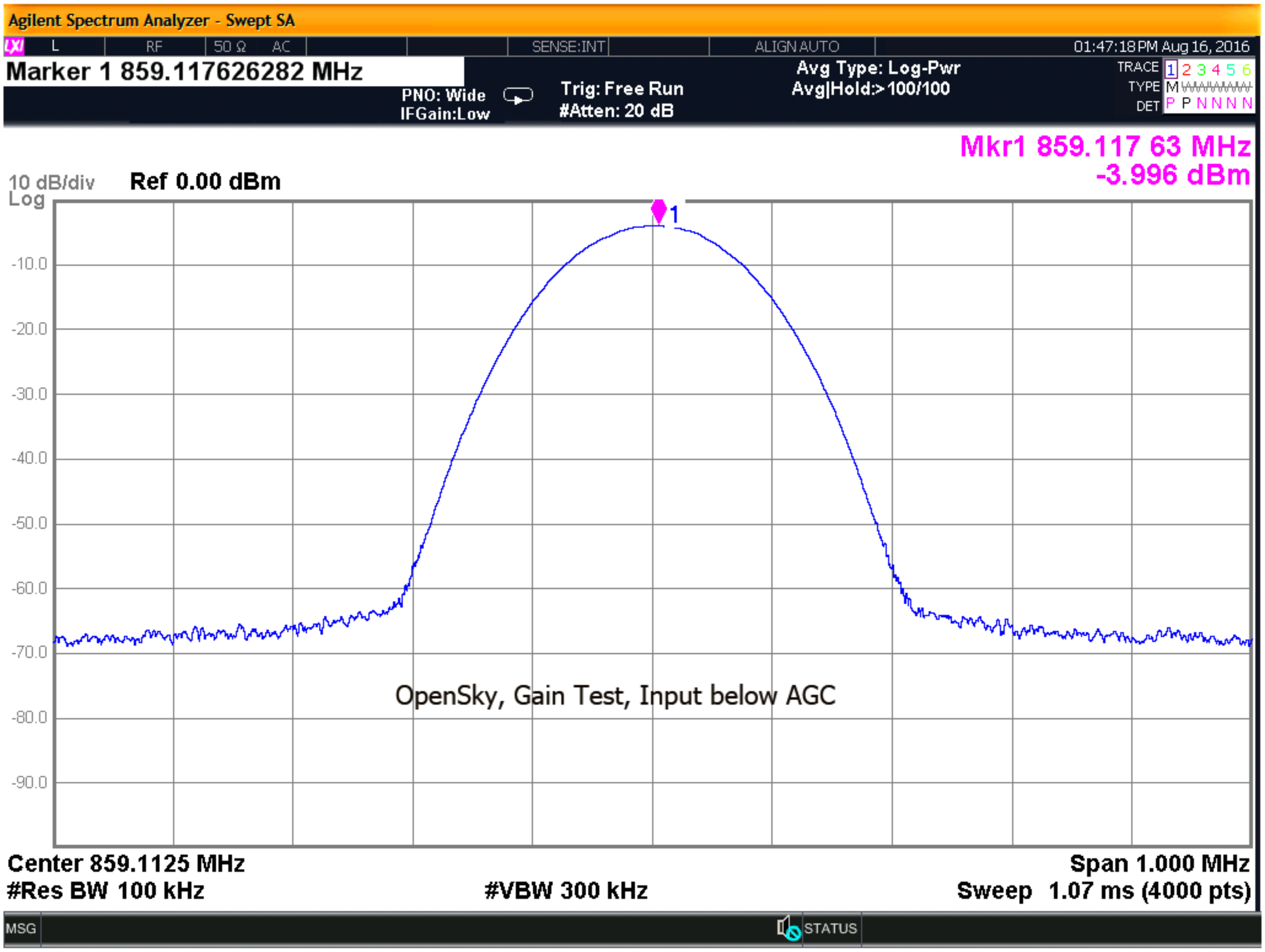


Figure 43 Power/Gain-OpenSky 4-GFSK Input set 0.5dB below threshold

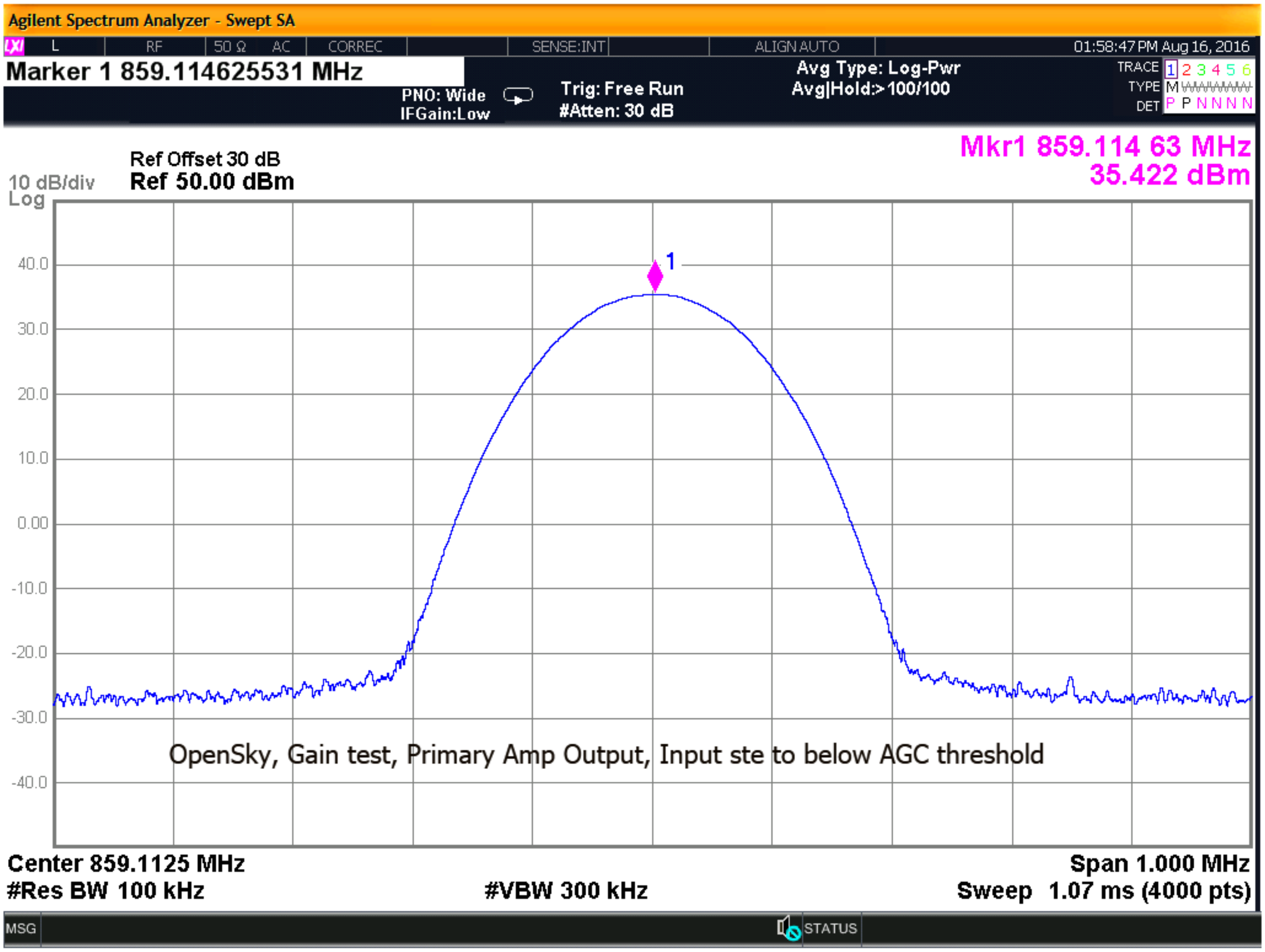


Figure 44 Power/Gain-OpenSky 4-GFSK Output set 0.5dB below threshold-Secondary Amp

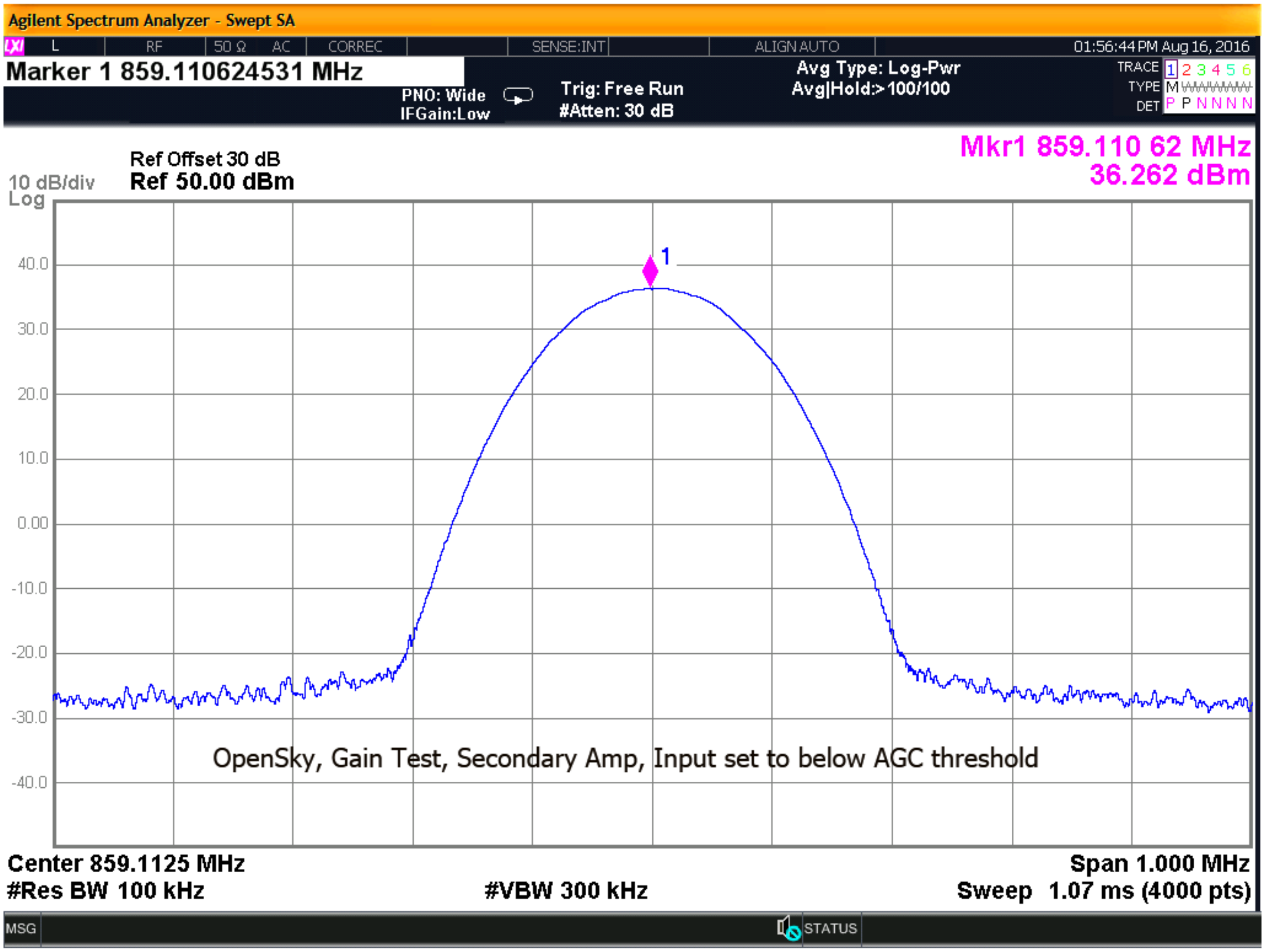


Figure 45 Power/Gain-OpenSky 4-GFSK Output set 0.5dB below threshold-Secondary Amp

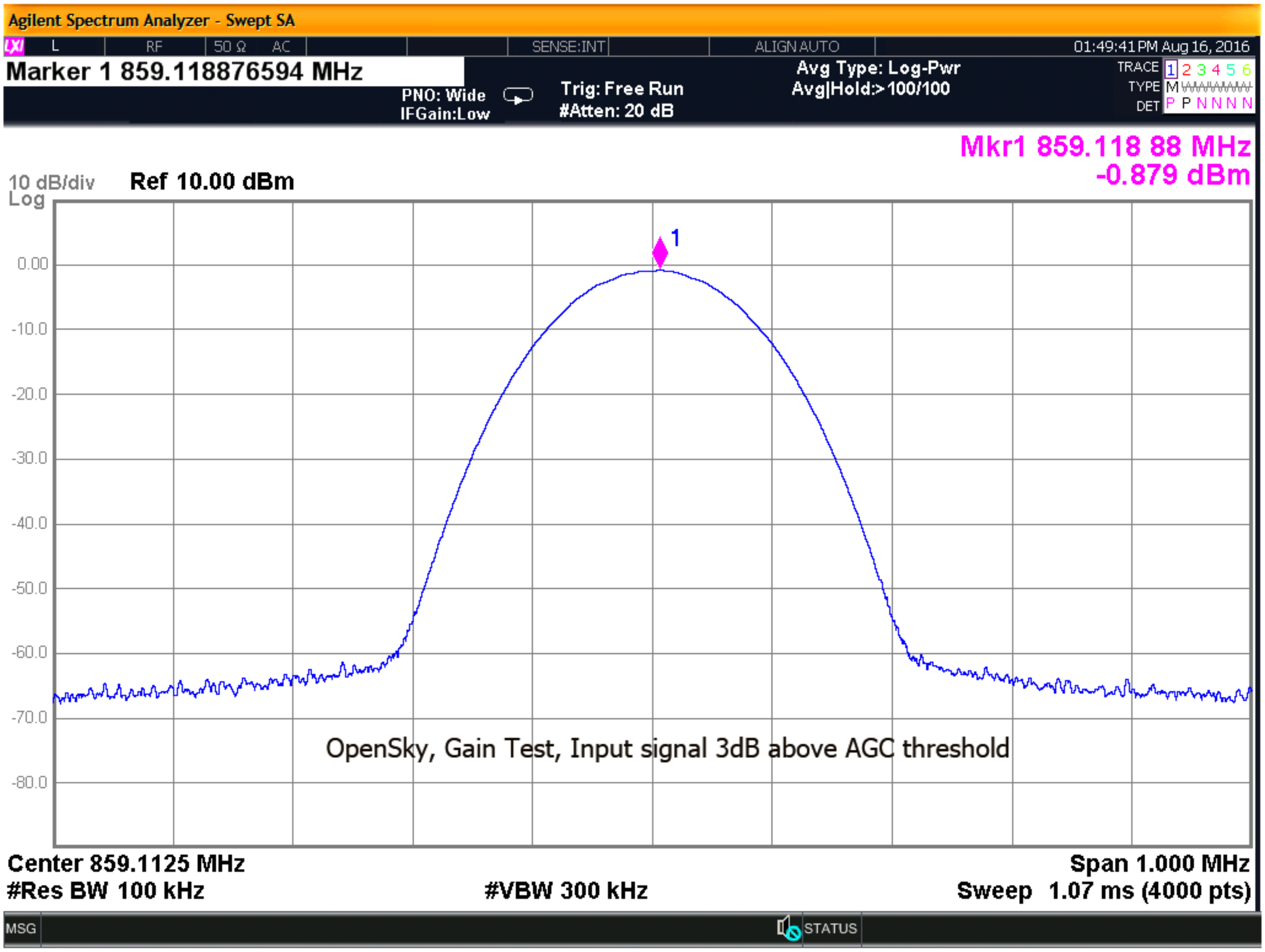


Figure 46 Power/Gain-OpenSky 4-GFSK Input set 3dB above threshold

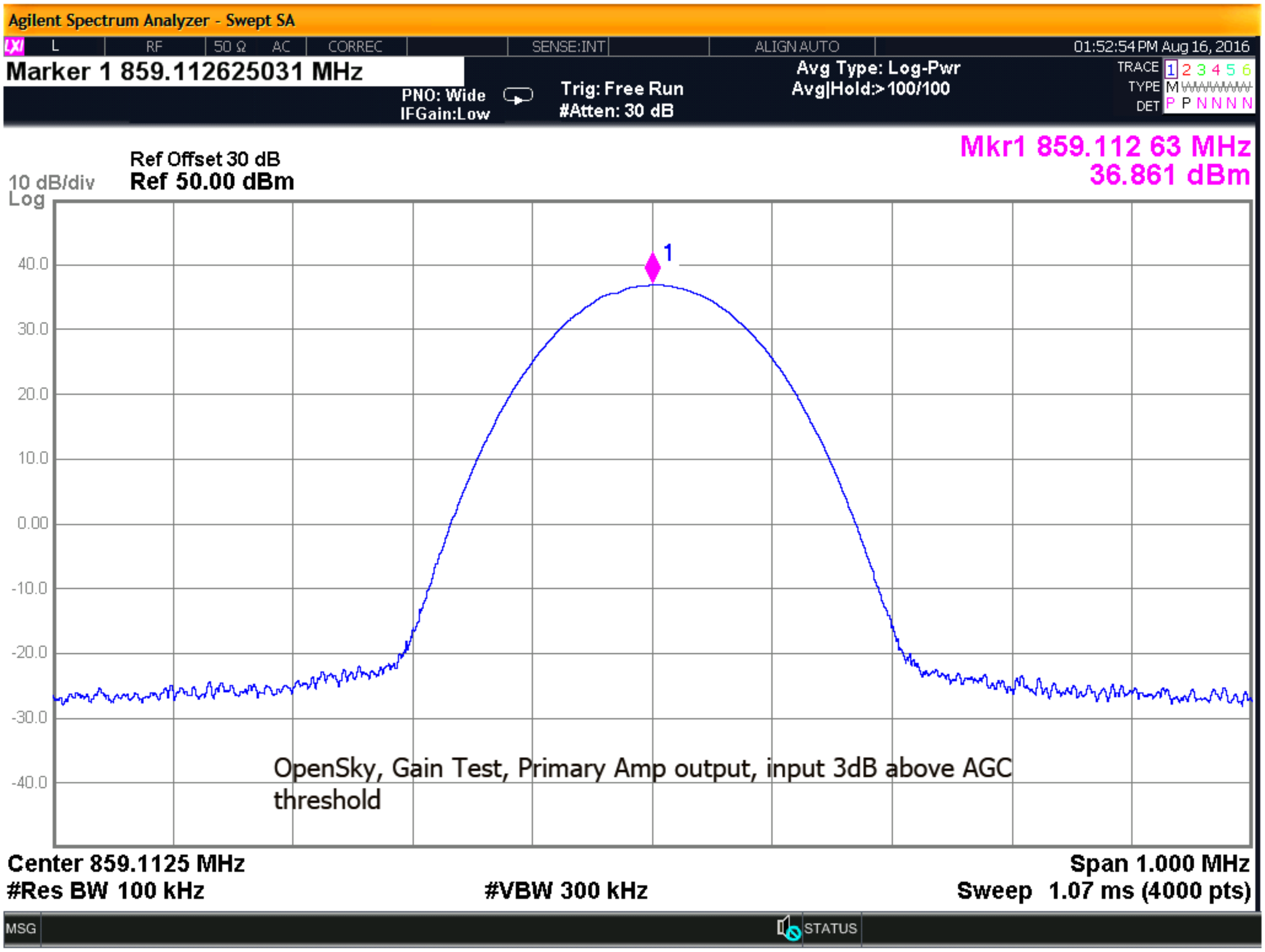


Figure 47 Power/Gain-OpenSky 4-GFSK Output set 3dB above threshold-Secondary Amp

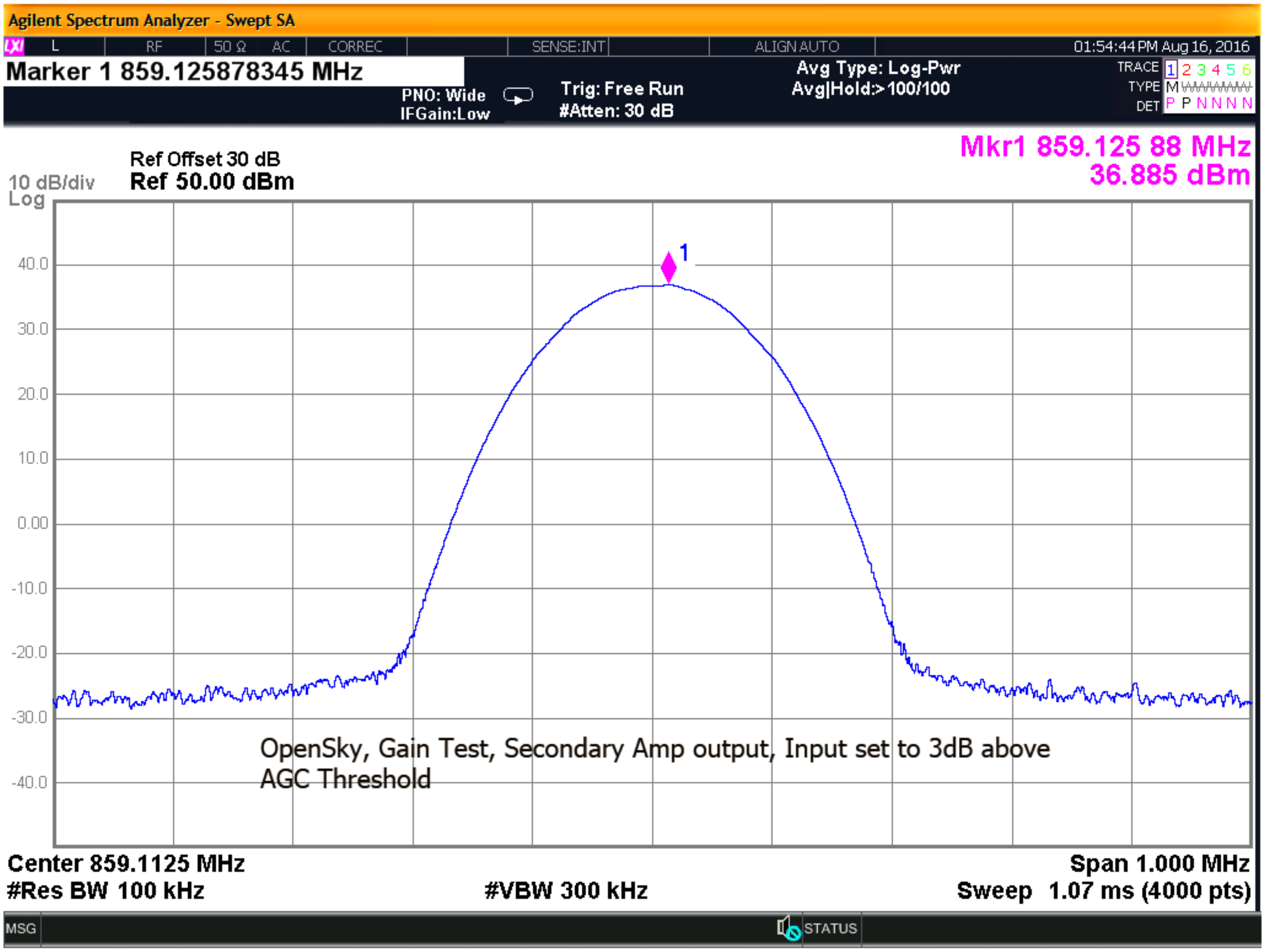


Figure 48 Power/Gain-OpenSky 4-GFSK Output set 3dB above threshold-Secondary Amp

4.5 EUT noise figure measurement (935210 DO5 section 4.6)

Section 4.6: 90.219(e)(2) limits the noise figure of a signal booster to ≤ 9 dB in either direction. The following guidance is offered with regards to measuring the noise figure to demonstrate compliance to this limitation.

There are several widely recognized methods for performing noise figure measurements. Some require the use of specialized equipment such as a noise figure analyzer and/or an excess noise ratio (ENR) calibrated noise source, while others involve the use of conventional measurement instrumentation such as a spectrum analyzer. The methodology that requires the use of a noise

figure analyzer is generally accepted as producing the most accurate results, and thus is considered to be the primary method within this document, while other methods are considered to be acceptable alternatives. Consult the relevant instrumentation application notes for detailed

guidance regarding the selection and application of an appropriate methodology for performing noise figure measurements. It should also be noted that noise figure measurements will require that any AGC circuitry be disabled over the duration of the measurement.

Since a Noise figure analyzer was not available, an alternate method utilizing the definition of

Noise Figure was utilized.

$$F_n = P_n / (kT_oBG)$$

Noise Factor Equation

Where:
F_n=Noise Factor
P_n=Power of the channel noise
k =Boltzmann's constant 1.38E-23 J/K
T0=290k
B = the channel bandwidth
G = the gain of the amplifier

$$NF = 10 \text{Log } F_n$$

Noise Figure Equation

Where:
Fn = the Noise Factor
NF = the Noise Figure

To perform the measurement, each window input was terminated with 50 ohms. The window and amplifier were enabled and the spectrum analyzer was tuned to the center frequency of window. The analyzer was configured to make a channel power measurement with an integration bandwidth of 12.5kHz since this is the typical channel bandwidth and we are interested in the amount of noise introduced to the channel by the amplifier.

4.5.1 4.5.1 Results

Each window met the requirements of ≤ 9 dB noise figure. See Table 8 for tabulated results.

Table 8: Noise Figure

Amplifier	Gain (dB)	Bandwidth (kHz)	Noise Power $\{P_n\}$ (Watts)	Noise Figure $\{F_n\}$ (dB)
851-860MHz Primary	40.170	12.5	2.51E-12	4.8
851-860 MHz Secondary	40.390	12.5	3.66E-12	6.7

4.6 Out-of-band/block (intermodulation & spurious emissions (935210 DO5 section 4.4)

Section 4.7 Specifies the limits of §90.210 apply on unwanted (out-of-band/block and spurious) emissions.

There are two requirements in this section: Intermodulation products and Spurious emissions.

KDB 935210 D05 Section 4.7.2 EUT out-of-band/block emissions conducted measurement

Intermodulation products shall be measured while applying two CW tones spaced in frequency

±12.5 kHz relative to the center frequency (f_0) as determined from 4.4.

a) Connect a signal generator to the input of the EUT.

NOTE—If the signal generator is not capable of producing two independent modulated carriers simultaneously, then two discrete signal generators can be connected with an appropriate combining network to support the two-tone test.

b) Configure the two signal generators to produce CW tones on frequencies spaced at ± 12.5 kHz relative to f_0 with amplitude levels set just below the AGC threshold (see 4.2).

c) Connect a spectrum analyzer to the EUT output.

d) Set the span to 100 kHz.

e) Set the resolution bandwidth to 300 Hz with a video bandwidth ≥ 3 × RBW. f) Set the detector to power average (rms).

g) Place a marker on highest intermodulation product amplitude. h) Capture the plot for inclusion in the test report.

4.6.1 Results

No intermodulation products exceed the limits. See Table 9 for tabular results. See

Figure 49 through Figure 60 for the plots.

Table 9: Intermodulation products

Frequency Band (MHz)	Input level (AGC Threshold at -4 dBm)	Channel Spacing (KHz)	Maximum Intermodulation Level (dBm)	Limit (dBm)	Margin (db)
851-854	-4.5dBm	12.5	-23.42	-13	-10.42
851-854	-1.0dBm	25	-17.48	-13	-4.48
854-869	-4.5dBm	12.5	-16.68	-13	-3.68
854-869	-1.0dBm	25	-17.67	-13	-4.67

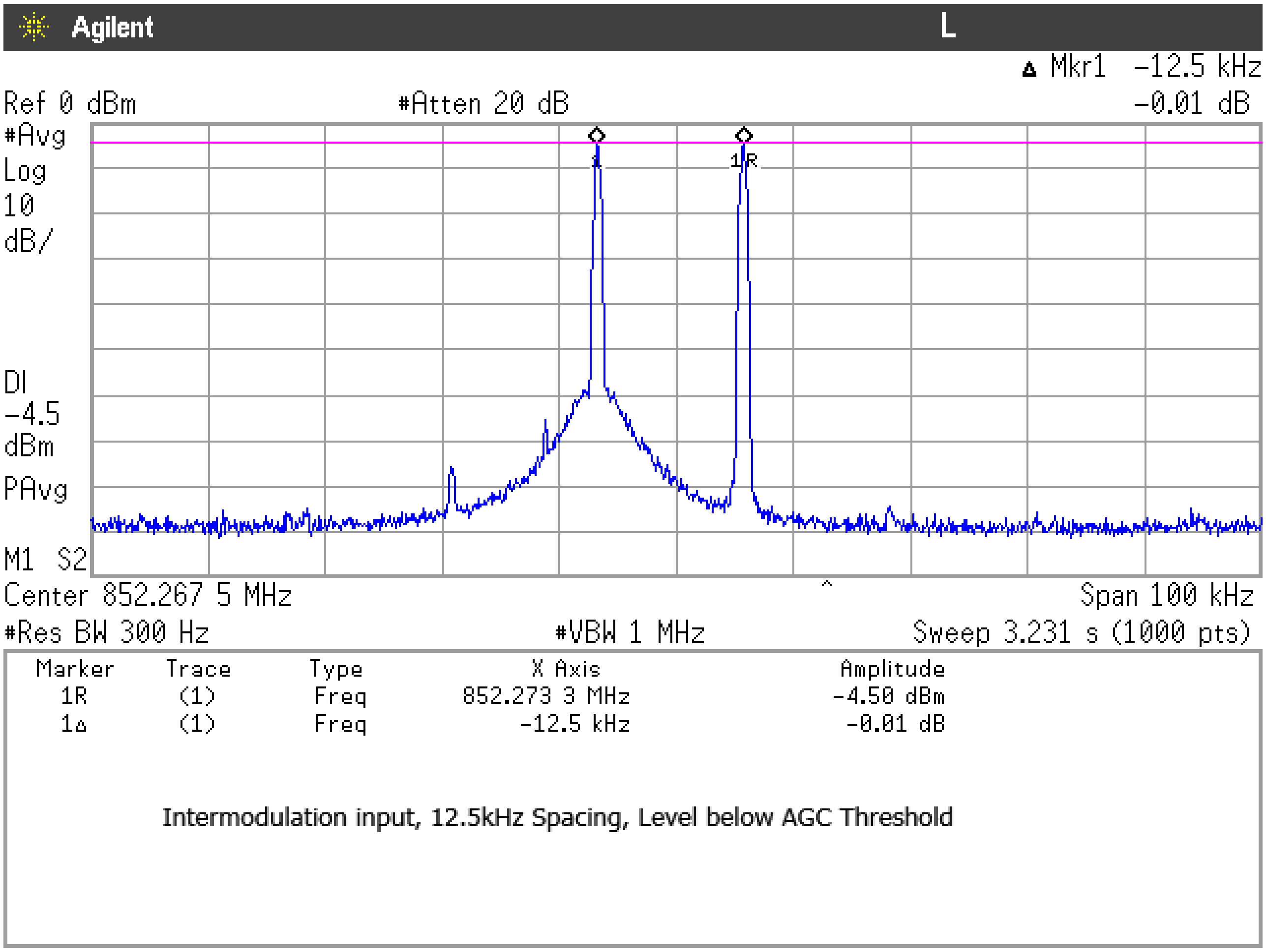


Figure 49: Intermod, 851-854MHz Band, 12.5 kHz, Input below AGC

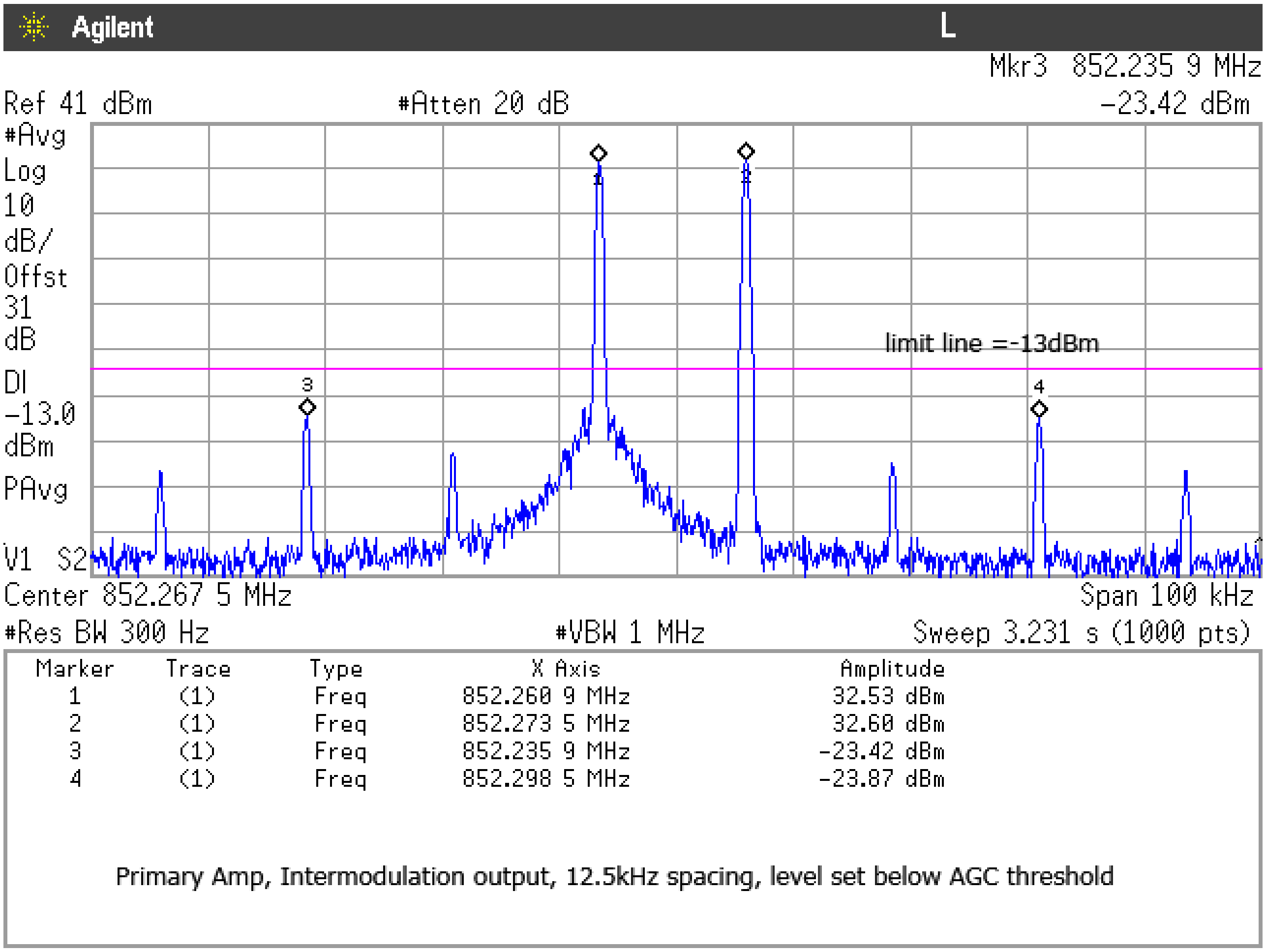


Figure 50: Intermod, 851-854MHz Band, 12.5kHz, Primary Amp, Input below AGC

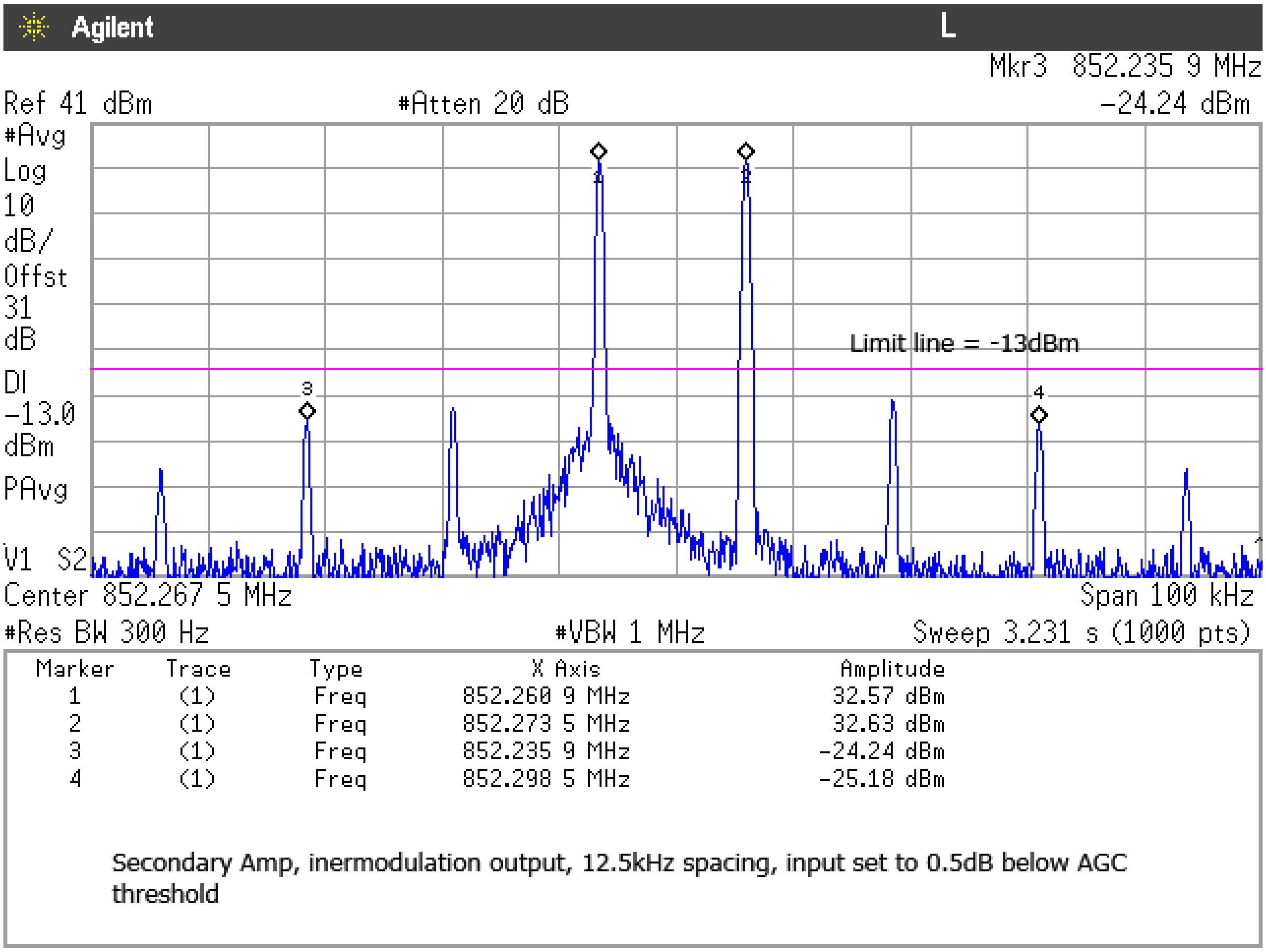


Figure 51: Intermod, 851-854MHz Band, 12.5kHz, Secondary Amp, Input below AGC

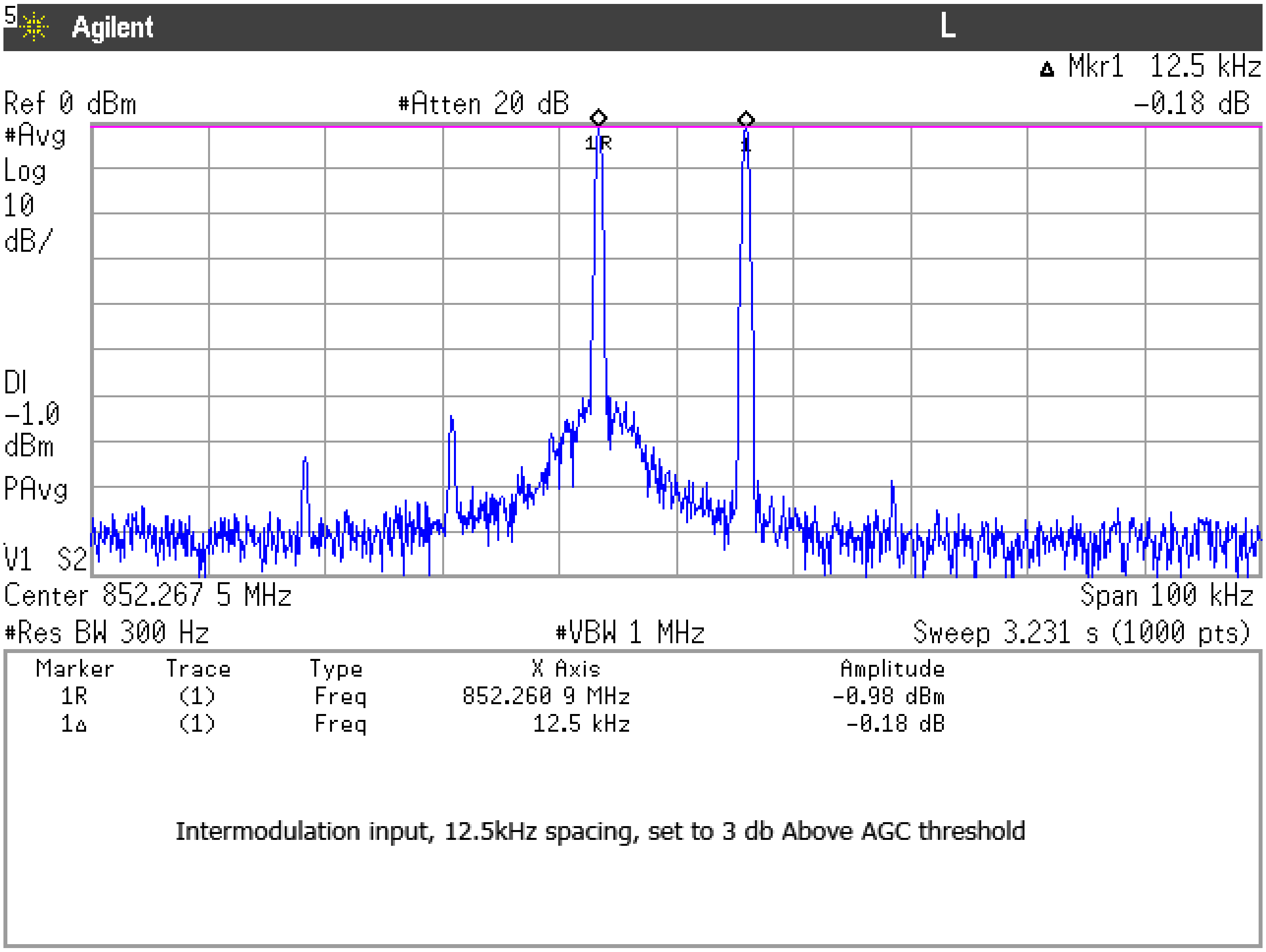
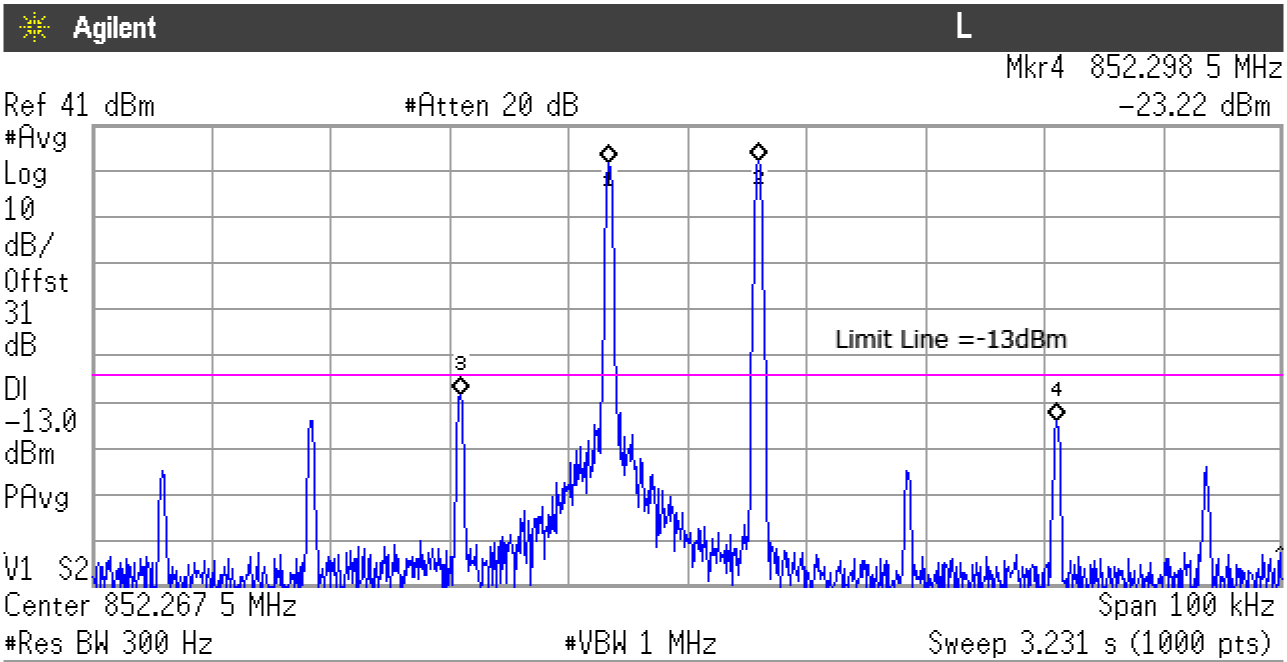


Figure 52: Intermod, 851-854MHz Band, 12.5kHz, Input above AGC



Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	852.260 9 MHz	32.95 dBm
2	(1)	Freq	852.273 5 MHz	33.16 dBm
3	(1)	Freq	852.248 4 MHz	-17.48 dBm
4	(1)	Freq	852.298 5 MHz	-23.22 dBm

Primary Amp, Intermodulation output, 12.5kHz spacing, level set above AGC threshold

Figure 53: Intermod, 851-854MHz Band, 12.5kHz, Primary Amp, Input above AGC

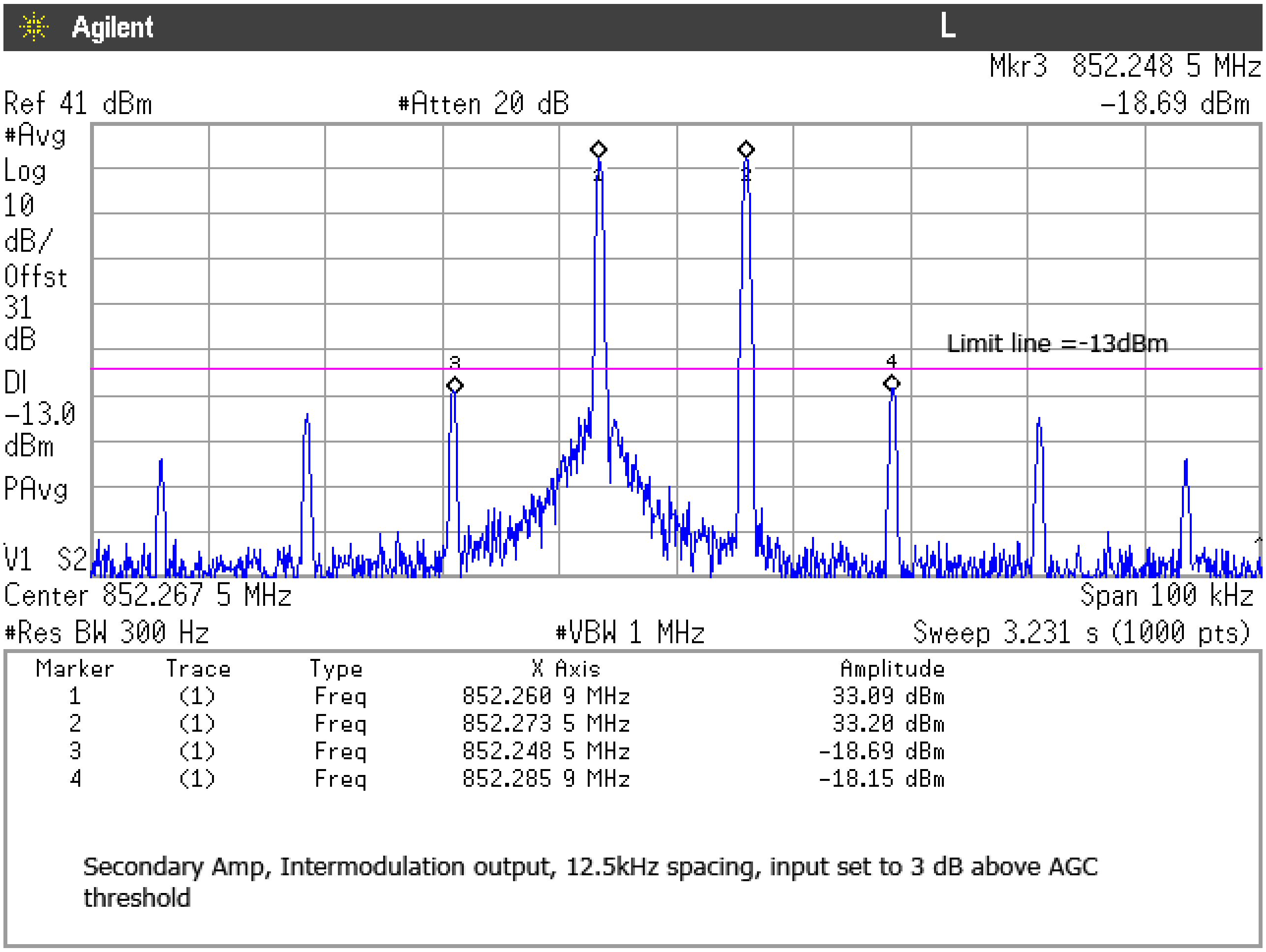


Figure 54: Intermod, 851-854MHz Band, 12.5kHz, Secondary Amp, Input above AGC

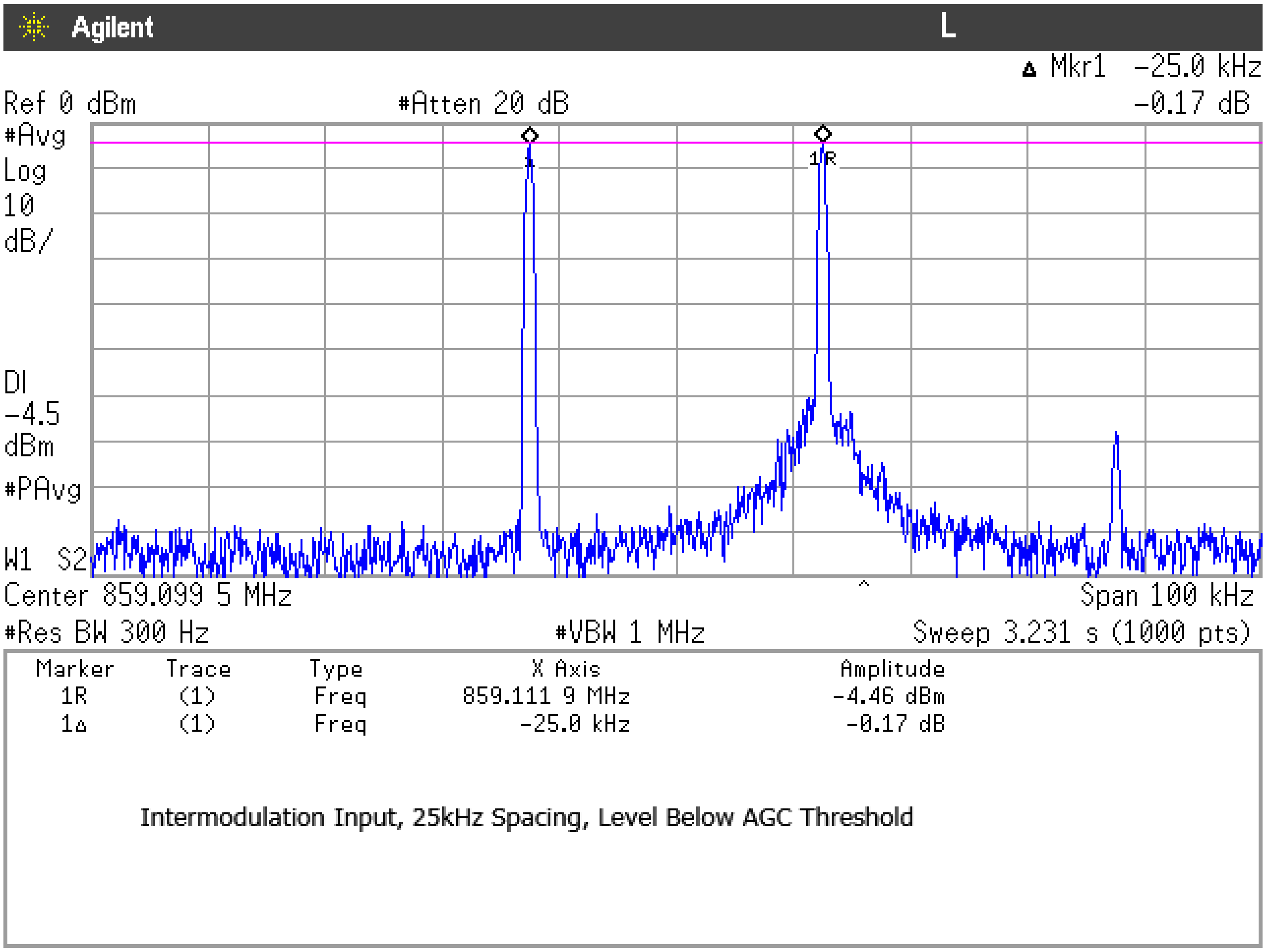


Figure 55: Intermod, 854-869MHz Band, 25kHz, Input below AGC

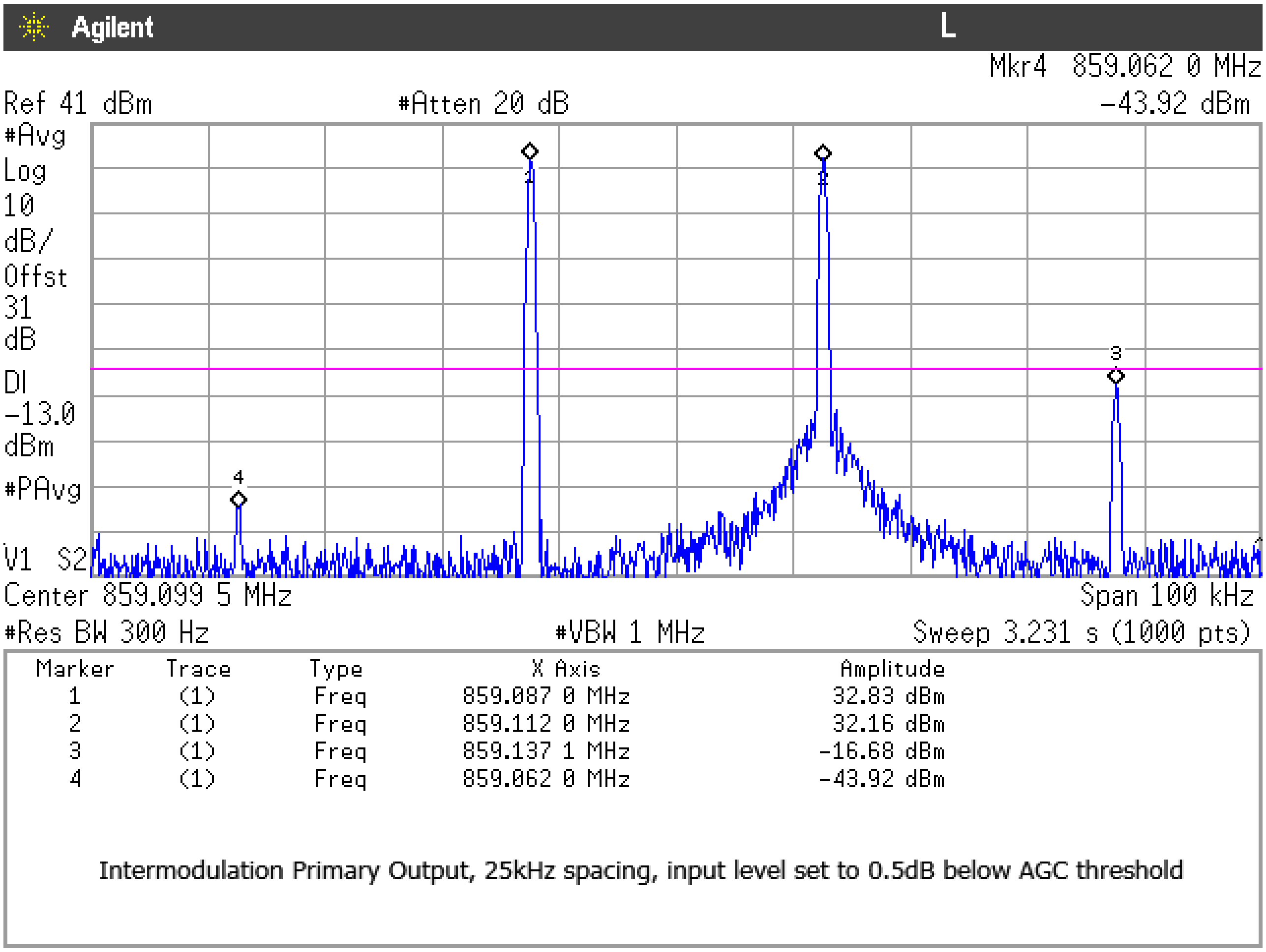


Figure 56: Intermod, 854-869MHz Band, 25kHz, Primary Amp, Input below AGC

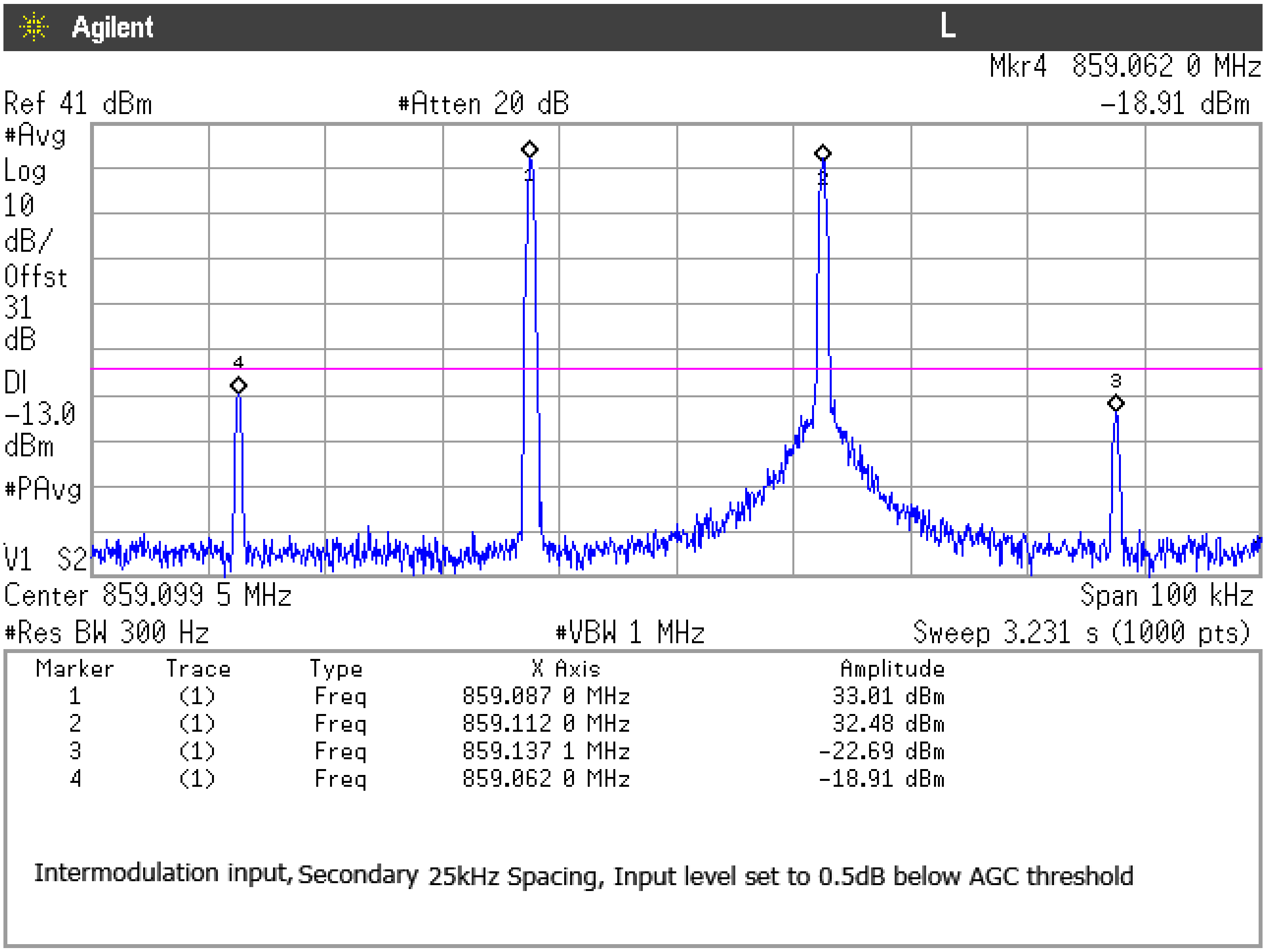


Figure 57: Intermod, 854-869MHz Band, 25kHz, Secondary Amp, Input below AGC

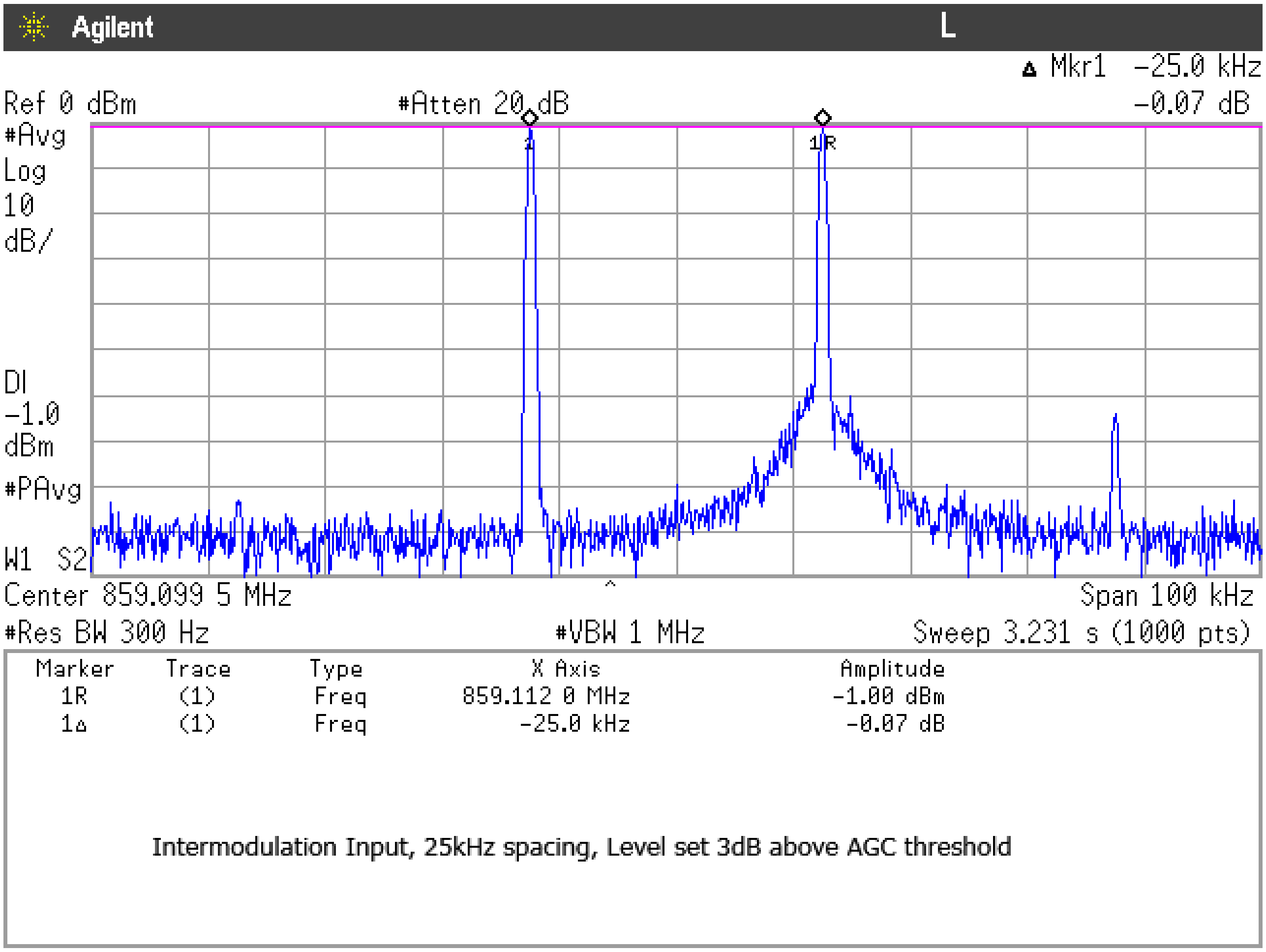


Figure 58: Intermod, 854-869MHz Band, 25kHz, Input above AGC

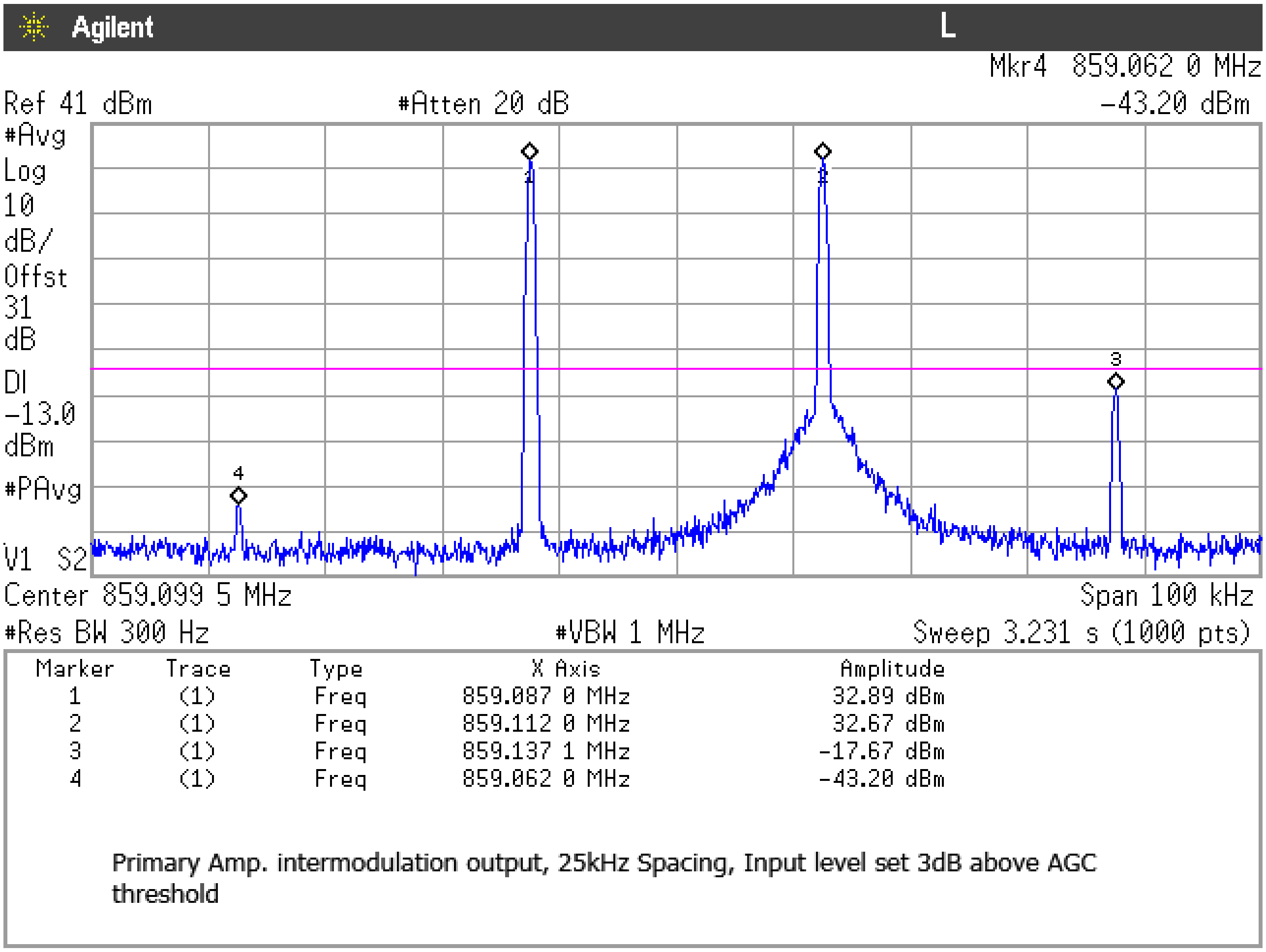


Figure 59: Intermod, 854-869MHz Band, 25kHz, Primary Amp, Input above AGC

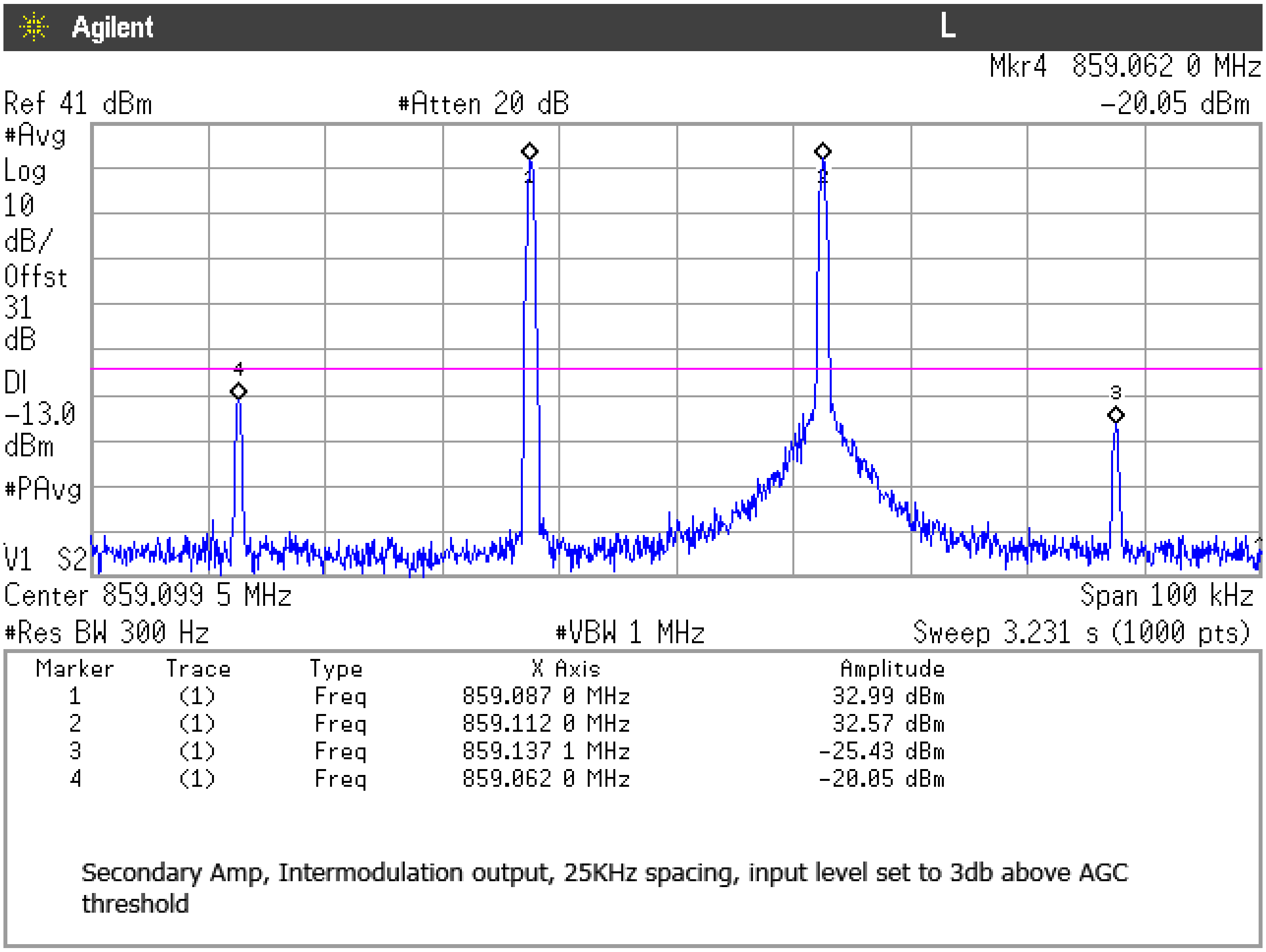


Figure 60: Intermod, 854-869MHz Band, 25kHz, Secondary Amp, Input above AGC

4.6.2 KDB 935210 D05 Section 4.7.3 EUT spurious emissions conducted measurement

a) Connect a signal generator to the input of the EUT.

b) Configure the signal generator to produce a CW signal.

c) Set the frequency of the CW signal to the center channel of the pass band.

d) Set the output power level so that the resultant signal is just below the AGC threshold (see 4.2).

e) Connect a spectrum analyzer to the output of the EUT using appropriate attenuation as necessary.

f) Set the RBW to 100 kHz.

g) Set the VBW = 3 × RBW.

h) Set the Sweep time = auto-couple. i) Set the detector to PEAK.

j) Set the analyzer start frequency to 30 MHz (or the lowest radio frequency signal generated in the equipment, without going below 9 kHz if the EUT has internal clock frequencies) and the stop frequency to 10 × the highest allowable frequency of the pass band.

k) Select MAX HOLD and use the marker peak function to find the highest emission(s) outside the pass band. (This could be either at a frequency lesser or greater than the pass band.)

l) Capture a plot for inclusion in the test report.

m) Repeat steps c) to l) for each authorized frequency band/block of operation.

As the out of band limits for the 851-854MHz and 854-869MHz bands have the same value (-13dBm) with the test modulation set to CW, a low middle and high frequency was selected from the 851 to 860MHz range (859.5125Hz is the highest EUT channel)

4.6.2.1 Results

No out of band spurious emissions exceeded the limits in any band of operation. See Figure 61 through Figure 96 for the plots of the spurious emissions.

The EUT complies with FCC 219(e)(3) that a booster must not exceed -13dBm in any 100kHz bandwidth.

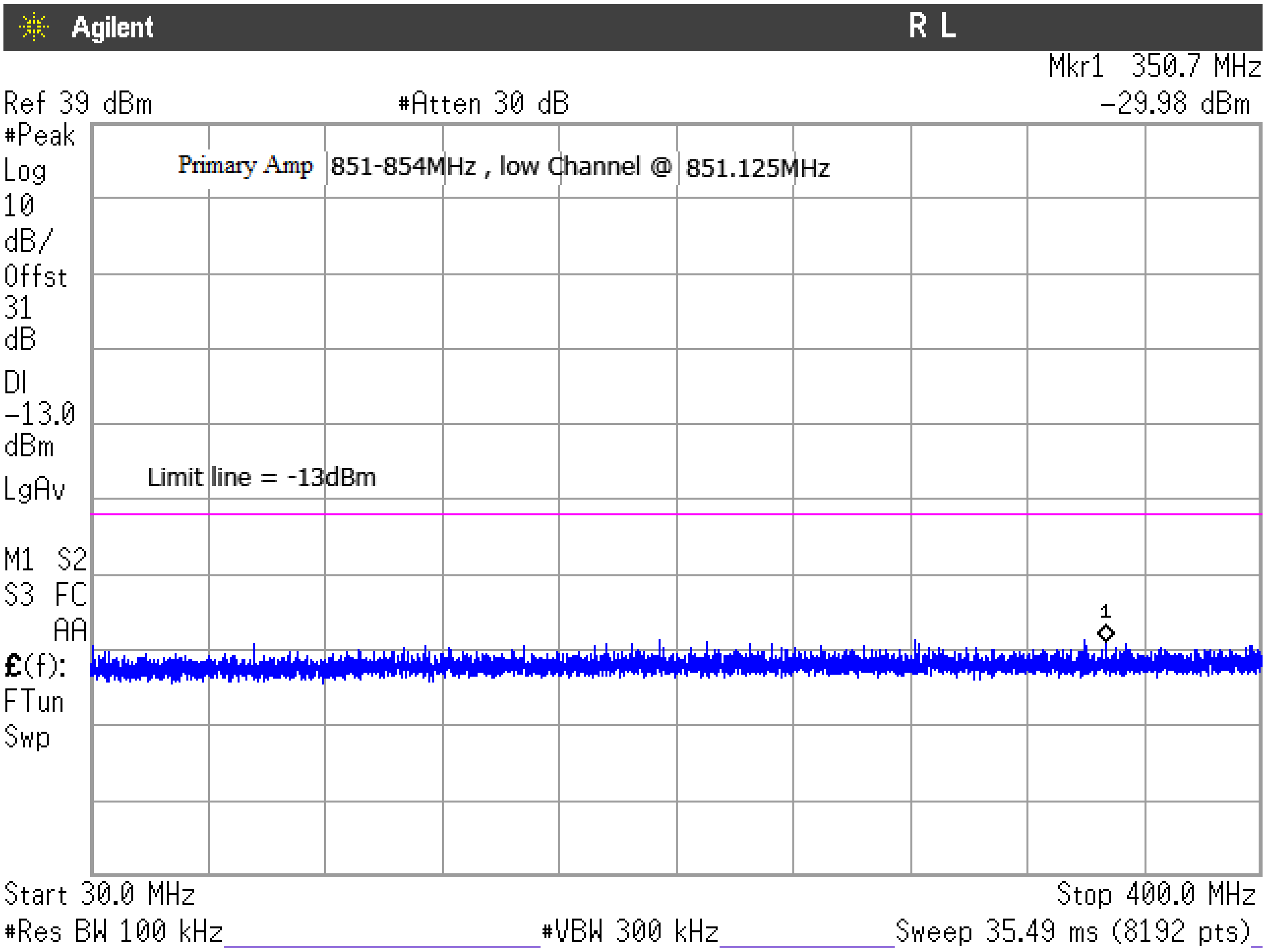


Figure 61: Conducted Spurious 851-860MHz, Primary Amp, Low Channel 30-400MHz

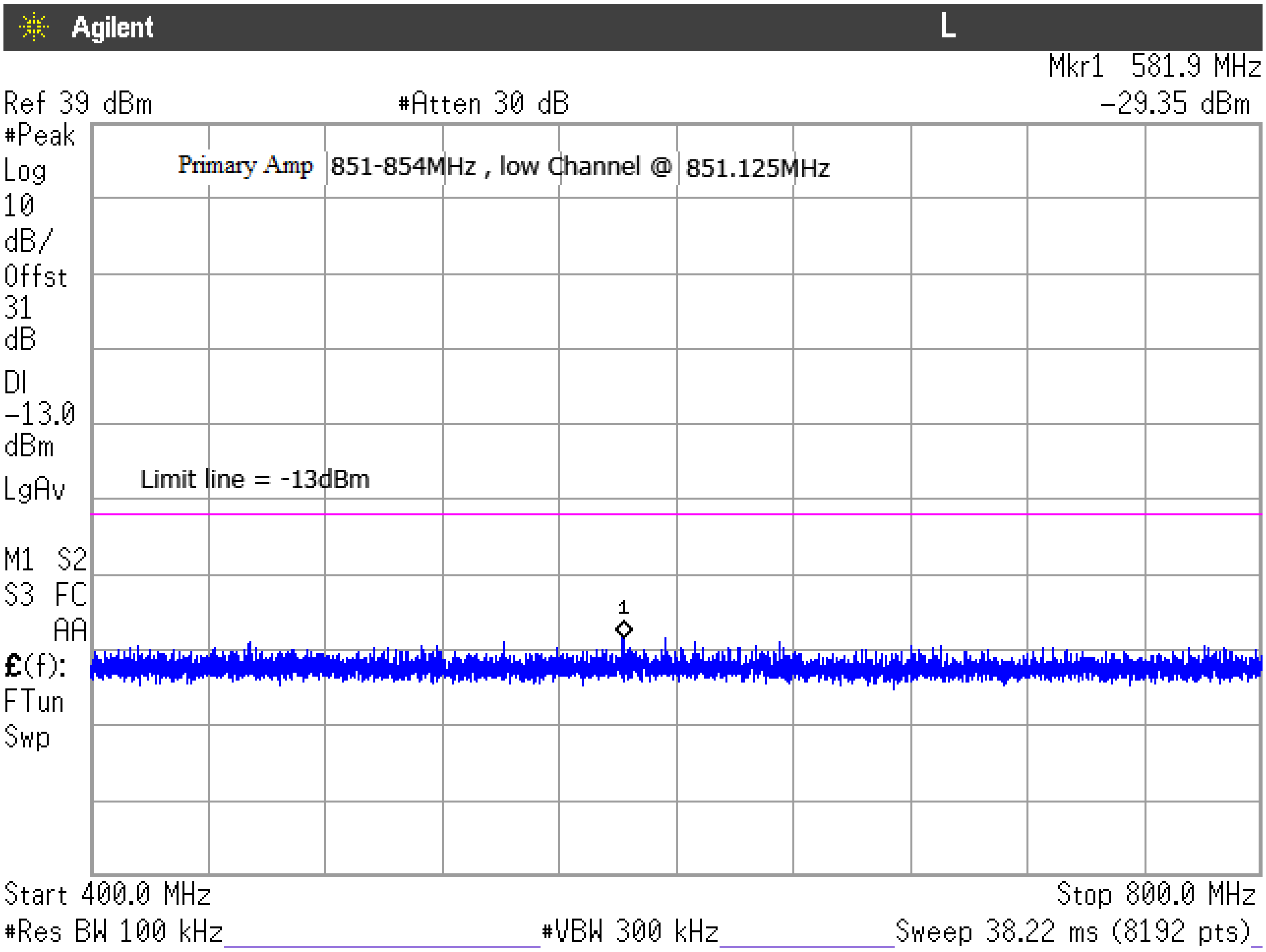


Figure 62: Conducted Spurious 851-860MHz, Primary Amp, Low Channel 400-800MHz

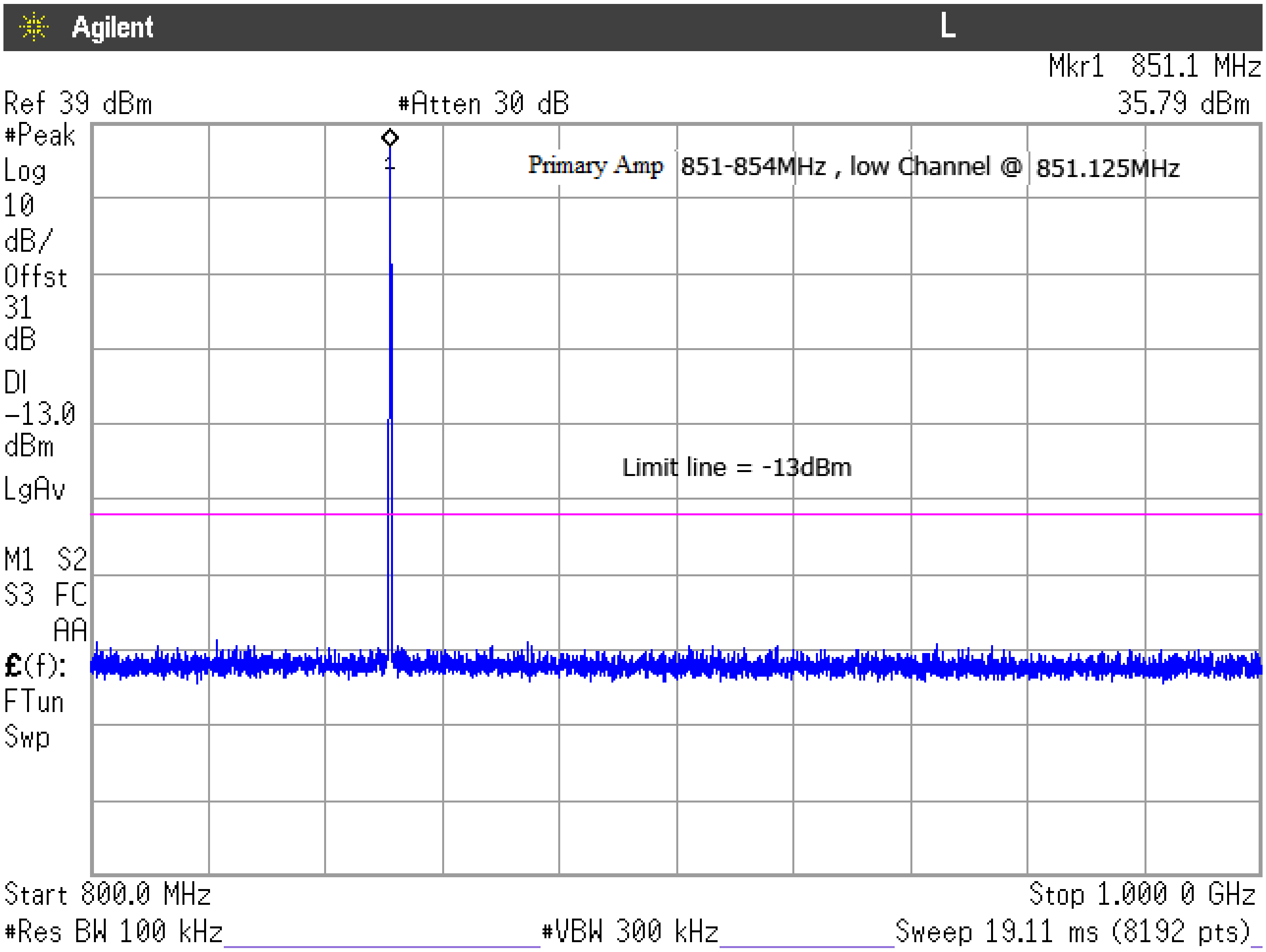


Figure 63: Conducted Spurious 851-860MHz, Primary Amp, Low Channel 800-1000MHz

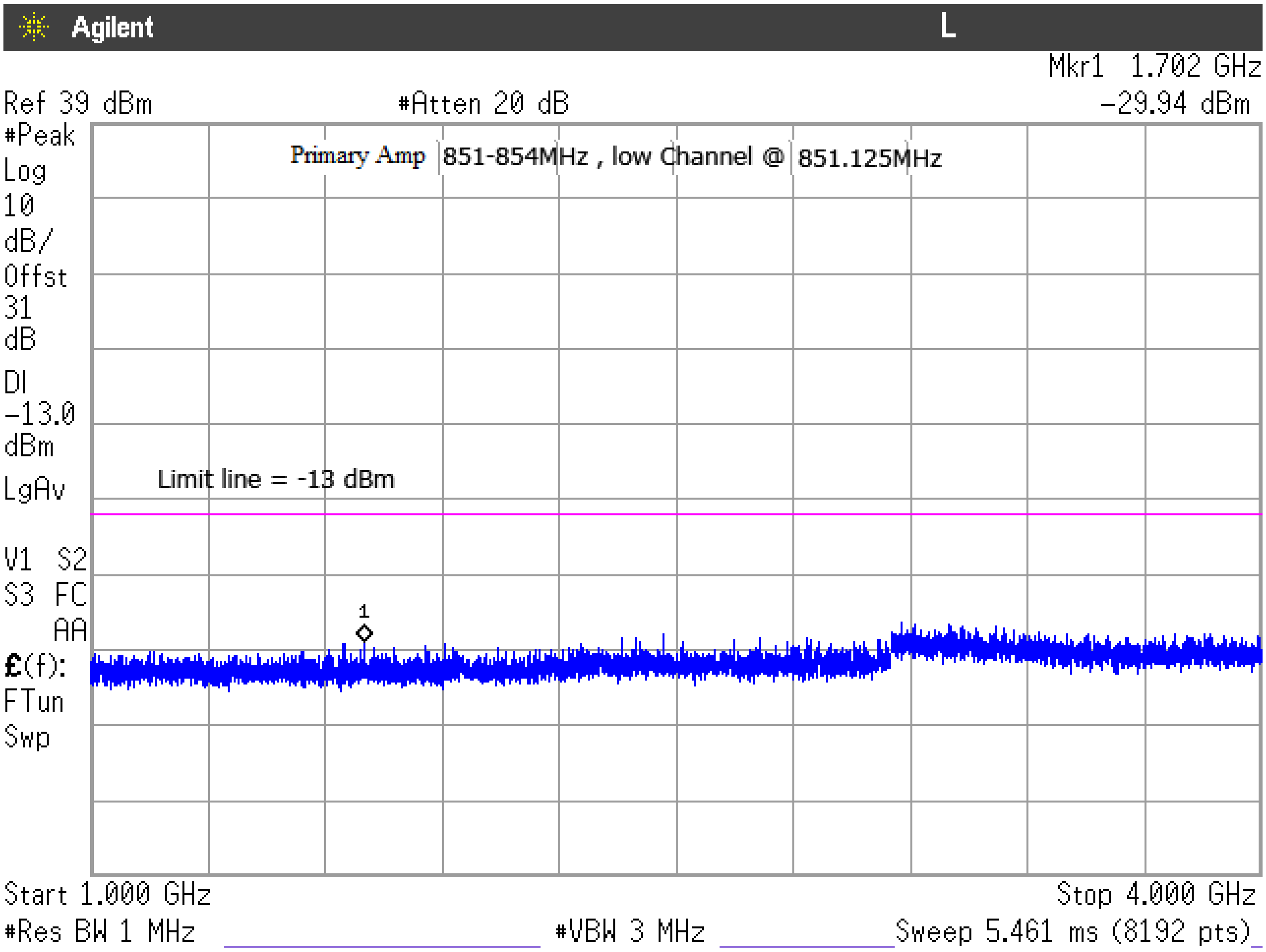


Figure 64: Conducted Spurious 851-860MHz, Primary Amp, Low Channel 1-4GHz

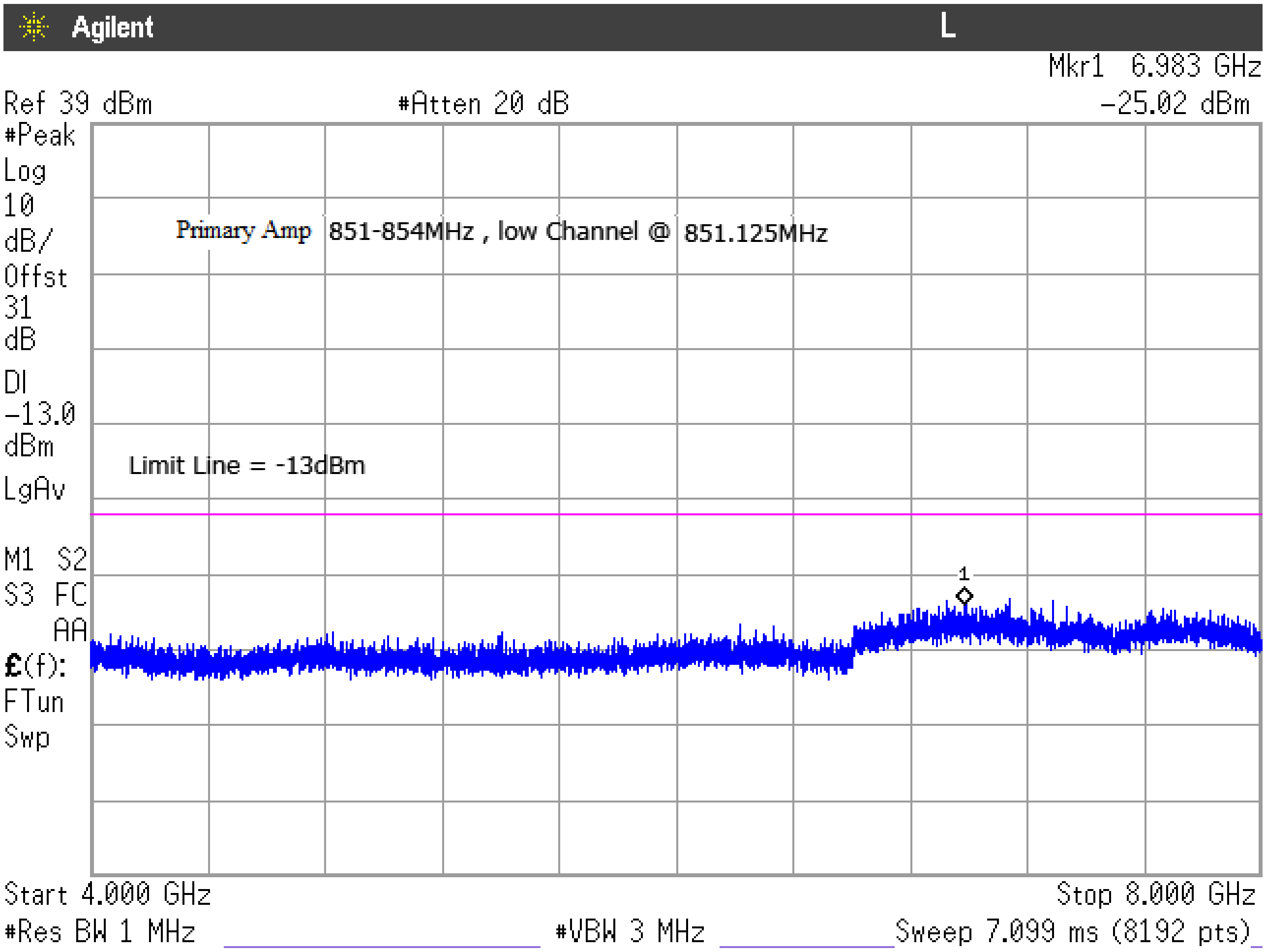


Figure 65: Conducted Spurious 851-860MHz, Primary Amp, Low Channel 4-8GHz

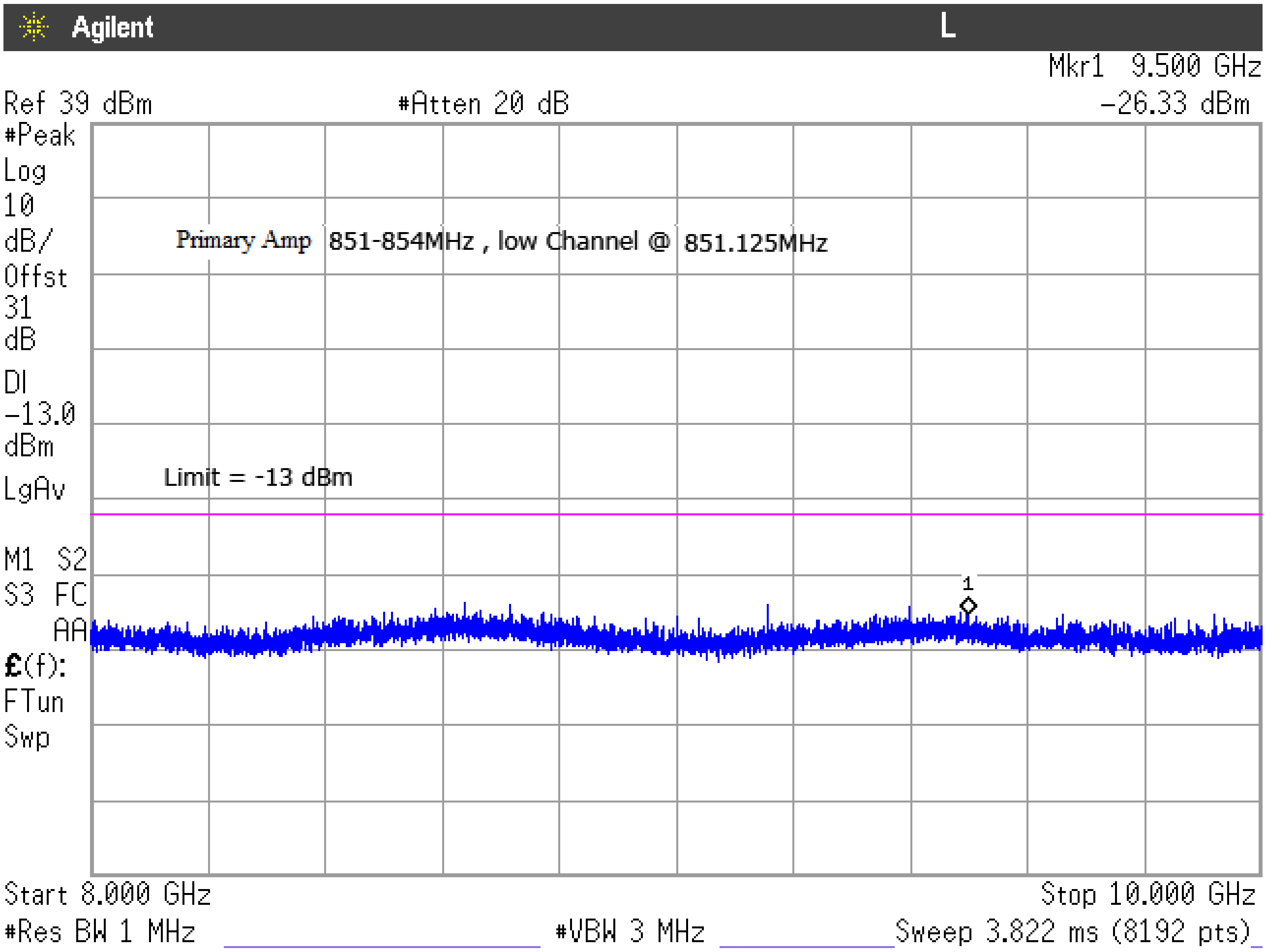


Figure 66: Conducted Spurious 851-860MHz, Primary Amp, Low Channel 8-10GHz

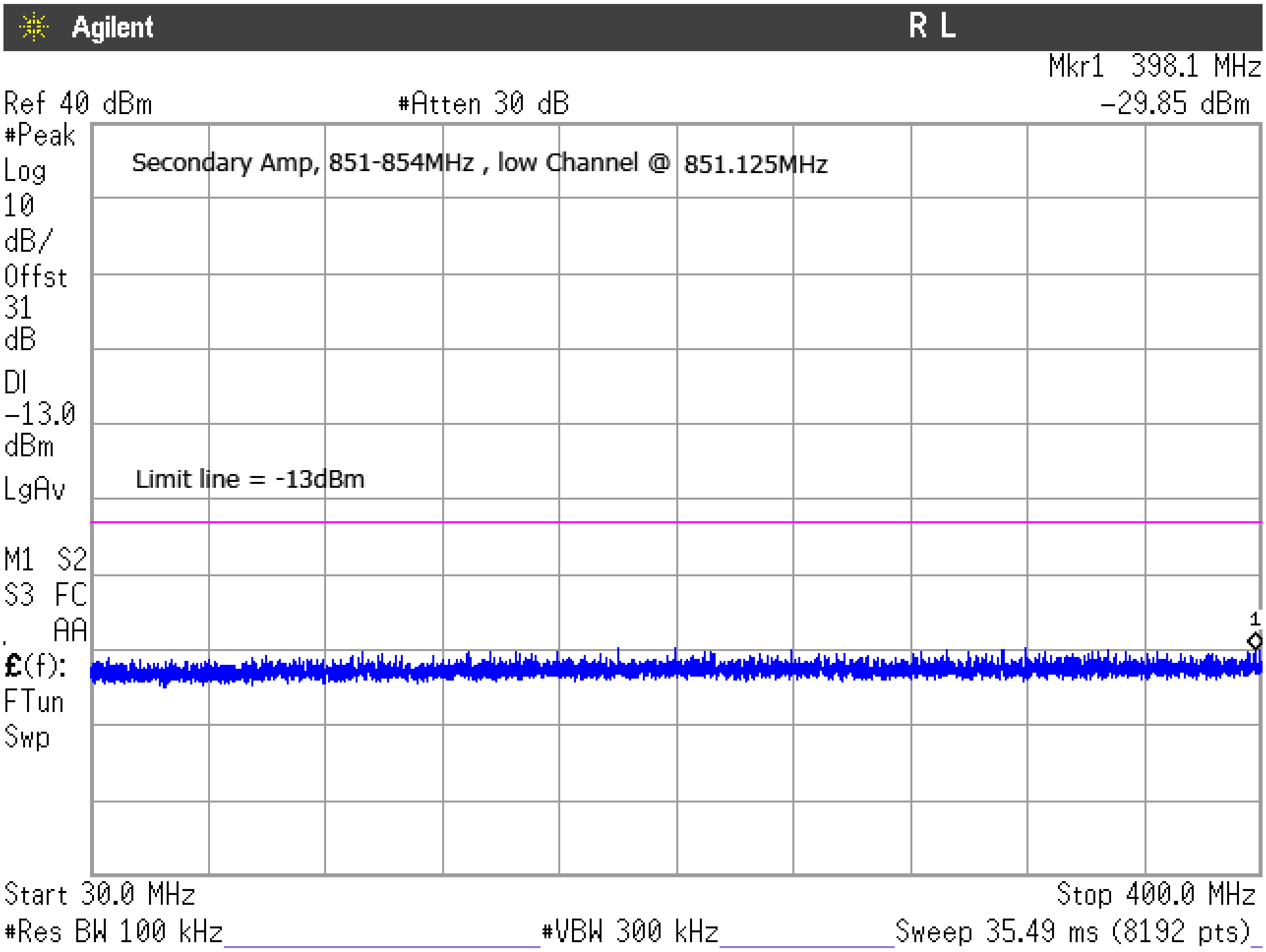


Figure 67: Conducted Spurious 851-860MHz, Secondary Amp, Low Channel 30-400MHz

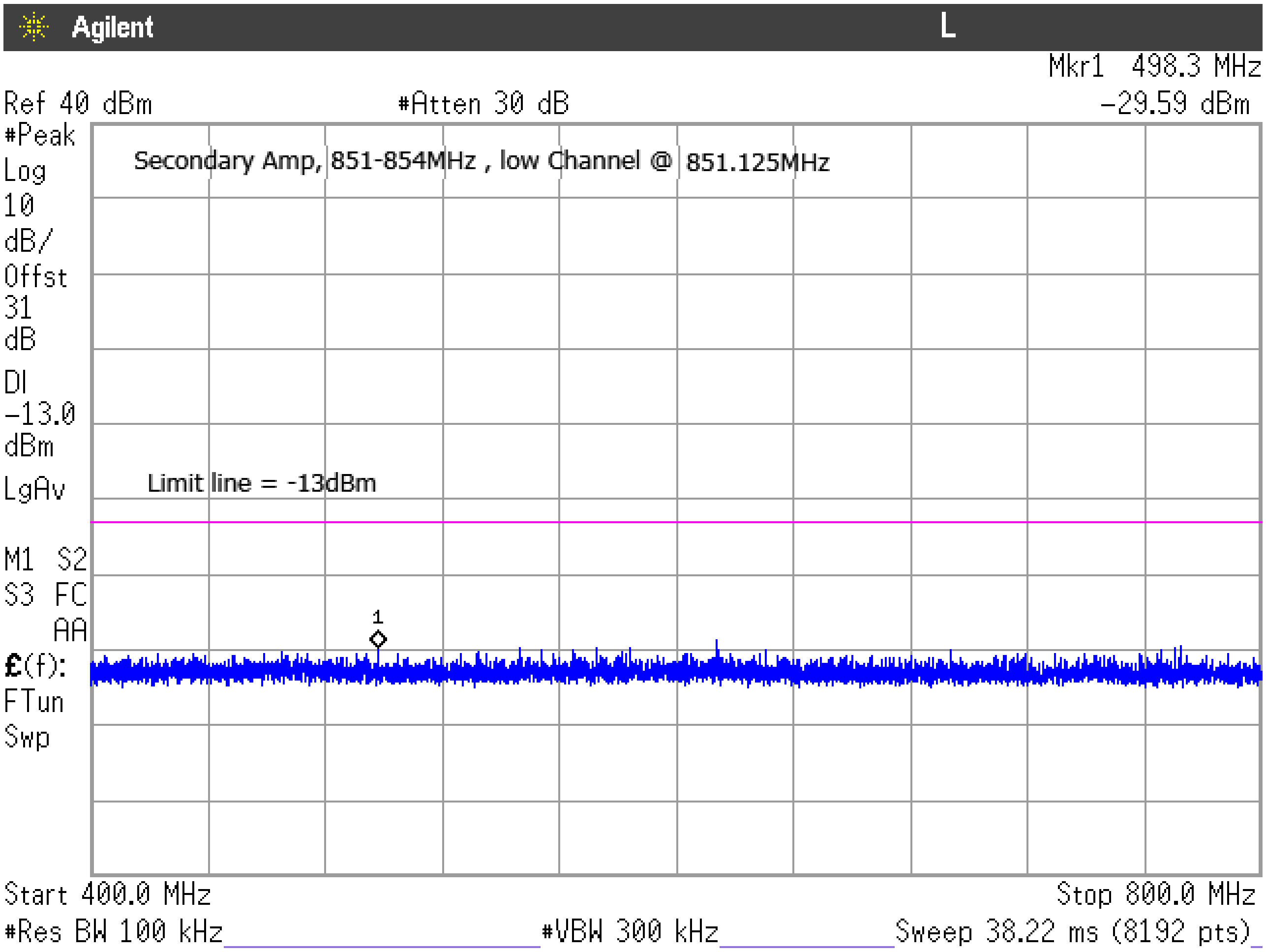


Figure 68: Conducted Spurious 851-860MHz, Secondary Amp, Low Channel 400-800MHz

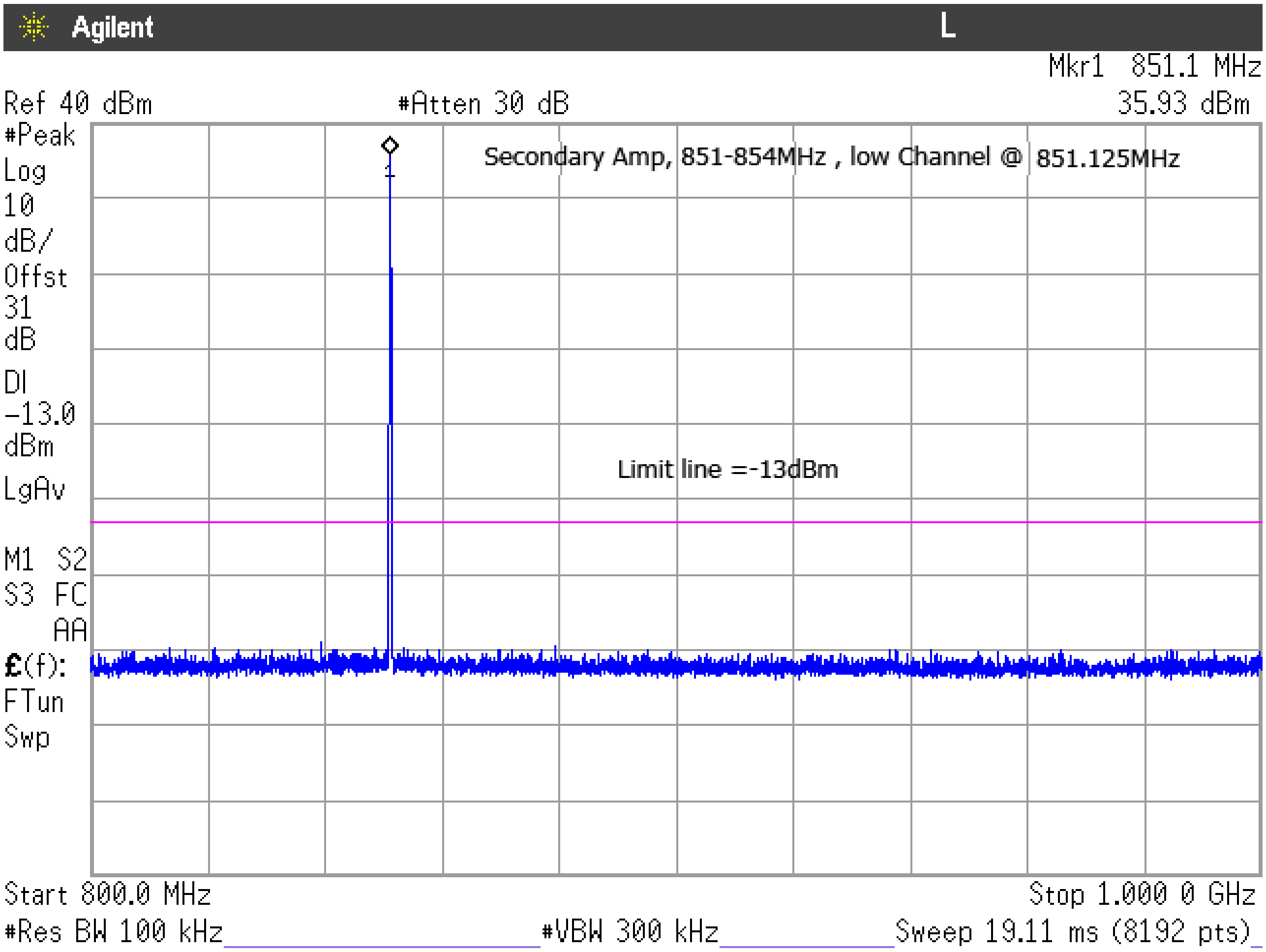


Figure 69: Conducted Spurious 851-860MHz, Secondary Amp, Low Channel 800-1000MHz

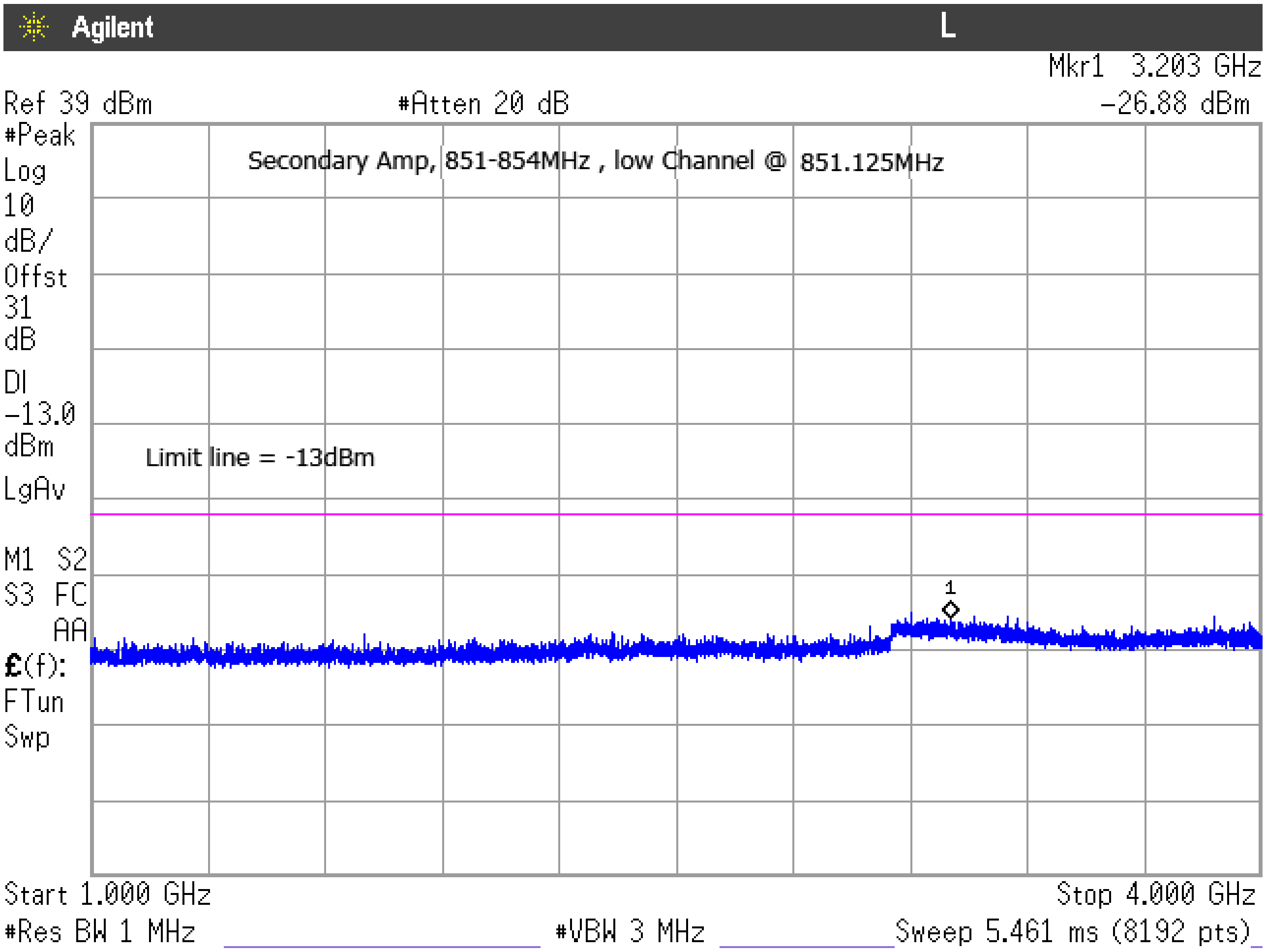


Figure 70: Conducted Spurious 851-860MHz, Secondary Amp, Low Channel 1-4GHz

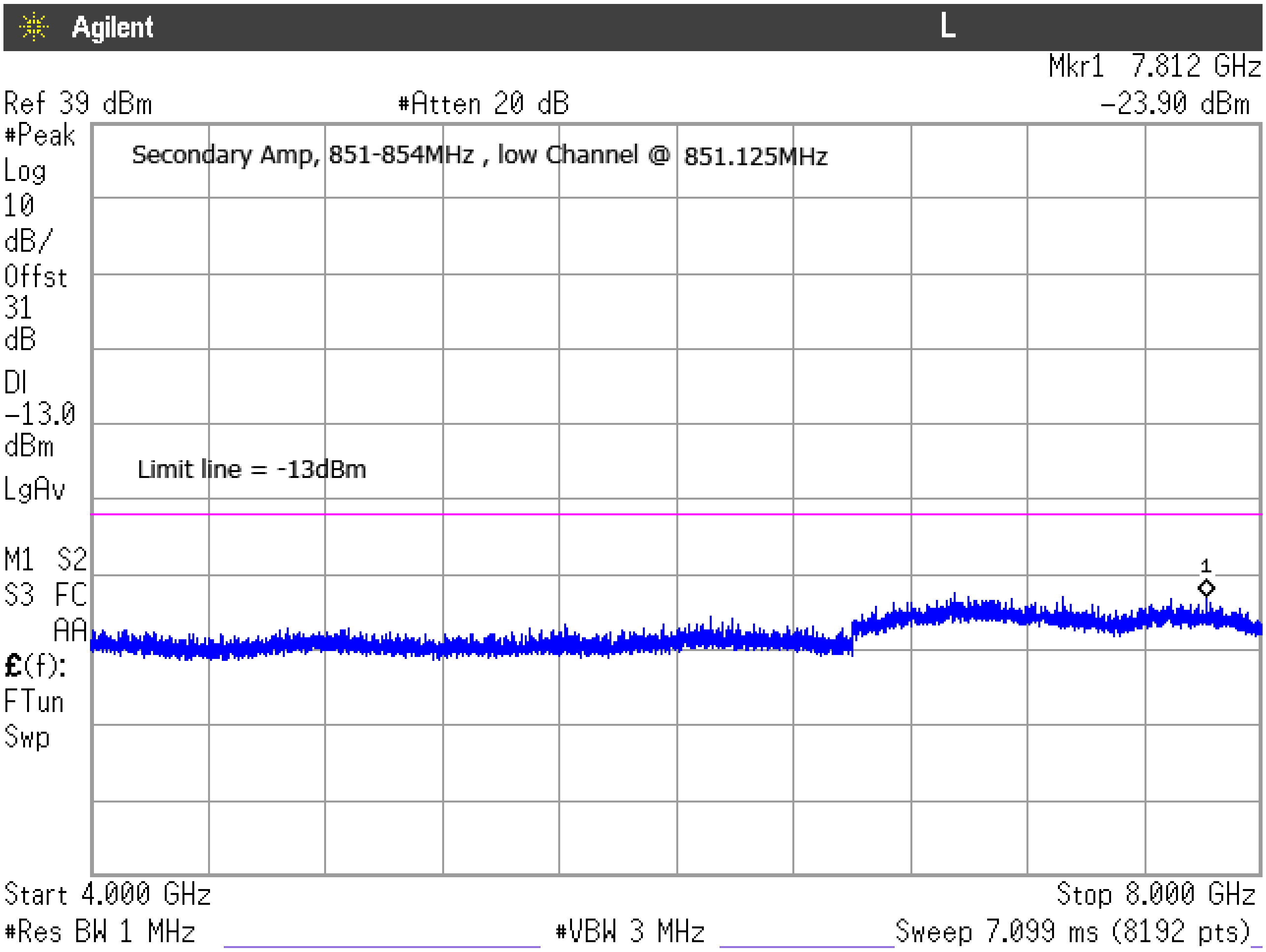


Figure 71: Conducted Spurious 851-860MHz, Secondary Amp, Low Channel 4-8GHz

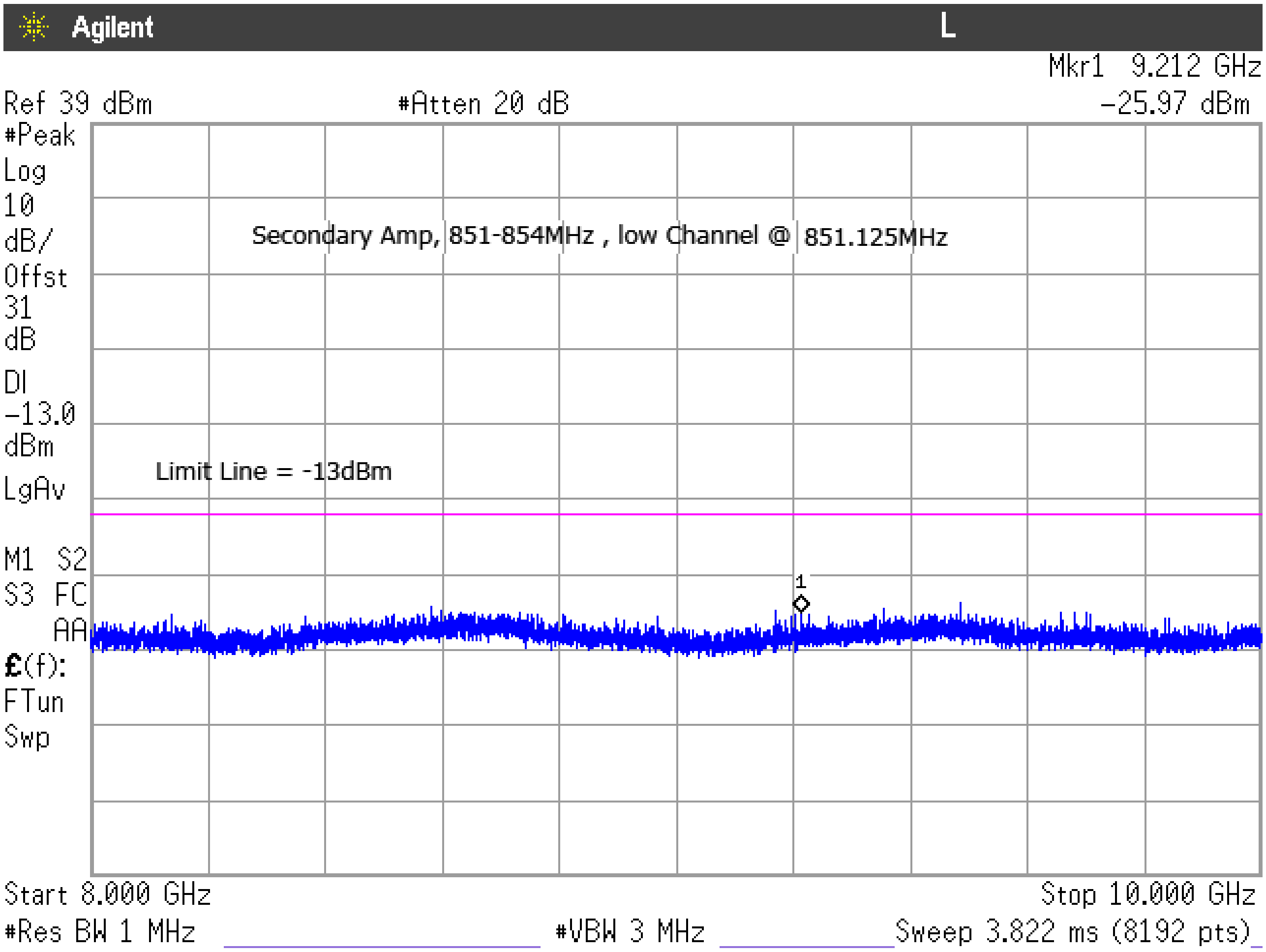


Figure 72: Conducted Spurious 851-860MHz, Secondary Amp, Low Channel 8-10GHz

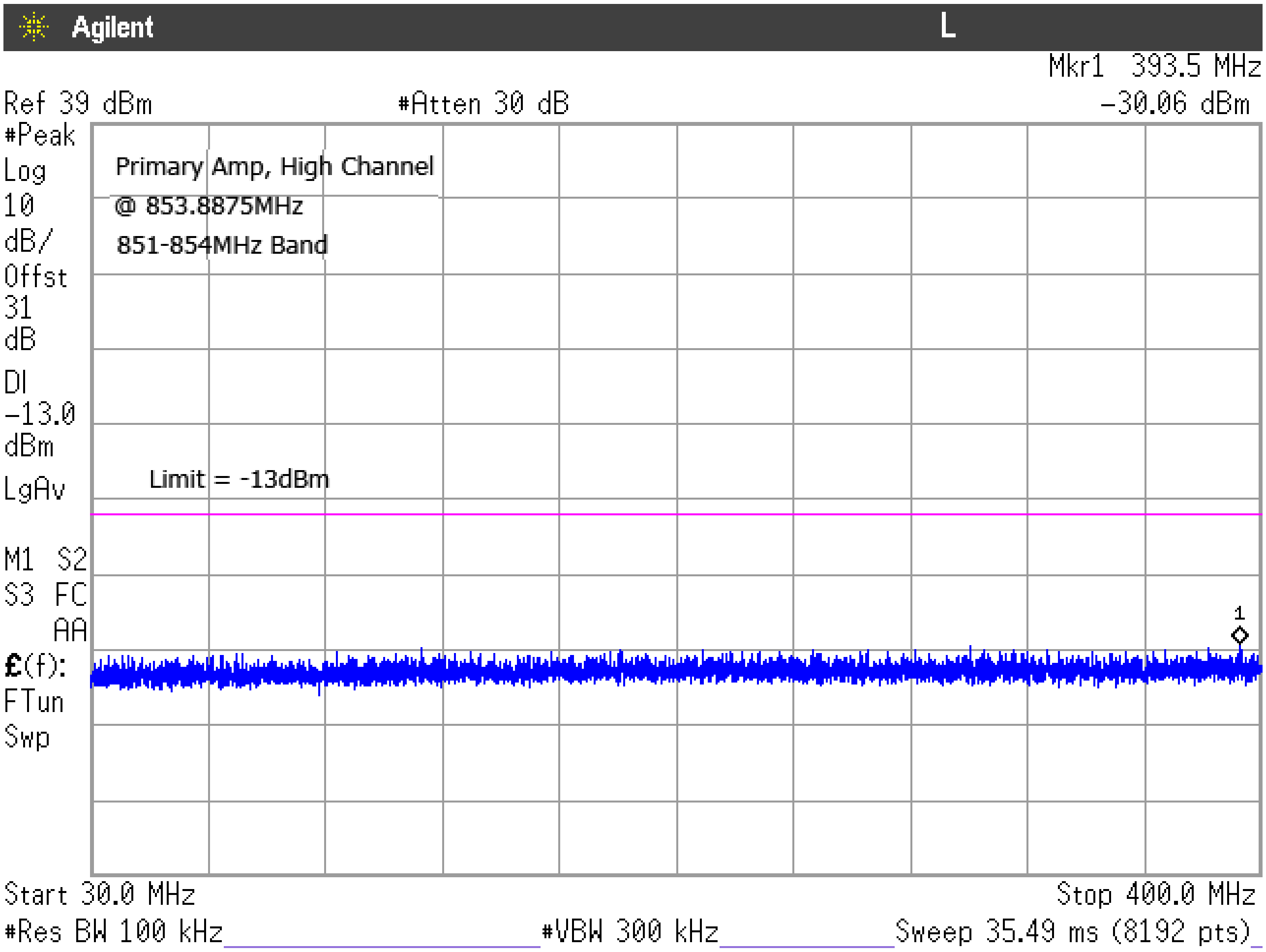


Figure 73: Conducted Spurious 851-860MHz, Primary Amp, Center Channel 30-400MHz

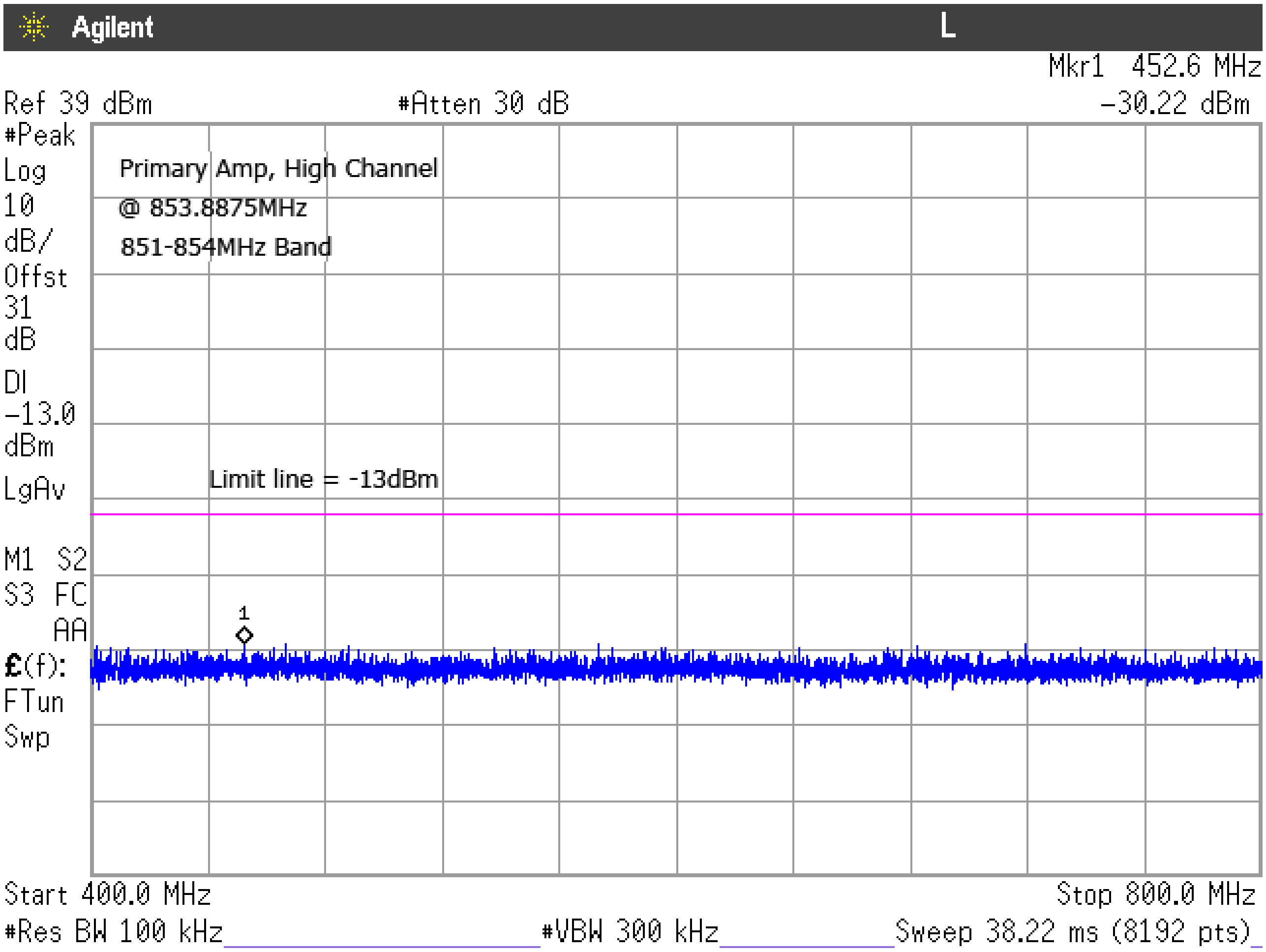


Figure 74: Conducted Spurious 851-860MHz, Primary Amp, Center Channel 400-800MHz

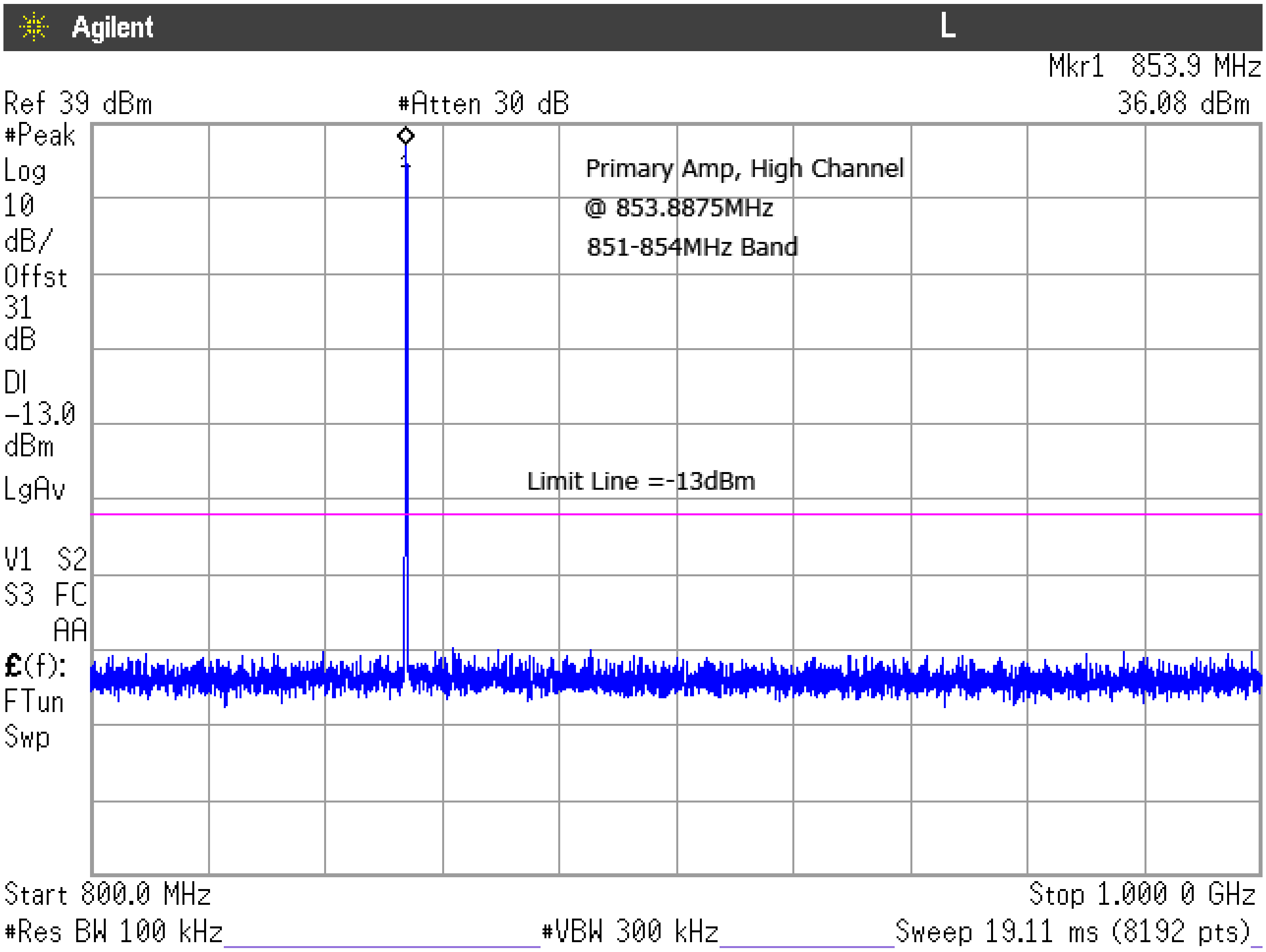


Figure 75: Conducted Spurious 851-860MHz, Primary Amp, Center Channel 800-1000MHz

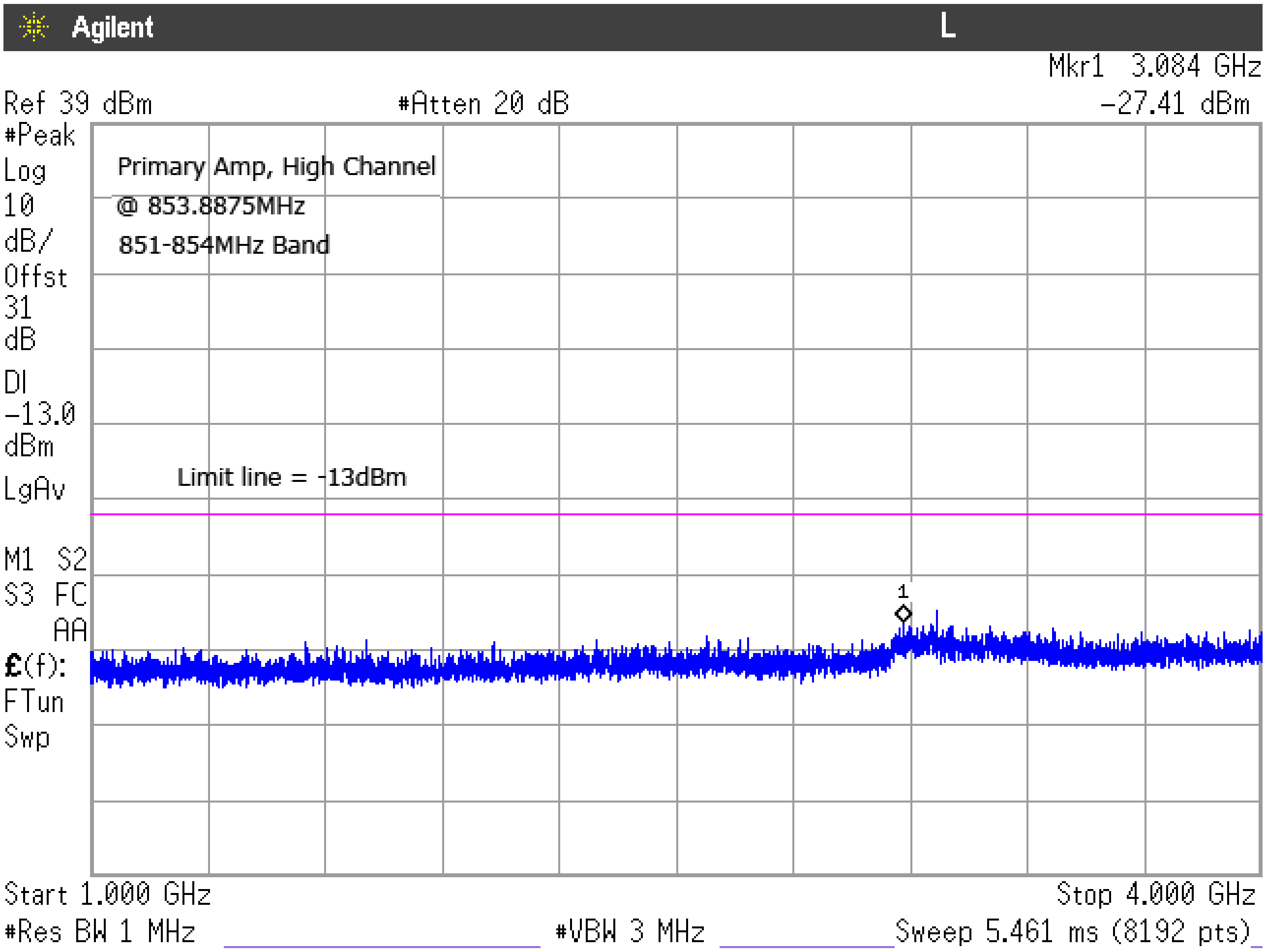


Figure 76: Conducted Spurious 851-860MHz, Primary Amp, Center Channel 1-4GHz

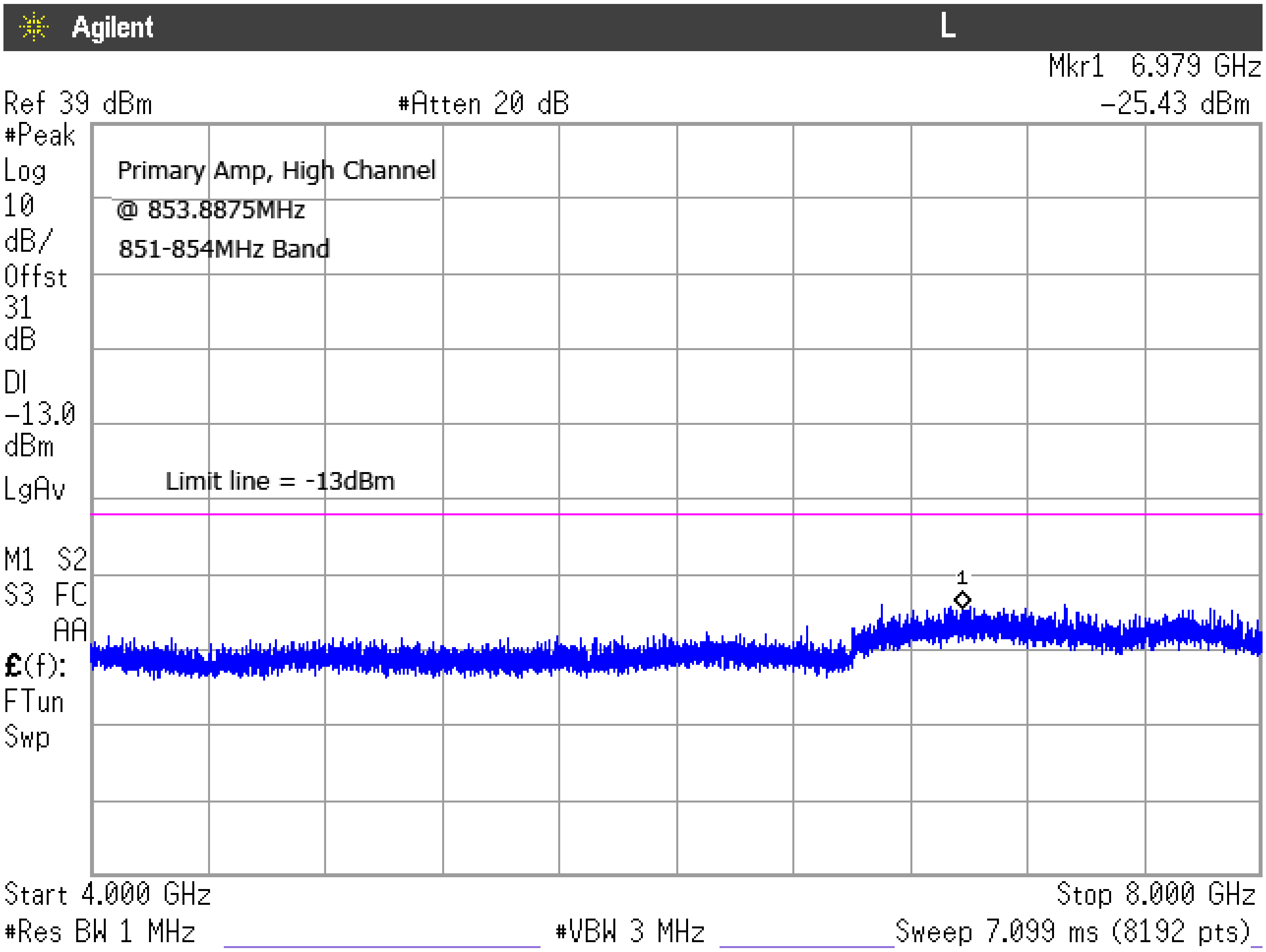


Figure 77: Conducted Spurious 851-860MHz, Primary Amp, Center Channel 4-8GHz

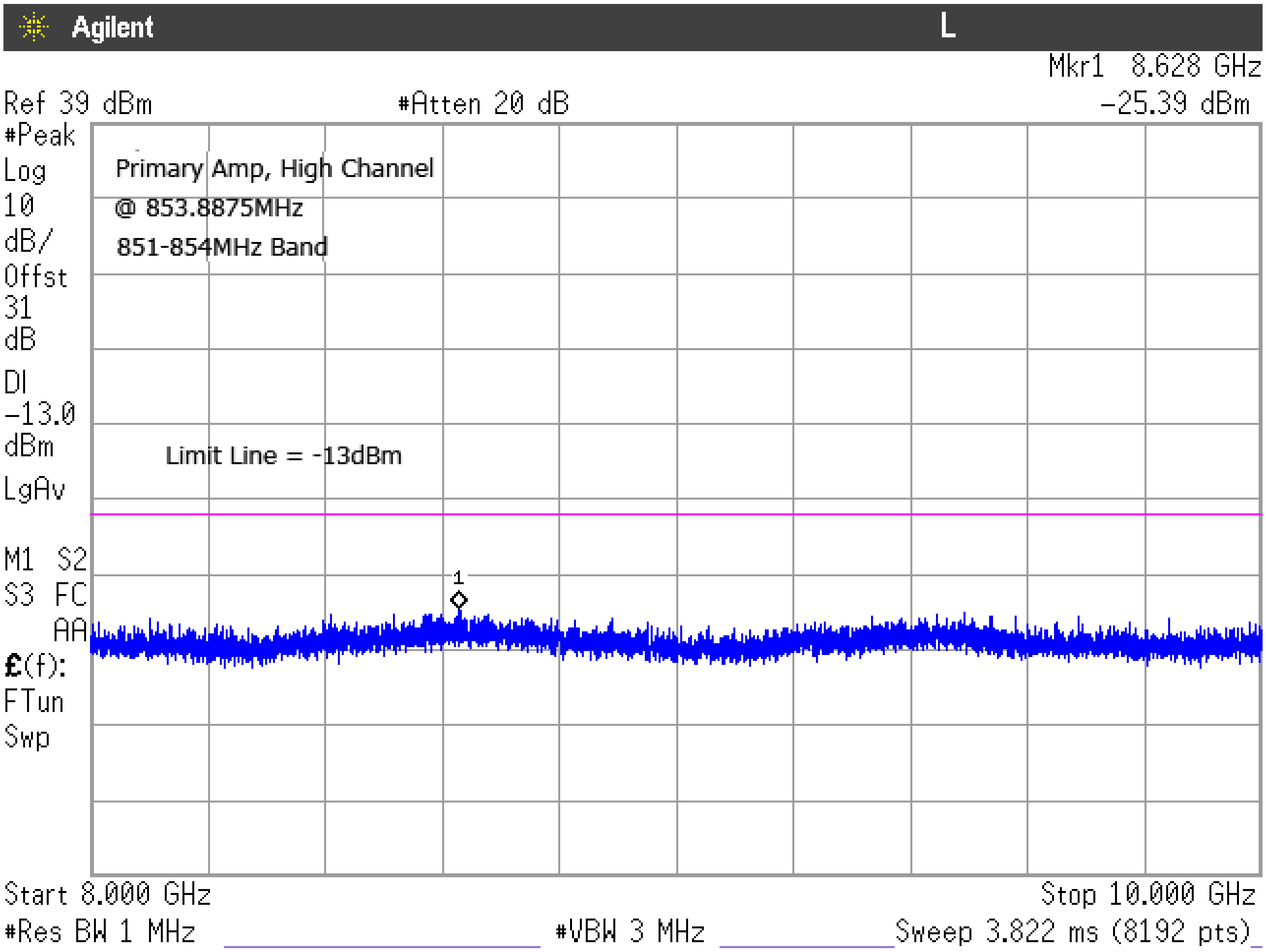


Figure 78: Conducted Spurious 851-860MHz, Primary Amp, Center Channel 8-10GHz

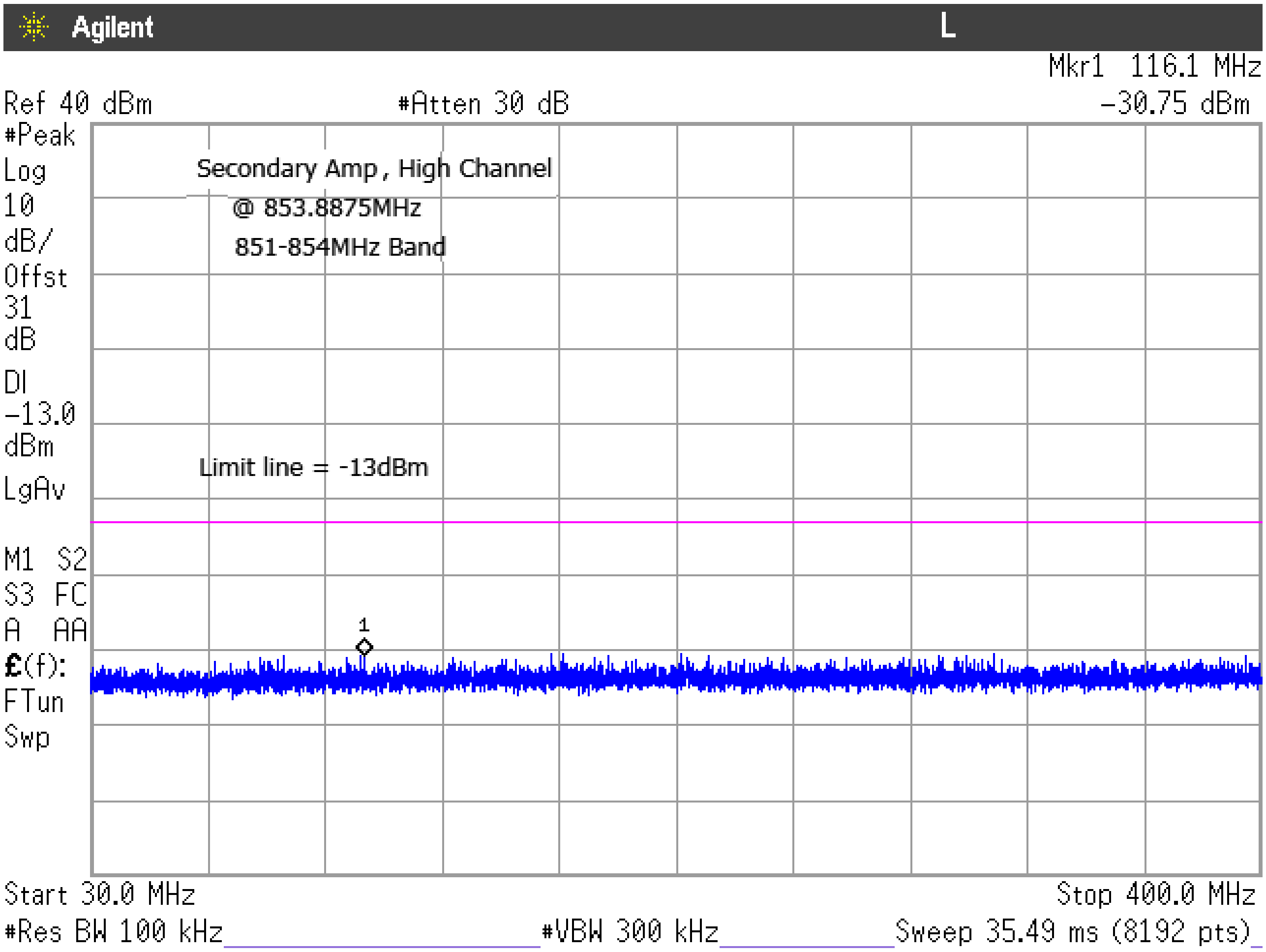


Figure 79: Conducted Spurious 851-860MHz, Secondary Amp, Center Channel 30-400MHz

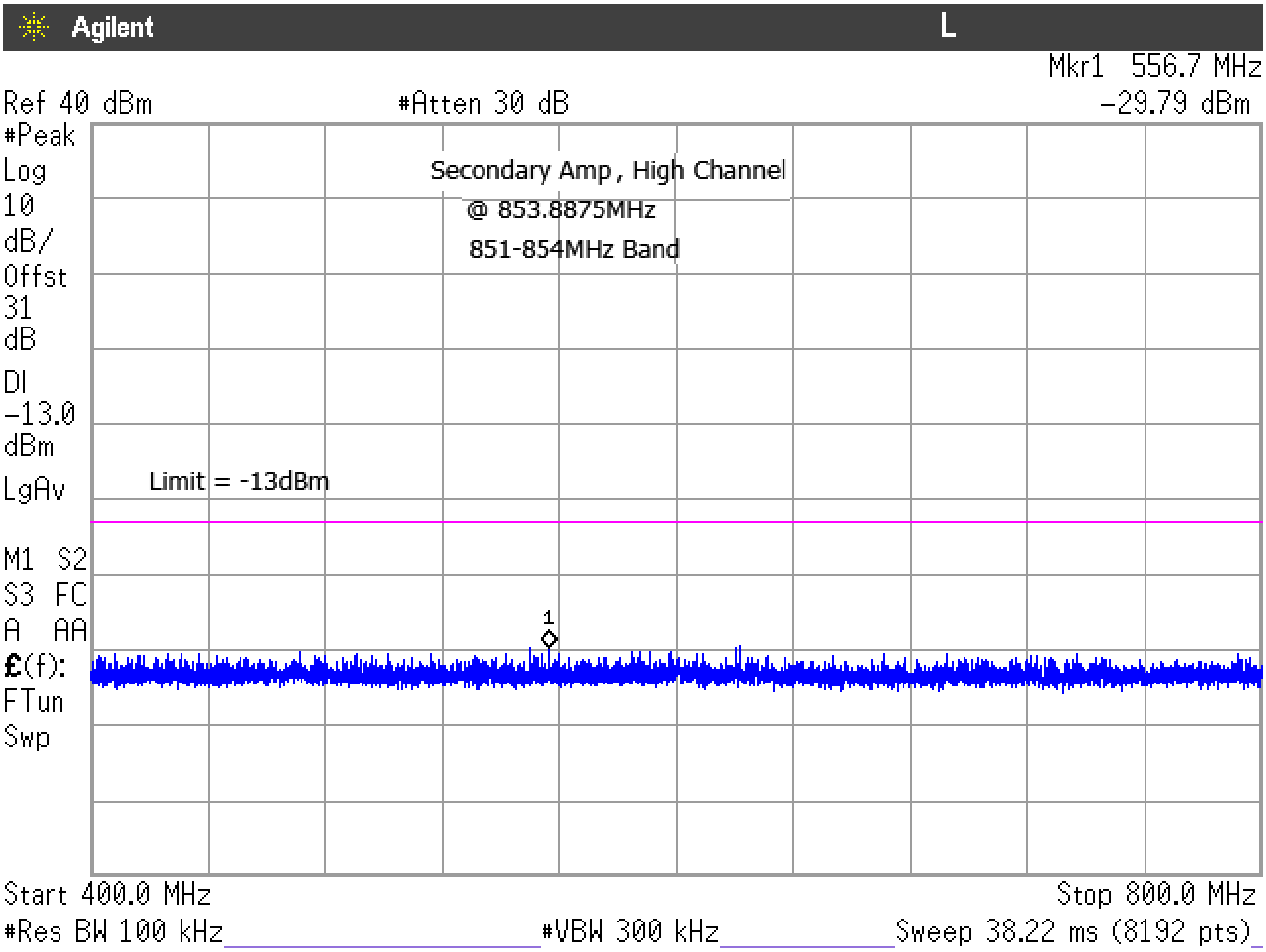


Figure 80: Conducted Spurious 851-860MHz, Secondary Amp, Center Channel 400-800MHz

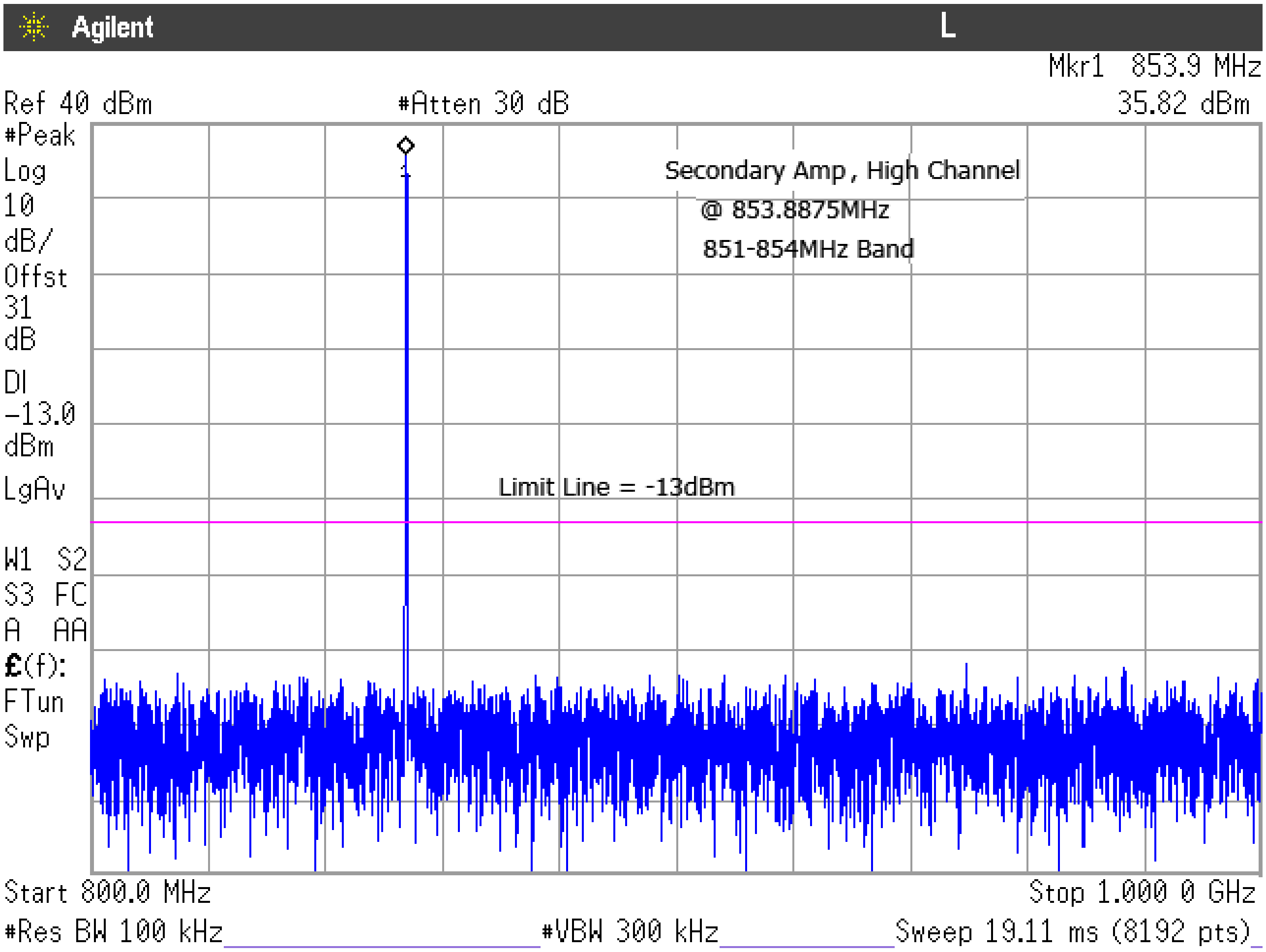


Figure 81: Conducted Spurious 851-860MHz, Secondary Amp, Center Channel 800-1000MHz

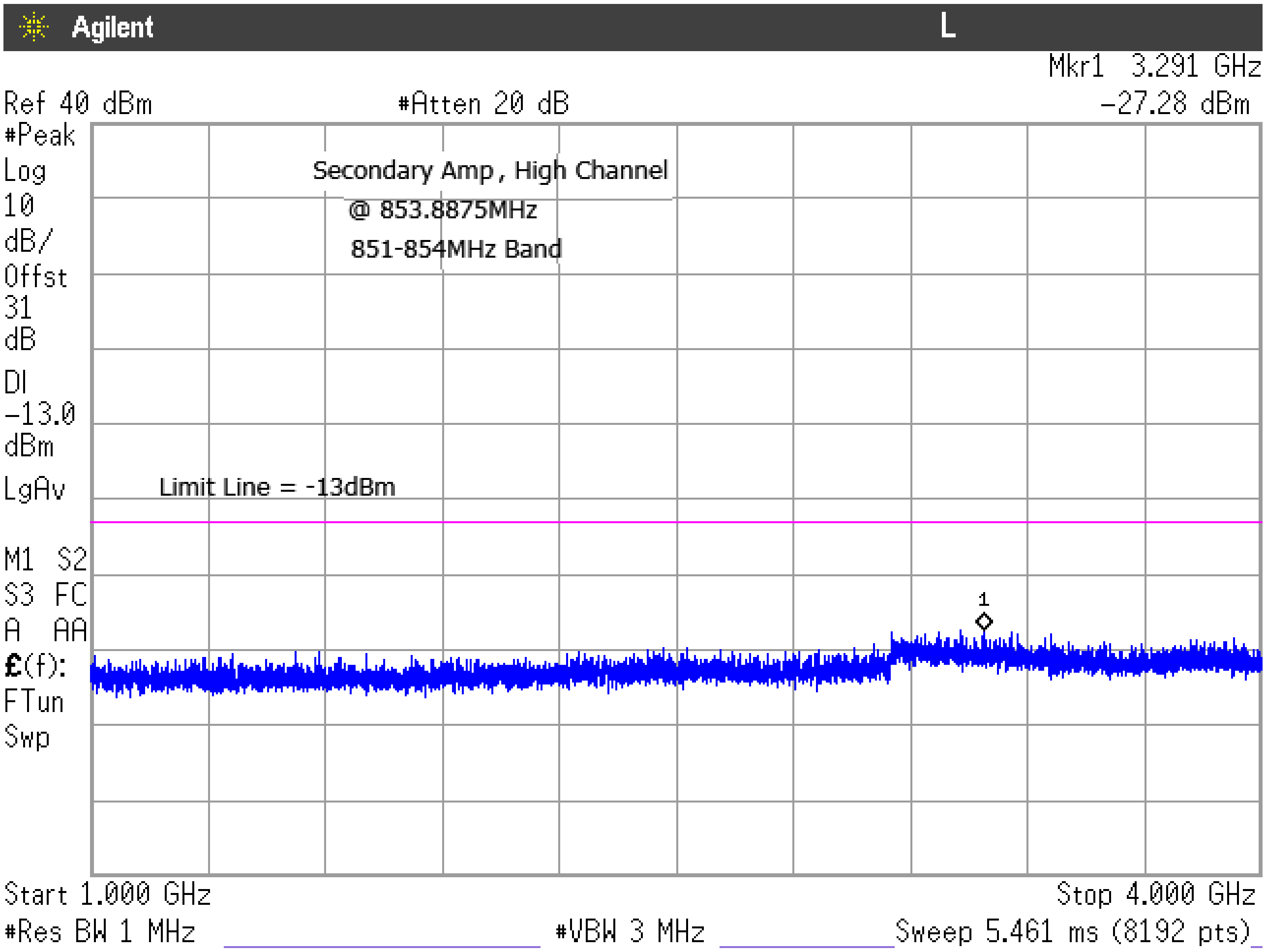


Figure 82: Conducted Spurious 851-860MHz, Secondary Amp, Center Channel 1-4GHz

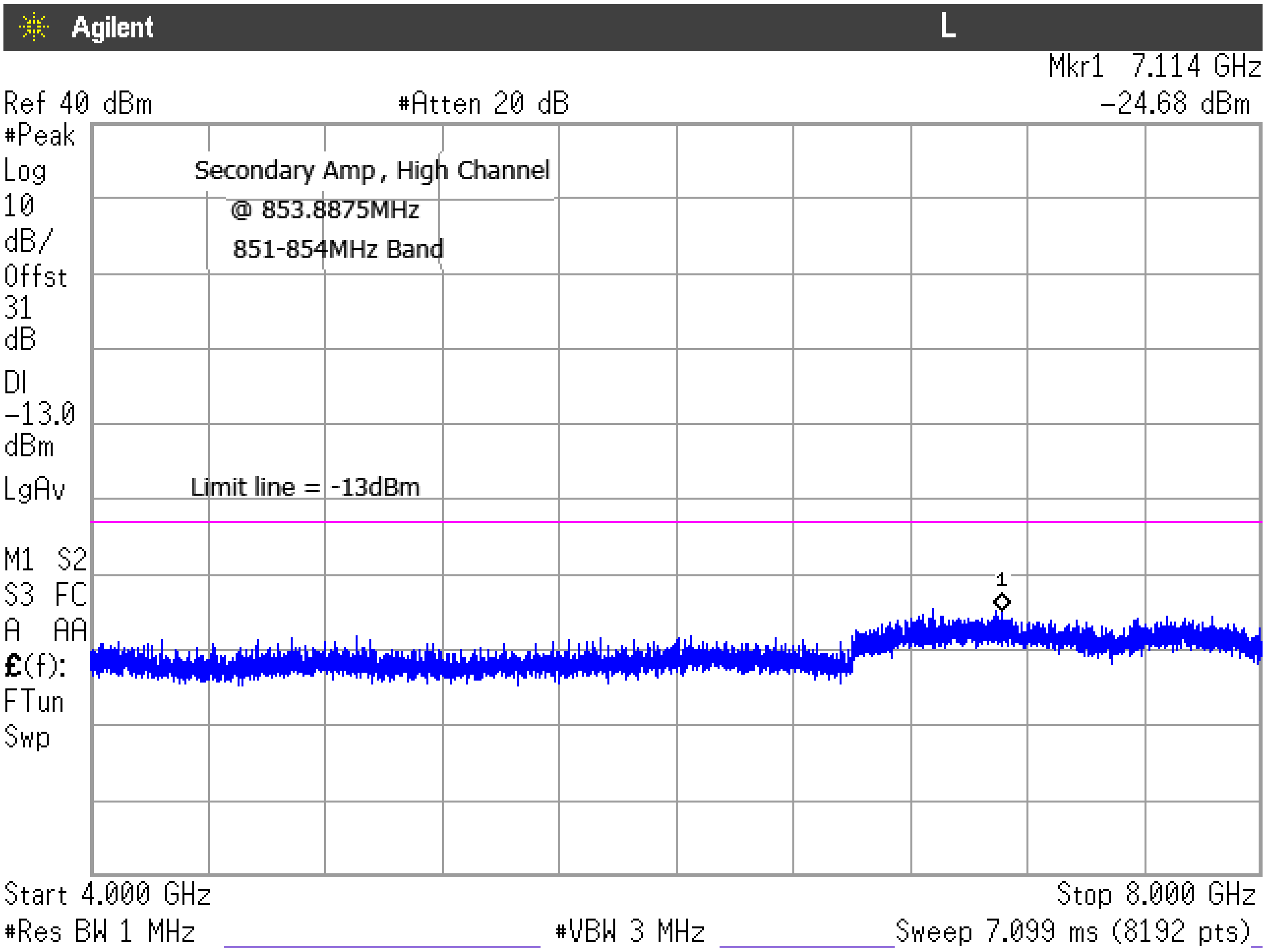


Figure 83: Conducted Spurious 851-860MHz, Secondary Amp, Center Channel 4-8GHz

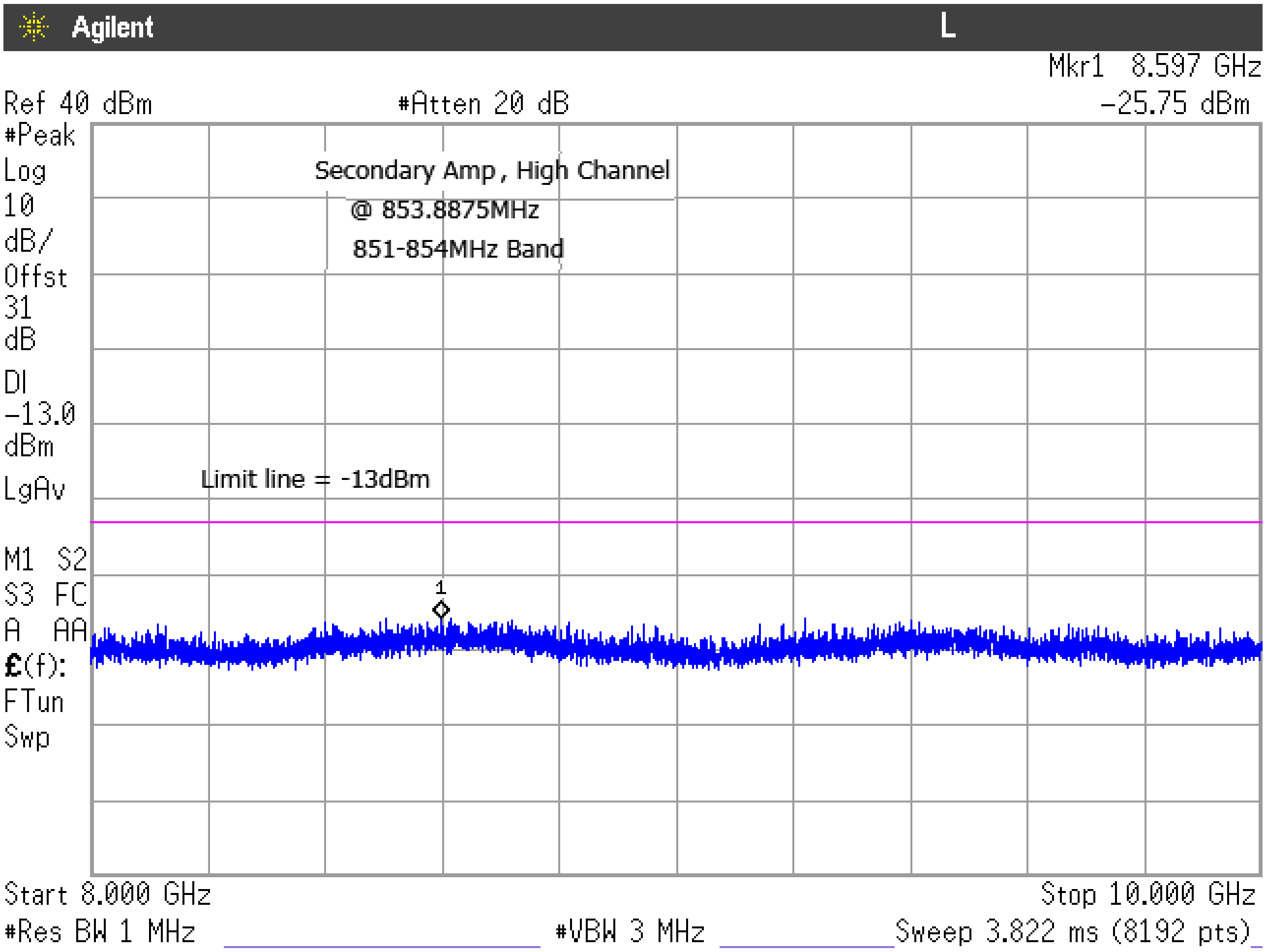


Figure 84: Conducted Spurious 851-860MHz, Secondary Amp, Center Channel 8-10GHz

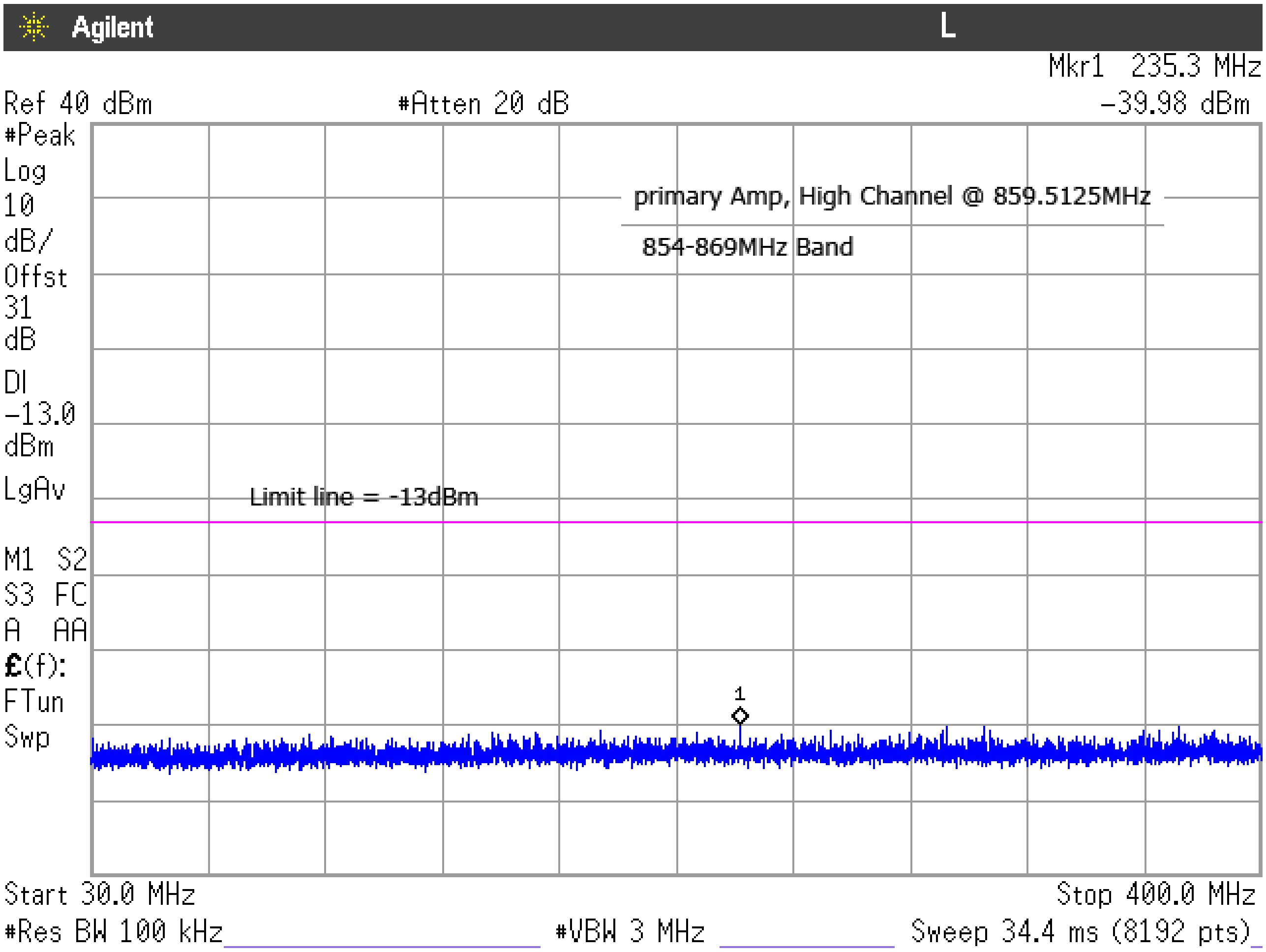


Figure 85: Conducted Spurious 851-860MHz, Primary Amp, High Channel 30-400MHz

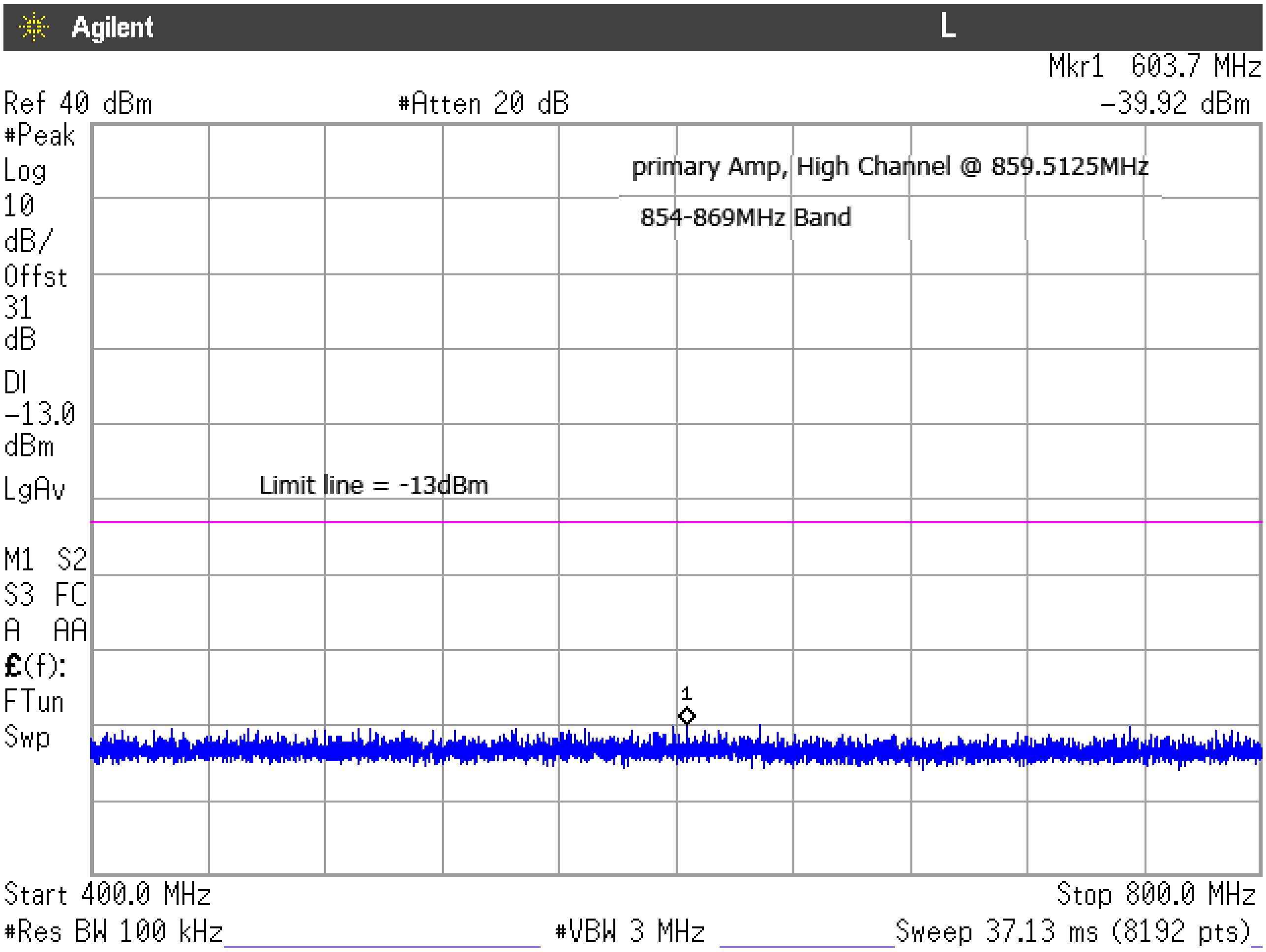


Figure 86: Conducted Spurious 851-860MHz, Primary Amp, High Channel 400-800MHz

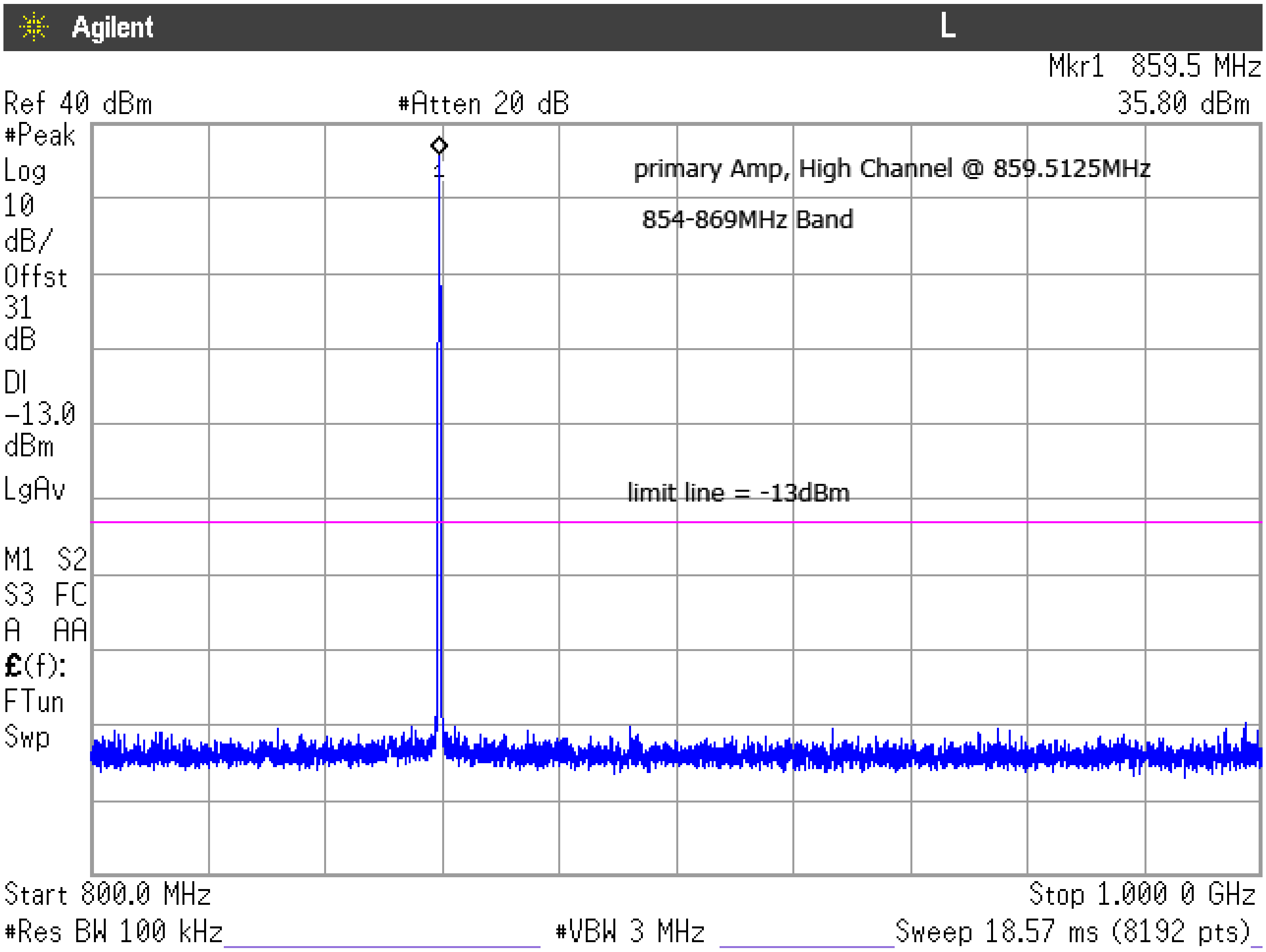


Figure 87: Conducted Spurious 851-860MHz, Primary Amp, High Channel 800-1000MHz

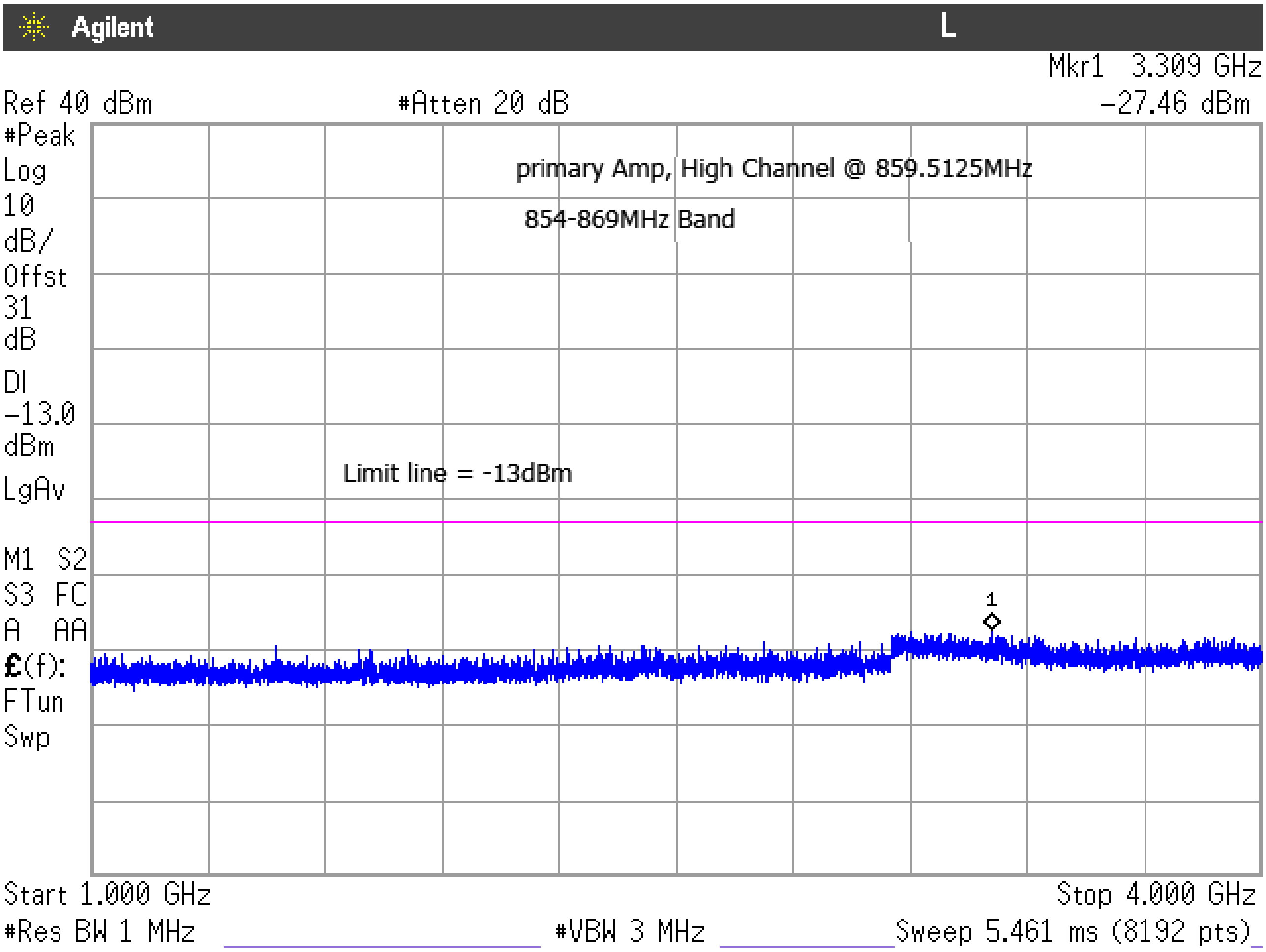


Figure 88: Conducted Spurious 851-860MHz, Primary Amp, High Channel 1-4GHz

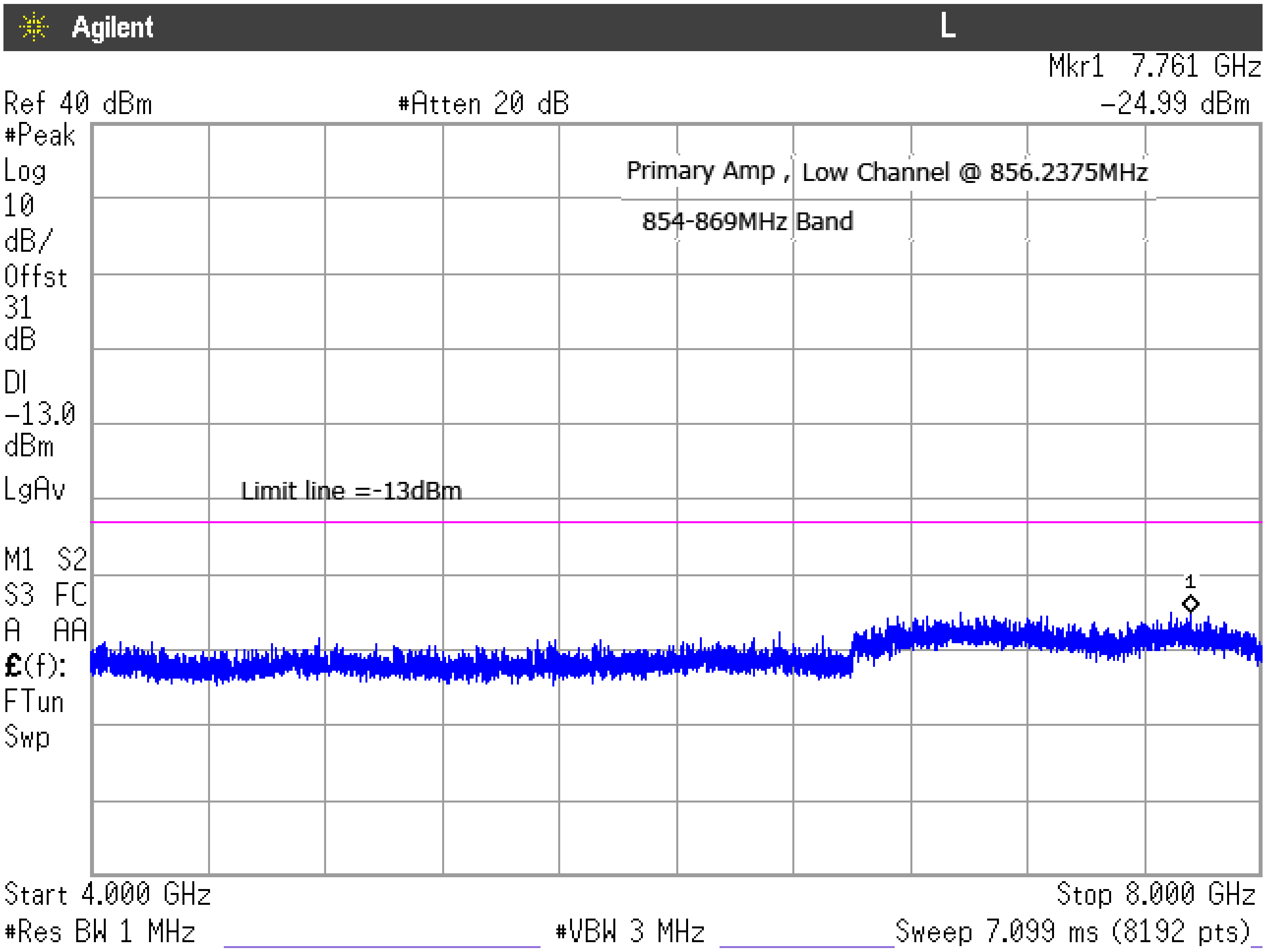


Figure 89: Conducted Spurious 851-860MHz, Primary Amp, High Channel 4-8GHz

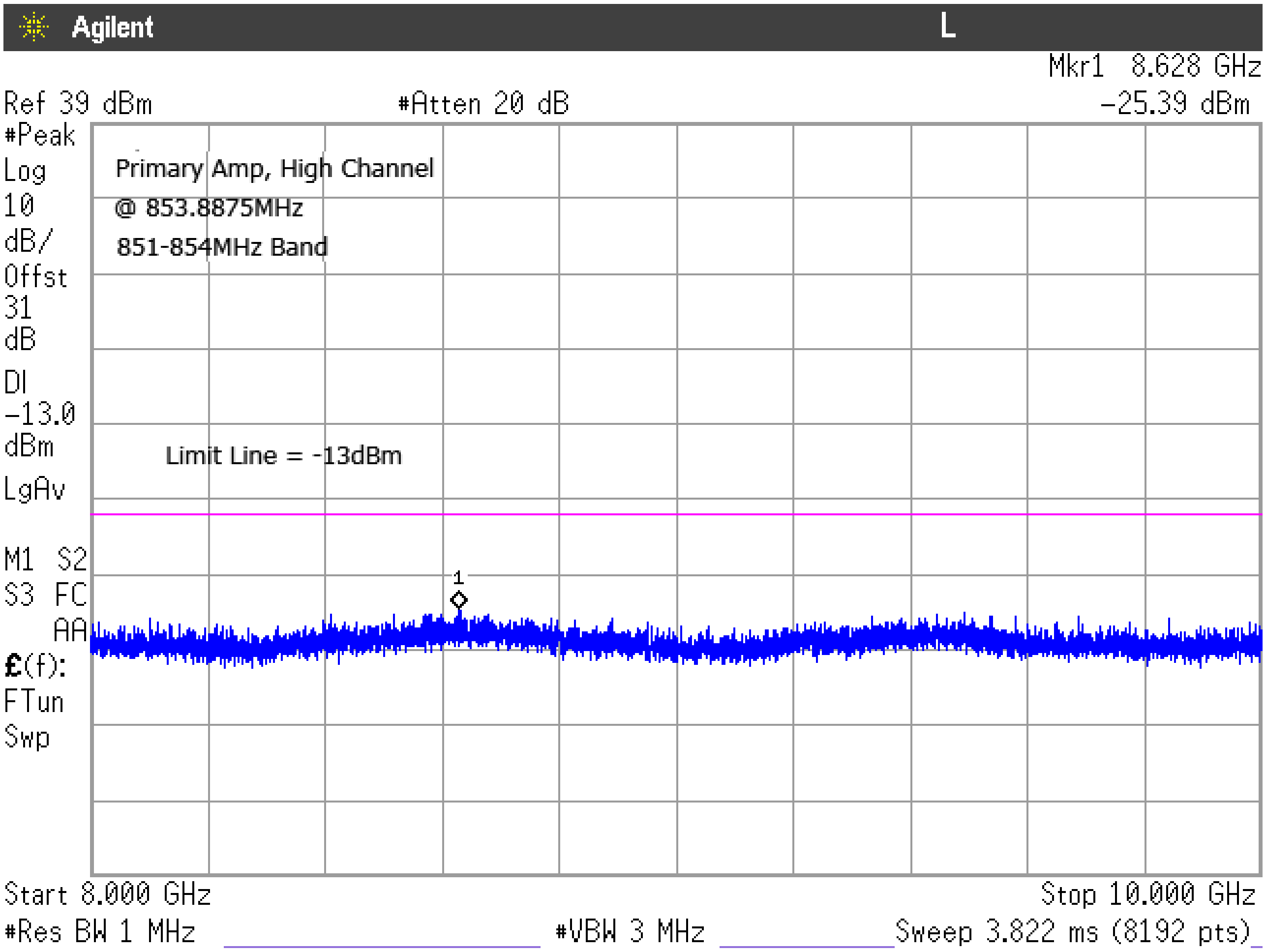


Figure 90: Conducted Spurious 851-860MHz, Primary Amp, High Channel 8-10GHz

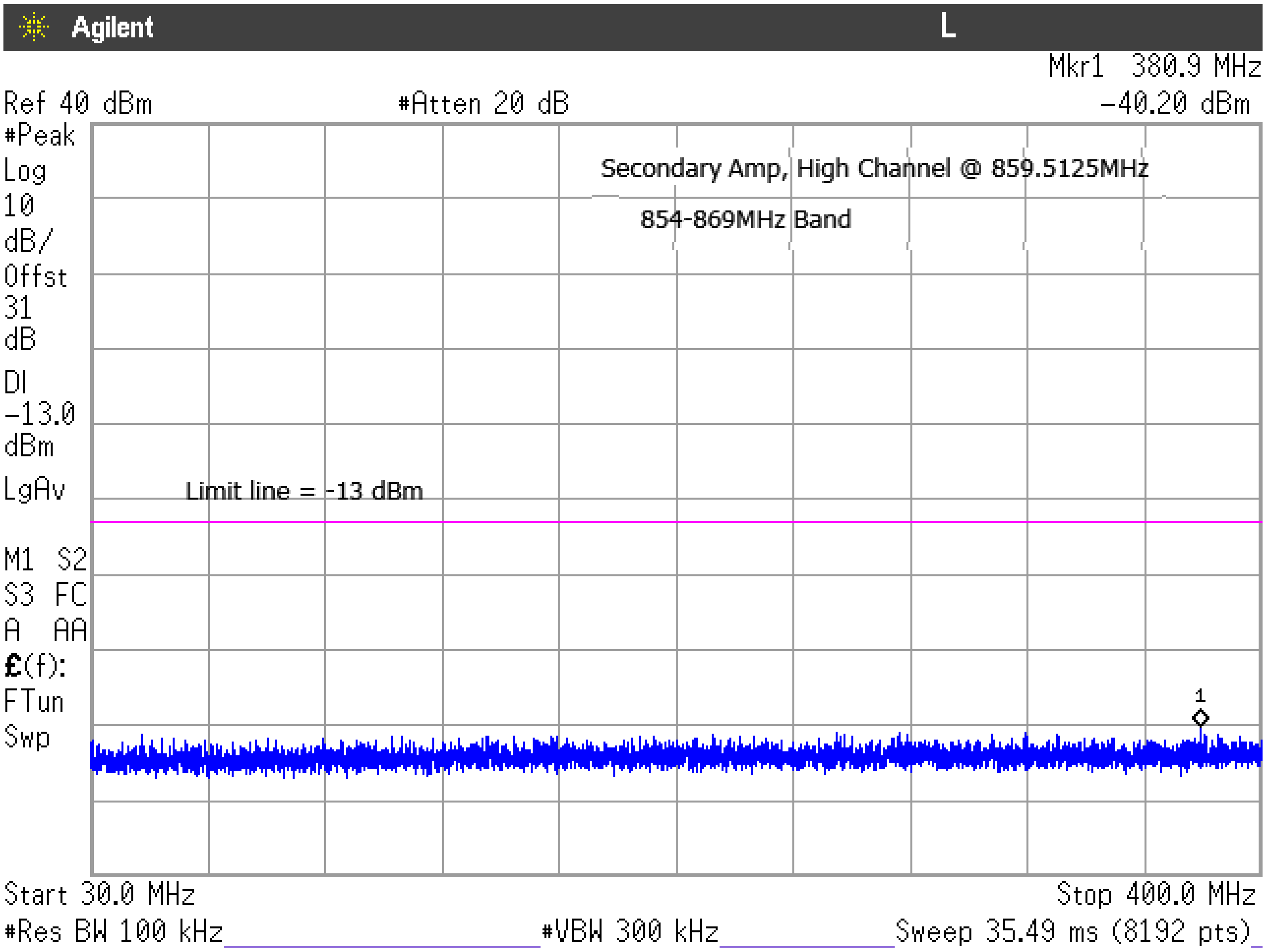


Figure 91: Conducted Spurious 851-860MHz, Secondary Amp, High Channel 30-400MHz

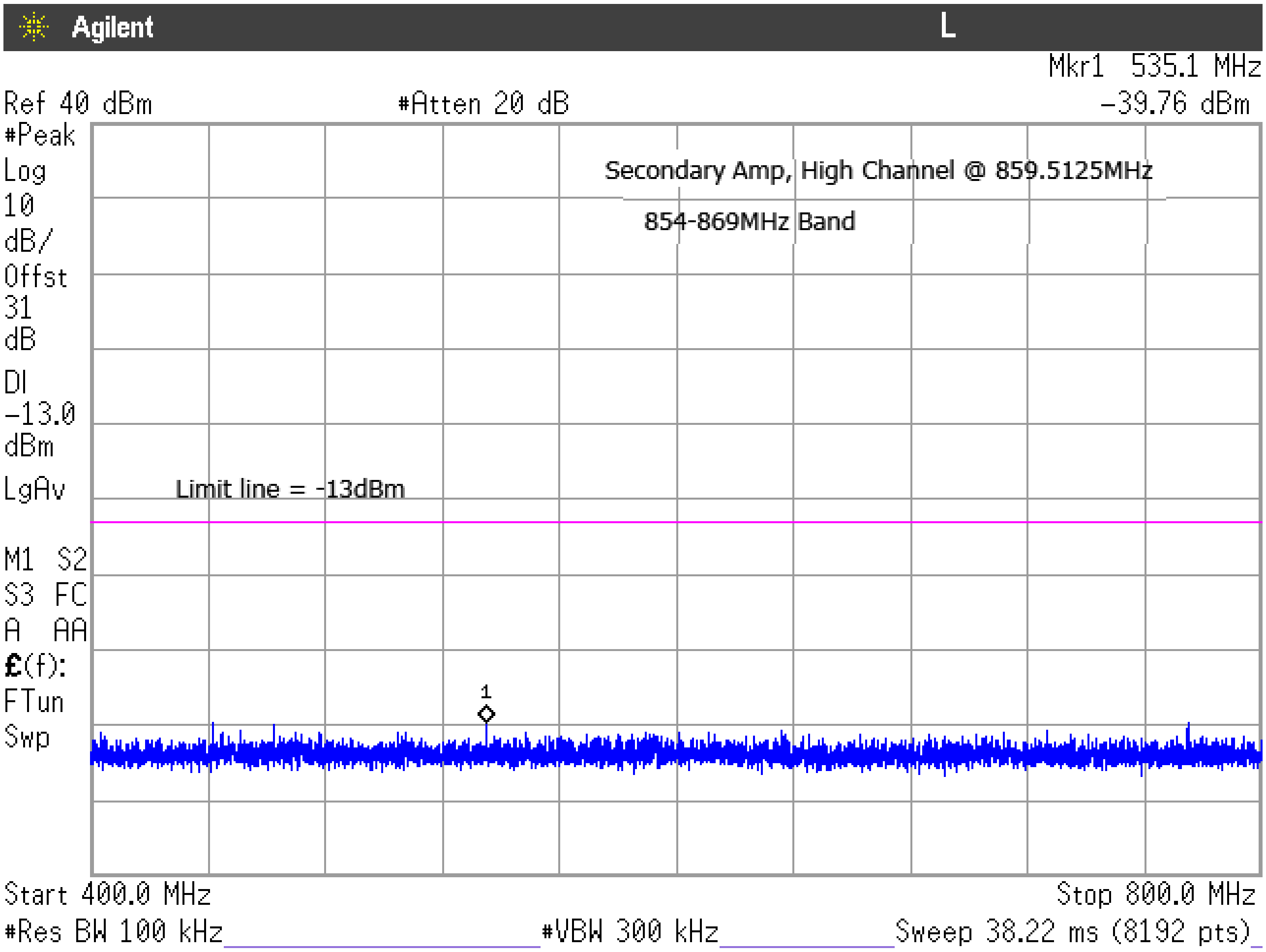


Figure 92: Conducted Spurious 851-860MHz, Secondary Amp, High Channel 400-800MHz

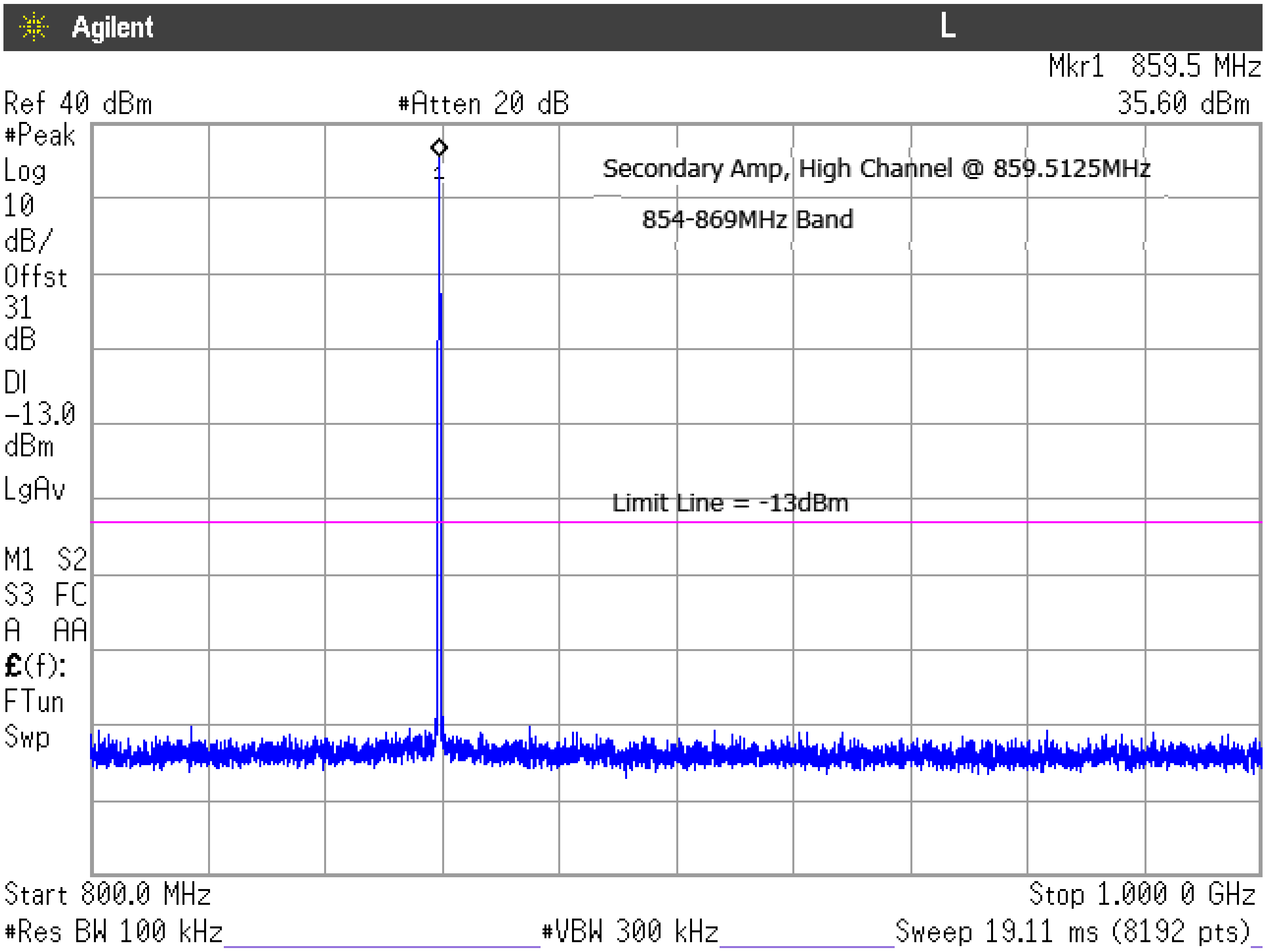


Figure 93: Conducted Spurious 851-860MHz, Secondary Amp, High Channel 800-1000MHz

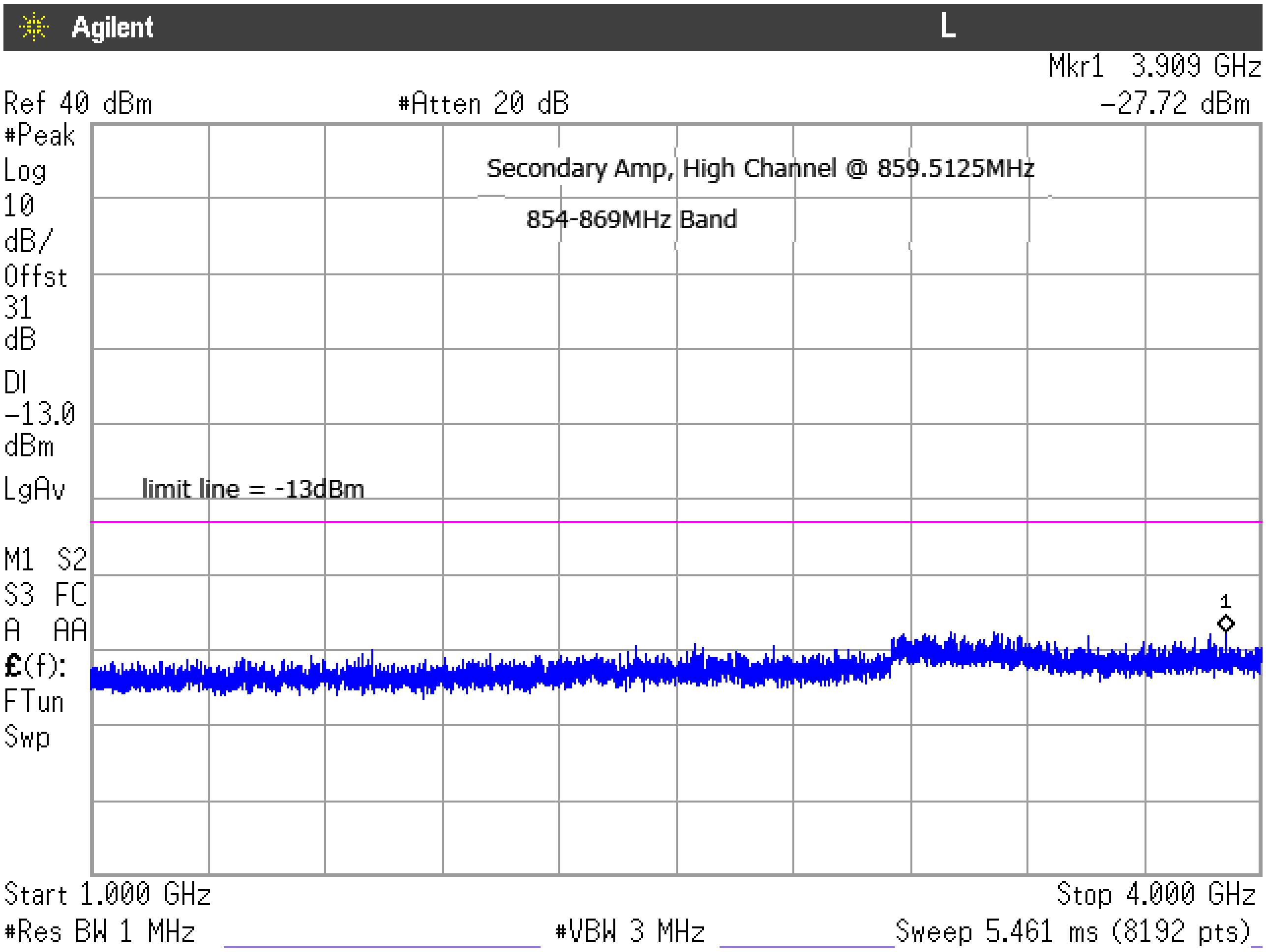


Figure 94: Conducted Spurious 851-860MHz, Secondary Amp, High Channel 1-4GHz

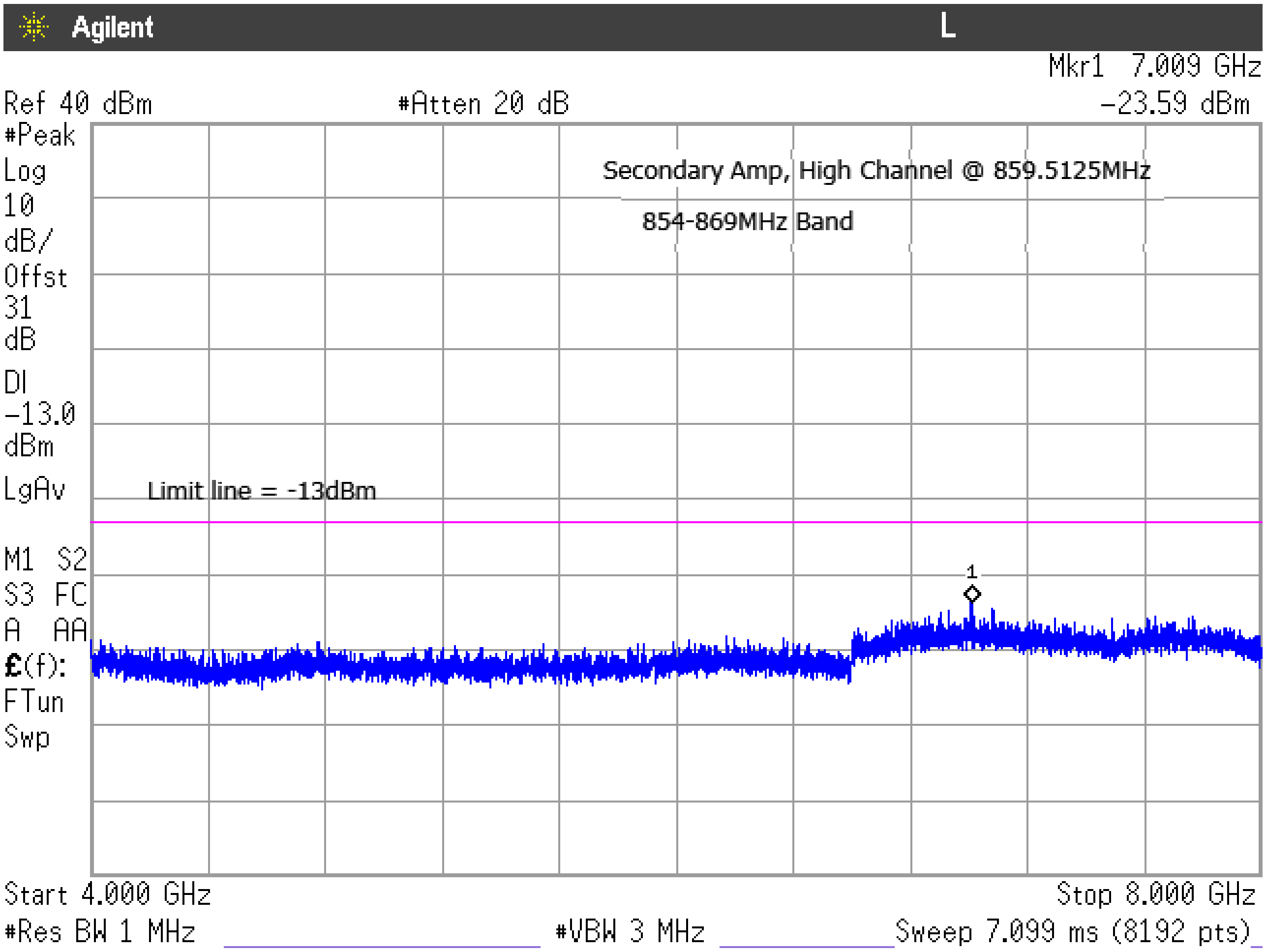


Figure 95: Conducted Spurious 851-860MHz, Secondary Amp, High Channel 4-8GHz

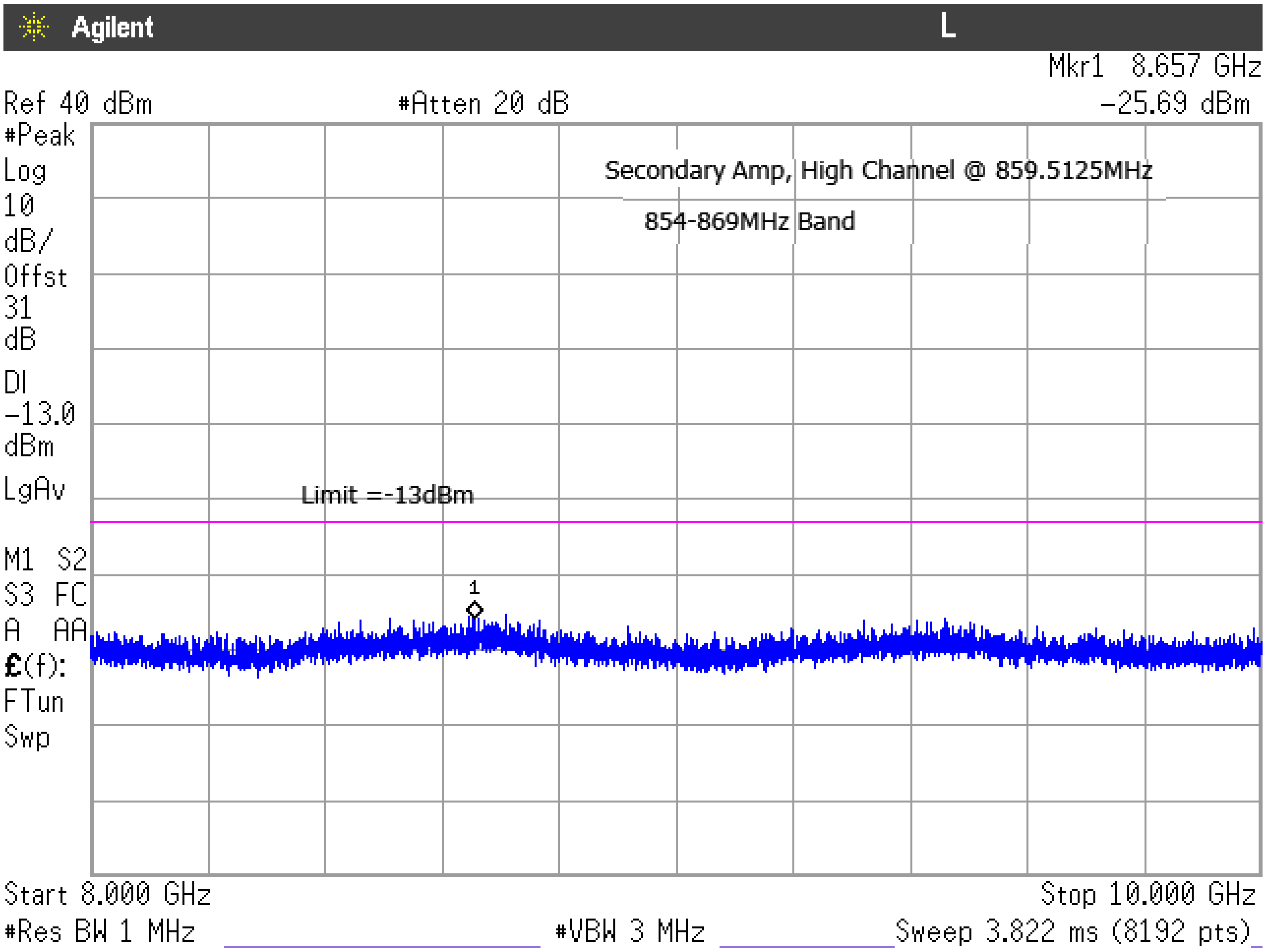


Figure 96: Conducted Spurious 851-860MHz, Secondary Amp, High Channel 8-10GHz

4.7 EUT frequency stability measurements (935210 DO5 section 4.8)

90.219(e)(4)(i) requires that a signal being retransmitted by an amplifier, booster, or repeater meet the frequency stability requirements of 90.213. However, this requirement presumes that the EUT processes an input signal in a manner that can influence the output signal frequency/frequencies (i.e., most signal boosters do not incorporate an oscillator). If this is not the case (i.e., the amplifier, booster, or repeater does not alter the input signal in any way), then a frequency stability test may not be required.

4.7.1 Summary

As this amplifier does not alter or influence the signal and does not include an oscillator frequency stability tests do not apply.

4.8 EUT spurious emissions radiated measurements (935210 DO5 section 4.9)

4.8.1 Test Method

The EUT was tested out of band (>250 % of authorized bandwidth) for radiated emissions on an open air test site (OATS) using a substitution method. The EUT was placed on motorized turntable for radiated testing on a 3-meter open field test site. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. Receiving antennas were mounted on an antenna mast to determine the height of maximum emissions. The EUT was tested in 3 orthogonal positions for compliance. A resolution bandwidth of 100 kHz was used for radiated measurements < 1GHz and a resolution bandwidth of 1MHz for measurements > 1GHz. The EUT antenna port was terminated for these readings.

853.8875MHz. Levels were set just below the AGC threshold.

4.8.2 Radiate Spurious Summary

The EUT complied with the requirements for radiated emissions per FCC part 90.210 mask s G & H. These masks have the same out of band limit of -13dBm.

Table 10: Radiated Spurious Results

Frequency (MHz)	Polarity	Azimuth	Ant. Height (m)	Spurious Level (dBuV)	Sub. Sig. Gen. Level (dBm)	Sub. Power Level (dBm)	Sub. Ant. Factor (dB)	Sub. Ant. Gain (dB)	EIRP Level (dBm)	Limit (dBm)	Margin (dB)
583.34	V	200.0	1.5	45.4	-39.1	-42.1	19.0	6.5	-35.6	-13	-22.6
625.00	V	225.0	1.3	42.7	-47.1	-50.2	19.2	6.9	-43.3	-13	-30.3
900.00	V	200.0	2.1	35.1	-47.7	-51.4	21.8	7.5	-43.9	-13	-30.9
1000.00	V	225.0	2.4	38.5	-42.6	-46.8	24.1	6.1	-40.7	-13	-27.7
1543.33	V	0.0	2.5	53.8	-46.1	-51.5	25.2	8.8	-42.7	-13	-29.7
2562.60	V	40.0	1.9	51.3	-43.6	-50.7	29.5	8.8	-41.9	-13	-28.9
1050.04	V	170.0	2.5	55.9	-49.9	-54.2	24.3	6.3	-47.9	-13	-34.9
1250.11	V	45.0	2.3	59.5	-47.0	-51.8	25.2	7.0	-44.8	-13	-31.8
1666.51	V	0.0	2.7	64.2	-41.0	-46.6	25.4	9.2	-37.4	-13	-24.4
1499.71	V	0.0	3.5	61.2	-44.0	-49.3	25.2	8.6	-40.7	-13	-27.7
1583.18	V	45.0	3.5	59.6	-45.0	-50.5	25.2	9.0	-41.5	-13	-28.5
1750.00	V	10.0	3.0	60.6	-42.0	-47.8	25.7	9.4	-38.4	-13	-25.4
2000.00	V	0.0	3.0	51.7	-45.0	-51.2	27.9	8.4	-42.9	-13	-29.9
2500.00	V	45.0	3.7	50.9	-43.0	-50.0	29.1	9.0	-41.0	-12	-29.0
3000.00	V	180.0	3.8	51.5	-41.0	-48.8	30.0	9.8	-39.1	-13	-26.1
6000.00	V	190.0	3.4	47.0	-31.0	-43.0	34.6	11.2	-31.8	-13	-18.8
325.00	H	225.0	1.1	52.3	-47.7	-50.1	14.0	6.4	-43.6	-13	-30.6
375.00	H	90.0	1.3	54.1	-45.3	-47.8	15.6	6.1	-41.7	-13	-28.7
425.00	H	45.0	1.2	49.5	-48.4	-51.0	16.9	5.9	-45.1	-13	-32.1
500.00	H	100.0	1.2	48.0	-46.0	-48.7	16.7	7.5	-41.2	-13	-28.2
583.19	H	225.0	1.4	47.3	-46.2	-49.2	19.0	6.5	-42.7	-13	-29.7
625.00	H	45.0	1.3	45.5	-47.2	-50.3	19.2	6.9	-43.4	-13	-30.4
833.36	H	45.0	1.1	48.4	-39.1	-42.7	22.1	6.5	-36.2	-13	-23.2
916.58	H	90.0	1.1	39.3	-45.6	-49.4	22.4	7.1	-42.3	-13	-29.3
1056.00	H	0.0	2.5	62.3	-44.2	-48.5	24.4	6.3	-42.2	-13	-29.2
1250.11	H	360.0	4.0	58.0	-45.9	-50.7	25.2	7.0	-43.7	-13	-30.7
1333.55	H	0.0	2.5	58.2	-45.9	-50.9	25.3	7.4	-43.5	-13	-30.5
1499.71	H	45.0	2.3	61.2	-43.1	-48.4	25.2	8.6	-39.8	-13	-26.8
1583.18	H	0.0	1.7	58.9	-44.1	-49.6	25.2	9.0	-40.6	-13	-27.6
1666.51	H	360.0	3.0	62.9	-41.9	-47.5	25.4	9.2	-38.3	-13	-25.3
1750.00	H	45.0	2.5	57.9	-45.2	-51.0	25.7	9.4	-41.6	-13	-28.6
2000.00	H	270.0	2.0	50.7	-48.5	-54.7	27.9	8.4	-46.4	-13	-33.4
2500.00	H	0.0	3.8	53.5	-41.0	-48.0	29.1	9.0	-39.0	-13	-26.0
2562.60	H	360.0	3.4	50.2	-42.9	-50.0	29.5	8.8	-41.2	-13	-28.2
3000.00	H	260.0	3.8	50.1	-41.0	-48.8	30.0	9.8	-39.1	-13	-26.1
6000.00	H	90.0	3.0	46.0	-27.5	-39.5	34.6	11.2	-28.3	-13	-15.3

