

2021 EK60/80 Calibration Report

NOAA Ship *Okeanos Explorer*

EX-21-01: EM 304 SAT and Shakedown

Authors: Adrienne Copeland¹, Lu Wang¹, Sam Candio², and Shannon Hoy²

¹ NOAA Ocean Exploration

² NOAA Ocean Exploration (Cherokee Nation Strategic Programs)

Table of Contents

Table of Contents	1
Introduction	5
Location and Conditions	5
Calibration Parameters	6
Calibration Procedure	9
Calibration Results	10
Appendix A: Channel Results	15
18 kHz: 8.192 ms	15
18 kHz: 4.096 ms	16
18 kHz: 1.024 ms	17
38 kHz (CW): 2.048 ms	18
38 kHz (CW): 1.024 ms	19
38 kHz (FM): 4.096 ms	20
38 kHz (FM): 1.024 ms	21
70 kHz (CW): 2.048 ms	22
70 kHz (CW): 1.024 ms	23
70 kHz (FM): 2.048 ms	24
70 kHz (FM): 1.024 ms	25
120 kHz: 1.024 ms	26
200 kHz: 1.024 ms	27
Appendix B: General Results	28
18 kHz: 8.192 ms	28
18 kHz: 4.096 ms	29
18 kHz: 1.024 ms	30

38 kHz (CW): 2.048 ms	31
38 kHz (CW): 1.024 ms	32
38 kHz (FM): 4.096 ms	33
38 kHz (FM): 1.024 ms	34
70 kHz (CW): 2.048 ms	35
70 kHz (CW): 1.024 ms	36
70 kHz (FM): 2.048 ms	37
70 kHz (FM): 1.024 ms	38
120 kHz: 1.024 ms	39
200 kHz: 1.024 ms	40
Appendix C: TS Results	41
18 kHz: 8.192 ms	41
18 kHz: 4.096 ms	42
18 kHz: 1.024 ms	43
38 kHz (CW): 2.048 ms	44
38 kHz (CW): 1.024 ms	45
38 kHz (FM): 4.096 ms	46
38 kHz (FM): 1.024 ms	47
70 kHz (CW): 2.048 ms	48
70 kHz (CW): 1.024 ms	49
70 kHz (FM): 2.048 ms	50
70 kHz (FM): 1.024 ms	51
120 kHz: 1.024 ms	52
200 kHz: 1.024 ms	53
Appendix D: Results	54
18 kHz: 8.192 ms	54

18 kHz: 4.096 ms	55
18 kHz: 1.024 ms	56
38 kHz (CW): 2.048 ms	57
38 kHz (CW): 1.024 ms	58
38 kHz (FM): 4.096 ms	59
38 kHz (FM): 1.024 ms	60
70 kHz (CW): 2.048 ms	61
70 kHz (CW): 1.024 ms	62
70 kHz (FM): 2.048 ms	63
70 kHz (FM): 1.024 ms	64
120 kHz: 1.024 ms	65
200 kHz: 1.024 ms	66
Appendix E: Error Analysis	67
18 kHz: 8.192 ms	67
18 kHz: 4.096 ms	68
18 kHz: 1.024 ms	69
38 kHz (CW): 2.048 ms	70
38 kHz (CW): 1.024 ms	71
38 kHz (FM): 4.096 ms	72
38 kHz (FM): 1.024 ms	73
70 kHz (CW): 2.048 ms	74
70 kHz (CW): 1.024 ms	75
70 kHz (FM): 2.048 ms	76
70 kHz (FM): 1.024 ms	77
120 kHz: 1.024 ms	78
200 kHz: 1.024 ms	79

Appendix F: Detailed List of .raw and .xml Calibration Files	80
Appendix G: Vessel Offsets for Transducer Hull Locations	89

Introduction

NOAA Ocean Exploration is the only federal program dedicated to exploring the deep ocean, closing prominent gaps in our basic understanding of U.S. deep waters and the seafloor and delivering the ocean information needed to strengthen the economy, health, and security of our nation.

Using the latest tools and technology, NOAA Ocean Exploration explores previously unknown areas of our deep ocean, making discoveries of scientific, economic, and cultural value. Through live video streams, online coverage, training opportunities, and real-time events, NOAA Ocean Exploration allows scientists, resource managers, students, members of the general public, and others to actively experience ocean exploration, expanding available expertise, cultivating the next generation of ocean explorers, and engaging the public in exploration activities. To better understand our ocean, we make exploration data available to the public. This allows us, collectively, to more effectively maintain ocean health, sustainably manage our marine resources, accelerate our national economy, and build a better appreciation of the value and importance of the ocean in our everyday lives.

This document provides all the information for the NOAA Ocean Exploration 2021 calibration of the Simrad EK60/80 echosounders on NOAA Ship *Okeanos Explorer* during EX-21-01. The calibration occurred on April 26, 2021 off of Key West, FL and May 1, 2021 off of the Florida Atlantic coast. During this procedure, the general purpose transceiver (GPT) frequencies - 18, 120, and 200 kilohertz (kHz) - were calibrated at the pulse length of 1.024 milliseconds (ms) and maximum power for each frequency. The 18 kHz was calibrated at the additional pulse lengths of 8.192 and 4.096 ms. The 38 and 70 kHz wideband transceivers (WBT) were also calibrated at both the continuous wave (CW) and frequency modulated (FM) modes. The CW modes for both frequencies were calibrated at 1.024 and 2.048 ms. The FM modes for the 38 and 70 kHz were calibrated at 1.024 and 4.096 ms, and 1.024 and 2.048 ms pulse lengths, respectively.

Location and Conditions

- The ship was located west of Key West, FL at coordinates 24.1720°, -82.5008° for April 26, 2021 and in the Atlantic Ocean at 28.4643°, -78.3049° for May 1, 2021 calibrations.
- The vessel was drifting in waters deeper than 500 meters.
- A CastAway conductivity, temperature, depth (CTD) cast was performed before commencing calibration to obtain the required water properties necessary for calibration, including the temperature and salinity at the depth of the sphere.

- Average speed of sound at the calibration depth (12 meters) for the 38, 70, 120, and 200 kHz transducers was 1537.81 meters per second. At 12 meters the average temperature was 25.8 °C and average salinity was 36 psu (practical salinity unit).
- Average speed of sound at the calibration depth (31 meters) for the 18 kHz transducer was 1535.56 meters per second. At 31 meters the average temperature was 24.5 °C and average salinity was 37 psu.

Calibration Parameters

- All frequencies were calibrated with a pulse length of 1.024 ms. The 18 kHz was calibrated at the additional pulse lengths of 8.192 and 4.096 ms. The 38 kHz and 70 kHz CW modes were calibrated at 1.024 and 2.048 ms. The FM modes for the 38 kHz and 70 kHz were calibrated at 1.024 and 4.096 ms, and 1.024 and 2.048 ms pulse lengths, respectively.
- Ping rate was 1 ping/second.
- Power was set to maximum for each frequency.
- See **Tables 1 and 2** of this document for a complete list of parameters used during calibration.

Table 1. List of relevant parameters and initial settings used during the 2021 calibration of the EK60 General Purpose Transceivers (GPTs). For more information, see Appendix A containing the channel tab for each frequency calibrated.

Frequency (kHz)	18	18	18	120	200
GPT/WBT serial number	GPT	GPT	GPT	GPT	GPT
EK 80 software version	2.0.0.0	2.0.0.0	2.0.0.0	2.0.0.0	2.0.0.0
Transducer model	ES18	ES18	ES18	ES120-7C	ES200-7C
Transducer serial number	2097	2097	2097	1256	596
Transducer draft setting (m)	4.58	4.58	4.58	4.59	4.59
Transmit power (W)	1600	1600	1600	250	150
Pulse length (ms)	8.192	4.096	1.024	1.024	1.024
Two-way beam angle (dB)	-17.0	-17.0	-17.0	-20.70	-20.70
Transducer peak gain (dB)	23.00	23.00	22.40	27.00	26.00
Sa correction (dB)	0.00	0.00	0.00	0.00	0.00
Absorption coefficient (dB/km)	0.00	0.00	0.00	0.00	0.00
Speed of sound (m/s)	1535.56	1535.56	1535.56	1537.81	1537.81
3 dB beamwidth (°) alongship/athwartship	10.05/9.87	9.69/9.86	11.00/11.00	7.00/7.00	7.00/7.00
Angle offset (°) alongship/athwartship	0.04/0.06	0.09/-0.01	0.00/0.00	0.00/0.00	0.00/0.00

Table 2. List of relevant parameters and initial settings used during the 2021 calibration of the EK80 Wide Band Transceivers (WBTs) in CW and FM mode. For more information, see Appendix A containing the channel tab for each frequency calibrated.

Frequency (kHz)	38 (CW)	38 (CW)	38 (FM)	38 (FM)	70 (CW)	70 (CW)	70 (FM)	70 (FM)
Frequency Range (kHz)	38	38	34 to 45	34 to 45	70	70	45 to 90	45 to 90
GPT/WBT serial number	WBT 748247	WBT 748247	WBT 748247	WBT 748247	WBT 746998	WBT 746998	WBT 746998	WBT 746998
EK 80 software version	2.0.0.0	2.0.0.0	2.0.0.0	2.0.0.0	2.0.0.0	2.0.0.0	2.0.0.0	2.0.0.0
Transducer model	ES38-7	ES38-7	ES38-7	ES38-7	ES70-7C	ES70-7C	ES70-7C	ES70-7C
Transducer serial number	291	291	291	291	343	343	343	343
Transducer draft setting (m)	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59
Transmit power (W)	2000	2000	2000	2000	750	750	750	750
Pulse length (ms)	2.048	1.024	4.096	1.024	2.048	1.024	2.048	1.024
Slope (%)	5.1398	10.2796	2.8722	11.4890	1.395	2.790	2.1701	4.340
Two-way beam angle (dB)	-20.70	-20.70	-20.70	-20.70	-20.70	-20.70	-20.70	-20.70
Transducer peak gain (dB)	25.50	25.50	25.75 - 27.72	25.44 - 27.87	27.00	27.00	23.69 - 29.71	21.85 - 29.05
Sa correction (dB)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Absorption coefficient (dB/km)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Speed of sound (m/s)	1537.81	1537.81	1537.81	1537.81	1537.81	1537.81	1537.81	1537.81
3 dB beamwidth (°) along/athwart	6.40/6.32	7.00/7.00	see XML file	see XML file	6.57/6.64	7.00/7.00	see XML file	see XML file
Angle offset (°) along/athwart	0.00/0.00	0.00/0.00	see XML file	0.00/0.00	0.00/0.00	0.00/0.00	0.00/0.00	see XML file

Calibration Procedure

To minimize the time and setup required, one sphere (38.1 mm tungsten carbide with a 6% cobalt binder) was used to calibrate all frequencies except for the 18 kHz which used a 64 mm copper sphere. The pod below refers to the transducers (38, 70, 120 and 200 kHz) that are near each other on the hull of the ship. The pod is more forward and starboard of the 18 kHz transducer so separate techniques are used to calibrate the pod versus the 18 kHz. Reference Appendix G for the X, Y, and Z hull locations for each of the transducers.

Calibrations were performed using Simrad's EK80 calibration software (version 2.0.0.0) and custom software from the NOAA Northeast Fisheries Science Center (NEFSC) to electronically control the downriggers. For the setup of the downriggers, consult the NOAA Ocean Exploration Standard Operating Procedure: EK60/EK80 Calibration¹. For the pod setup calibration, the sphere was suspended about 5 meters (16 feet) below the swivels and a five pound lead fishing weight was suspended about 3 meters (10 feet) below the sphere for stability. For the 18 kHz calibration, the sphere was suspended about 10 meters (33 feet) below the swivels and a five pound lead fishing weight was suspended about 15 meters (50 feet) below the sphere for stability.

The three calibration lines were joined using typical calibration procedures (lowering a rope under the bow with the port side calibration line attached to the end of it and retrieving the rope from the starboard side once passed under the keel). For the 18 kHz calibration, the reciprocal was used with the line being attached to the starboard side and pulling up on the port side. Prior to deployment, the sphere was soaked in a soapy water solution to break surface tension. The sphere was then lowered to a depth of approximately 15 m and 35 m from the surface of the water for the pod and 18 kHz calibration, respectively (range of about 10 m and 30 m from the transducers). This depth was achieved by having 55 feet of line out of each downrigger for the pod. For the 18 kHz calibration, the line out count was about 100 feet at the water line for each downrigger.

The target strength (TS) of the sphere used for calibration was calculated based on the CastAway CTD measurements of salinity, temperature, and depth of the sphere. See **Table 3** for the TS values of the sphere for each frequency and consult the Location and Conditions section for the CTD values. For each frequency, the sphere was initially positioned in the center of the transducer beam (on-axis) and data were recorded for several minutes. The sphere was moved throughout the beam to achieve adequate coverage (greater than 70% coverage in the center and overall - see Appendix B).

¹ Request from oar.oer.exmappingteam@noaa.gov

Table 3. Target strength (TS; units=dB) values of the spheres used during calibration based on the values calculated in the Simrad EK80 calibration software from the CTD provided temperature and salinity.

Frequency (kHz)	64 mm diameter copper sphere TS (dB)	38.1 mm diameter tungsten carbide sphere TS (dB)
18	-34.29	N/A
38 (CW)	N/A	-42.33
38 (FM)	N/A	See XML file
70 (CW)	N/A	-41.67
70 (FM)	N/A	See XML file
120	N/A	-40.05
200	N/A	-38.86

Calibration Results

There was very good coverage for all frequencies with over 300 sphere detections in each beam and root mean square (RMS) error values below the recommended 0.4 threshold (per manufacturer recommendations). See Appendix C (and XML files) for the total number of sphere detections in the beam for each frequency calibrated. See Appendix E (and XML files) for beam coverage and error values of each of the calibrated frequencies. All .raw and .xml files were saved and recorded and the updated calibration settings were applied to each transducer. See Appendix F for a complete list of the .raw and .xml files recorded during calibration.

The calibration results were comparable to the past two calibrations on NOAA Ship *Okeanos Explorer*. Aside from the new 38 kHz transducer, all other values did not deviate significantly from 2018 to present (**Table 4**). The 38 kHz transducer and topside unit (WBT) was upgraded and replaced during dry dock prior to the calibration in 2021, leading to successful acceptance and calibration of this transducer/transceiver. Note that the 18 kHz calibration occurred in a different location than past calibrations and that the 8.192 pulse length was calibrated for the first time in 2021.

Table 4. 2018-2021 calibration results. From 2018-2019, the 38 kHz system was not successfully calibrated due to a potentially damaged transducer. This transducer and the topside unit (WBT) was replaced in 2021 leading to successful calibrations. See Appendix D for the screenshots detailing the results from the 2021 calibration.

18 kHz: Pulse length: 8.192 ms	March 2018 results	May 2019 results	April 2021 results
Transducer peak gain (dB)	N/A	N/A	23.15
Sa correction (dB)	N/A	N/A	-0.3022
Beamwidth (°) alongship/athwartship	N/A	N/A	9.95/9.93
Beam offset (°) alongship/athwartship	N/A	N/A	0.03/0.06
RMS deviation (dB)	N/A	N/A	0.09
18 kHz: Pulse length: 4.096 ms	March 2018 results	May 2019 results	April 2021 results
Transducer peak gain (dB)	20.54	22.68	23.29
Sa correction (dB)	-0.47	0.11	-0.4128
Beamwidth (°) alongship/athwartship	12.05/11.70	9.94/10.31	9.87/10.05
Beam offset (°) alongship/athwartship	0.41/-0.08	0.01/0.11	0.04/0.06
RMS deviation (dB)	0.35	0.24	0.07
18 kHz: Pulse length: 1.024 ms	March 2018 results	May 2019 results	April 2021 results
Transducer peak gain (dB)	20.09	22.28	22.94
Sa correction (dB)	-0.68	0.01	-0.7154
Beamwidth (°) alongship/athwartship	11.64/11.84	10.29/11.24	9.86/9.69
Beam offset (°) alongship/athwartship	0.12/0.14	-0.02/-0.08	0.09/-0.01
RMS deviation (dB)	0.37	0.20	0.11
38 kHz(CW): Pulse length: 2.048 ms	March 2018 results	May 2019 results	April 2021 results
Transducer peak gain (dB)	N/A	N/A	26.75
Sa correction (dB)	N/A	N/A	-0.1628

38 kHz(CW): Pulse length: 2.048 ms	March 2018 results	May 2019 results	April 2021 results
Beamwidth (°) alongship/athwartship	N/A	N/A	6.51/6.66
Beam offset (°) alongship/athwartship	N/A	N/A	-0.09/0.02
RMS deviation (dB)	N/A	N/A	0.08
38 kHz(CW): Pulse length: 1.024 ms	March 2018 results	May 2019 results	April 2021 results
Transducer peak gain (dB)	N/A	N/A	26.74
Sa correction (dB)	N/A	N/A	0.0106
Beamwidth (°) alongship/athwartship	N/A	N/A	6.32/6.40
Beam offset (°) alongship/athwartship	N/A	N/A	-0.08/-0.01
RMS deviation (dB)	N/A	N/A	0.14
38 kHz(FM): Pulse length: 4.096 ms	March 2018 results	May 2019 results	April 2021 results
Transducer peak gain (dB)	N/A	N/A	25.17 to 27.62
Sa correction (dB)	N/A	N/A	0.0000
Beamwidth (°) alongship/athwartship	N/A	N/A	See XML file
Beam offset (°) alongship/athwartship	N/A	N/A	See XML file
RMS deviation (dB)	N/A	N/A	0.3663 to 0.4393
38 kHz(FM): Pulse length: 1.024 ms	March 2018 results	May 2019 results	April 2021 results
Transducer peak gain (dB)	N/A	N/A	25.62 to 28.15
Sa correction (dB)	N/A	N/A	0.0000
Beamwidth (°) alongship/athwartship	N/A	N/A	See XML file
Beam offset (°) alongship/athwartship	N/A	N/A	See XML file
RMS deviation (dB)	N/A	N/A	0.1661 to 0.2429

70 kHz (CW): Pulse length: 2.048 ms	March 2018 GPT results	May 2019 WBT results	April 2021 results
Transducer peak gain (dB)	26.76	26.69	27.21
Sa correction (dB)	-0.24	-0.36	-0.0786
Beamwidth (°) alongship/athwartship	6.50/6.60	6.73/6.70	6.48/6.63
Beam offset (°) alongship/athwartship	0.05/0.36	0.19/0.35	-0.06/0.04
RMS deviation (dB)	0.16	0.34	0.09
70 kHz (CW): Pulse length: 1.024 ms	March 2018 GPT results	May 2019 WBT results	April 2021 results
Transducer peak gain (dB)	26.65	27.40	27.05
Sa correction (dB)	-0.36	0.08	-0.0954
Beamwidth (°) alongship/athwartship	6.79/6.51	6.00/5.94	6.64/6.57
Beam offset (°) alongship/athwartship	-0.03/-0.28	-0.19/-0.29	-0.02/0.00
RMS deviation (dB)	0.38	0.38	0.19
70 kHz (FM): Pulse length: 2.048 ms	March 2018 GPT results	May 2019 WBT results	April 2021 results
Transducer peak gain (dB)	N/A	21.72 to 29.56	21.85 to 29.05
Sa correction (dB)	N/A	0.00	0.00
Beamwidth (°) alongship/athwartship	N/A	See XML file	See XML file
Beam offset (°) alongship/athwartship	N/A	See XML file	See XML file
RMS deviation (dB)	N/A	0.2557 to 0.4686	0.0732 to 0.1955
70 kHz (FM): Pulse length: 1.024 ms	March 2018 GPT results	May 2019 WBT results	April 2021 results
Transducer peak gain (dB)	N/A	21.91 to 29.62	21.84 to 28.87
Sa correction (dB)	N/A	0.00	0.00
Beamwidth (°) alongship/athwartship	N/A	See XML file	See XML file
Beam offset (°) alongship/athwartship	N/A	See XML file	See XML file

70 kHz (FM): Pulse length: 1.024 ms	March 2018 GPT results	May 2019 WBT results	April 2021 results
RMS deviation (dB)	N/A	0.2785 to 0.4557	0.2319 to 0.3878
120 kHz: Pulse length: 1.024 ms	March 2018 results	May 2019 results	April 2021 results
Transducer peak gain (dB)	26.25	26.00	25.51
Sa correction (dB)	-0.38	-0.03	-0.2628
Beamwidth (°) alongship/athwartship	6.49/6.75	6.46/6.35	6.90/6.68
Beam offset (°) alongship/athwartship	-0.10/0.09	0.16/-0.14	-0.18/0.08
RMS deviation (dB)	0.22	0.28	0.21
200 kHz: Pulse length: 1.024 ms	March 2018 results	May 2019 results	April 2021 results
Transducer peak gain (dB)	26.34	26.27	26.21
Sa correction (dB)	-0.36	0.01	-0.2987
Beamwidth (°) alongship/athwartship	6.76/6.88	6.50/6.26	6.27/6.49
Beam offset (°) alongship/athwartship	0.04/0.13	0.11/0.00	0.04/0.12
RMS deviation (dB)	0.23	0.14	0.21

Appendix A: Channel Results

18 kHz: 8.192 ms

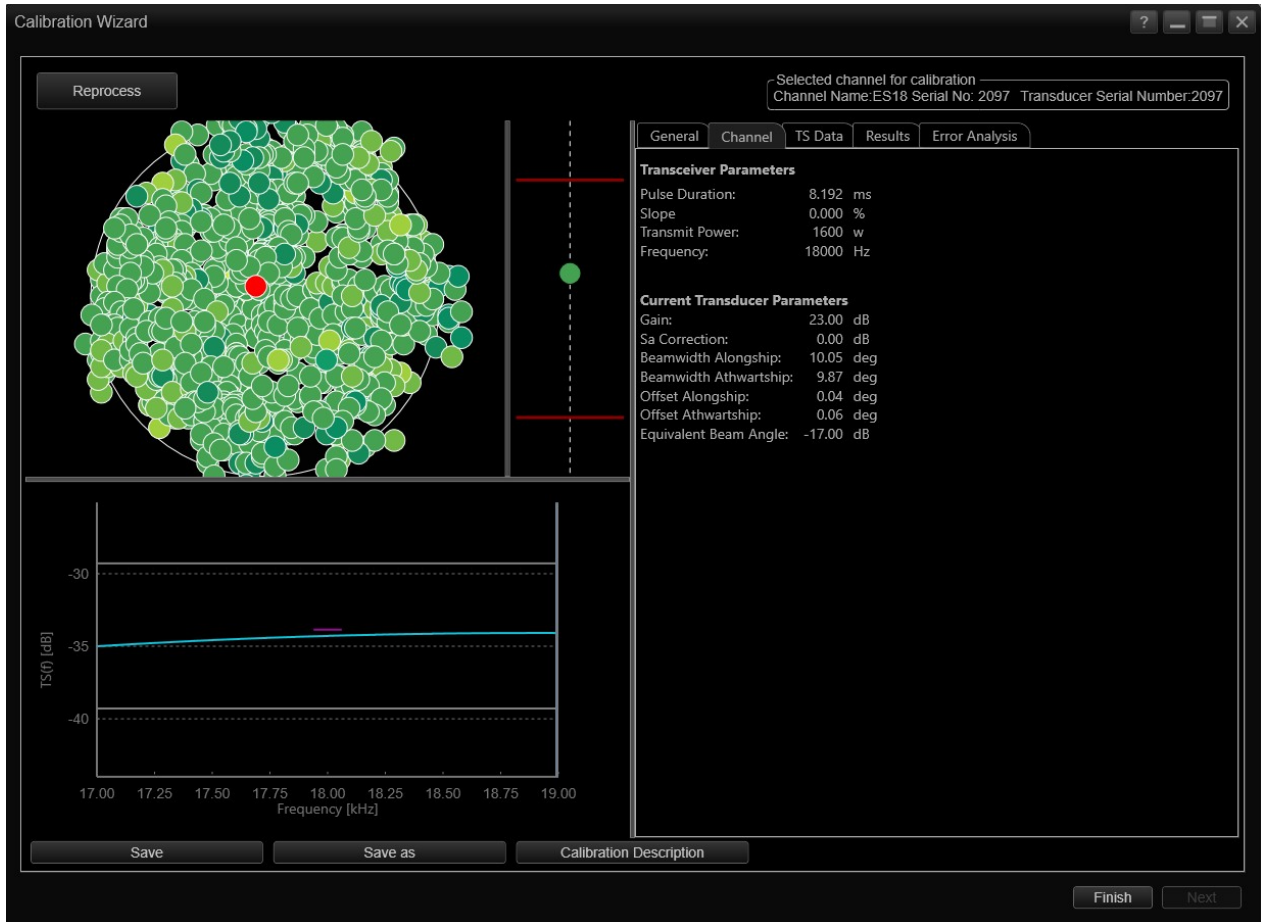


Figure 1. Screenshot of EK80 Calibration Wizard channel results for 18 kHz calibration at 8.192 ms.

18 kHz: 4.096 ms

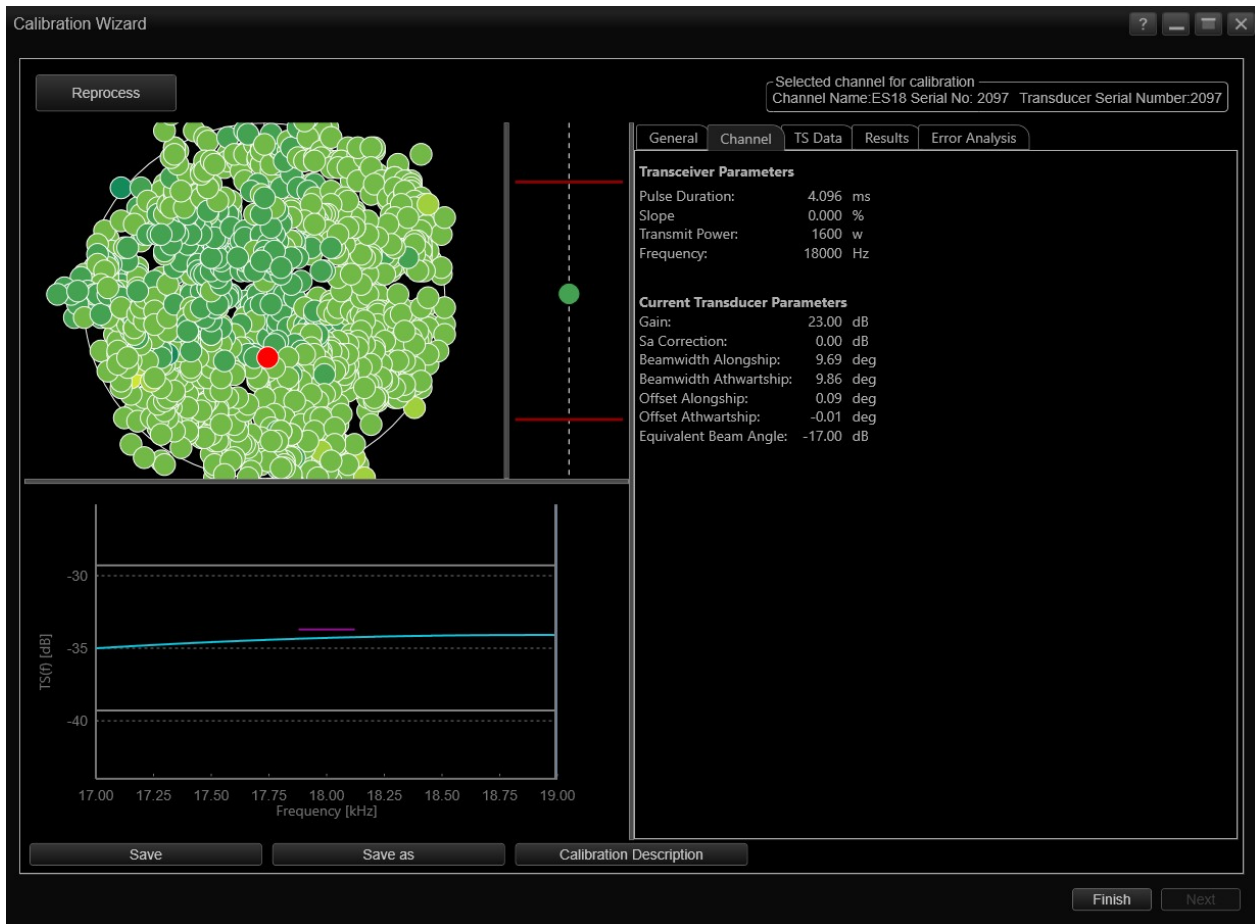


Figure 2. Screenshot of EK80 Calibration Wizard channel results for 18 kHz calibration at 4.096 ms.

18 kHz: 1.024 ms

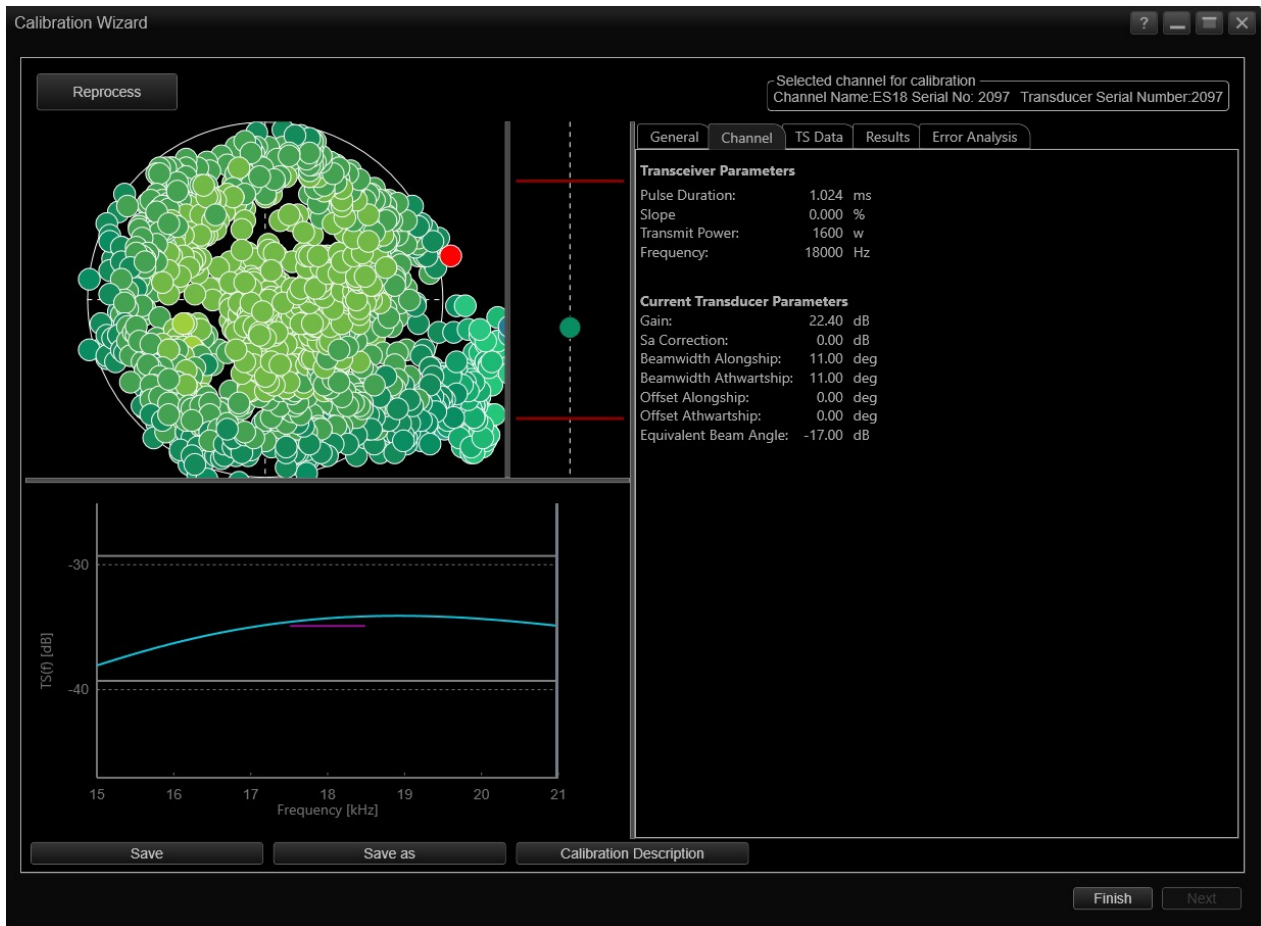


Figure 3. Screenshot of EK80 Calibration Wizard channel results for 18 kHz calibration at 1.024 ms.

38 kHz (CW): 2.048 ms

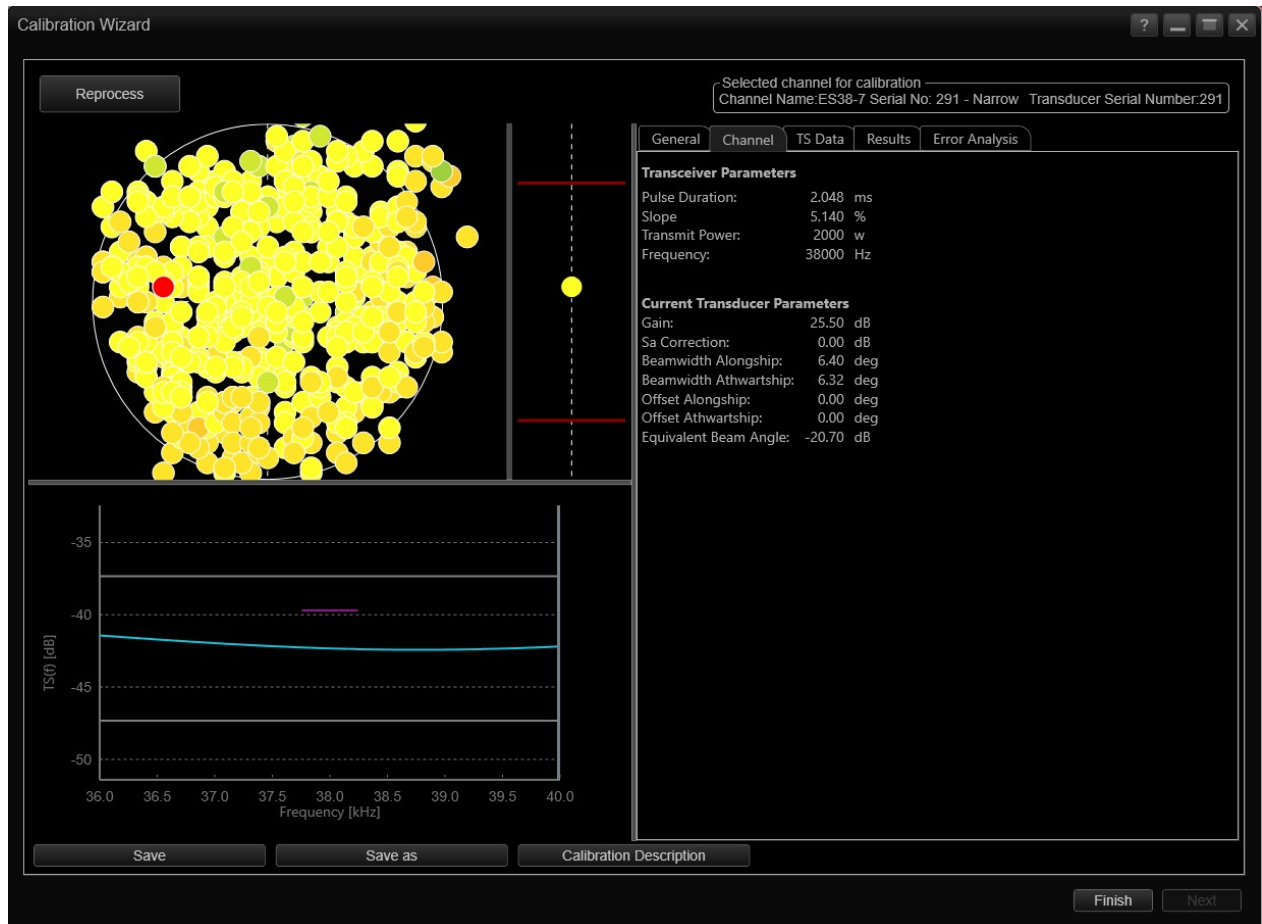


Figure 4. Screenshot of EK80 Calibration Wizard channel results for 38 kHz calibration at 2.048 ms in continuous wave (CW) mode.

38 kHz (CW): 1.024 ms

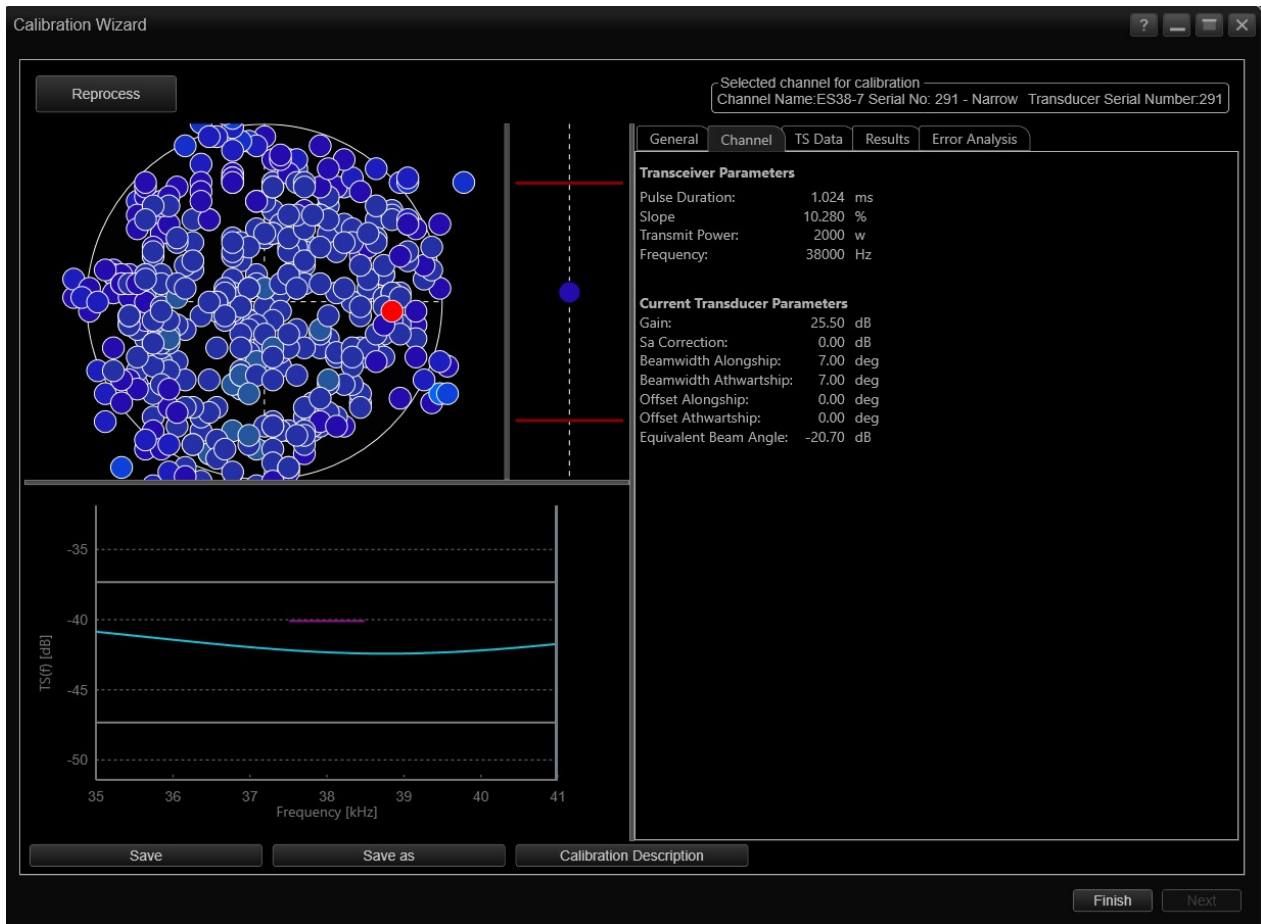


Figure 5. Screenshot of EK80 Calibration Wizard channel results for 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

38 kHz (FM): 4.096 ms

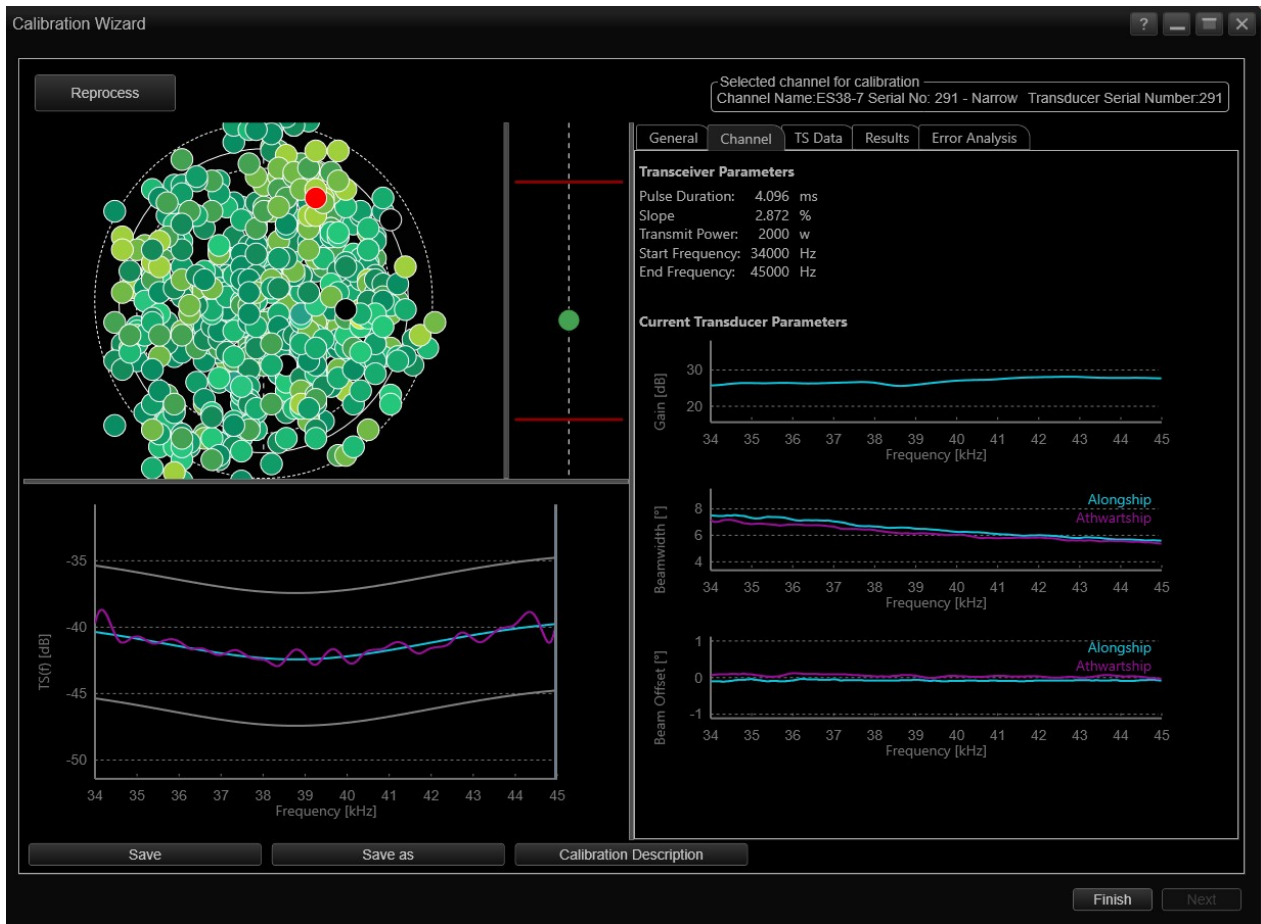


Figure 6. Screenshot of EK80 Calibration Wizard channel results for 38 kHz calibration at 4.096 ms in frequency modulated (FM) mode.

38 kHz (FM): 1.024 ms

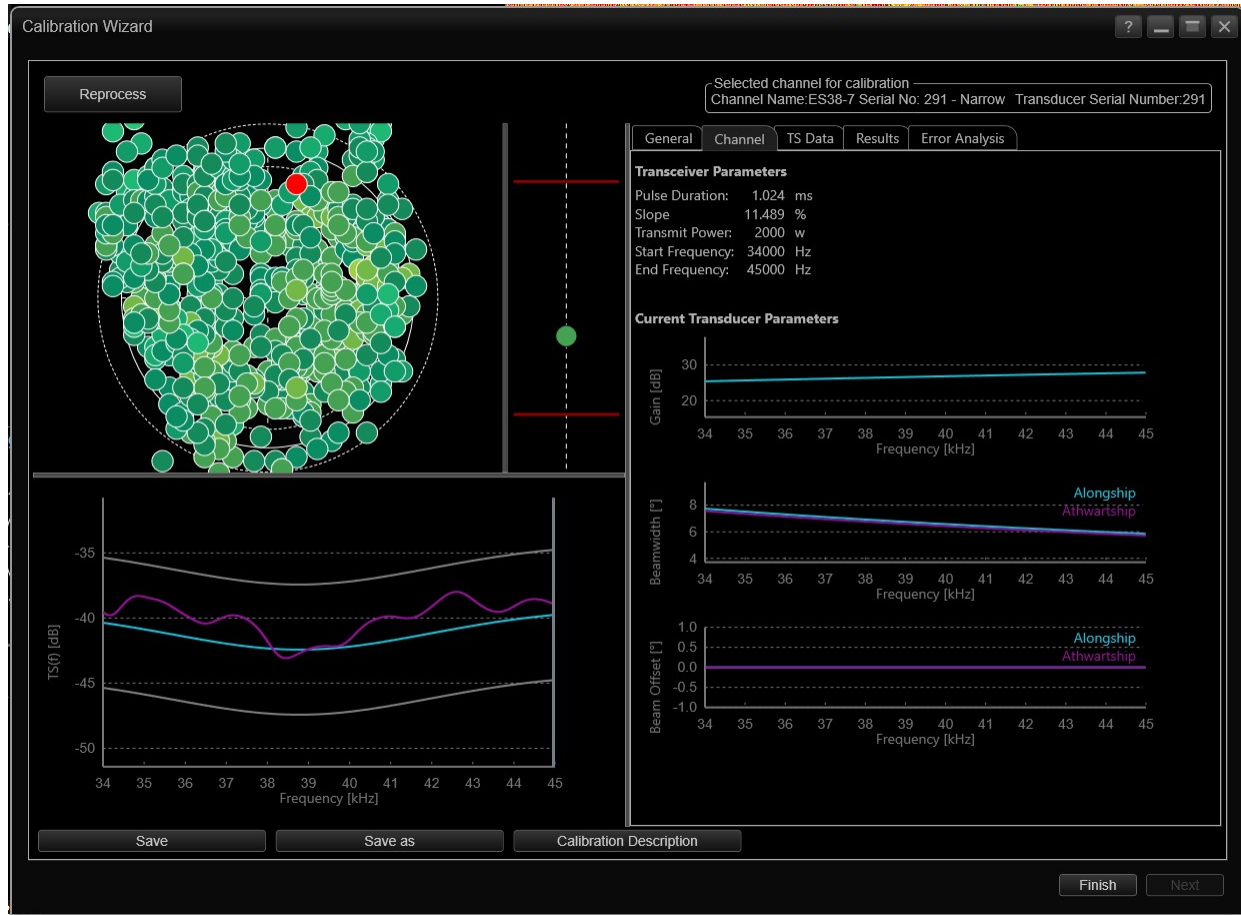


Figure 7. Screenshot of EK80 Calibration Wizard channel results for 38 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

70 kHz (CW): 2.048 ms

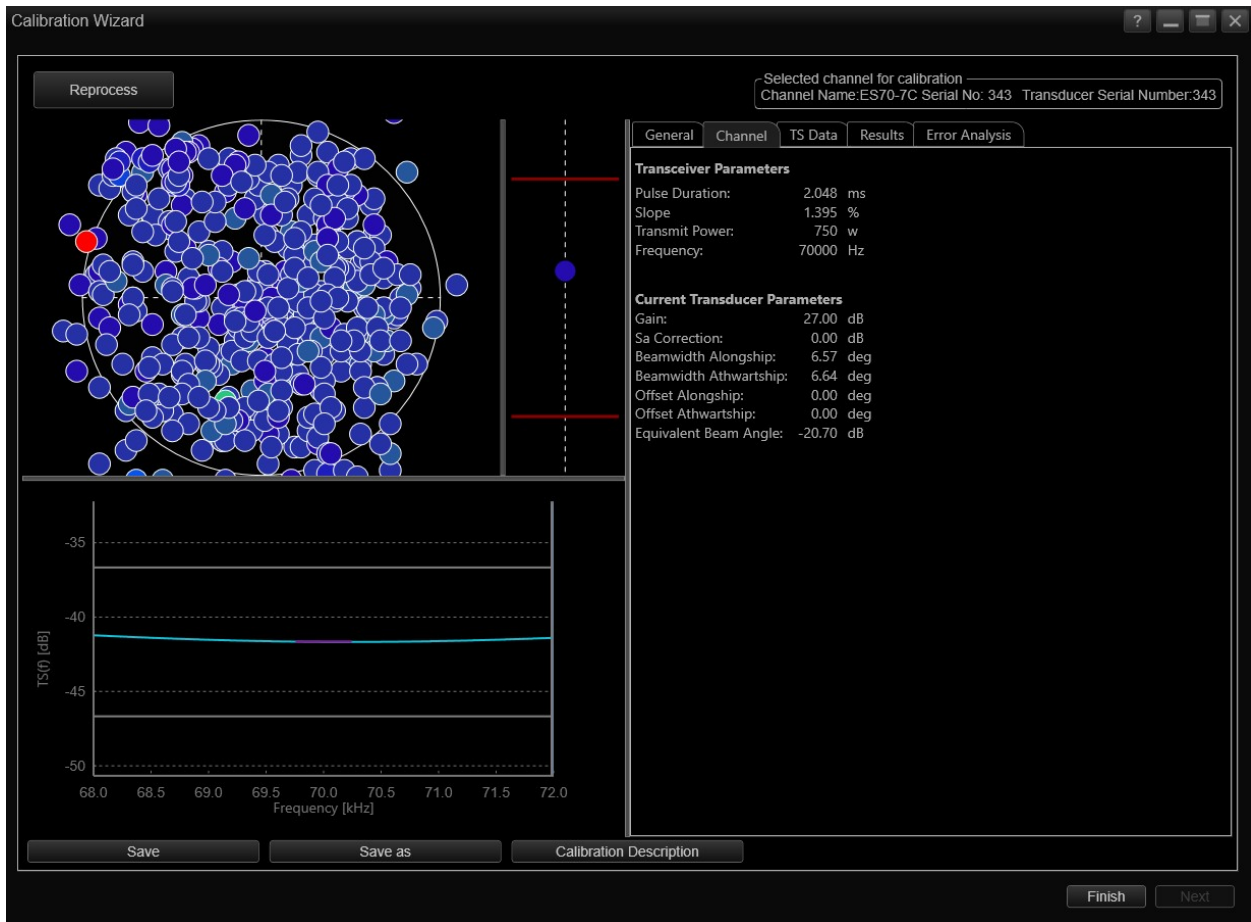


Figure 8. Screenshot of EK80 Calibration Wizard channel results for 70 kHz calibration at 2.048 ms in continuous wave (CW) mode.

70 kHz (CW): 1.024 ms

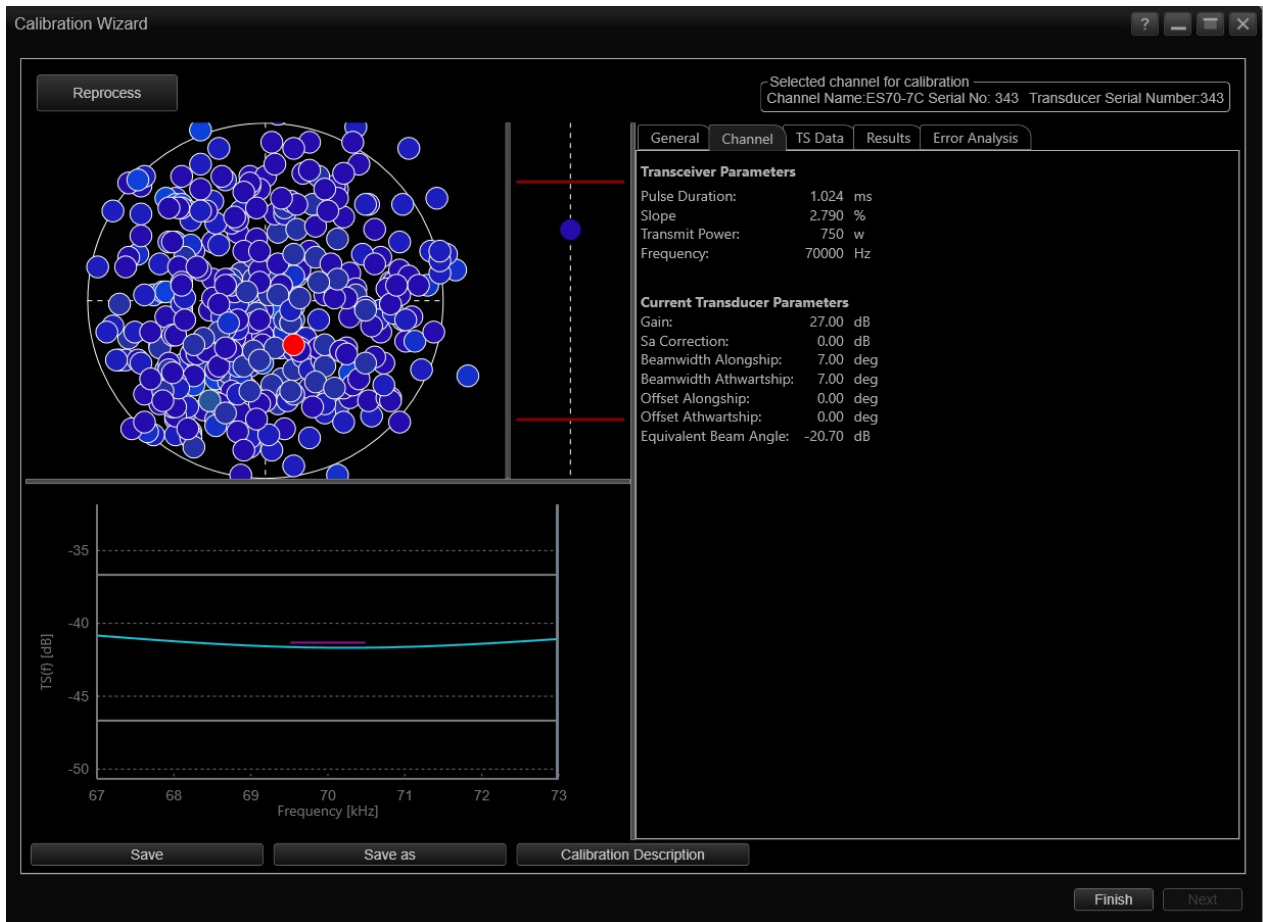


Figure 9. Screenshot of EK80 Calibration Wizard channel results for 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (FM): 2.048 ms

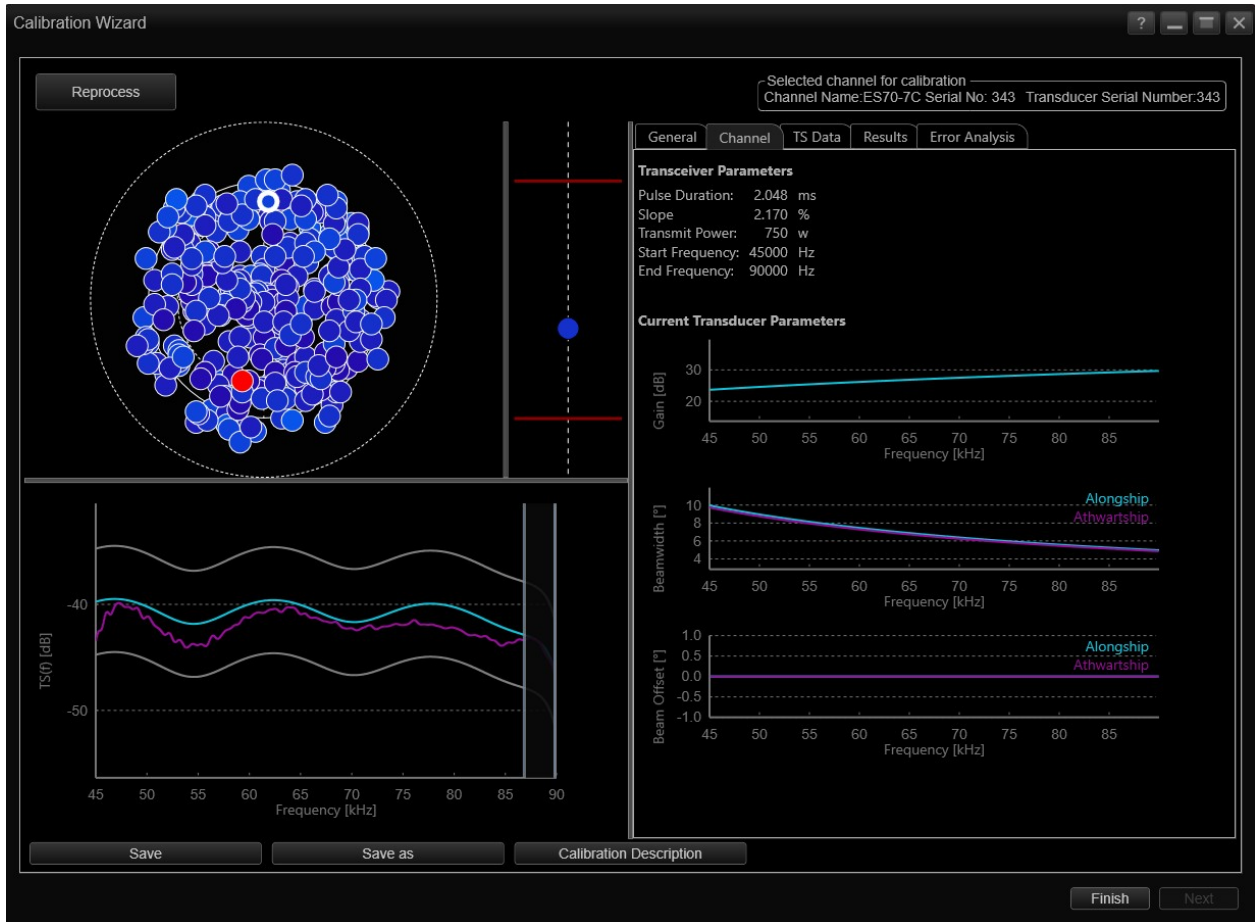


Figure 10. Screenshot of EK80 Calibration Wizard channel results for 70 kHz calibration at 2.048 ms in frequency modulated (FM) mode.

70 kHz (FM): 1.024 ms

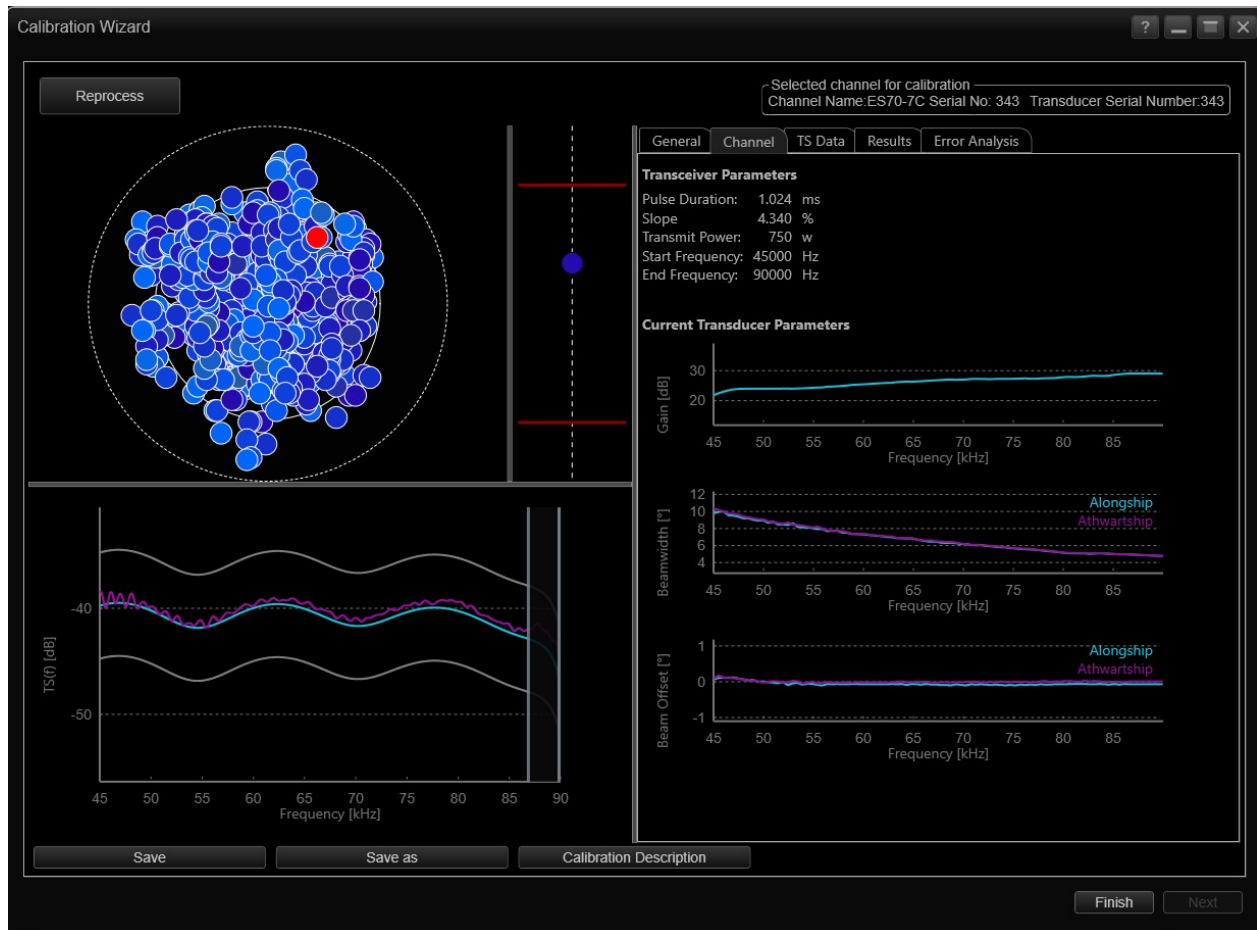


Figure 11. Screenshot of EK80 Calibration Wizard channel results for 70 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

120 kHz: 1.024 ms

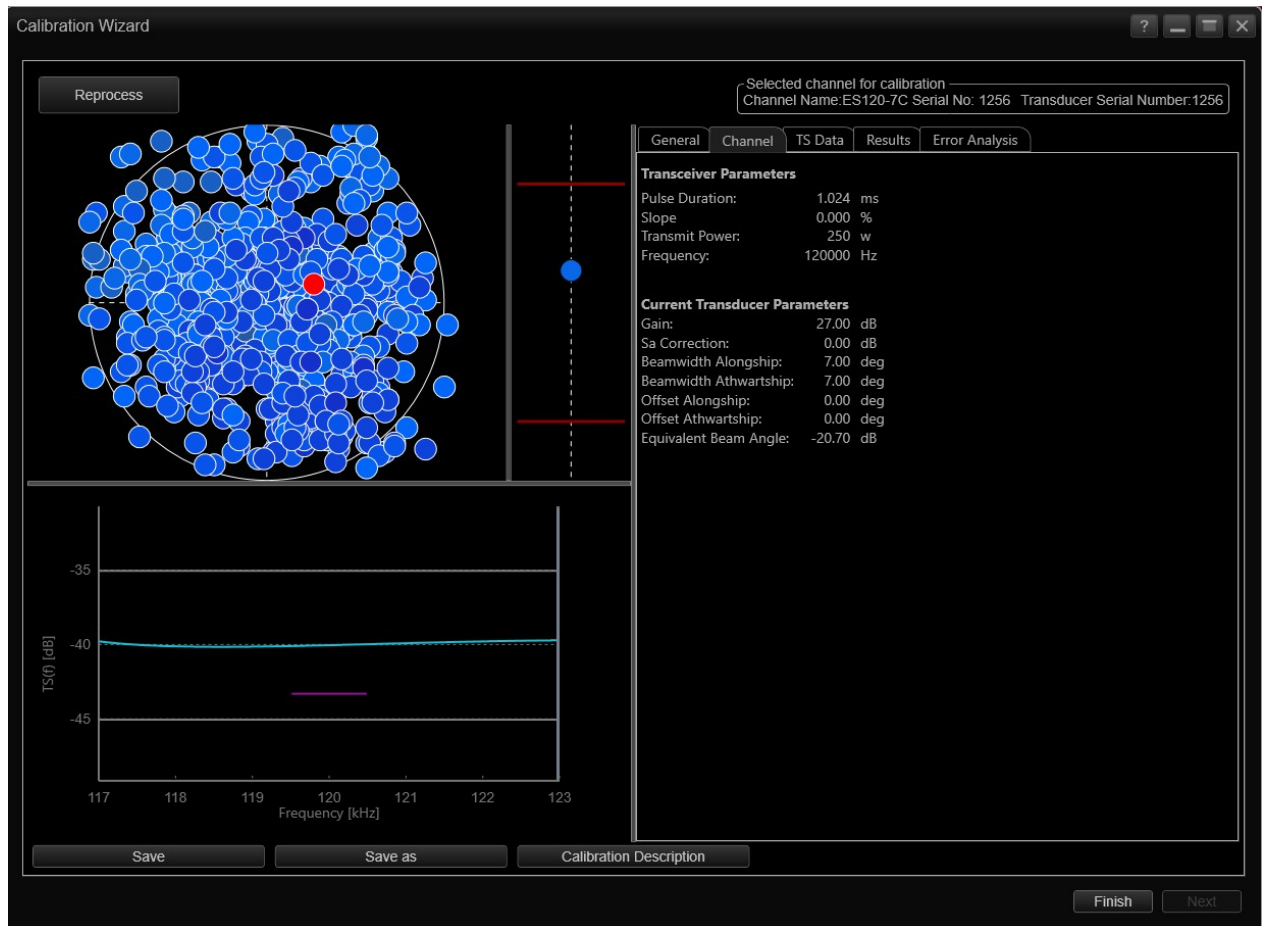


Figure 12. Screenshot of EK80 Calibration Wizard channel results for 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

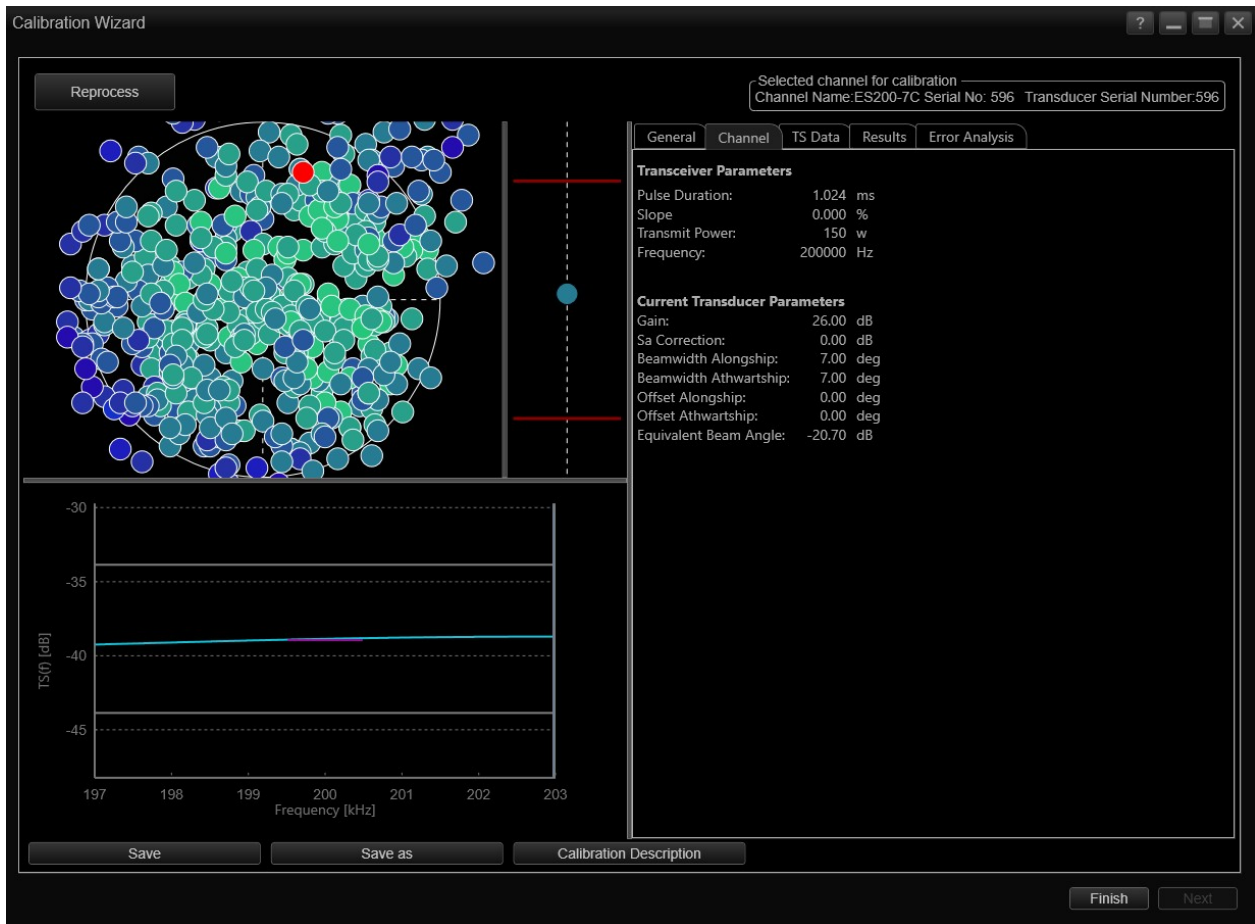


Figure 13. Screenshot of EK80 Calibration Wizard channel results for 200 kHz calibration at 1.024 ms.

Appendix B: General Results

18 kHz: 8.192 ms



Figure 14. Screenshot of EK80 Calibration Wizard general results for 18 kHz calibration at 8.192 ms.

18 kHz: 4.096 ms



Figure 15. Screenshot of EK80 Calibration Wizard general results for 18 kHz calibration at 4.096 ms.

18 kHz: 1.024 ms

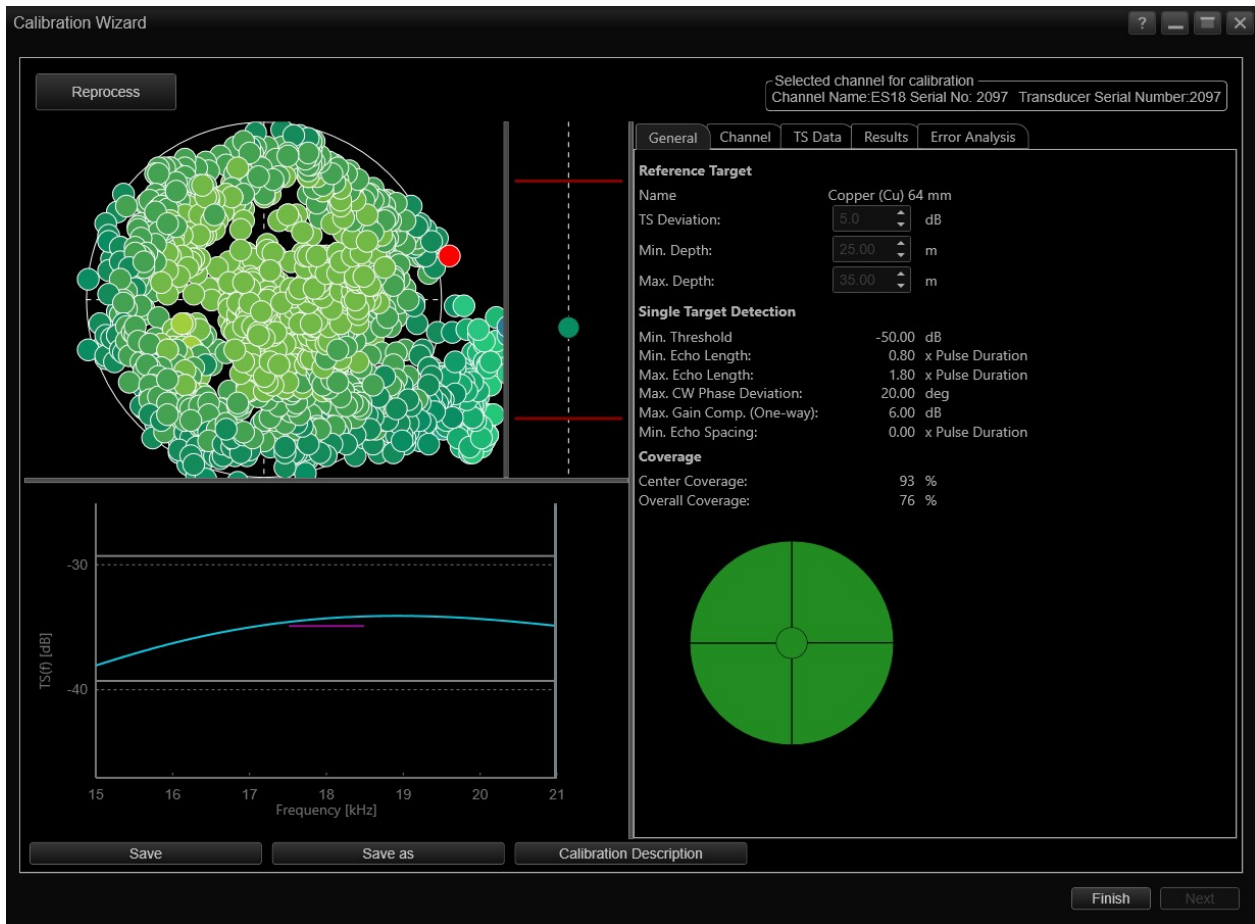


Figure 16. Screenshot of EK80 Calibration Wizard general results for 18 kHz calibration at 1.024 ms.

38 kHz (CW): 2.048 ms

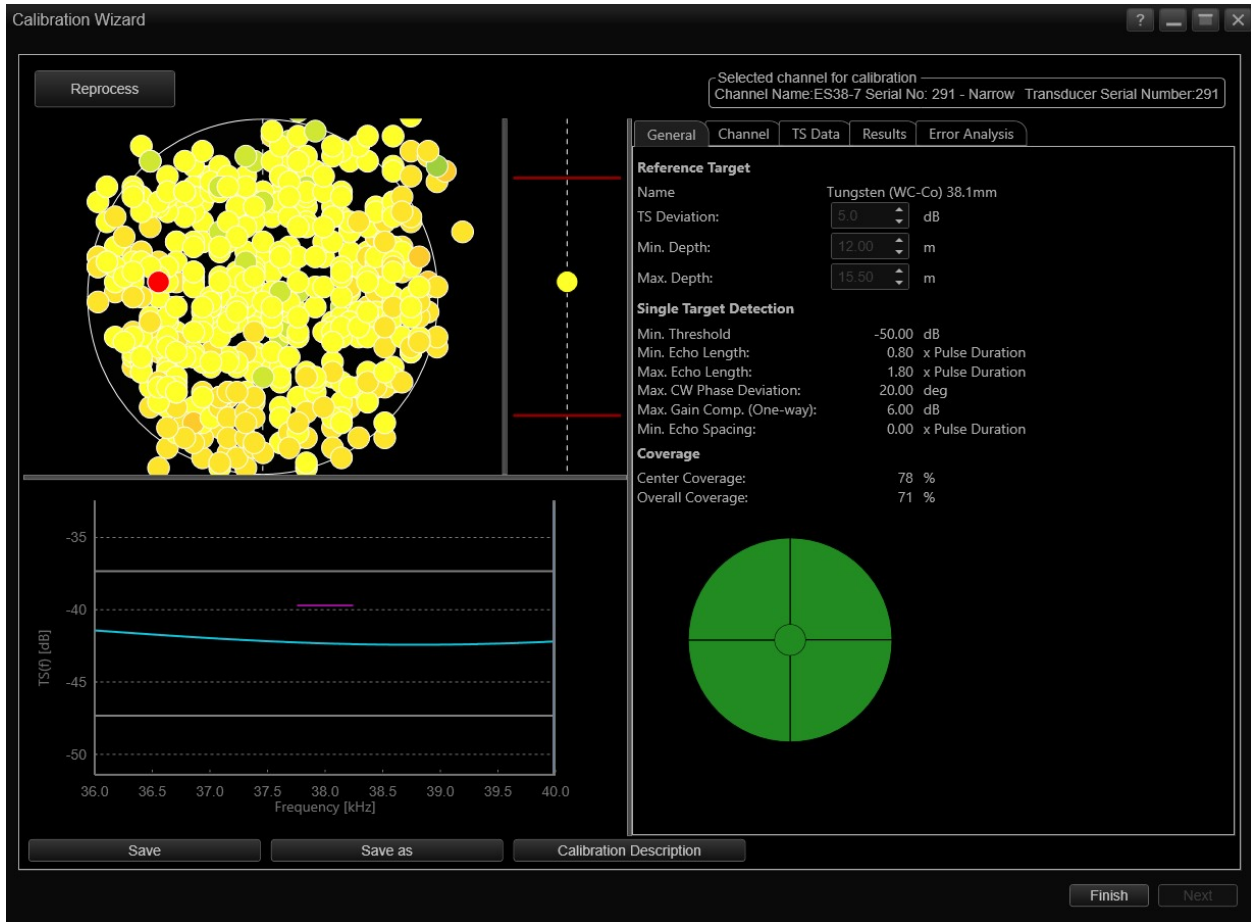


Figure 17. Screenshot of EK80 Calibration Wizard general results for 38 kHz calibration at 2.048 ms in continuous wave (CW) mode.

38 kHz (CW): 1.024 ms

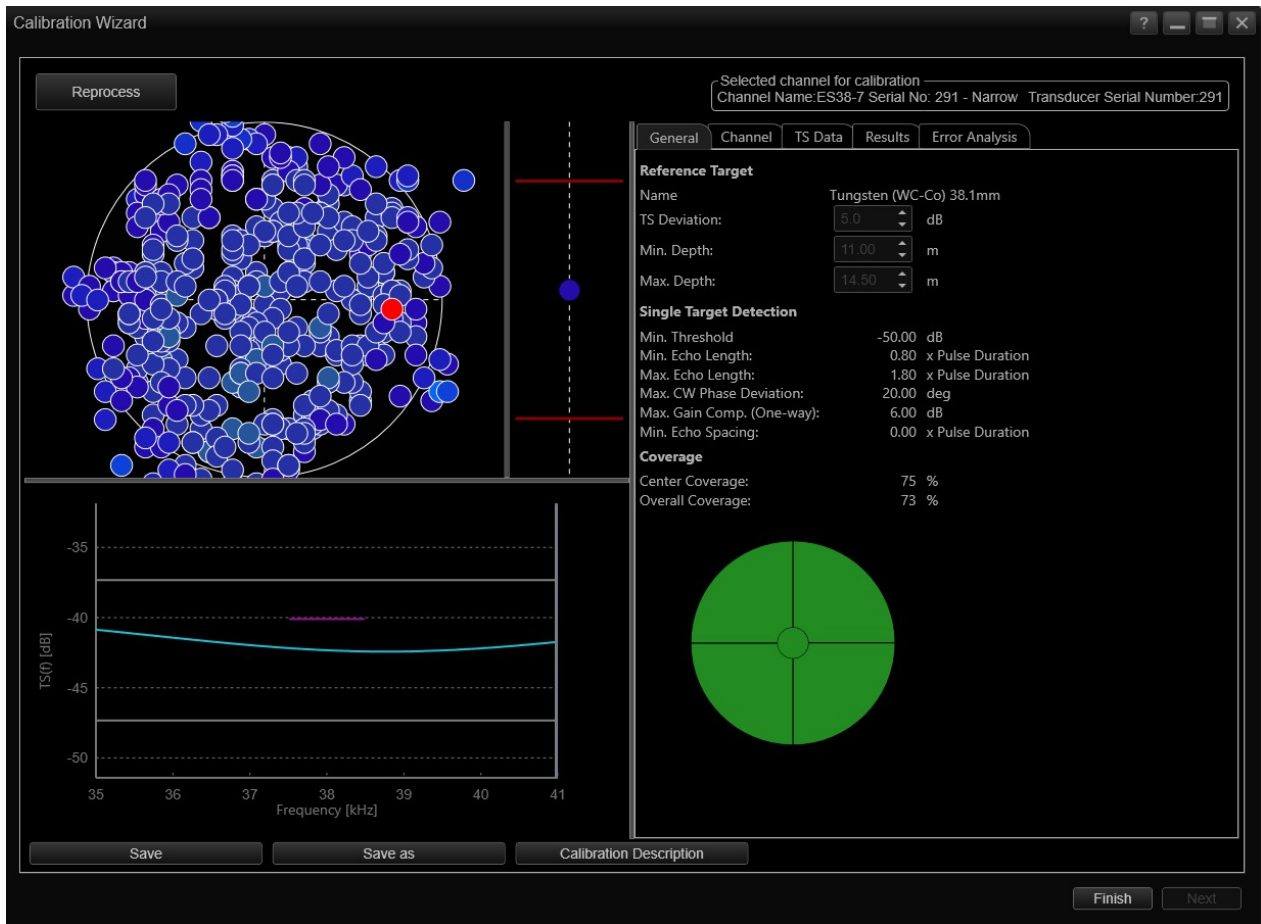


Figure 18. Screenshot of EK80 Calibration Wizard general results for 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

38 kHz (FM): 4.096 ms

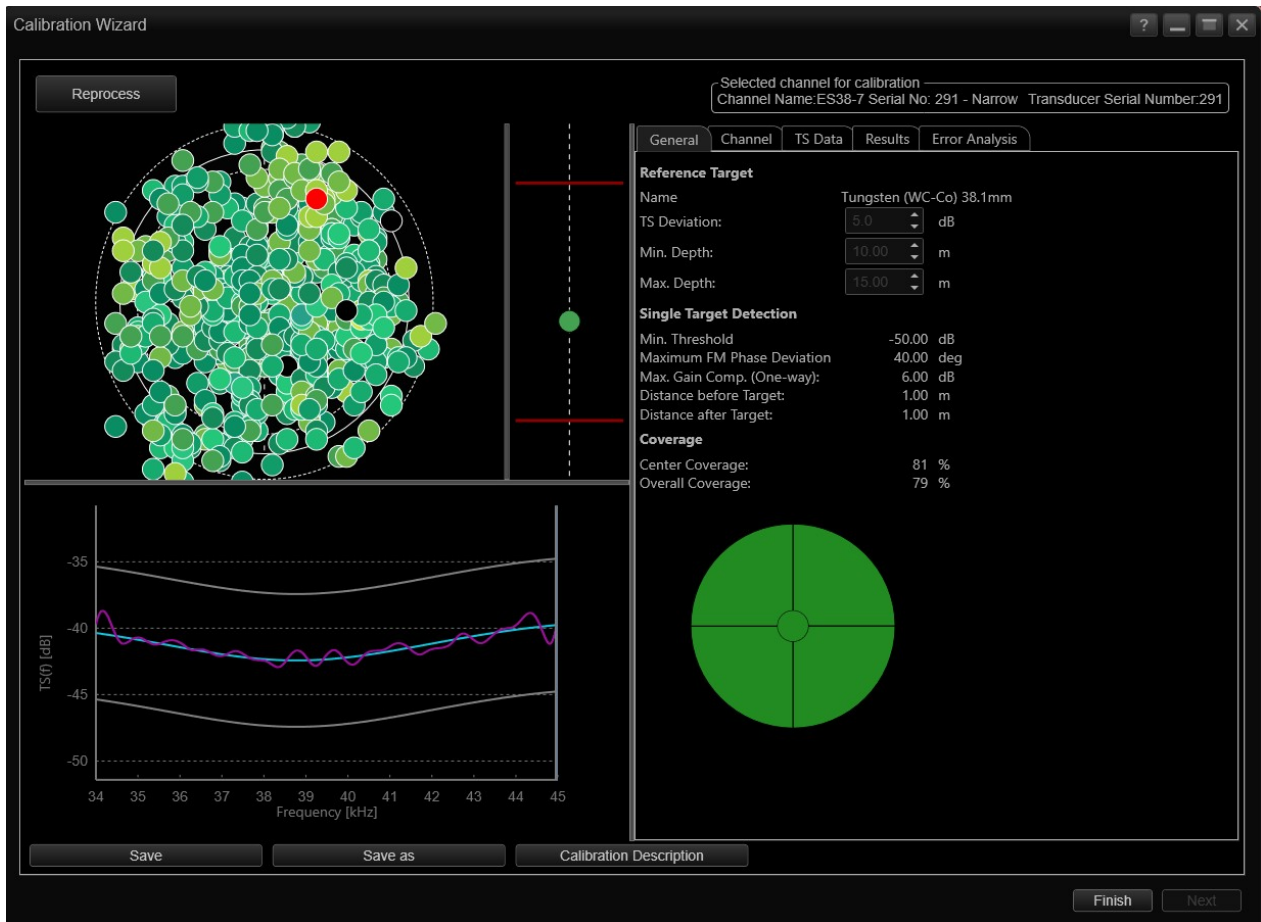


Figure 19. Screenshot of EK80 Calibration Wizard general results for 38 kHz calibration at 4.096 ms in frequency modulated (FM) mode.

38 kHz (FM): 1.024 ms

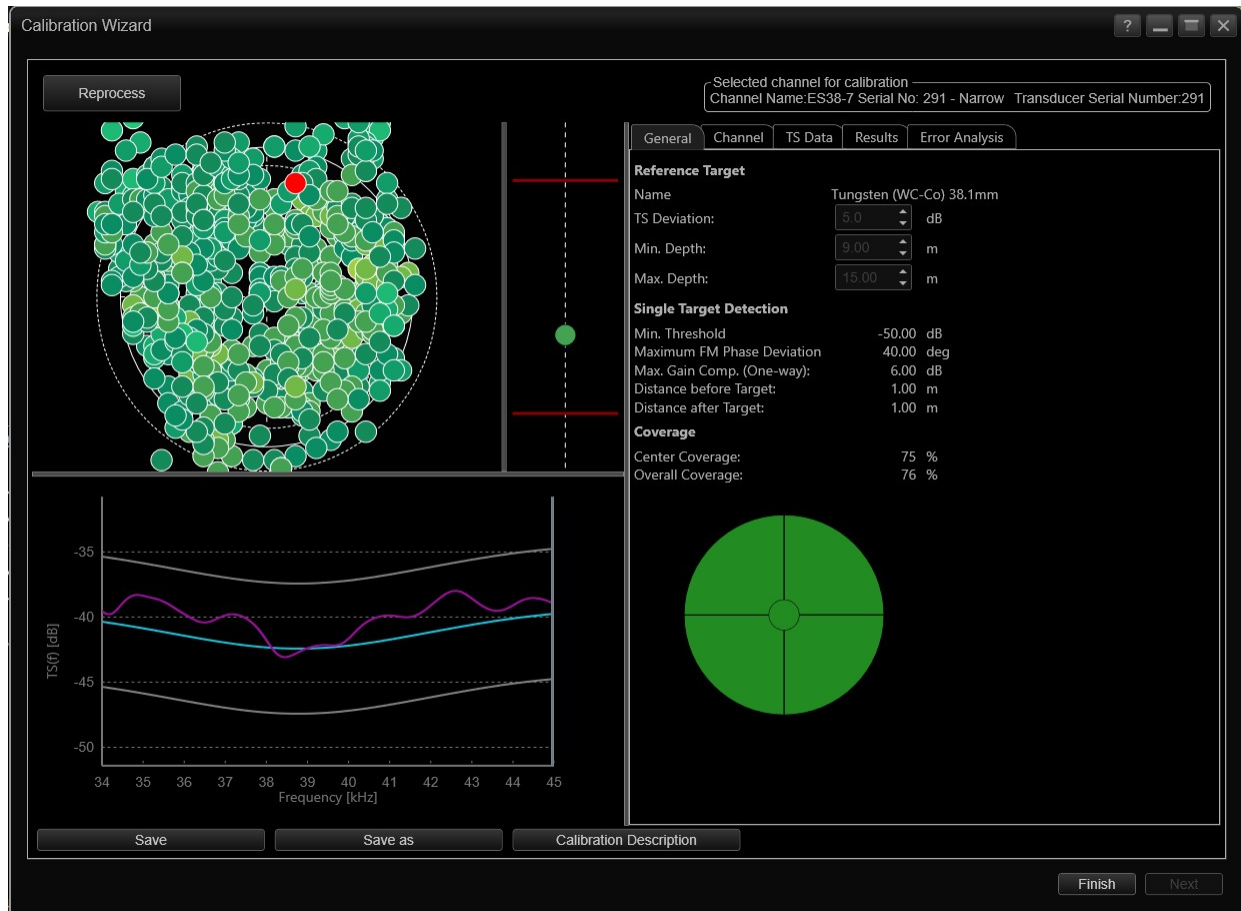


Figure 20. Screenshot of EK80 Calibration Wizard general results for 38 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

70 kHz (CW): 2.048 ms

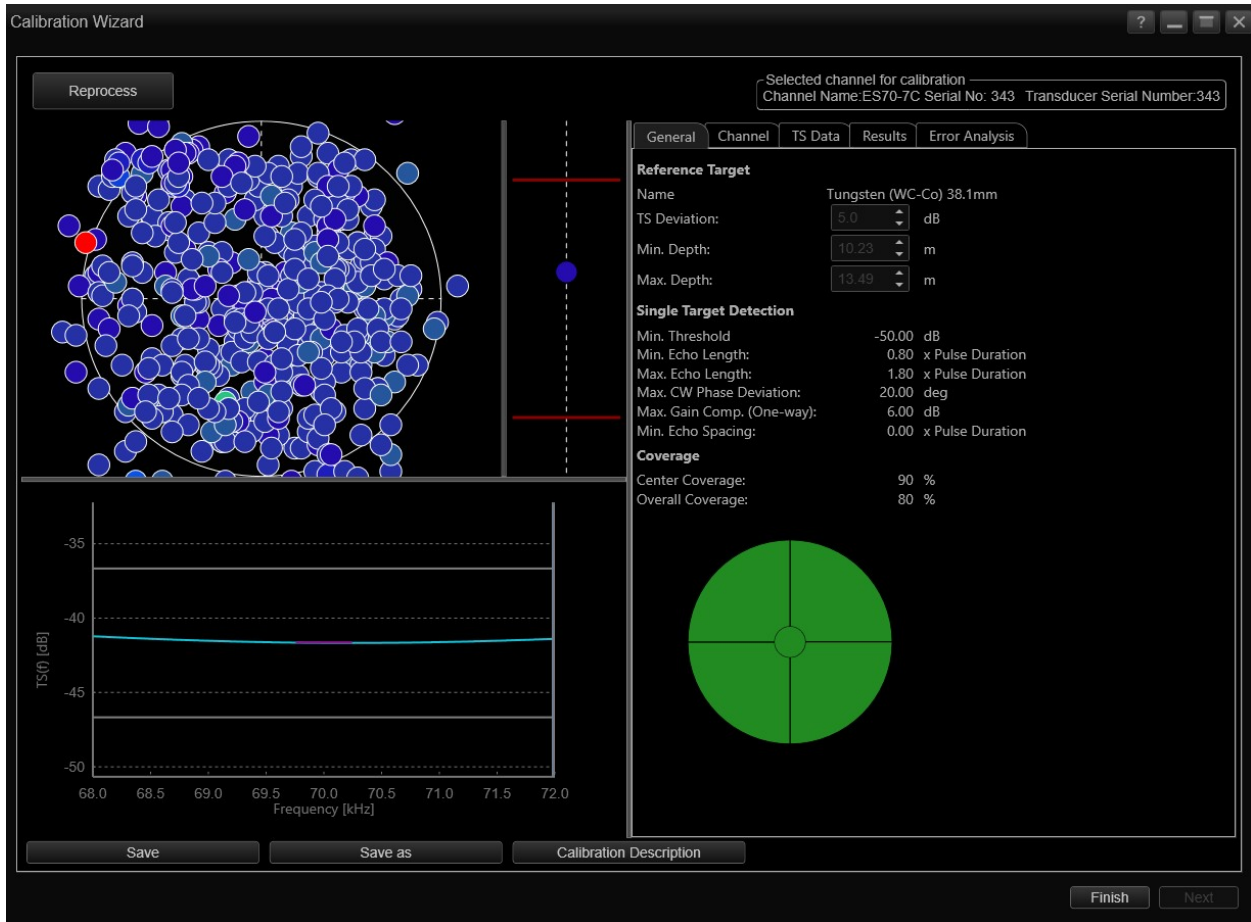


Figure 21. Screenshot of EK80 Calibration Wizard general results for 70 kHz calibration at 2.048 ms in continuous wave (CW) mode.

70 kHz (CW): 1.024 ms

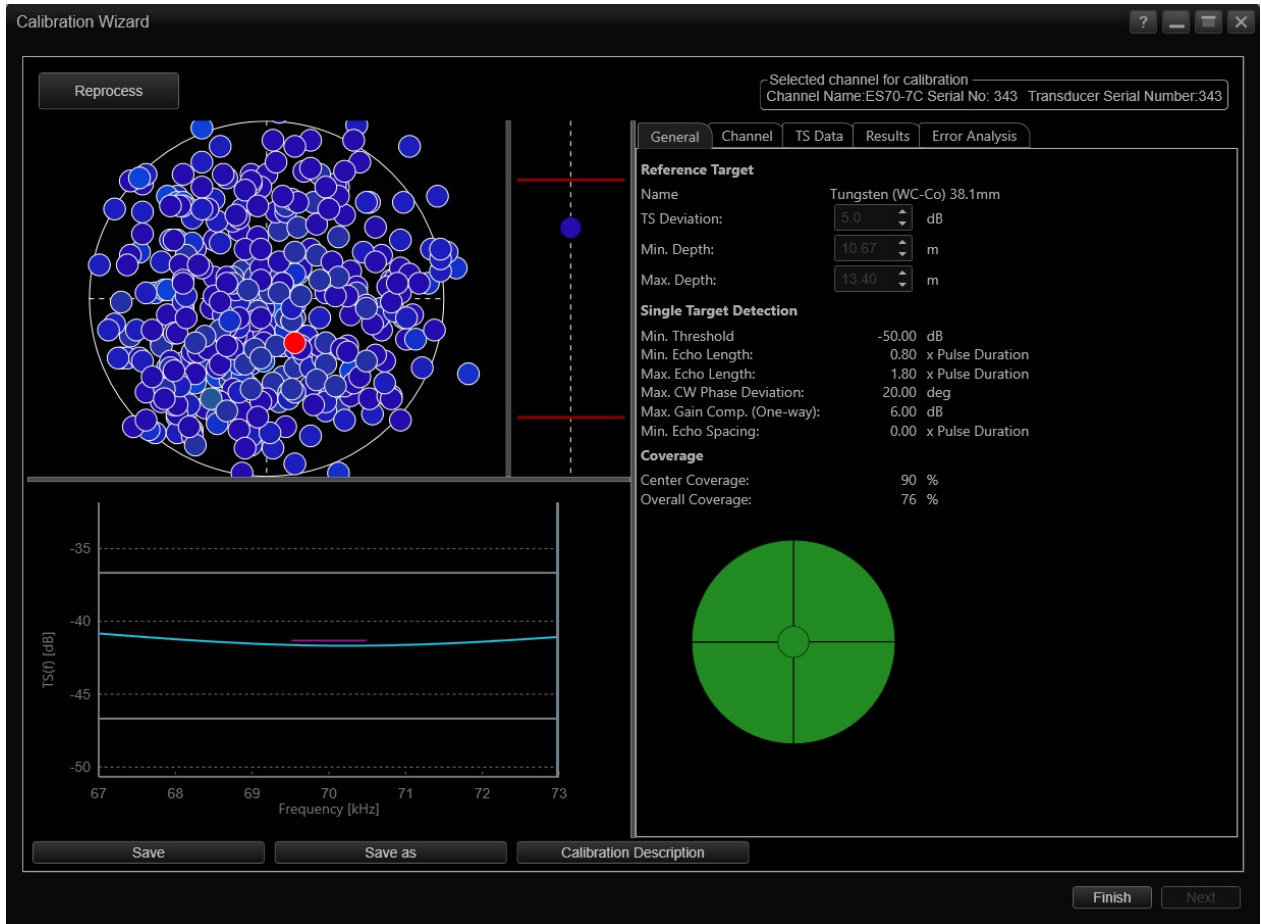


Figure 22. Screenshot of EK80 Calibration Wizard general results for 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (FM): 2.048 ms

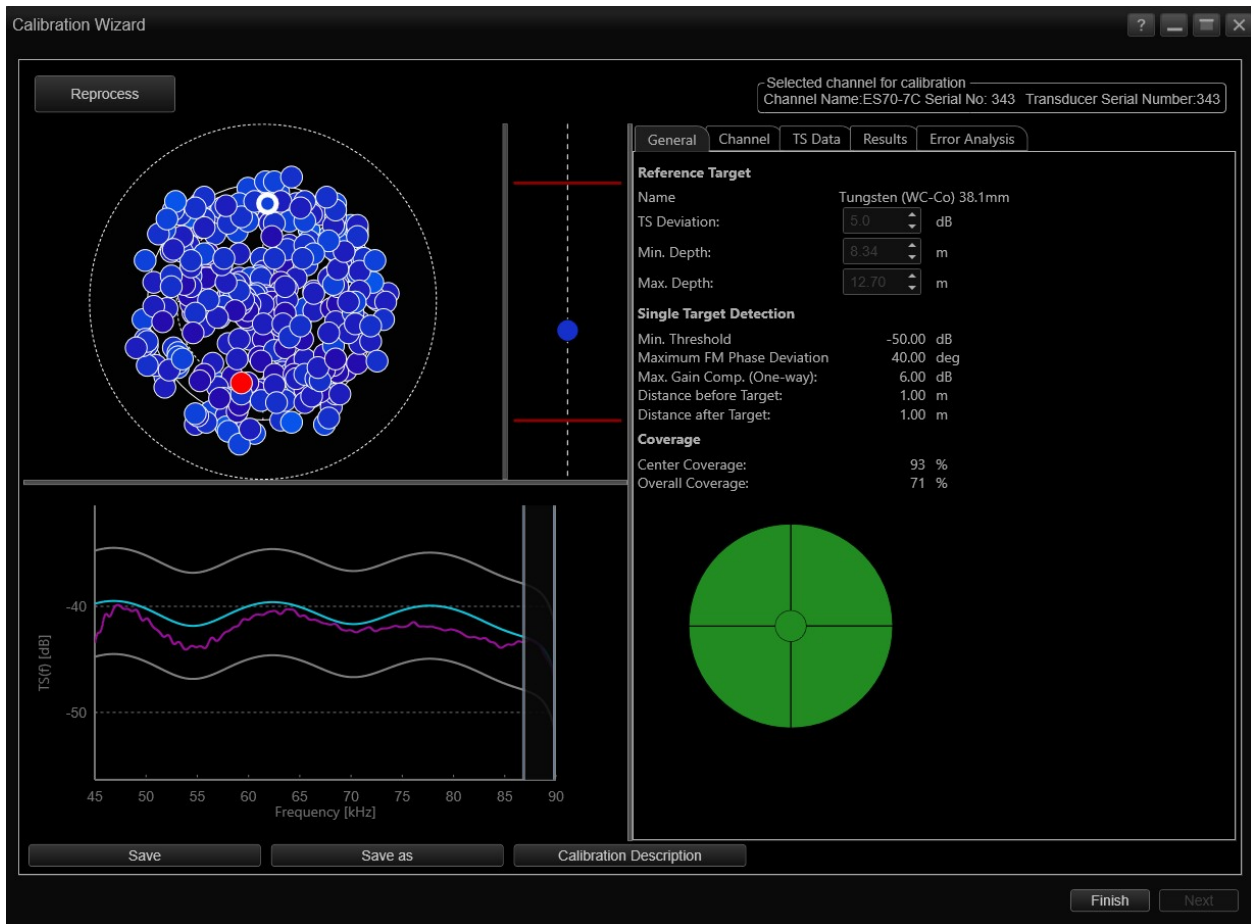


Figure 23. Screenshot of EK80 Calibration Wizard general results for 70 kHz calibration at 2.048 ms in frequency modulated (FM) mode.

70 kHz (FM): 1.024 ms

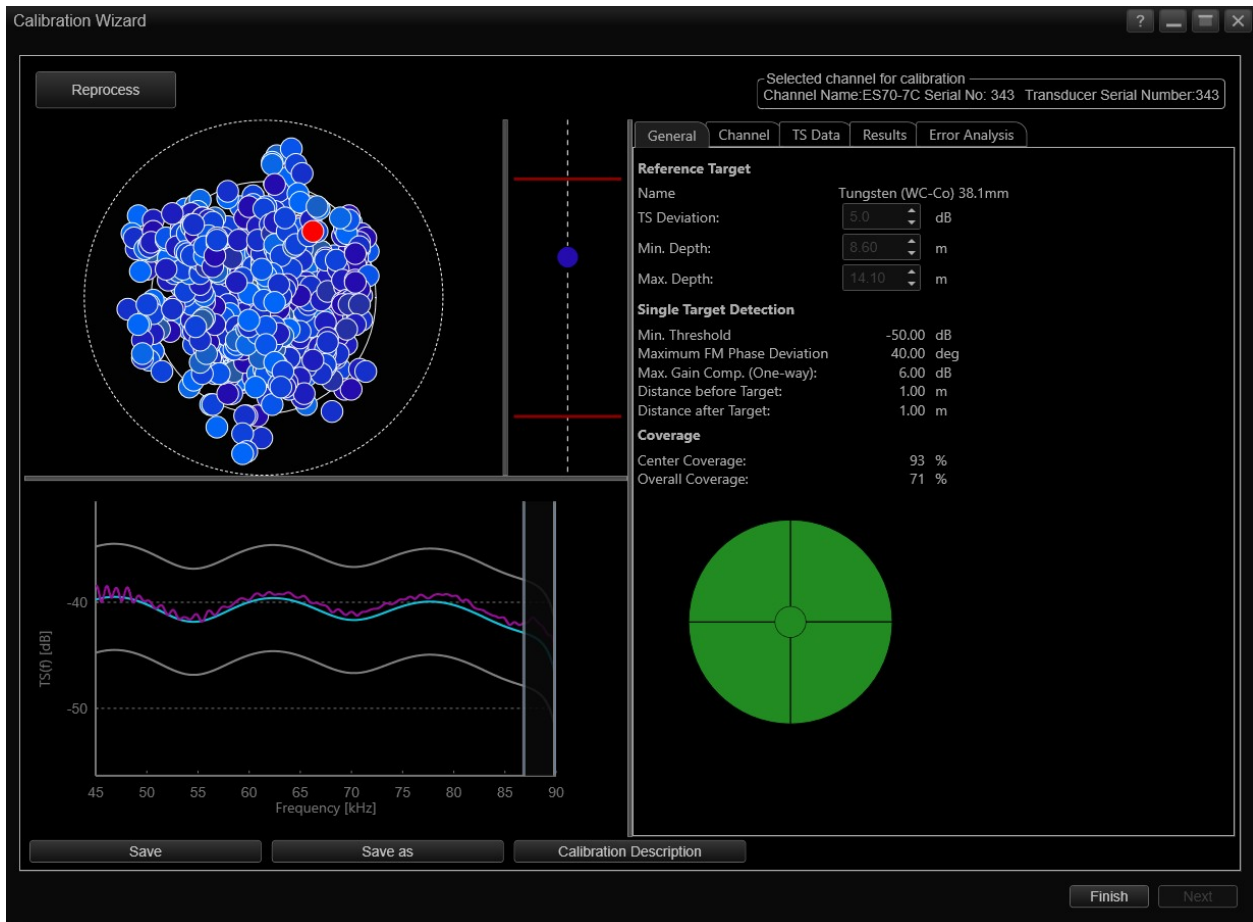


Figure 24. Screenshot of EK80 Calibration Wizard general results for 70 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

120 kHz: 1.024 ms

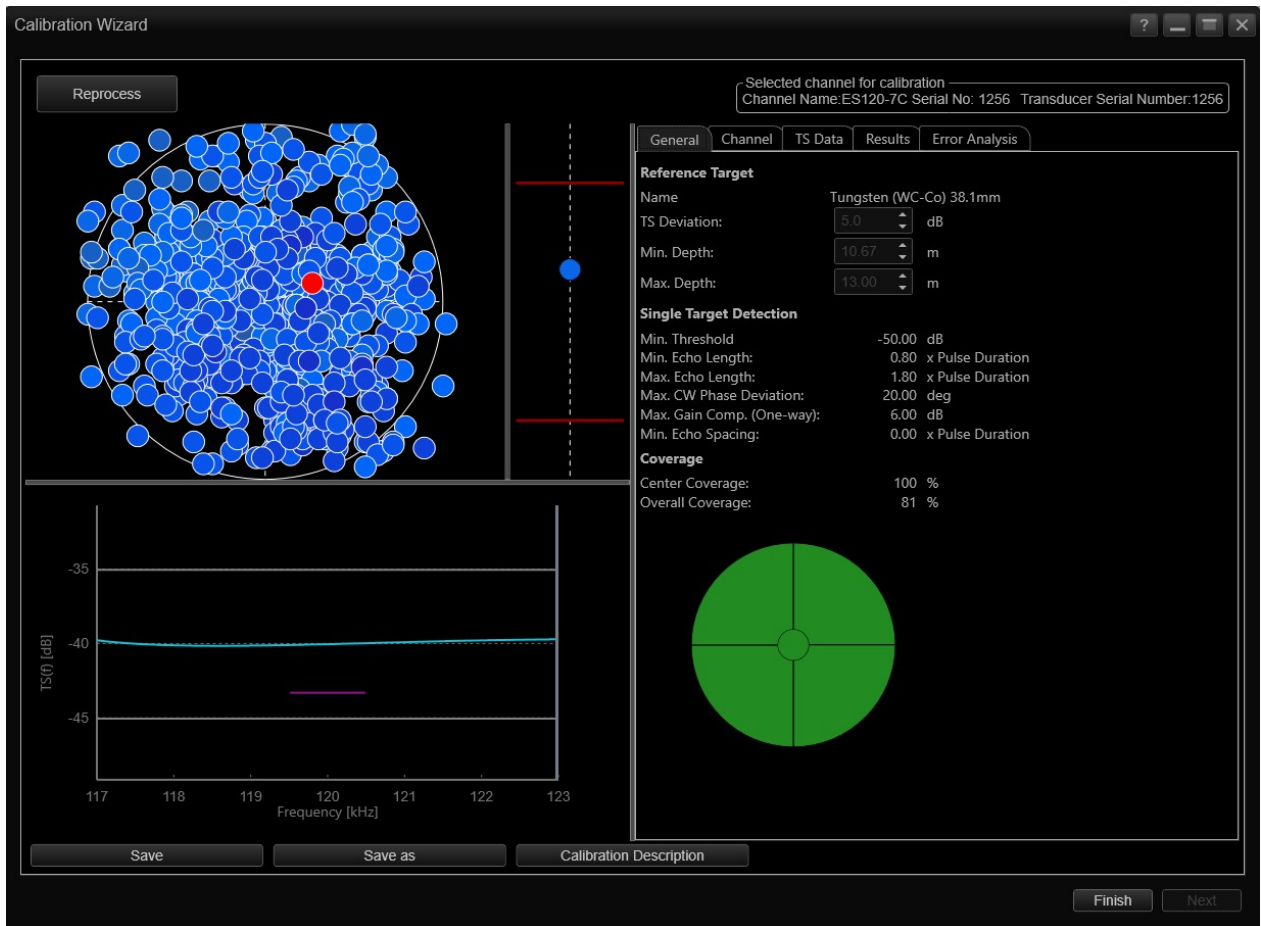


Figure 25. Screenshot of EK80 Calibration Wizard general results for 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

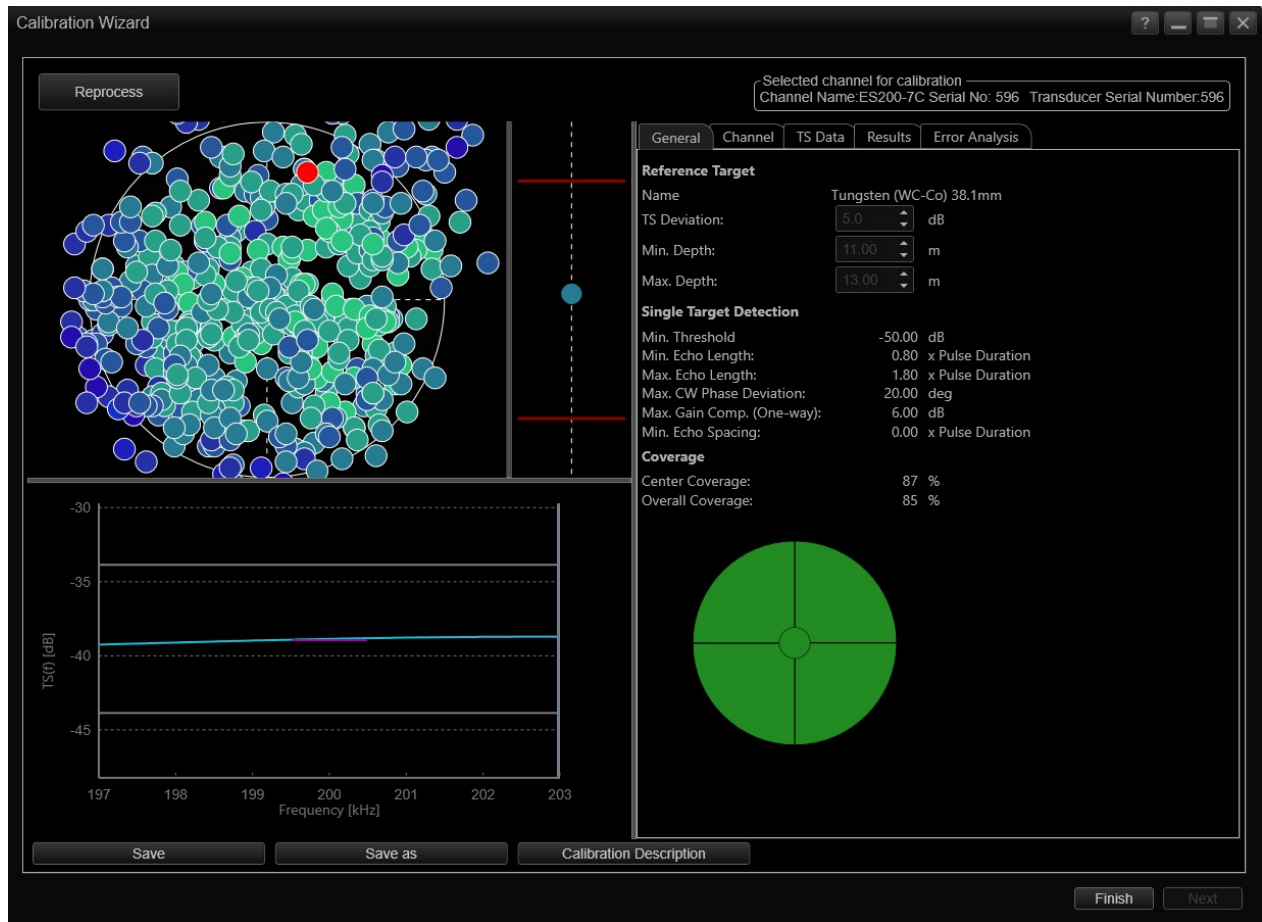


Figure 26. Screenshot of EK80 Calibration Wizard general results for 200 kHz calibration at 1.024 ms.

Appendix C: TS Results

18 kHz: 8.192 ms



Figure 27. Screenshot of EK80 Calibration Wizard TS results for 18 kHz calibration at 8.192 ms.

18 kHz: 4.096 ms

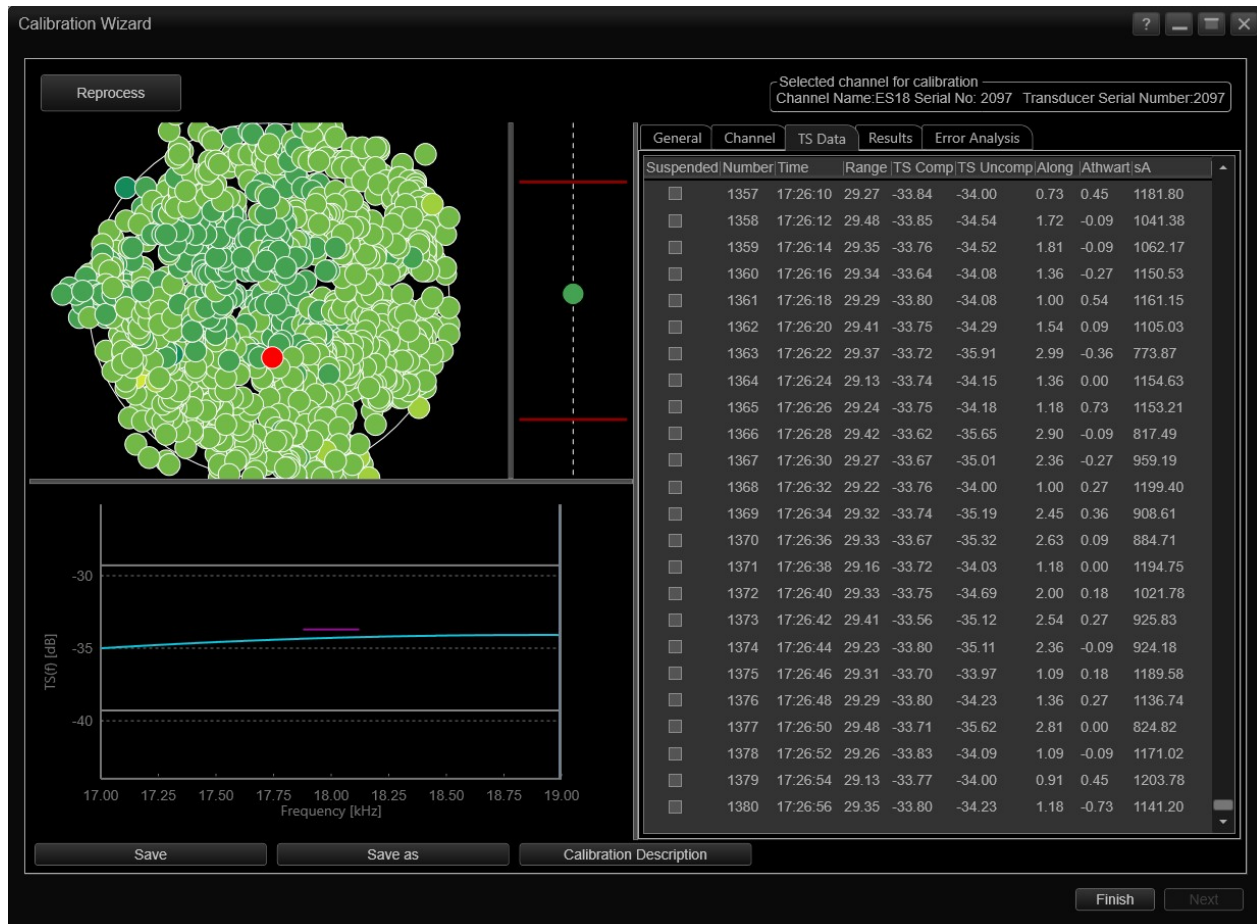


Figure 28. Screenshot of EK80 Calibration Wizard TS results for 18 kHz calibration at 4.096 ms.

18 kHz: 1.024 ms

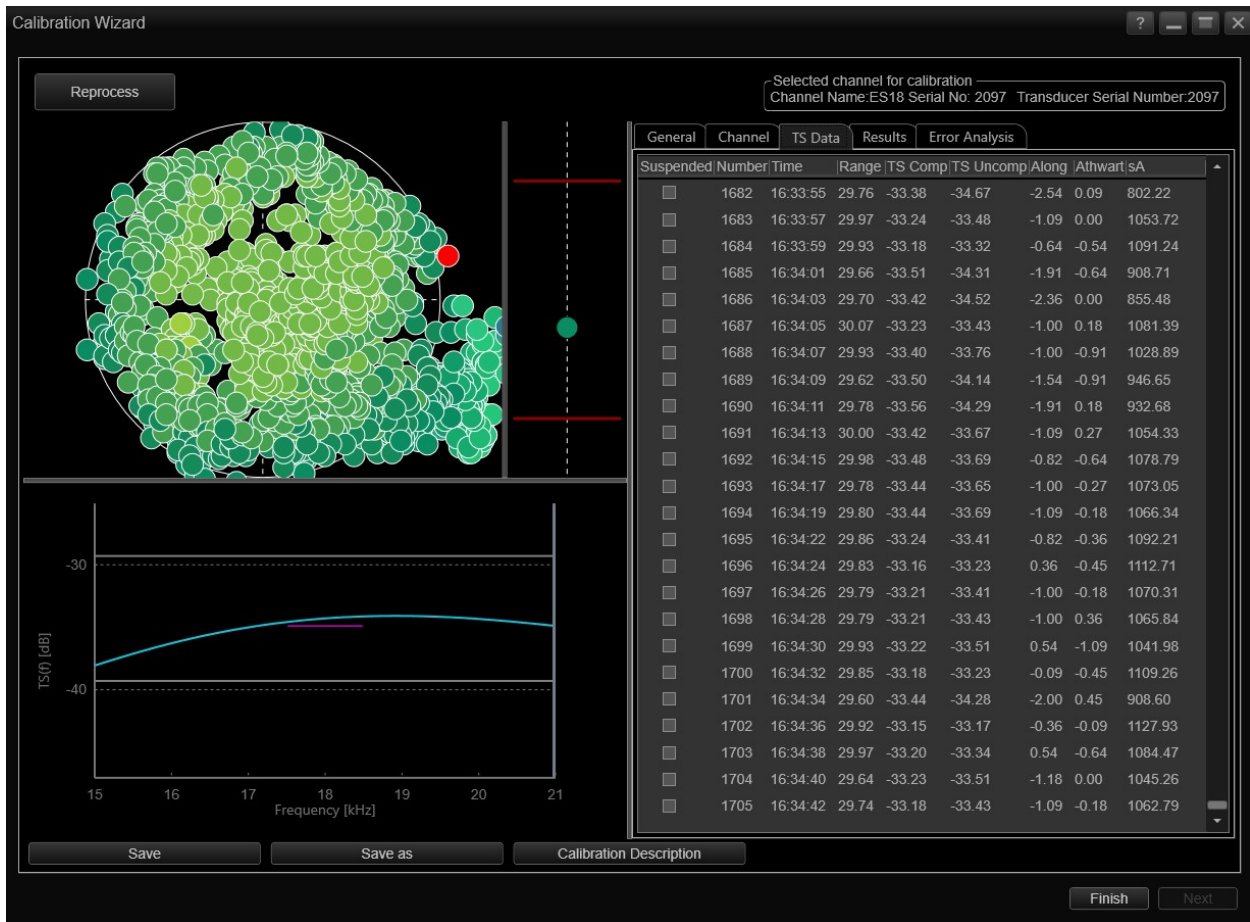


Figure 29. Screenshot of EK80 Calibration Wizard TS results for 18 kHz calibration at 1.024 ms.

38 kHz (CW): 2.048 ms

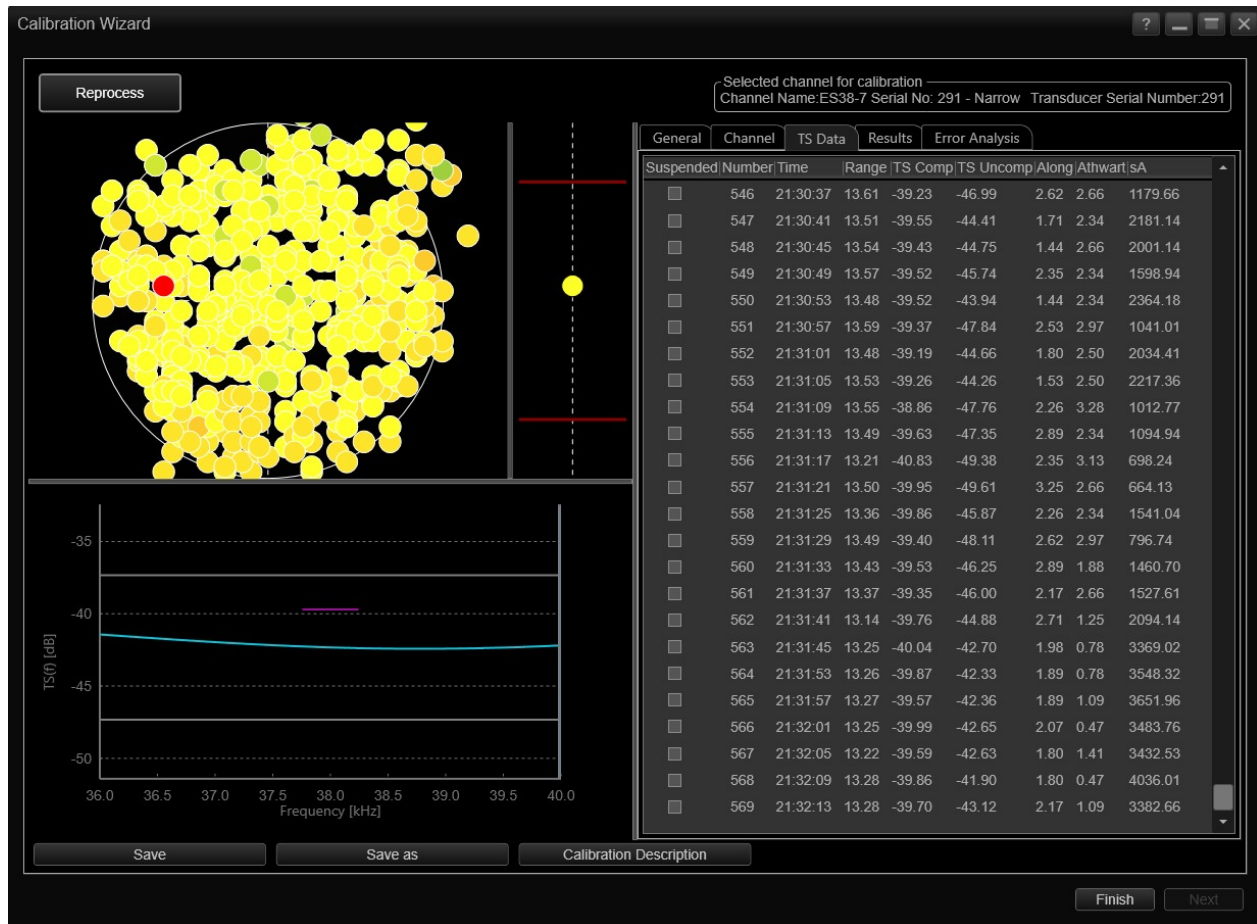


Figure 30. Screenshot of EK80 Calibration Wizard TS results for 38 kHz calibration at 2.048 ms in continuous wave (CW) mode.

38 kHz (CW): 1.024 ms

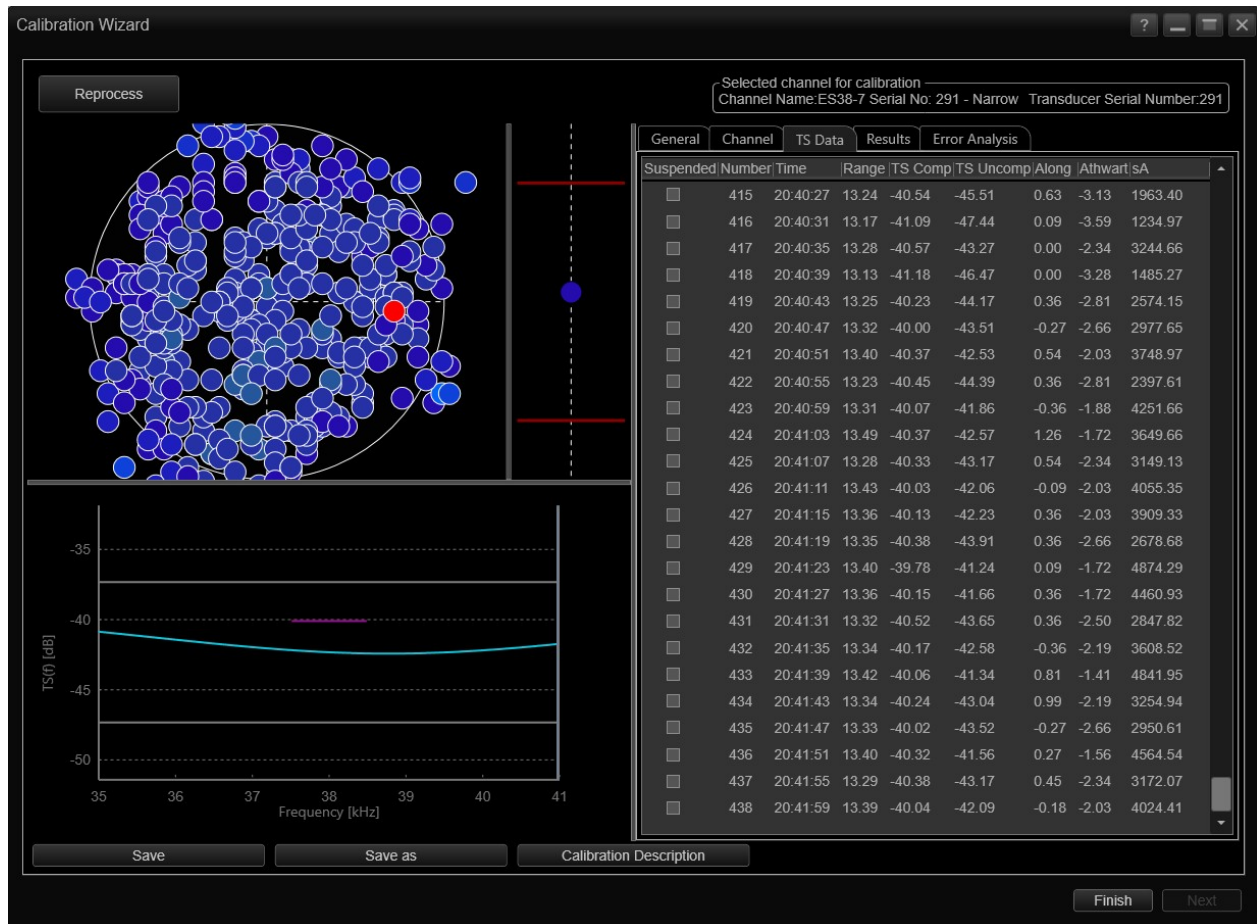


Figure 31. Screenshot of EK80 Calibration Wizard TS results for 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

38 kHz (FM): 4.096 ms

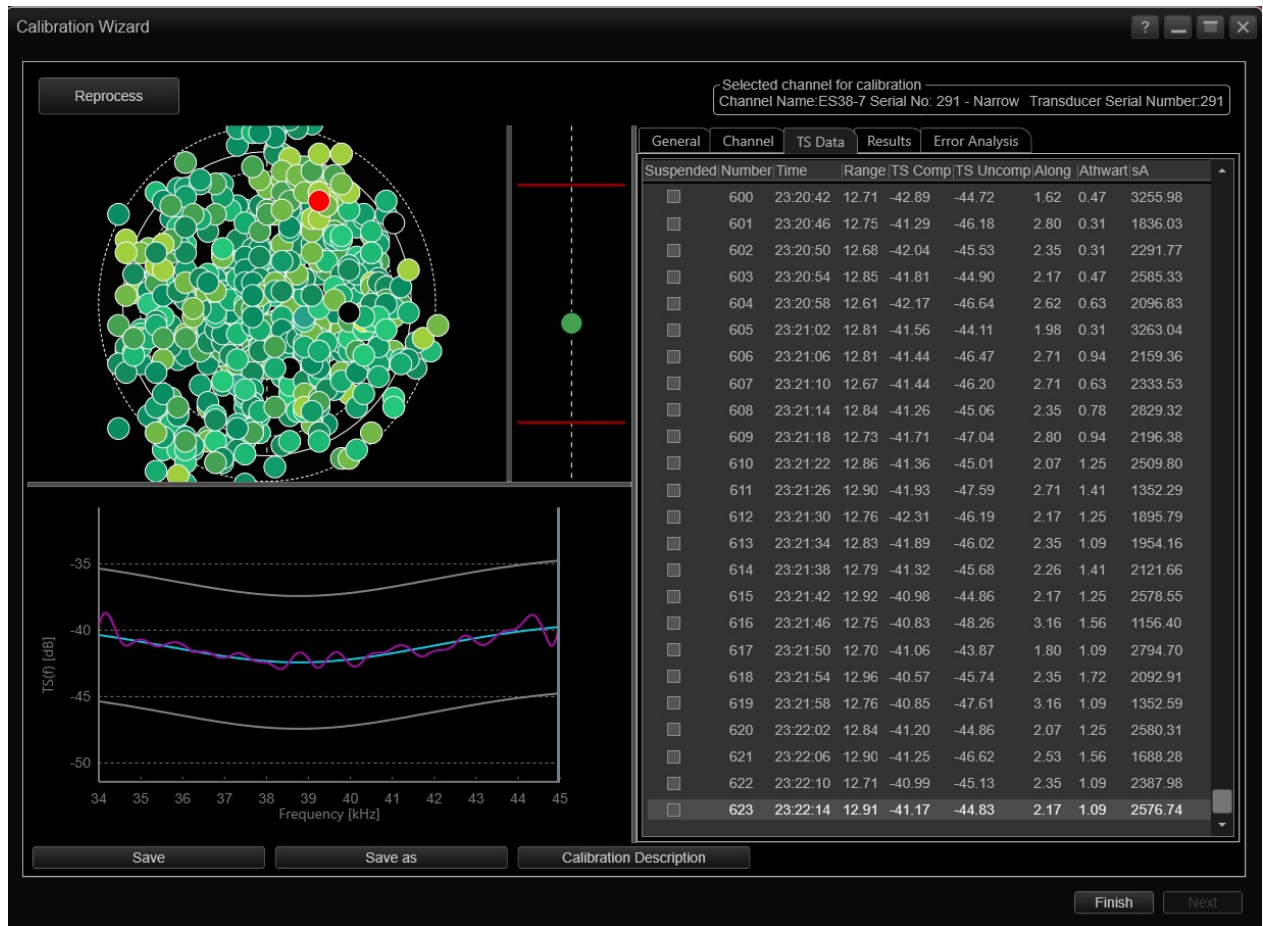


Figure 32. Screenshot of EK80 Calibration Wizard TS results for 38 kHz calibration at 4.096 ms in frequency modulated (FM) mode.

38 kHz (FM): 1.024 ms

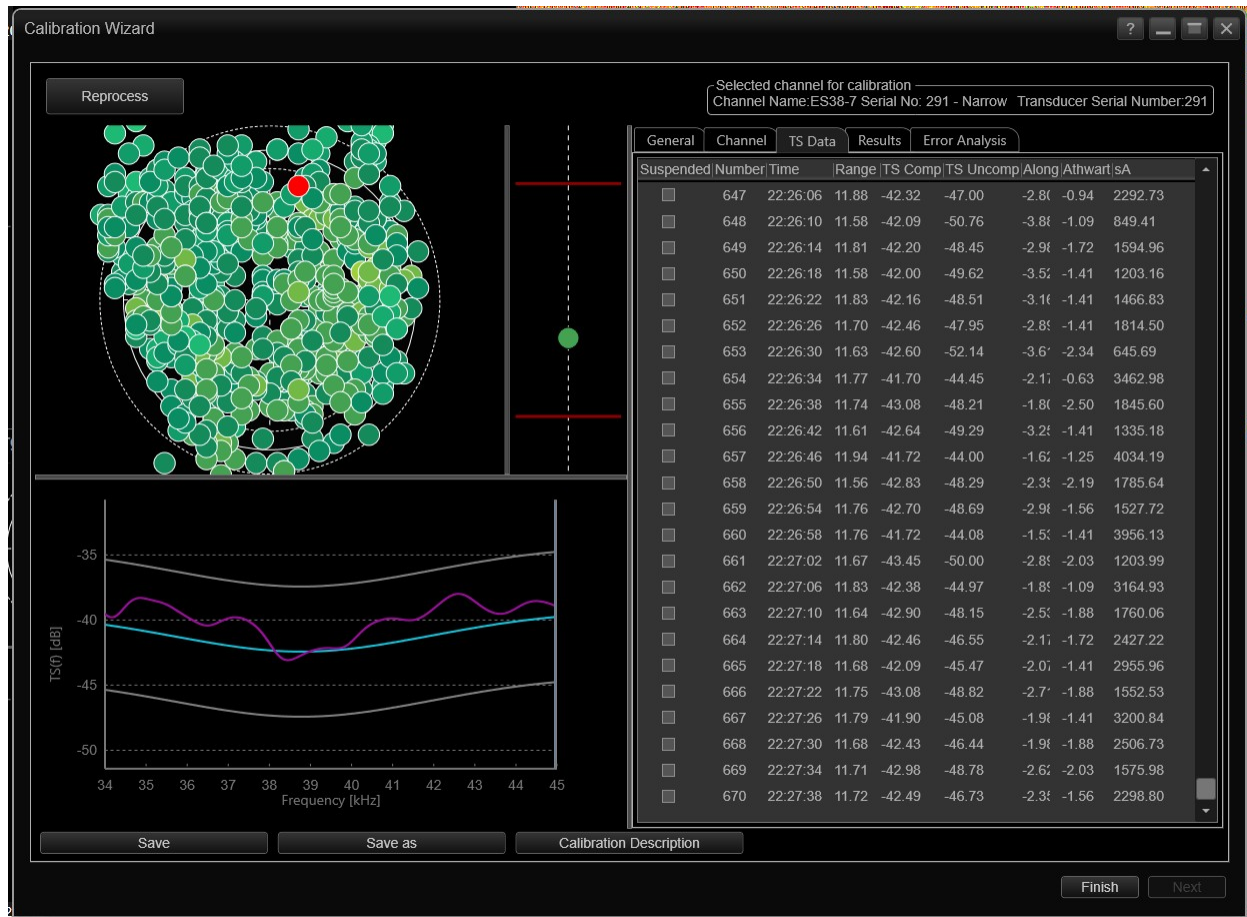


Figure 33. Screenshot of EK80 Calibration Wizard TS results for 38 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

70 kHz (CW): 2.048 ms

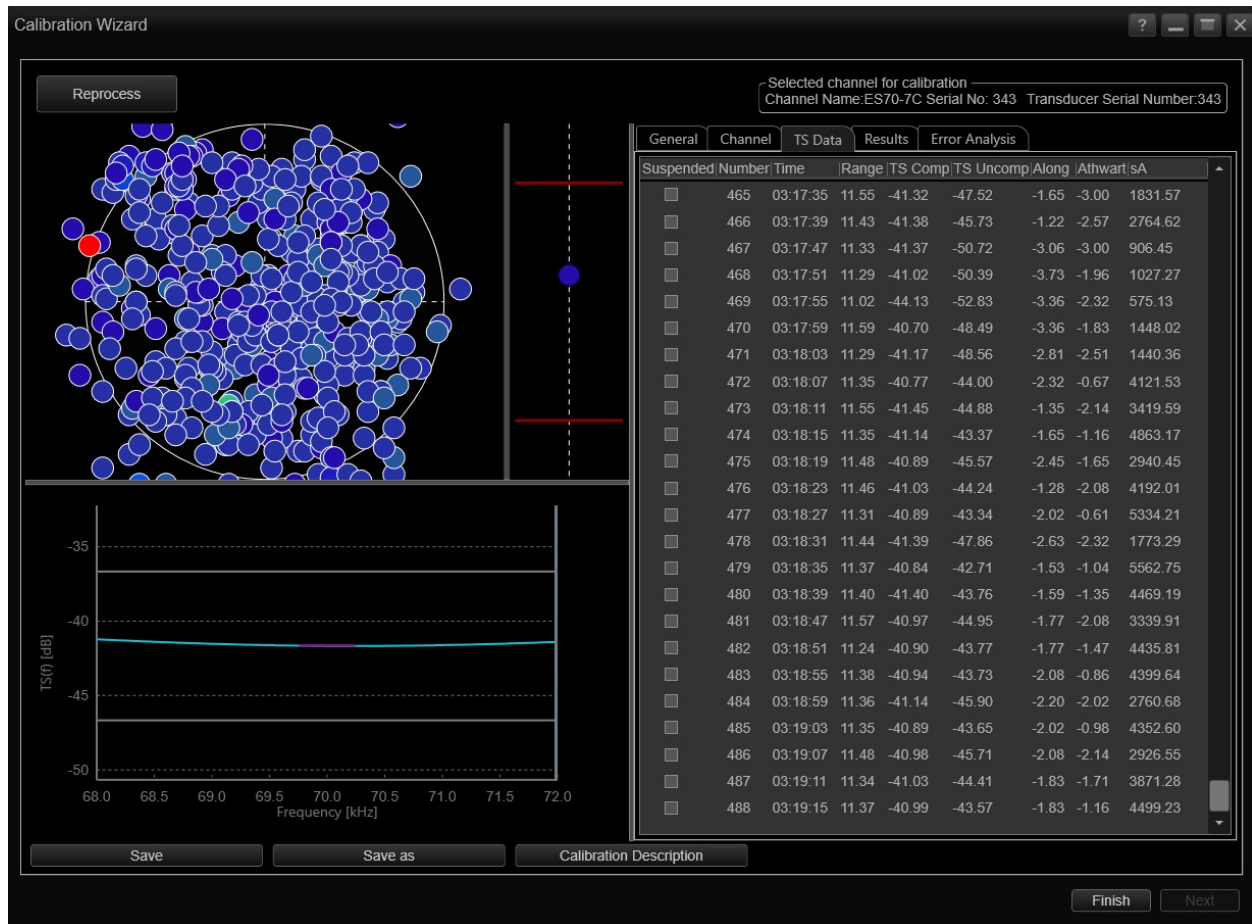


Figure 34. Screenshot of EK80 Calibration Wizard TS results for 70 kHz calibration at 2.048 ms in continuous wave (CW) mode.

70 kHz (CW): 1.024 ms

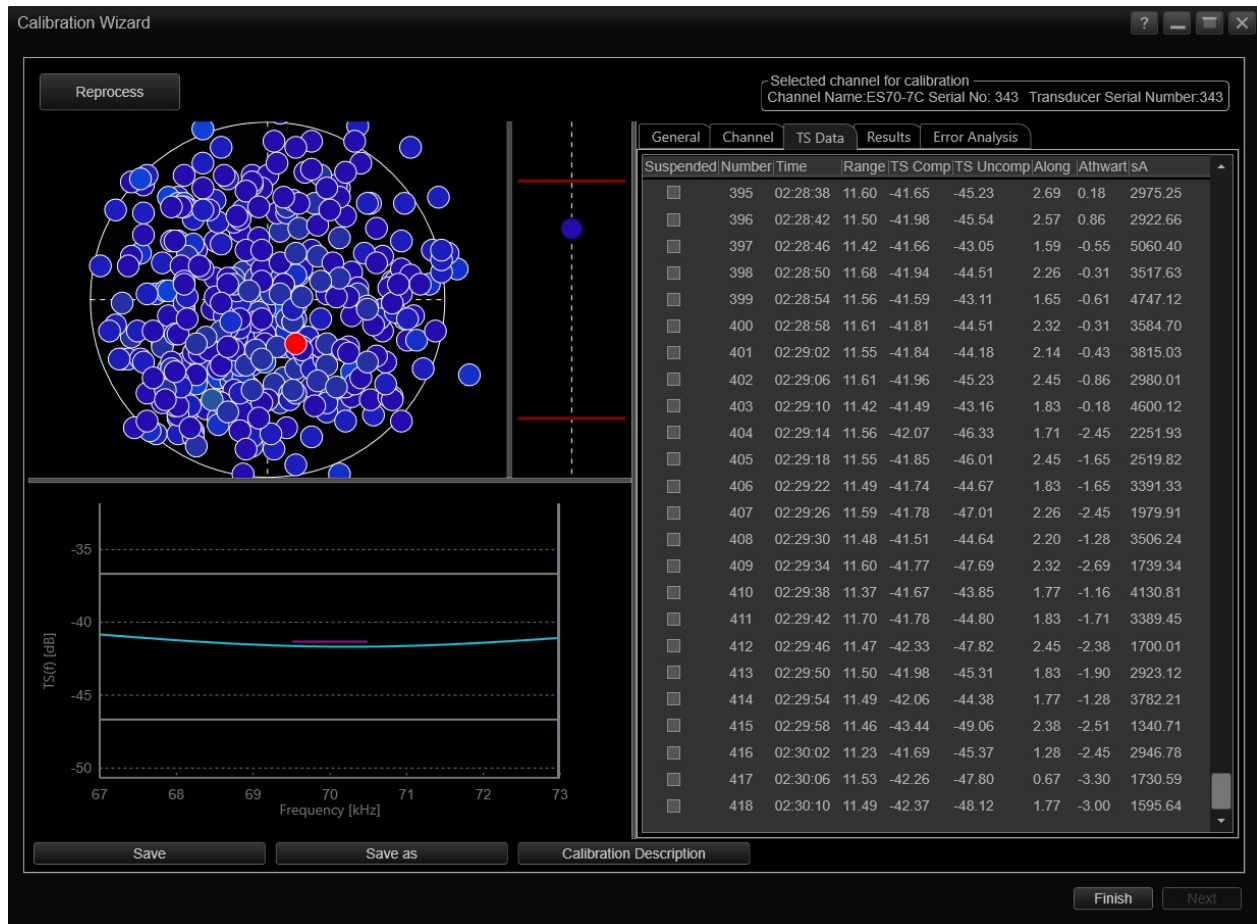


Figure 35. Screenshot of EK80 Calibration Wizard TS results for 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (FM): 2.048 ms

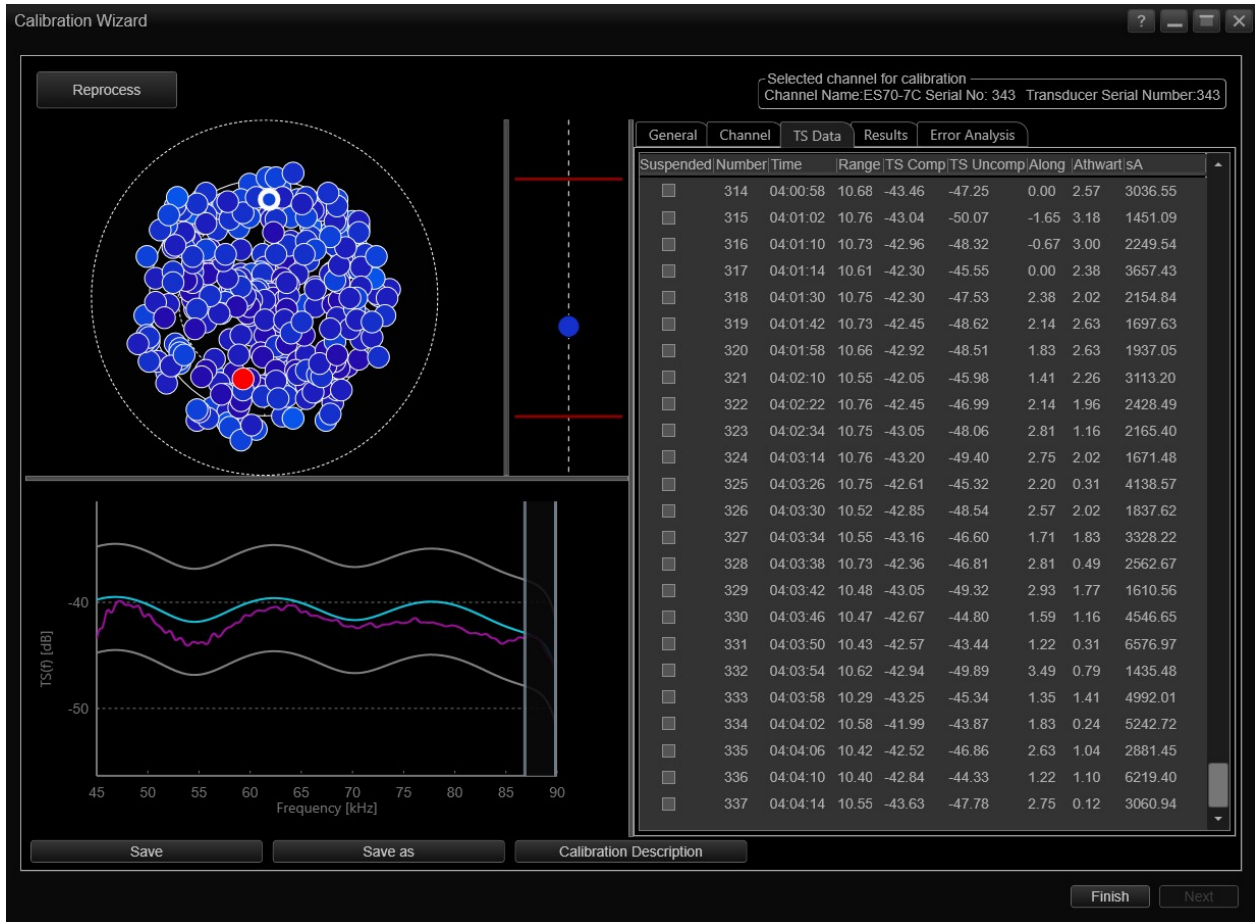


Figure 36. Screenshot of EK80 Calibration Wizard TS results for 70 kHz calibration at 2.048 ms in frequency modulated (FM) mode.

70 kHz (FM): 1.024 ms

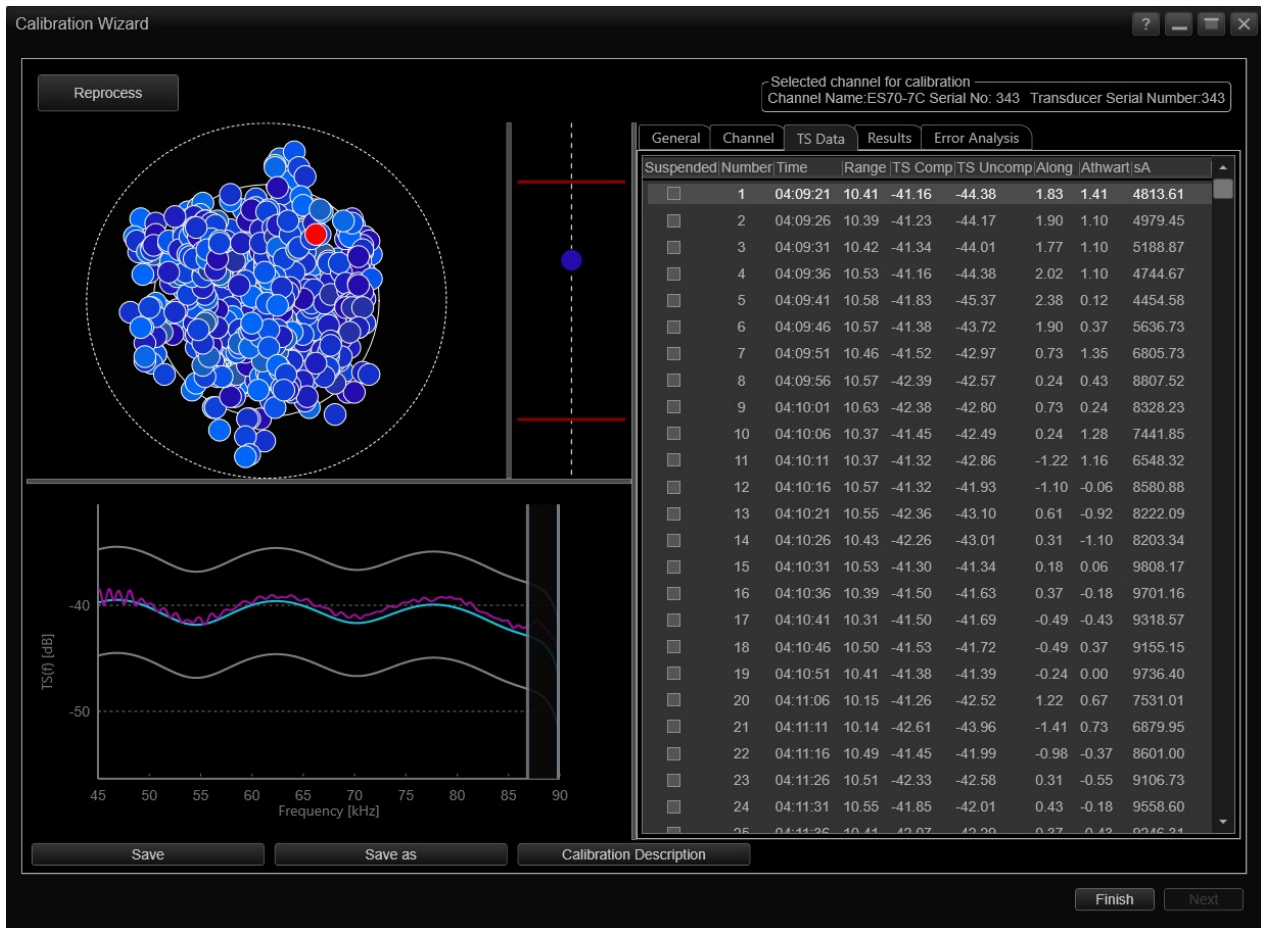


Figure 37. Screenshot of EK80 Calibration Wizard TS results for 70 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

120 kHz: 1.024 ms

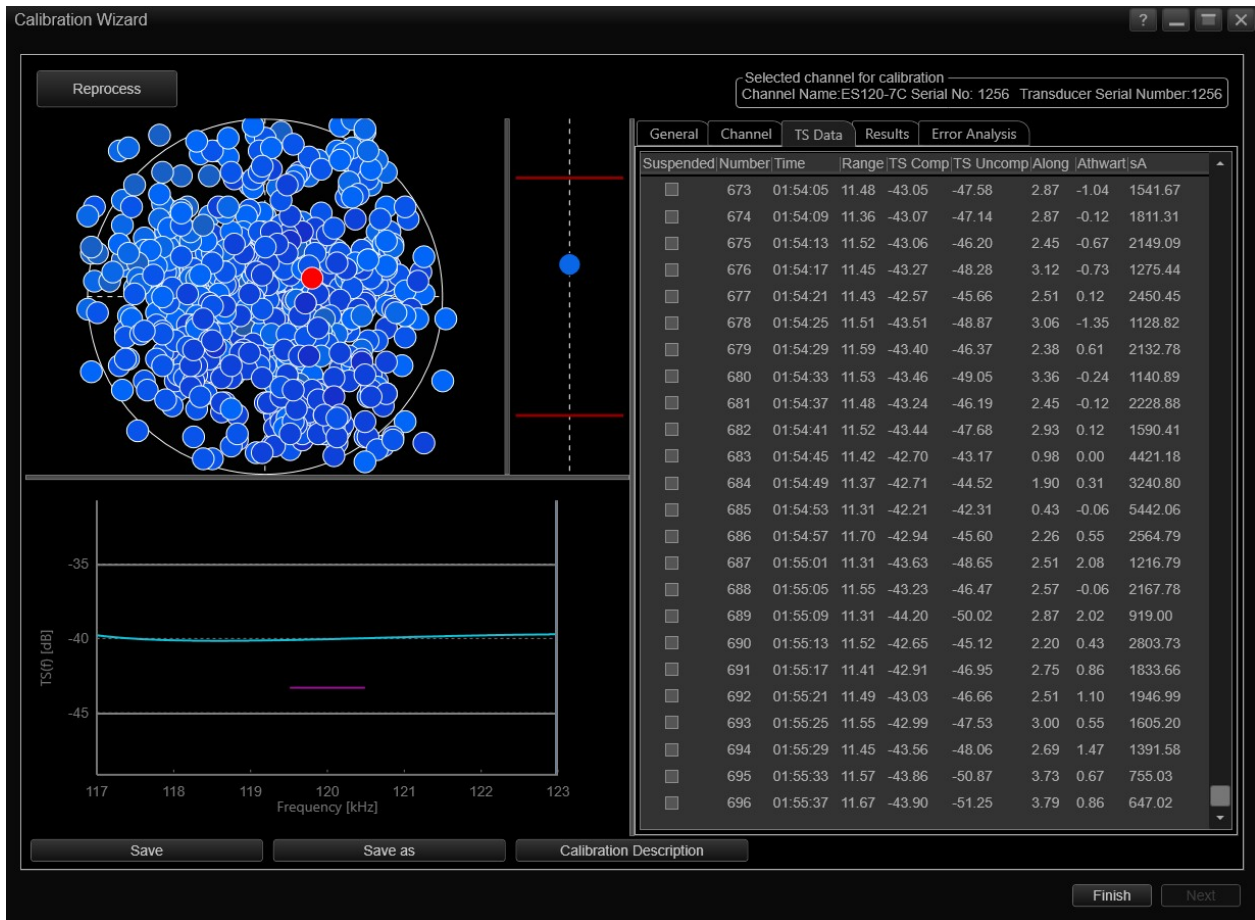


Figure 38. Screenshot of EK80 Calibration Wizard TS results for 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

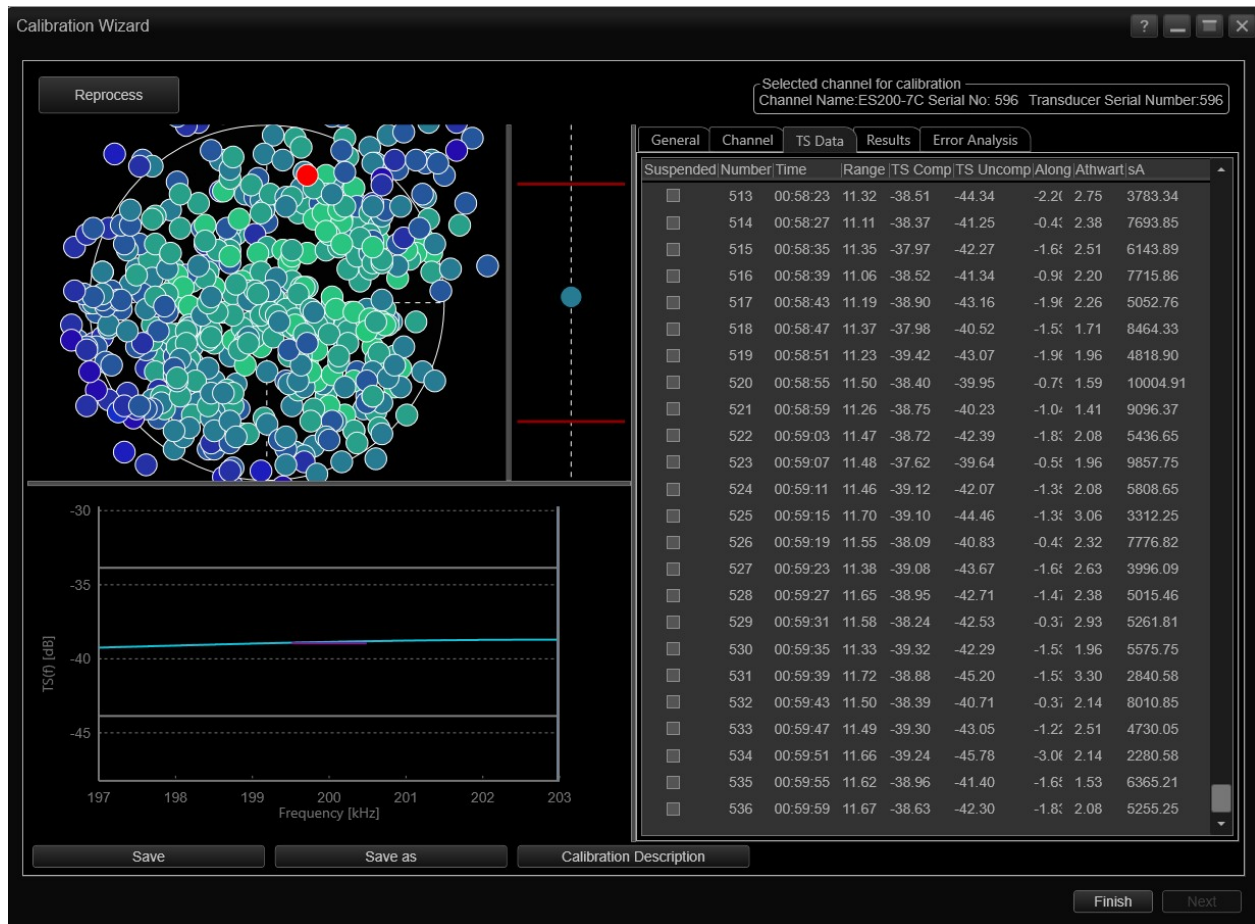


Figure 39. Screenshot of EK80 Calibration Wizard TS results for 200 kHz calibration at 1.024 ms.

Appendix D: Results

18 kHz: 8.192 ms

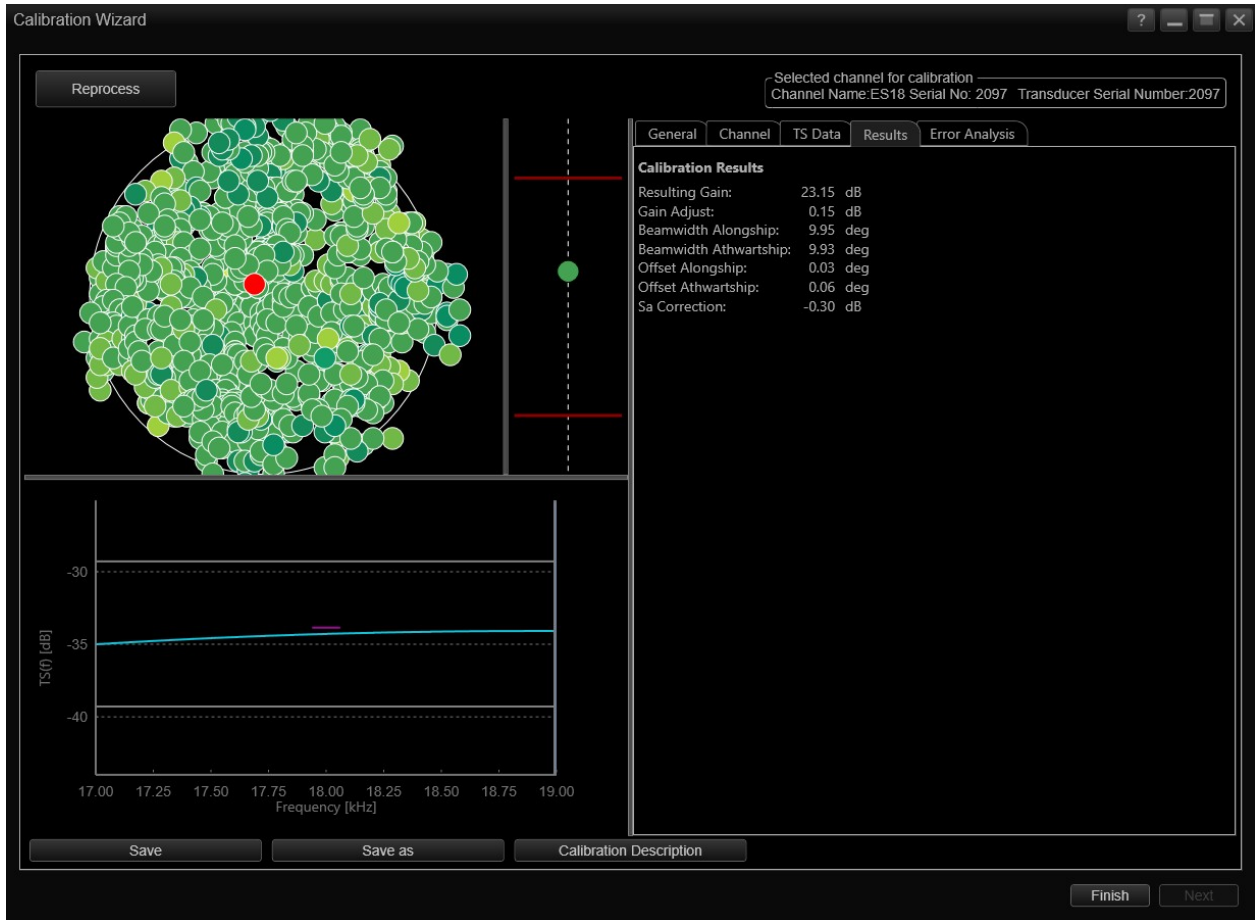


Figure 40. Screenshot of EK80 Calibration Wizard results for 18 kHz calibration at 8.192 ms.

18 kHz: 4.096 ms

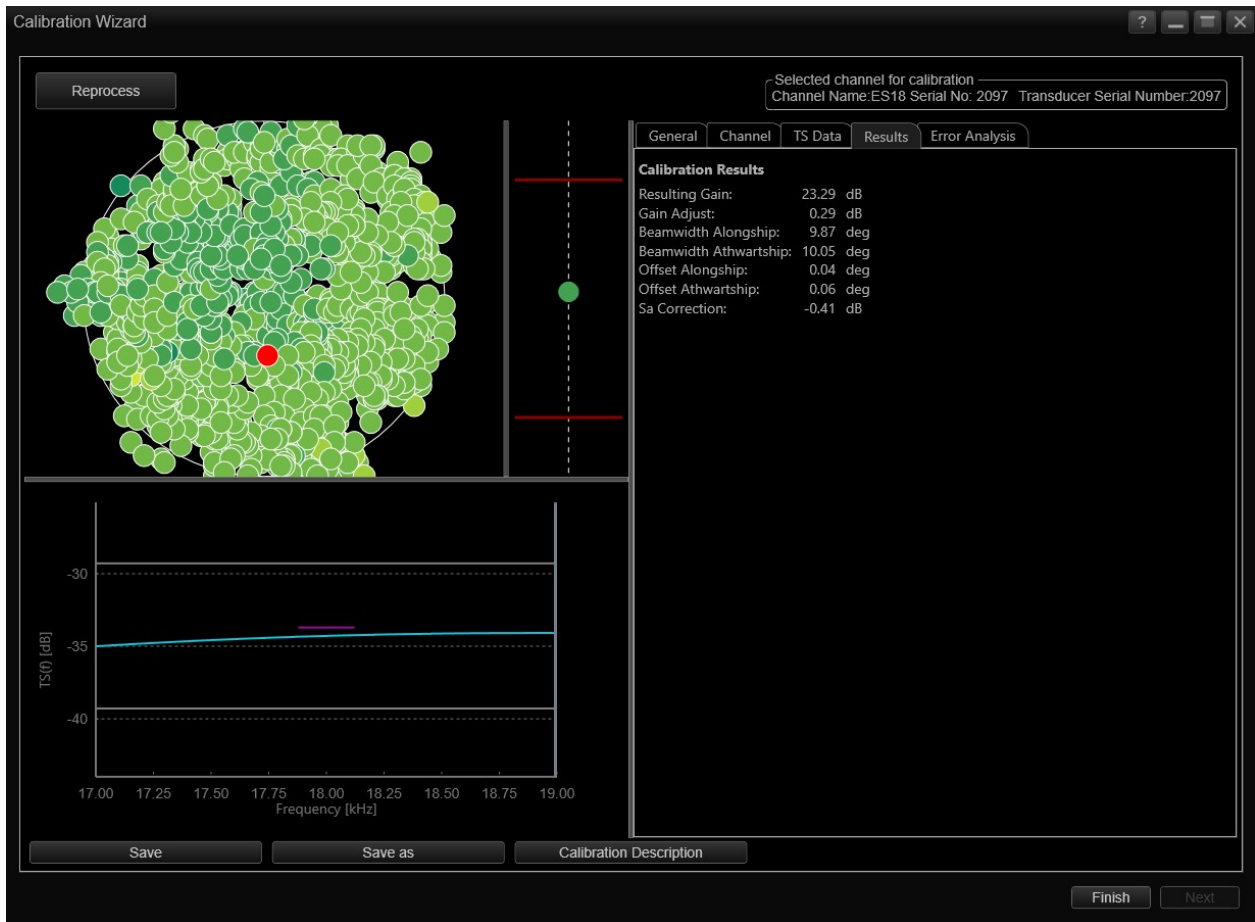


Figure 41. Screenshot of EK80 Calibration Wizard results for 18 kHz calibration at 4.096 ms.

18 kHz: 1.024 ms

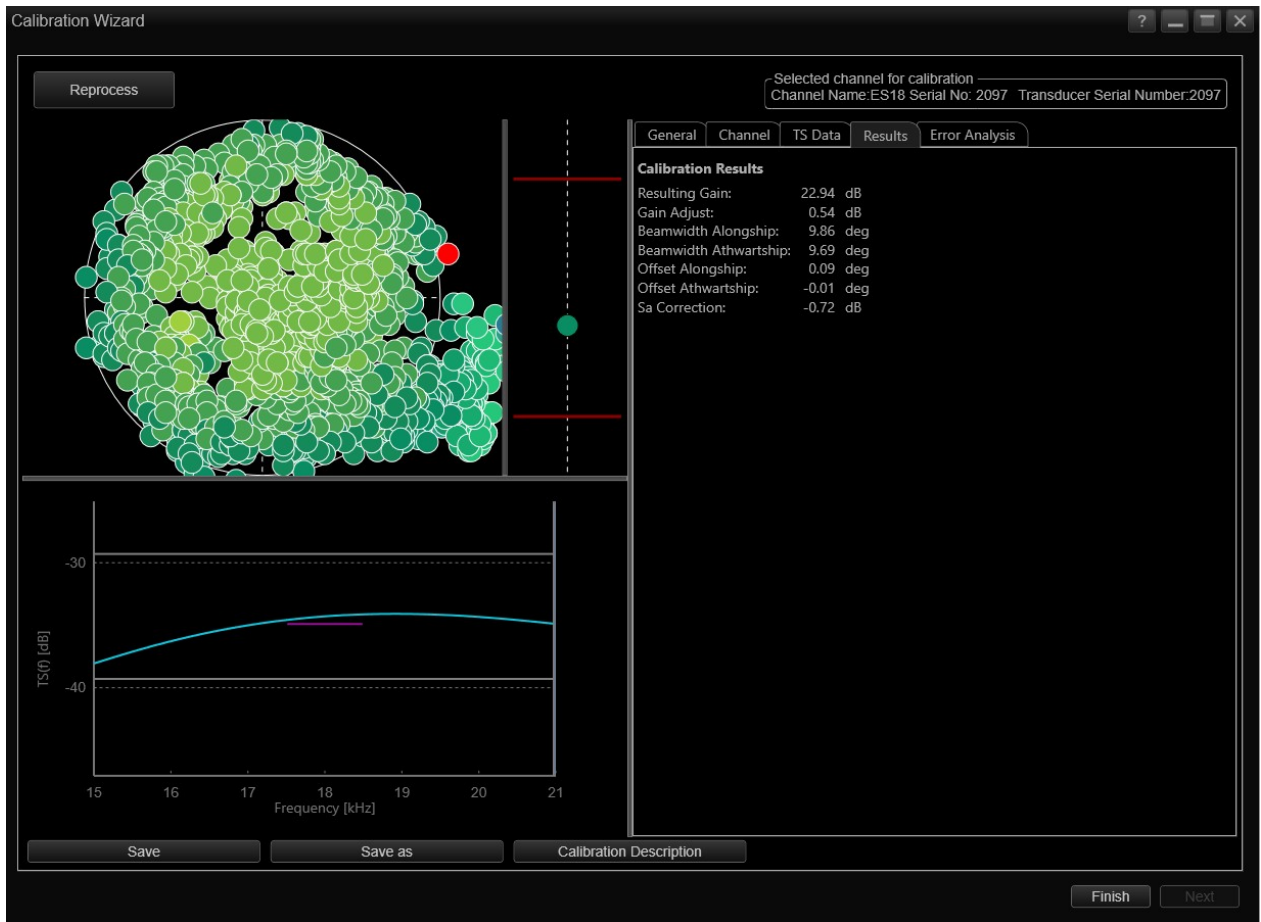


Figure 42. Screenshot of EK80 Calibration Wizard results for 18 kHz calibration at 1.024 ms.

38 kHz (CW): 2.048 ms

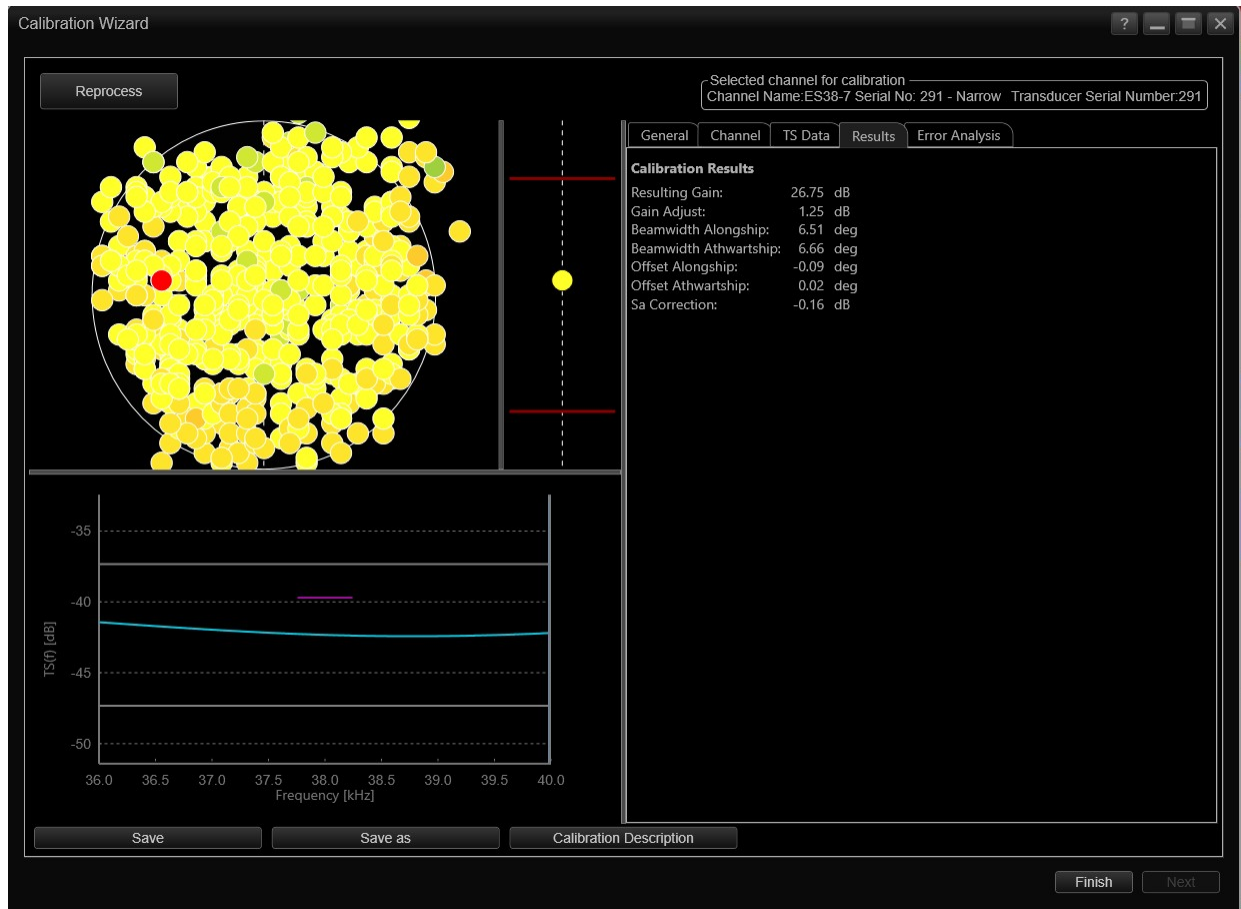


Figure 43. Screenshot of EK80 Calibration Wizard results for 38 kHz calibration at 2.048 ms in continuous wave (CW) mode.

38 kHz (CW): 1.024 ms

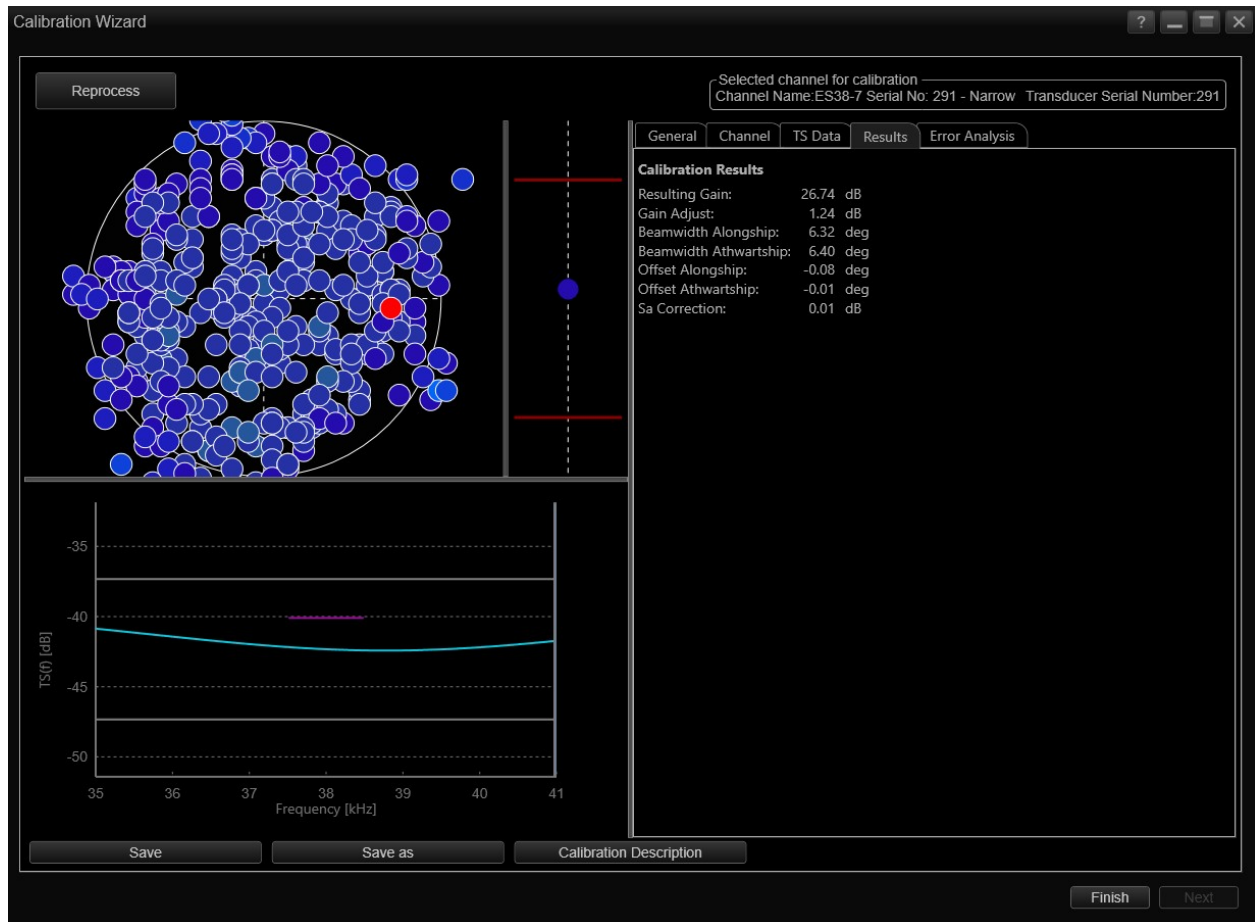


Figure 44. Screenshot of EK80 Calibration Wizard results for 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

38 kHz (FM): 4.096 ms

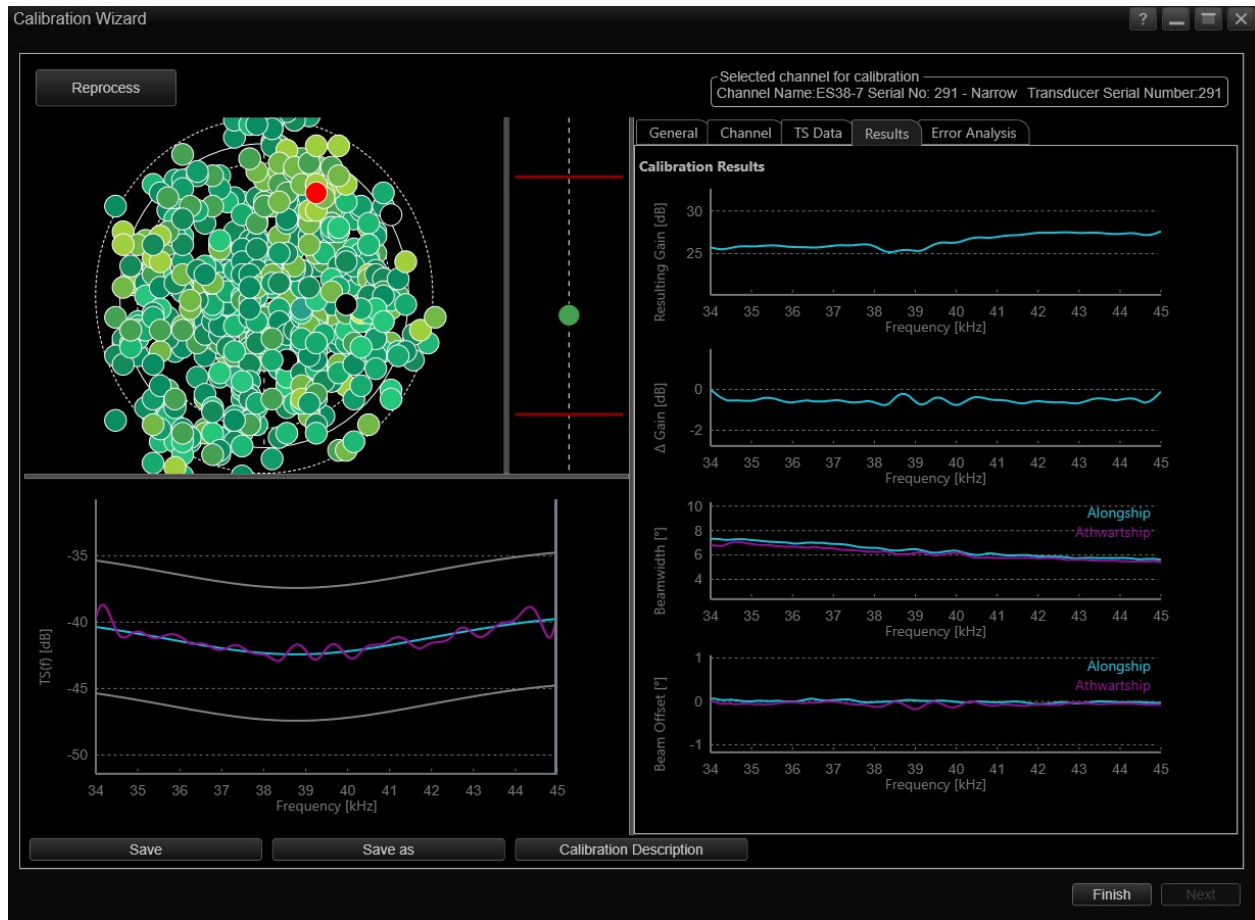


Figure 45. Screenshot of EK80 Calibration Wizard results for 38 kHz calibration at 4.096 ms in frequency modulated (FM) mode.

38 kHz (FM): 1.024 ms

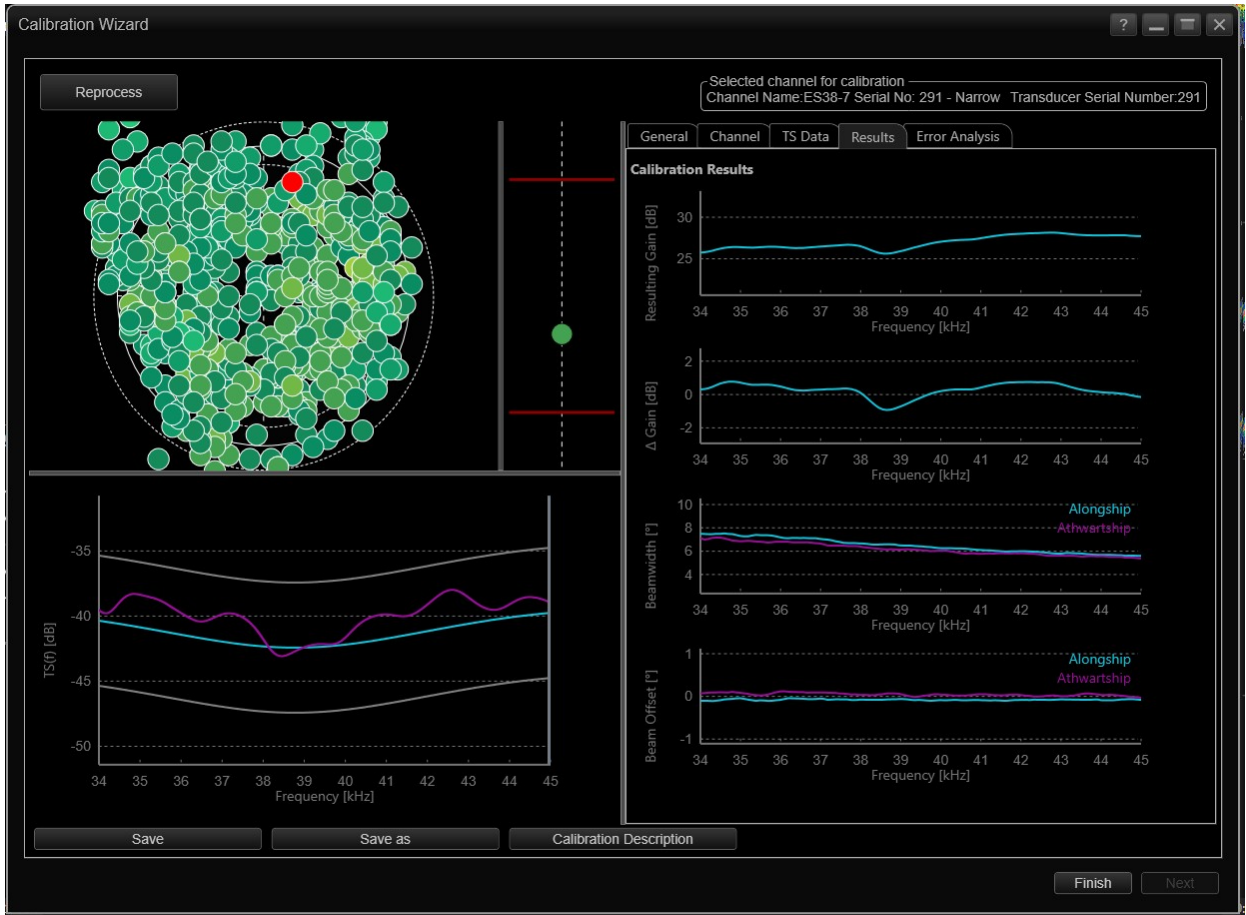


Figure 46. Screenshot of EK80 Calibration Wizard results for 38 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

70 kHz (CW): 2.048 ms

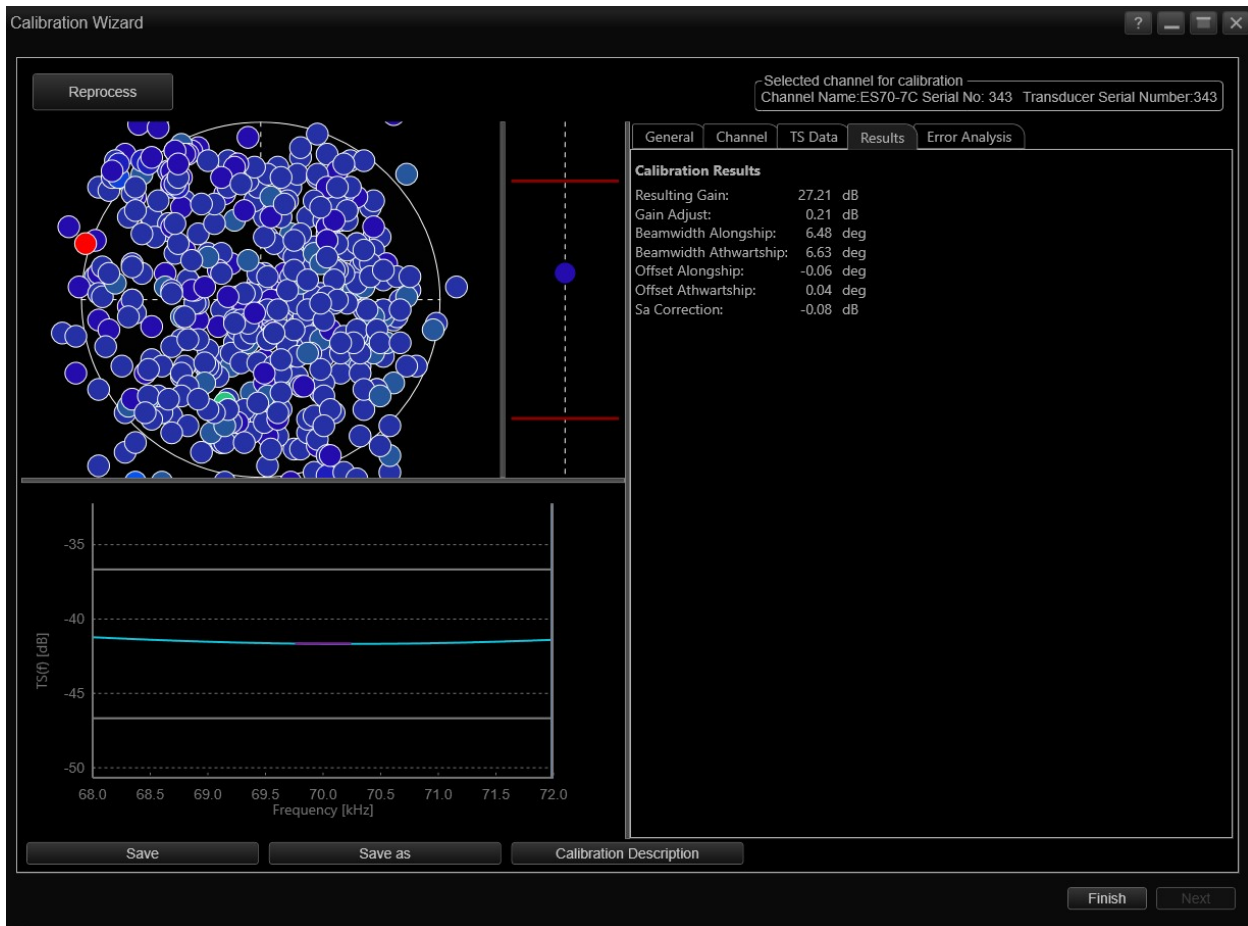


Figure 47. Screenshot of EK80 Calibration Wizard results for 70 kHz calibration at 2.048 ms in continuous wave (CW) mode.

70 kHz (CW): 1.024 ms

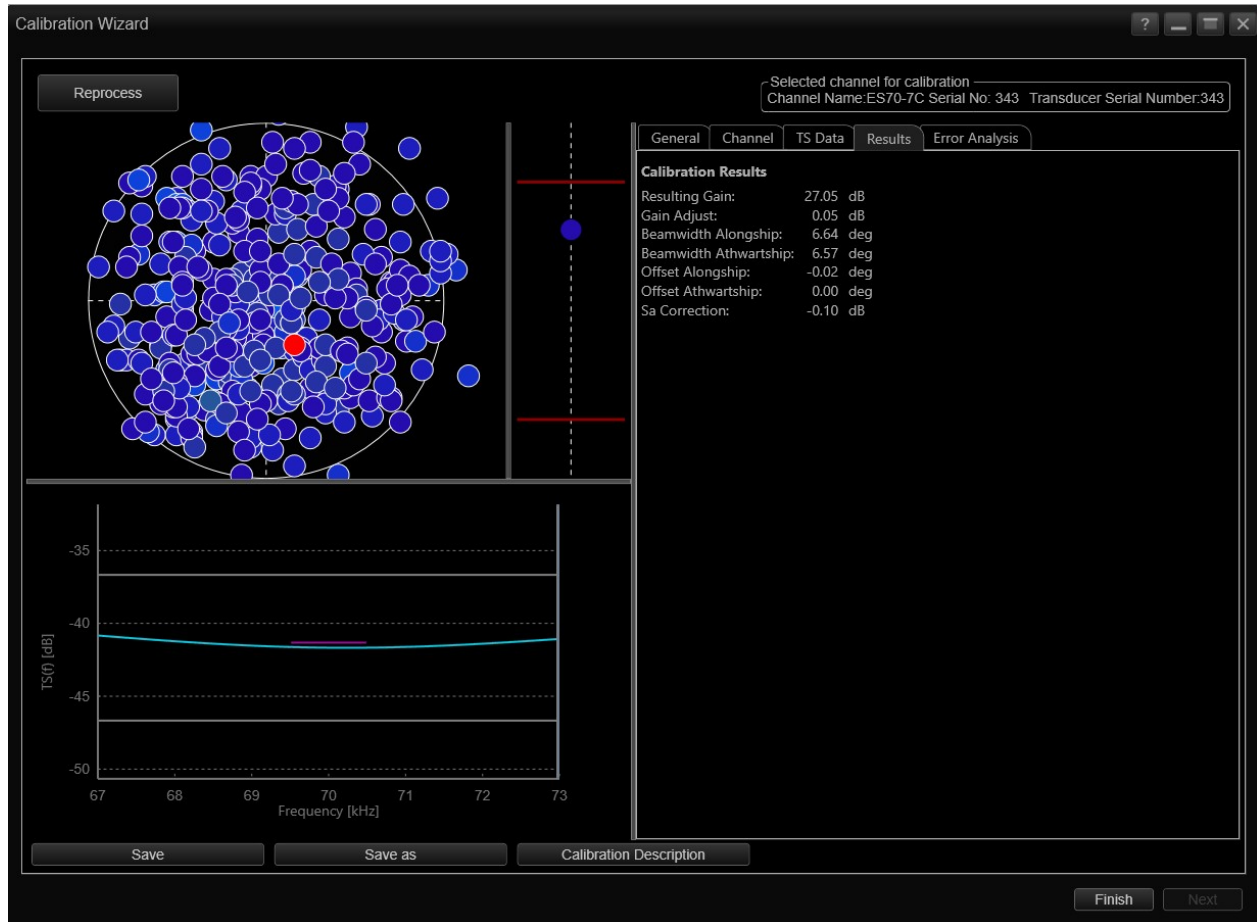


Figure 48. Screenshot of EK80 Calibration Wizard results for 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (FM): 2.048 ms

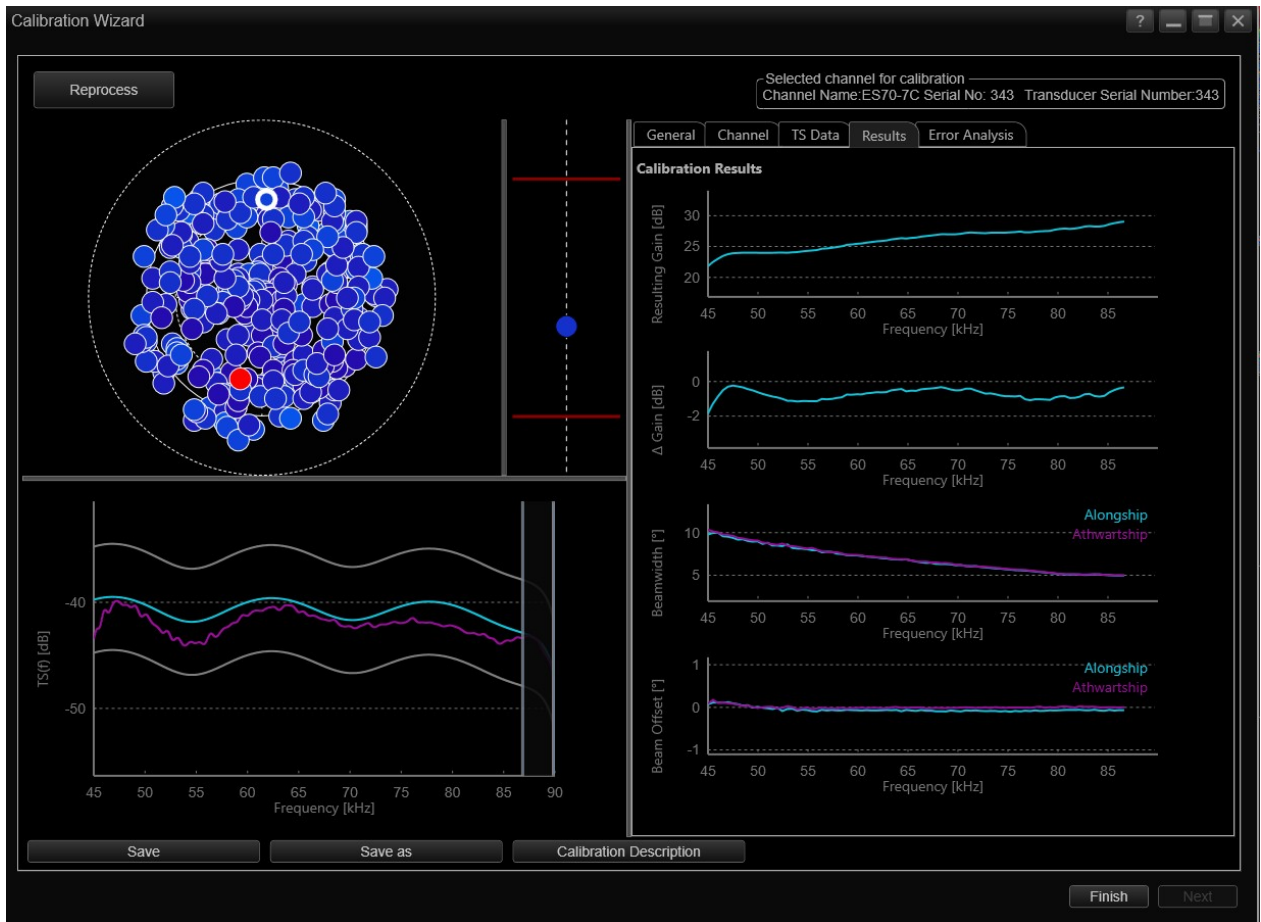


Figure 49. Screenshot of EK80 Calibration Wizard results for 70 kHz calibration at 2.048 ms in frequency modulated (FM) mode.

70 kHz (FM): 1.024 ms

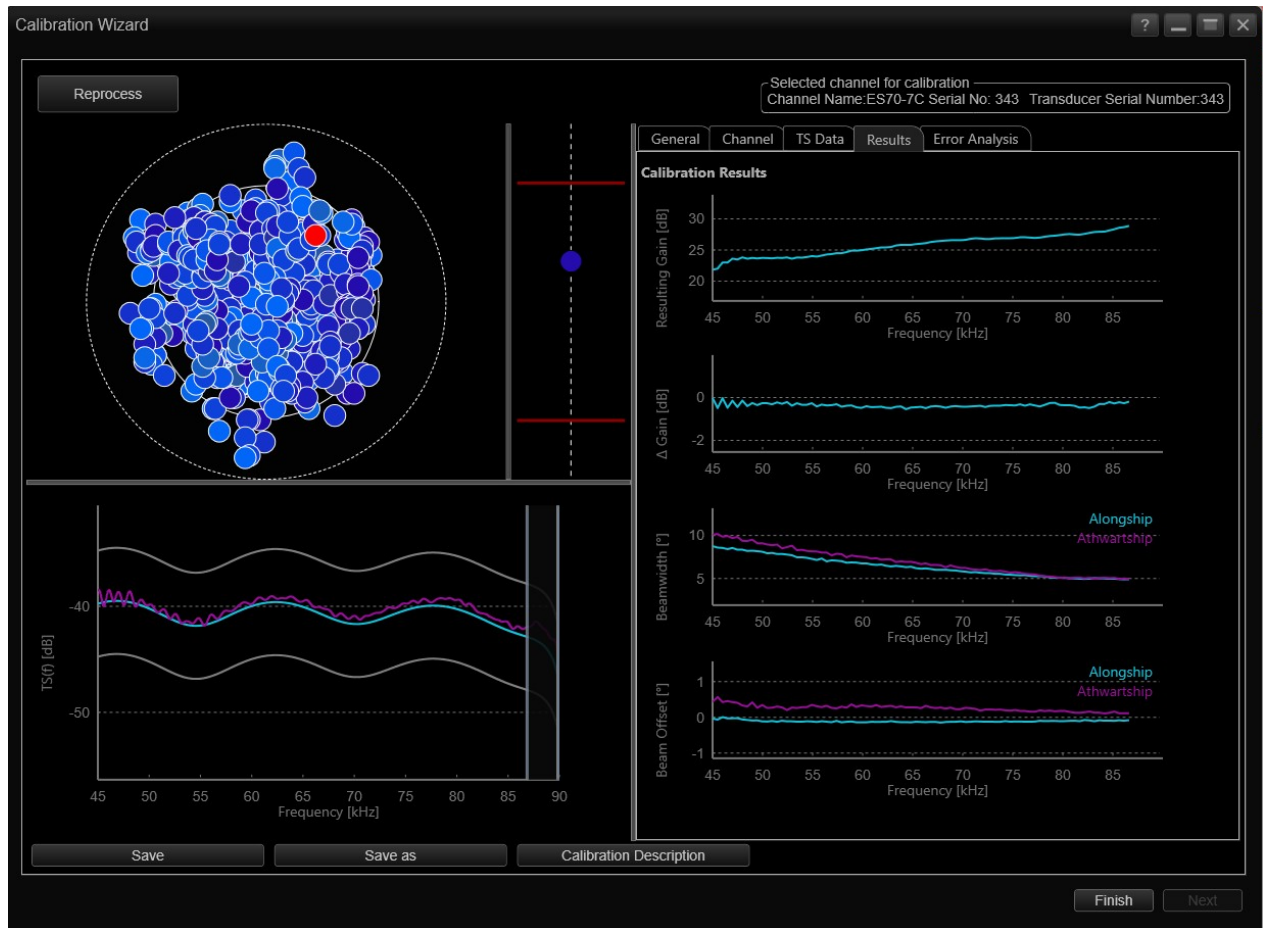


Figure 50. Screenshot of EK80 Calibration Wizard results for 70 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

120 kHz: 1.024 ms

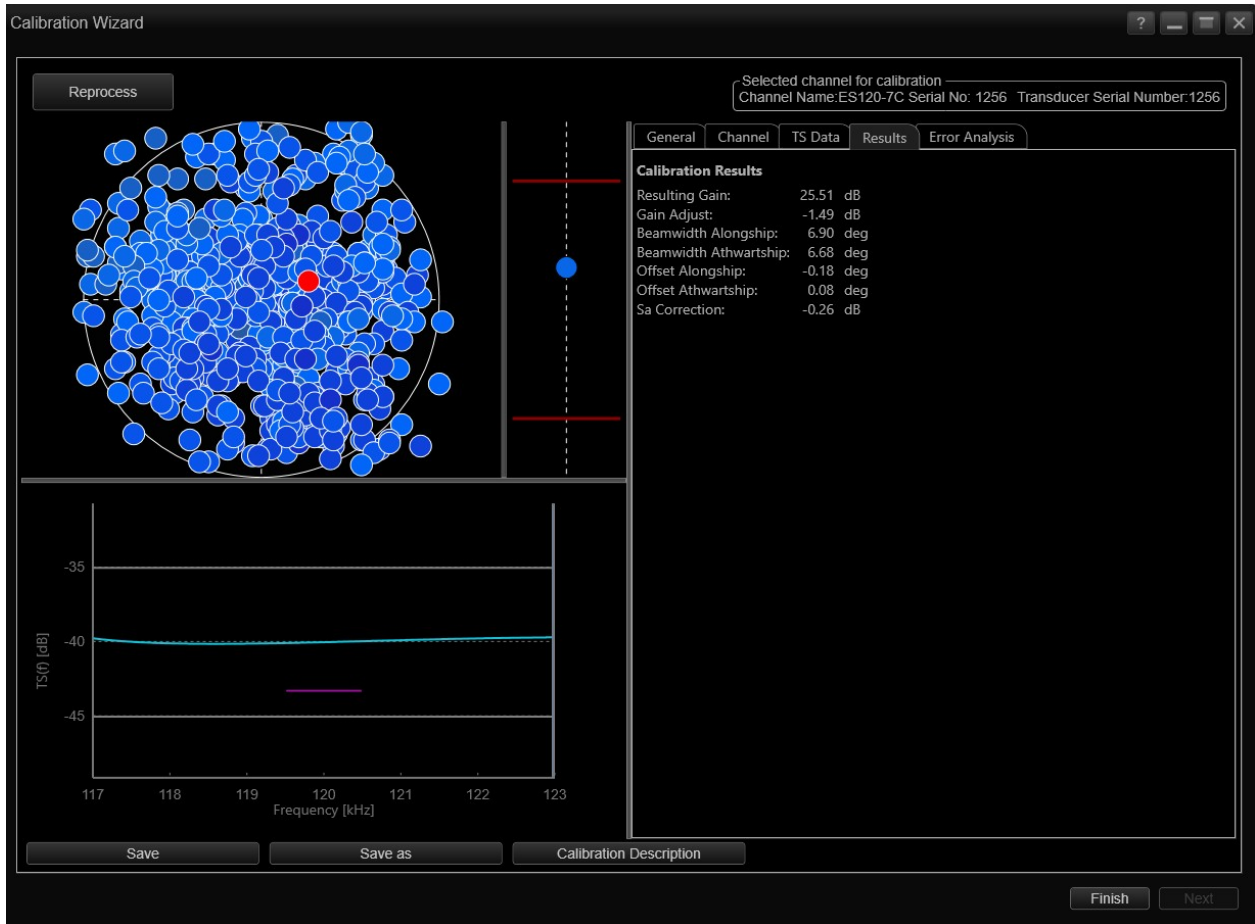


Figure 51. Screenshot of EK80 Calibration Wizard results for 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

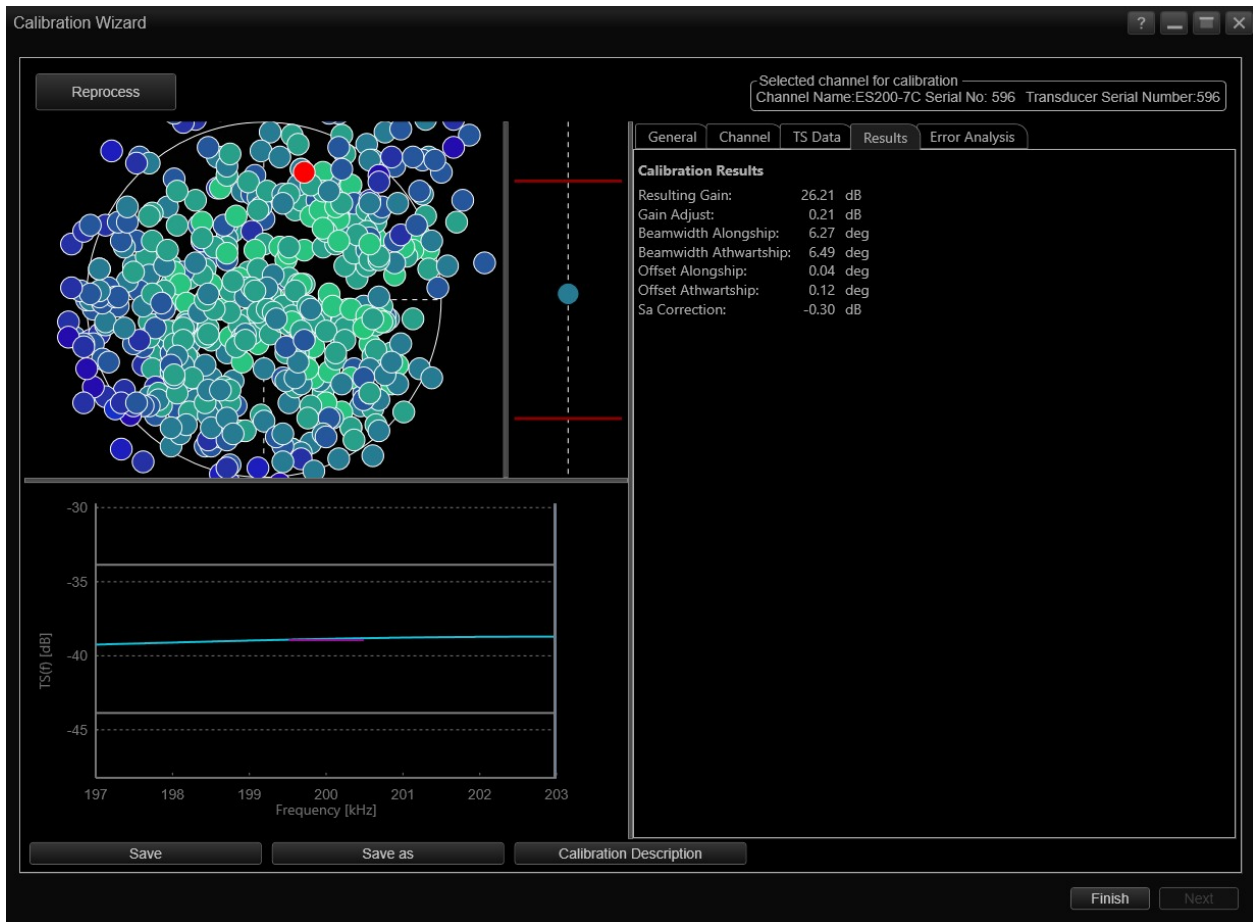


Figure 52. Screenshot of EK80 Calibration Wizard results for 200 kHz calibration at 1.024 ms.

Appendix E: Error Analysis

18 kHz: 8.192 ms

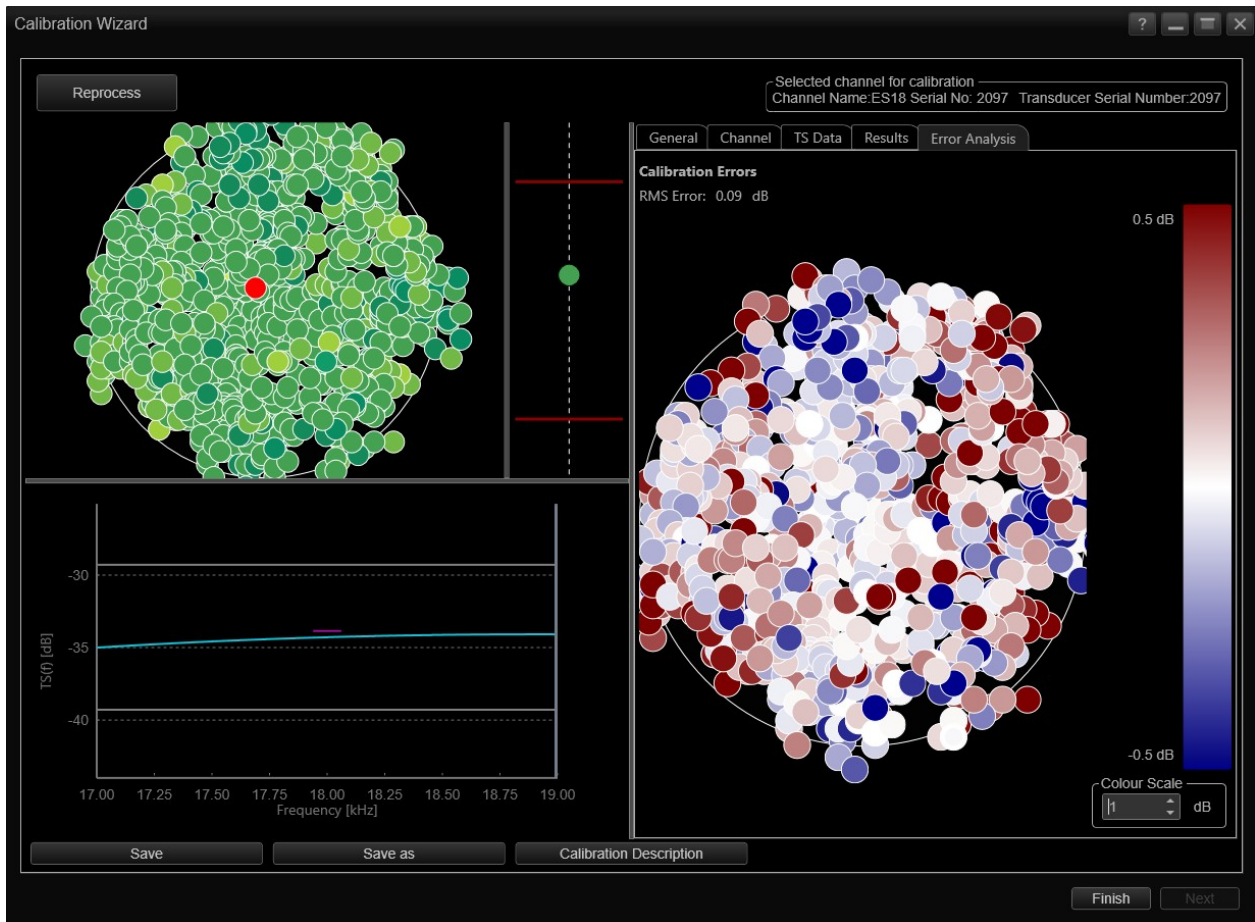


Figure 53. Screenshot of EK80 Calibration Wizard error analysis for 18 kHz calibration at 8.192 ms.

18 kHz: 4.096 ms

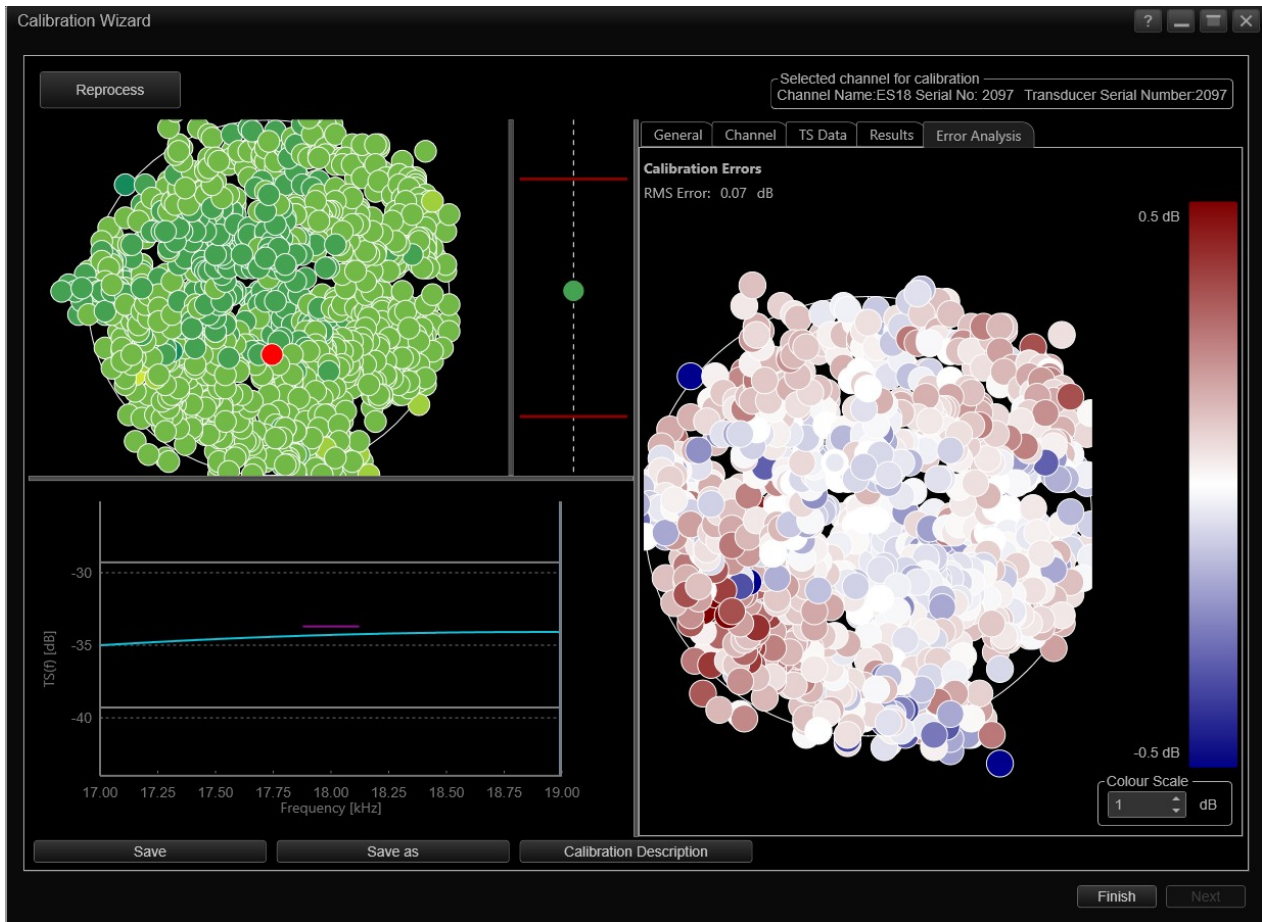


Figure 54. Screenshot of EK80 Calibration Wizard error analysis for 18 kHz calibration at 4.096 ms.

18 kHz: 1.024 ms

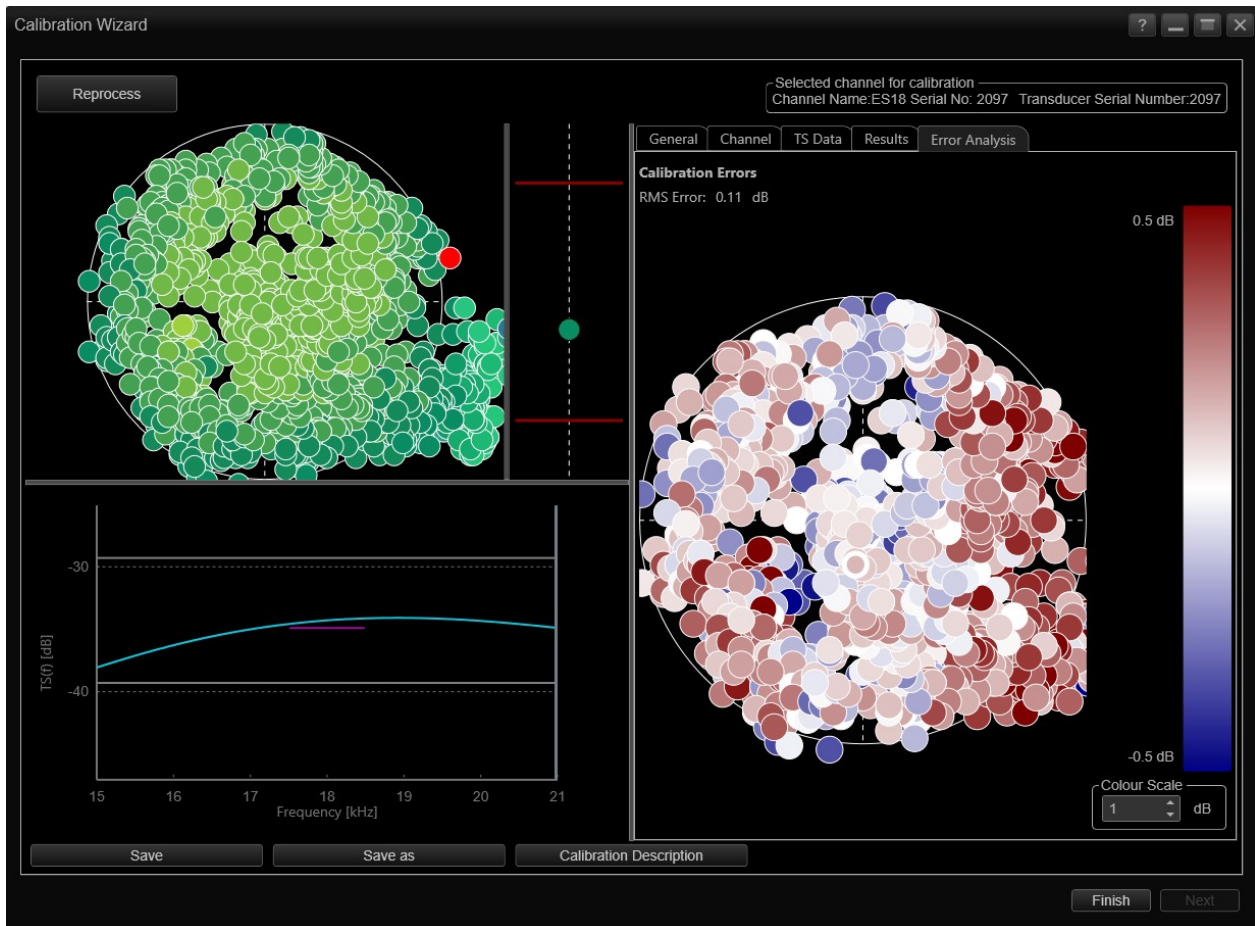


Figure 55. Screenshot of EK80 Calibration Wizard error analysis for 18 kHz calibration at 1.024 ms.

38 kHz (CW): 2.048 ms

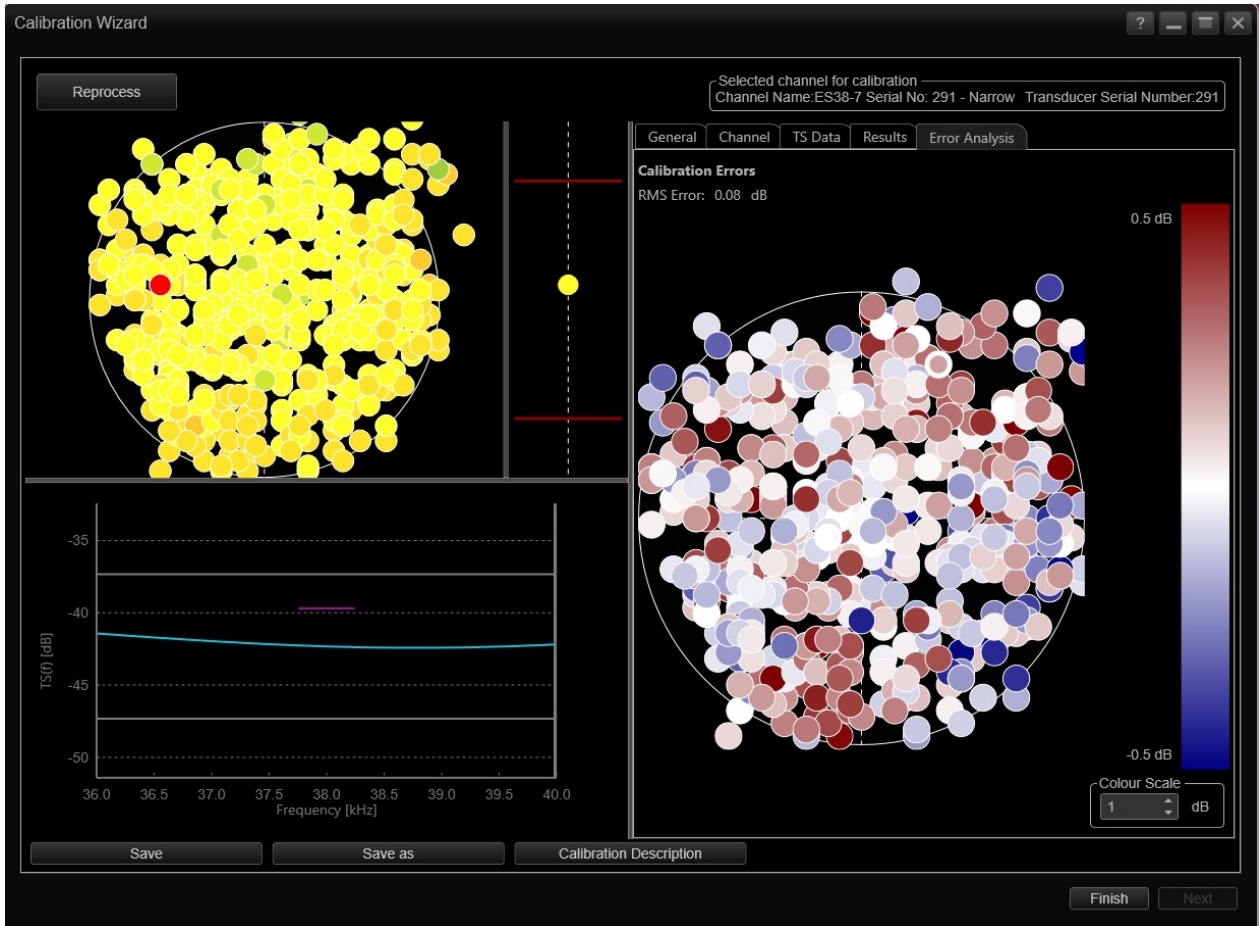


Figure 56. Screenshot of EK80 Calibration Wizard error analysis for 38 kHz calibration at 2.048 ms in continuous wave (CW) mode.

38 kHz (CW): 1.024 ms

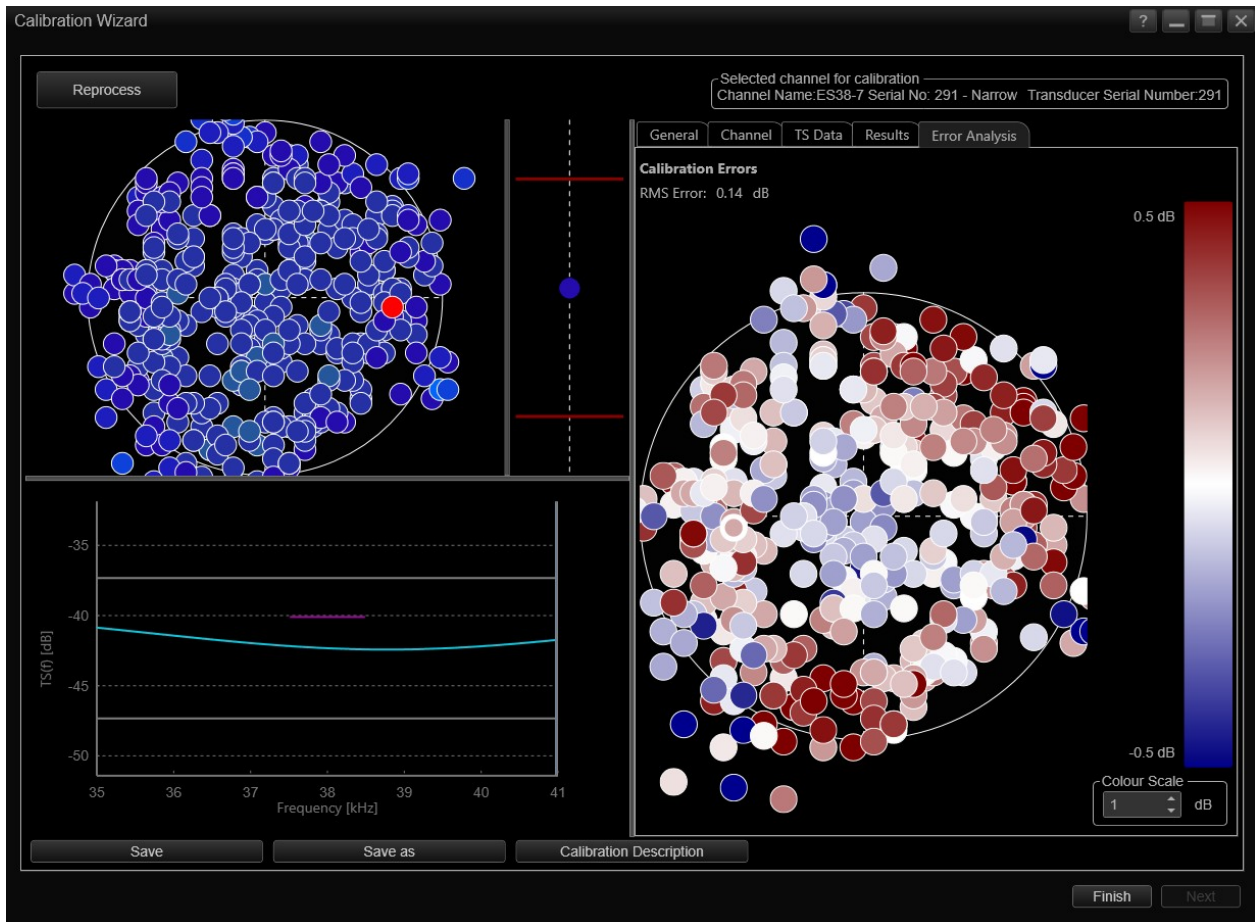


Figure 57. Screenshot of EK80 Calibration Wizard error analysis for 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

38 kHz (FM): 4.096 ms

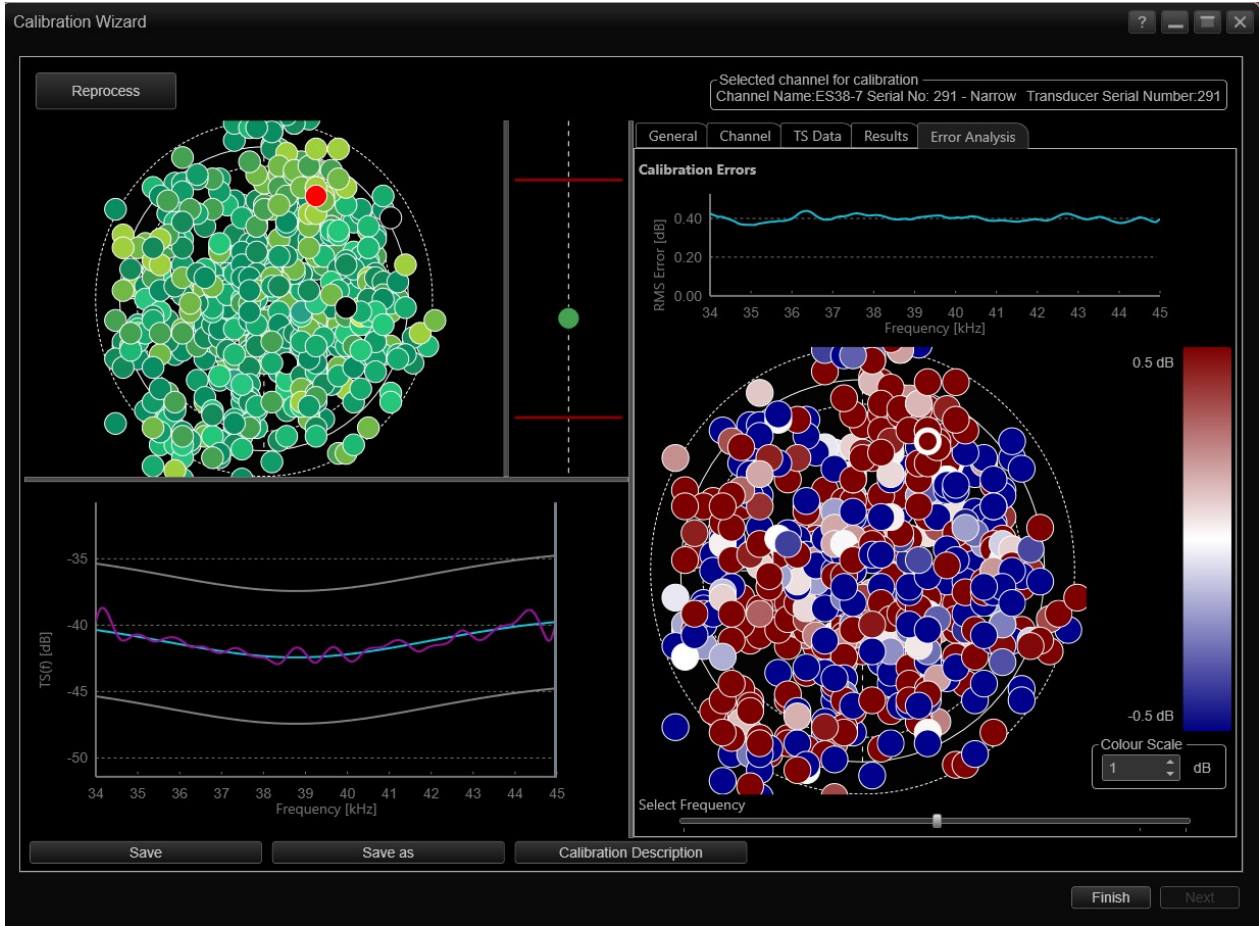


Figure 58. Screenshot of EK80 Calibration Wizard error analysis for 38 kHz calibration at 4.096 ms in frequency modulated (FM) mode.

38 kHz (FM): 1.024 ms

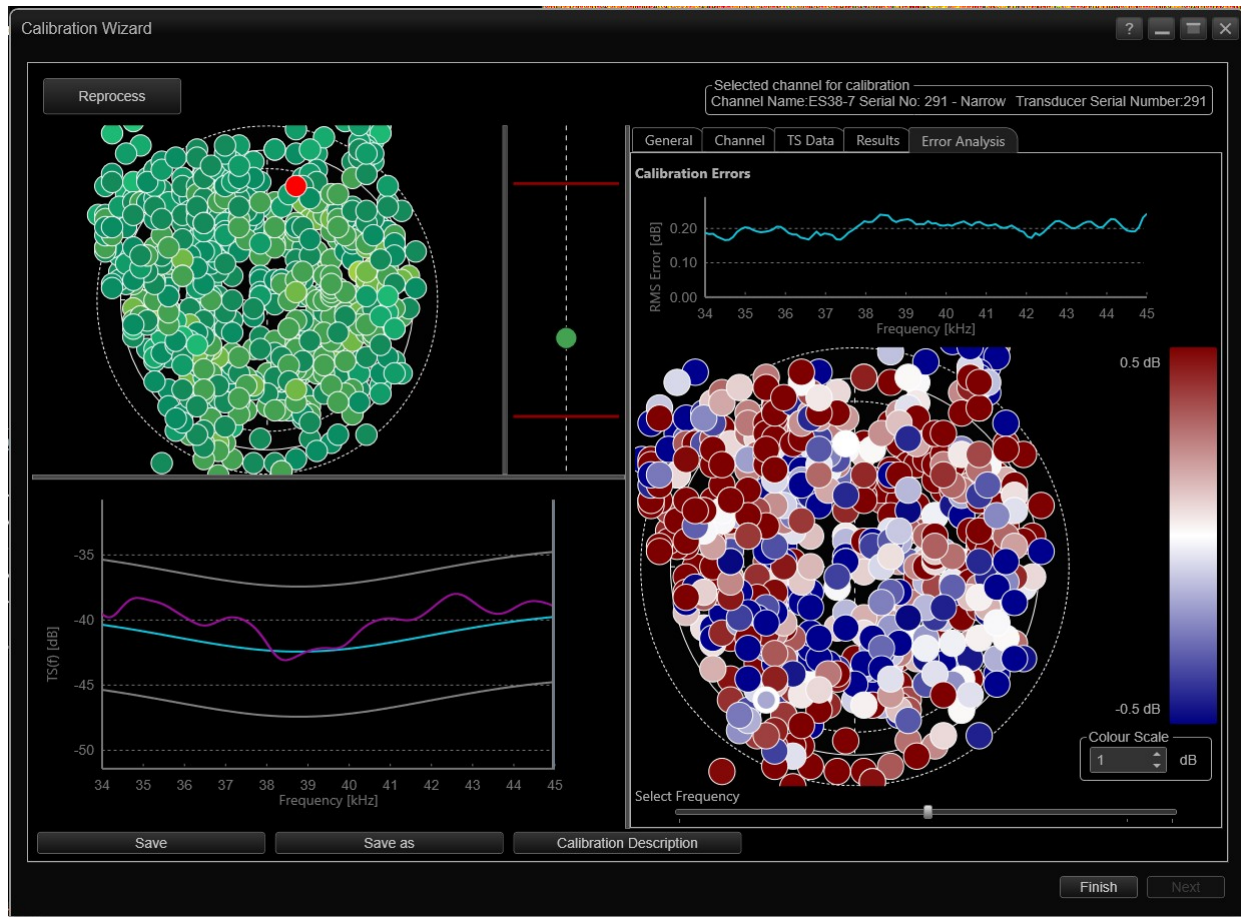


Figure 59. Screenshot of EK80 Calibration Wizard error analysis for 38 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

70 kHz (CW): 2.048 ms

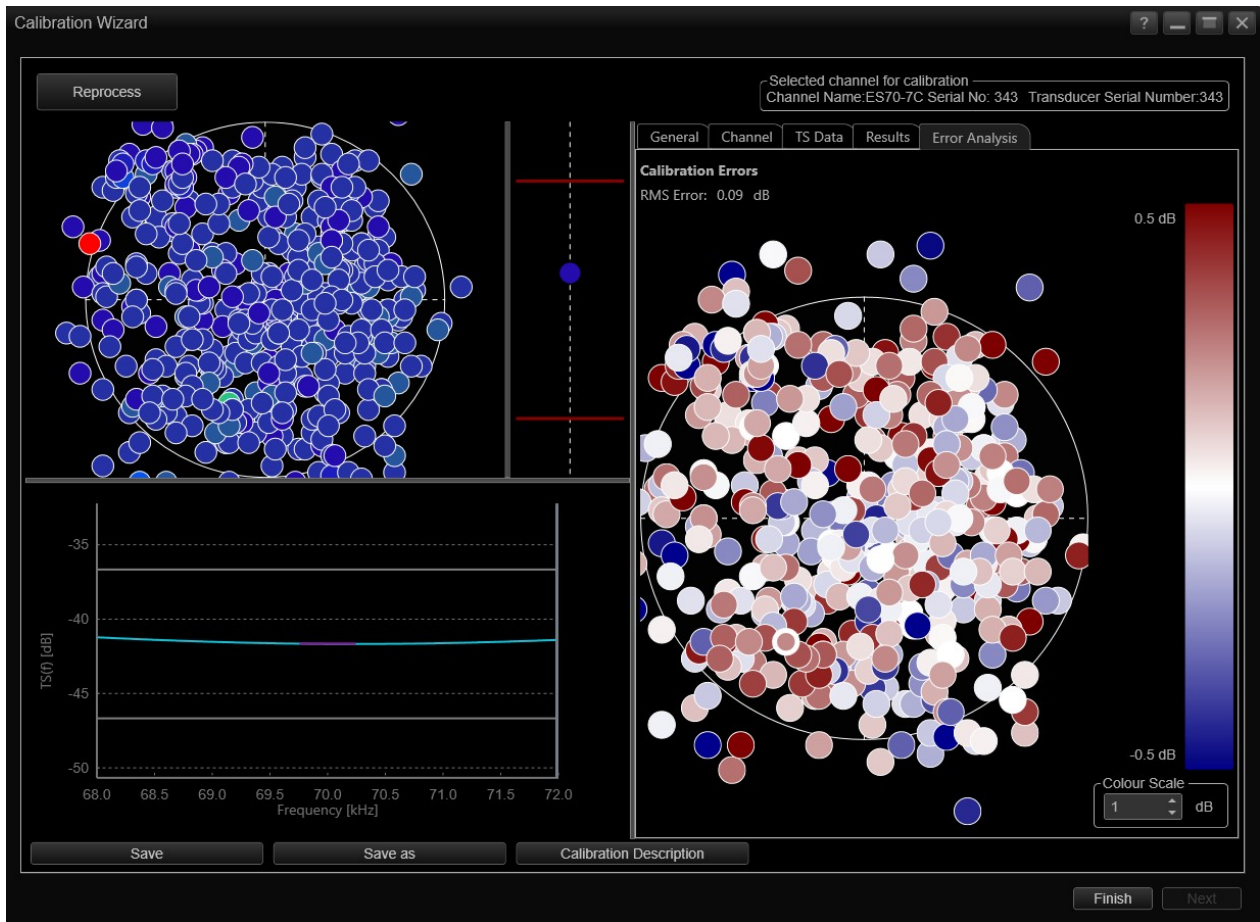


Figure 60. Screenshot of EK80 Calibration Wizard error analysis for 70 kHz calibration at 2.048 ms in continuous wave (CW) mode.

70 kHz (CW): 1.024 ms



Figure 61. Screenshot of EK80 Calibration Wizard error analysis for 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (FM): 2.048 ms

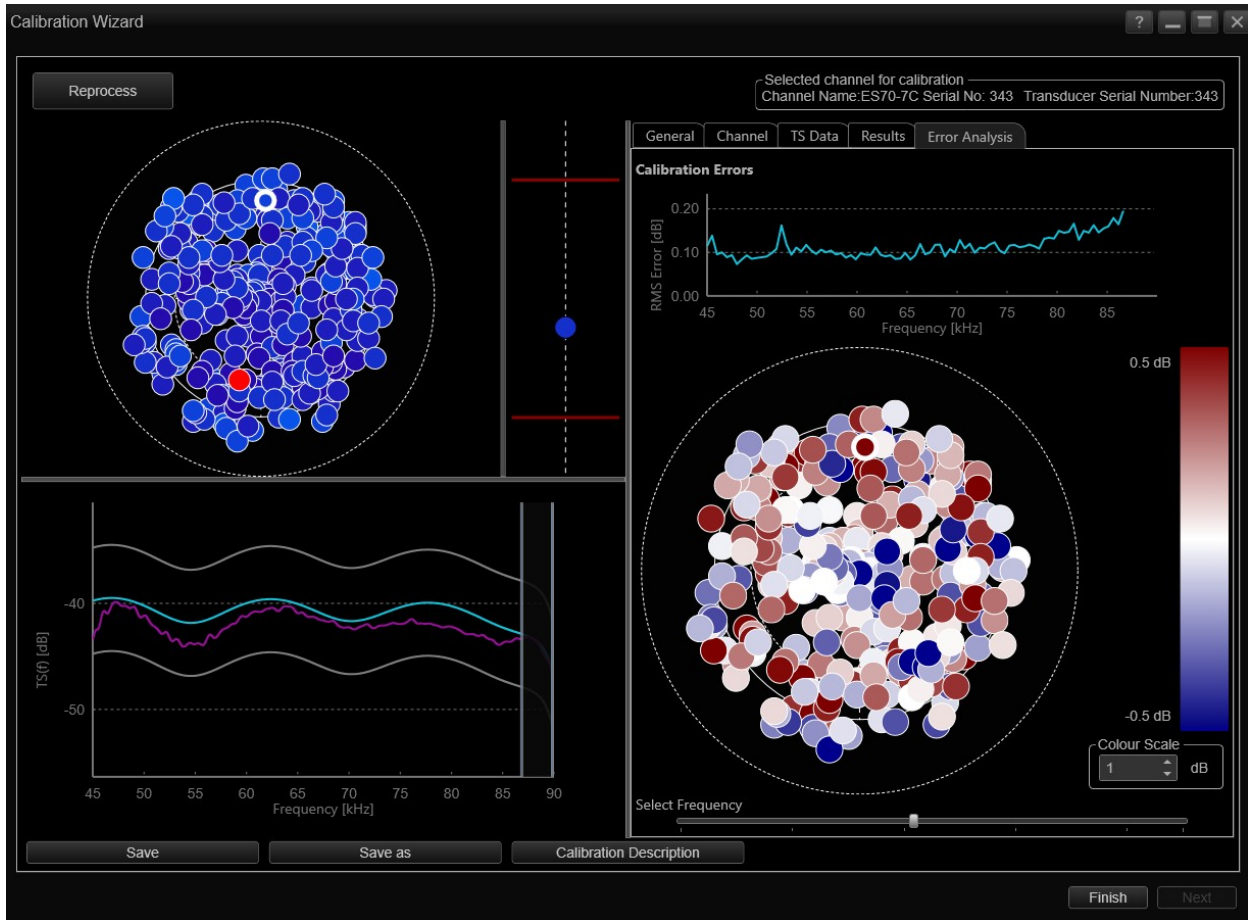


Figure 62. Screenshot of EK80 Calibration Wizard error analysis for 70 kHz calibration at 2.048 ms in frequency modulated (FM) mode.

70 kHz (FM): 1.024 ms

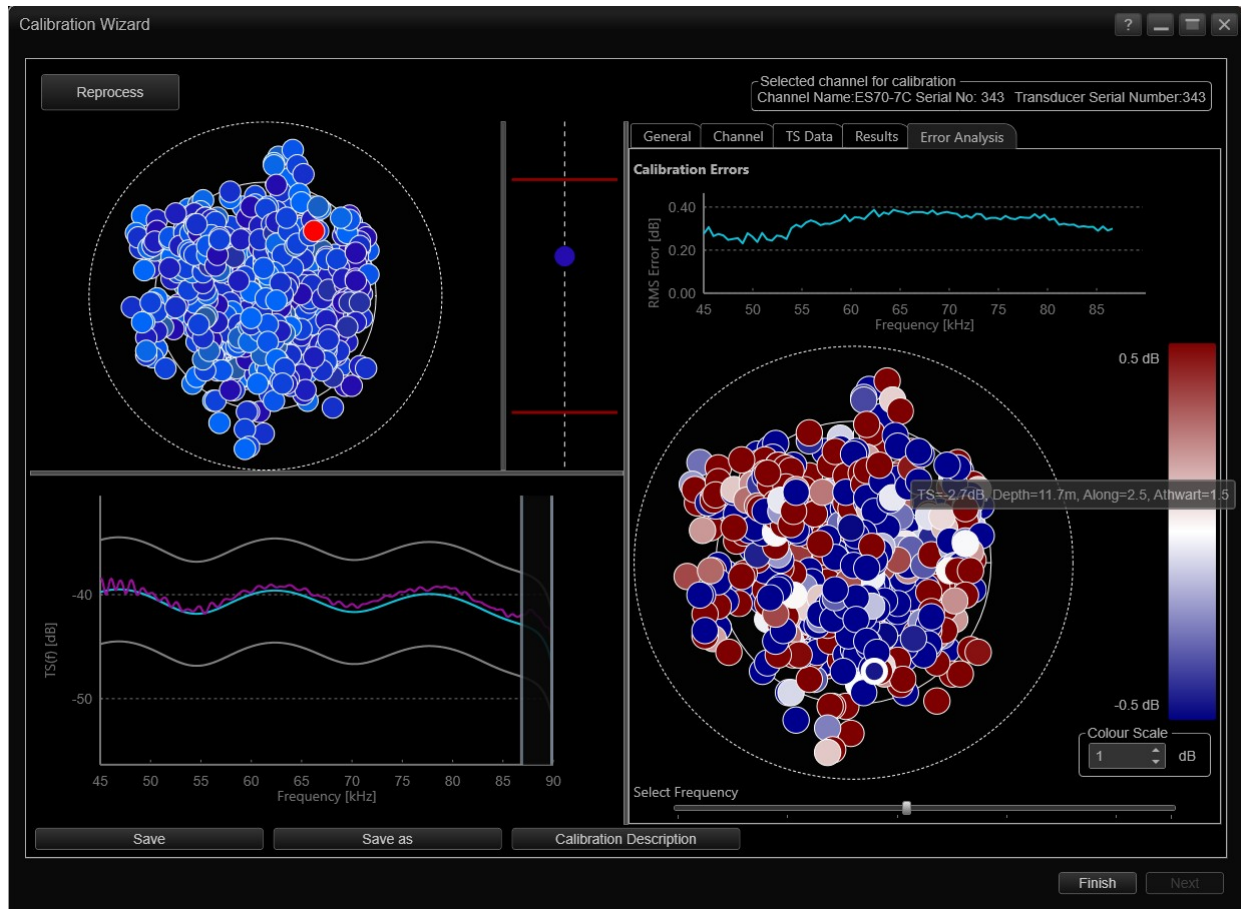


Figure 63. Screenshot of EK80 Calibration Wizard error analysis for 70 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

120 kHz: 1.024 ms

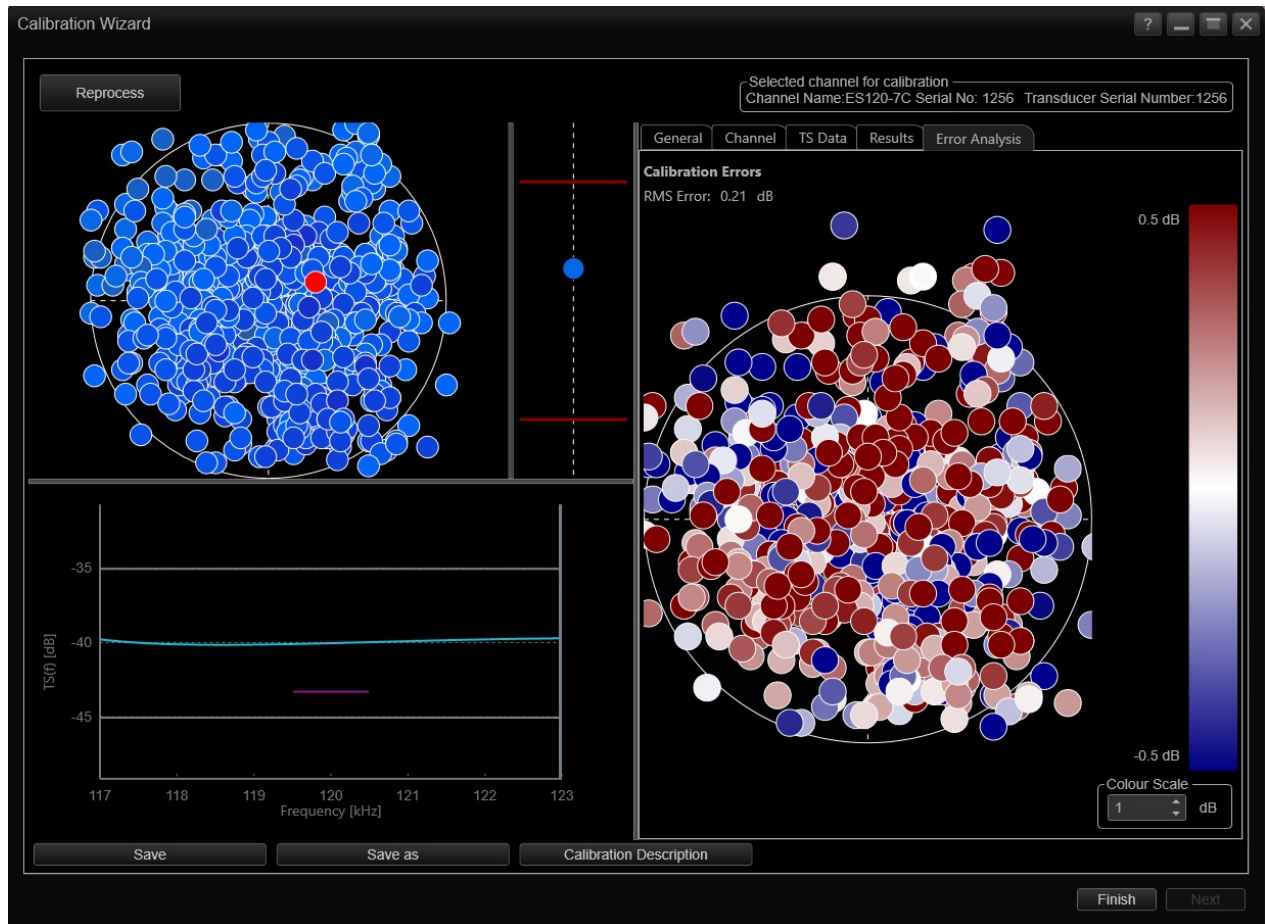


Figure 64. Screenshot of EK80 Calibration Wizard error analysis for 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

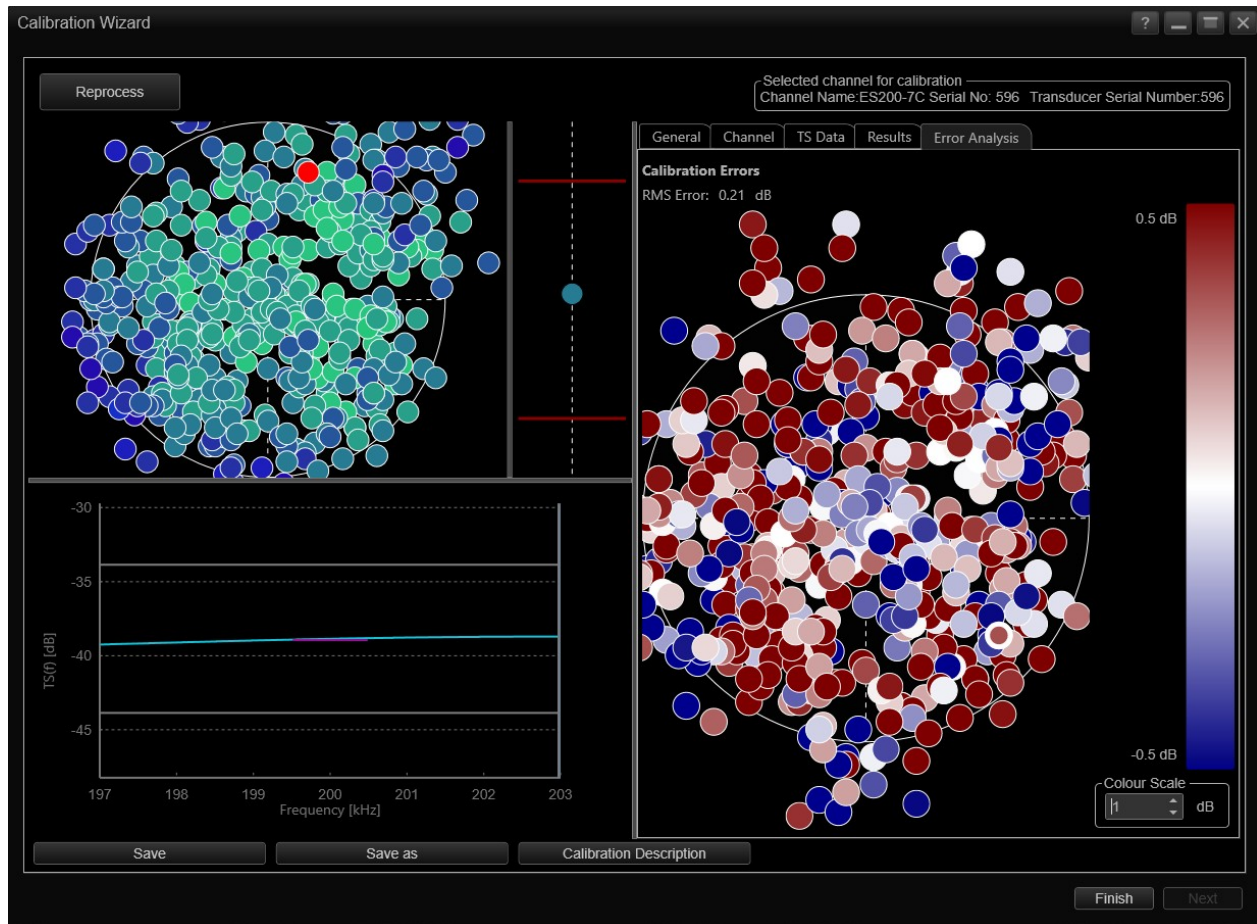


Figure 65. Screenshot of EK80 Calibration Wizard error analysis for 200 kHz calibration at 1.024 ms.

Appendix F: Detailed List of .raw and .xml Calibration Files

File name	Date (UTC)	Frequency (pulse length)
EX2101_EK60_calibration-D20210426-T200427.idx	04/26/2021	38 kHz - CW (1.024 ms)
EX2101_EK60_calibration-D20210426-T200427.raw	04/26/2021	38 kHz - CW (1.024 ms)
EX2101_EK60_calibration-D20210426-T203427.idx	04/26/2021	38 kHz - CW (1.024 ms)
EX2101_EK60_calibration-D20210426-T203427.raw	04/26/2021	38 kHz - CW (1.024 ms)
EX2101_EK60_calibration-D20210426-T204737.idx	04/26/2021	38 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210426-T204737.raw	04/26/2021	38 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210426-T212045.idx	04/26/2021	38 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210426-T212045.raw	04/26/2021	38 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210426-T213741.idx	04/26/2021	38 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210426-T213741.raw	04/26/2021	38 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210426-T214901.idx	04/26/2021	38 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210426-T214901.raw	04/26/2021	38 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210426-T215854.idx	04/26/2021	38 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210426-T215854.raw	04/26/2021	38 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210426-T220754.idx	04/26/2021	38 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210426-T220754.raw	04/26/2021	38 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210426-T221606.idx	04/26/2021	38 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210426-T221606.raw	04/26/2021	38 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210426-T222434.idx	04/26/2021	38 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210426-T222434.raw	04/26/2021	38 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210426-T223605.idx	04/26/2021	38 kHz - FM (4.096 ms)
EX2101_EK60_calibration-D20210426-T223605.raw	04/26/2021	38 kHz - FM (4.096 ms)
EX2101_EK60_calibration-D20210426-T224313.idx	04/26/2021	38 kHz - FM (4.096 ms)
EX2101_EK60_calibration-D20210426-T224313.raw	04/26/2021	38 kHz - FM (4.096 ms)

File name	Date (UTC)	Frequency (pulse length)
EX2101_EK60_calibration-D20210426-T225042.idx	04/26/2021	38 kHz - FM (4.096 ms)
EX2101_EK60_calibration-D20210426-T225042.raw	04/26/2021	38 kHz - FM (4.096 ms)
EX2101_EK60_calibration-D20210426-T225814.idx	04/26/2021	38 kHz - FM (4.096 ms)
EX2101_EK60_calibration-D20210426-T225814.raw	04/26/2021	38 kHz - FM (4.096 ms)
EX2101_EK60_calibration-D20210426-T230534.idx	04/26/2021	38 kHz - FM (4.096 ms)
EX2101_EK60_calibration-D20210426-T230534.raw	04/26/2021	38 kHz - FM (4.096 ms)
EX2101_EK60_calibration-D20210426-T231242.idx	04/26/2021	38 kHz - FM (4.096 ms)
EX2101_EK60_calibration-D20210426-T231242.raw	04/26/2021	38 kHz - FM (4.096 ms)
EX2101_EK60_calibration-D20210426-T231950.idx	04/26/2021	38 kHz - FM (4.096 ms)
EX2101_EK60_calibration-D20210426-T231950.raw	04/26/2021	38 kHz - FM (4.096 ms)
EX2101_EK60_calibration-D20210427-T002247.idx	04/27/2021	200 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T002247.raw	04/27/2021	200 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T003023.idx	04/27/2021	200 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T003023.raw	04/27/2021	200 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T003755.idx	04/27/2021	200 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T003755.raw	04/27/2021	200 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T004523.idx	04/27/2021	200 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T004523.raw	04/27/2021	200 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T005303.idx	04/27/2021	200 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T005303.raw	04/27/2021	200 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T010613.idx	04/27/2021	120 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T010613.raw	04/27/2021	120 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T011337.idx	04/27/2021	120 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T011337.raw	04/27/2021	120 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T012117.idx	04/27/2021	120 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T012117.raw	04/27/2021	120 kHz (1.024 ms)

File name	Date (UTC)	Frequency (pulse length)
EX2101_EK60_calibration-D20210427-T012849.idx	04/27/2021	120 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T012849.raw	04/27/2021	120 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T013625.idx	04/27/2021	120 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T013625.raw	04/27/2021	120 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T014401.idx	04/27/2021	120 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T014401.raw	04/27/2021	120 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T015141.idx	04/27/2021	120 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T015141.raw	04/27/2021	120 kHz (1.024 ms)
EX2101_EK60_calibration-D20210427-T020142.idx	04/27/2021	70 kHz - CW (1.024 ms)
EX2101_EK60_calibration-D20210427-T020142.raw	04/27/2021	70 kHz - CW (1.024 ms)
EX2101_EK60_calibration-D20210427-T020850.idx	04/27/2021	70 kHz - CW (1.024 ms)
EX2101_EK60_calibration-D20210427-T020850.raw	04/27/2021	70 kHz - CW (1.024 ms)
EX2101_EK60_calibration-D20210427-T021602.idx	04/27/2021	70 kHz - CW (1.024 ms)
EX2101_EK60_calibration-D20210427-T021602.raw	04/27/2021	70 kHz - CW (1.024 ms)
EX2101_EK60_calibration-D20210427-T022310.idx	04/27/2021	70 kHz - CW (1.024 ms)
EX2101_EK60_calibration-D20210427-T022310.raw	04/27/2021	70 kHz - CW (1.024 ms)
EX2101_EK60_calibration-D20210427-T023501.idx	04/27/2021	70 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210427-T023501.raw	04/27/2021	70 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210427-T024230.idx	04/27/2021	70 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210427-T024230.raw	04/27/2021	70 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210427-T024958.idx	04/27/2021	70 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210427-T024958.raw	04/27/2021	70 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210427-T025726.idx	04/27/2021	70 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210427-T025726.raw	04/27/2021	70 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210427-T030455.idx	04/27/2021	70 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210427-T030455.raw	04/27/2021	70 kHz - CW (2.048 ms)

File name	Date (UTC)	Frequency (pulse length)
EX2101_EK60_calibration-D20210427-T031223.idx	04/27/2021	70 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210427-T031223.raw	04/27/2021	70 kHz - CW (2.048 ms)
EX2101_EK60_calibration-D20210427-T032432.idx	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T032432.raw	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T032738.idx	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T032738.raw	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T033050.idx	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T033050.raw	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T033402.idx	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T033402.raw	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T033714.idx	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T033714.raw	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T034026.idx	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T034026.raw	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T034338.idx	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T034338.raw	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T034644.idx	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T034644.raw	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T034945.idx	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T034945.raw	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T035248.idx	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T035248.raw	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T035546.idx	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T035546.raw	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T035858.idx	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T035858.raw	04/27/2021	70 kHz - FM (2.048 ms)

File name	Date (UTC)	Frequency (pulse length)
EX2101_EK60_calibration-D20210427-T040210.idx	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T040210.raw	04/27/2021	70 kHz - FM (2.048 ms)
EX2101_EK60_calibration-D20210427-T040901.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T040901.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T041116.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T041116.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T041331.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T041331.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T041611.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T041611.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T041904.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T041904.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T042151.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T042151.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T042441.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T042441.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T042704.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T042704.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T042918.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T042918.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T043146.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T043146.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T043405.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T043405.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T043620.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T043620.raw	04/27/2021	70 kHz - FM (1.024 ms)

File name	Date (UTC)	Frequency (pulse length)
EX2101_EK60_calibration-D20210427-T043835.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T043835.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T044046.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T044046.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T044306.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T044306.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T044542.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T044542.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T044825.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T044825.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T045055.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T045055.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T045337.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T045337.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T045613.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T045613.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T045828.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T045828.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T050050.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T050050.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T050332.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T050332.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T050613.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T050613.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T050855.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T050855.raw	04/27/2021	70 kHz - FM (1.024 ms)

File name	Date (UTC)	Frequency (pulse length)
EX2101_EK60_calibration-D20210427-T051109.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T051109.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T051324.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T051324.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T051620.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T051620.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T051845.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T051845.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T052102.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T052102.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T052317.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T052317.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T052546.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T052546.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T052839.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T052839.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T053057.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T053057.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T053319.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T053319.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T053606.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T053606.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T053853.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T053853.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T054132.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T054132.raw	04/27/2021	70 kHz - FM (1.024 ms)

File name	Date (UTC)	Frequency (pulse length)
EX2101_EK60_calibration-D20210427-T054412.idx	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration-D20210427-T054412.raw	04/27/2021	70 kHz - FM (1.024 ms)
EX2101_EK60_calibration_-D20210501-T153155.idx	05/01/2021	18 kHz (1.024 ms)
EX2101_EK60_calibration_-D20210501-T153155.raw	05/01/2021	18 kHz (1.024 ms)
EX2101_EK60_calibration_-D20210501-T155238.idx	05/01/2021	18 kHz (1.024 ms)
EX2101_EK60_calibration_-D20210501-T155238.raw	05/01/2021	18 kHz (1.024 ms)
EX2101_EK60_calibration_-D20210501-T161332.idx	05/01/2021	18 kHz (1.024 ms)
EX2101_EK60_calibration_-D20210501-T161332.raw	05/01/2021	18 kHz (1.024 ms)
EX2101_EK60_calibration_-D20210501-T163417.idx	05/01/2021	18 kHz (1.024 ms)
EX2101_EK60_calibration_-D20210501-T163417.raw	05/01/2021	18 kHz (1.024 ms)
EX2101_EK60_calibration_-D20210501-T164026.idx	05/01/2021	18 kHz (4.096 ms)
EX2101_EK60_calibration_-D20210501-T164026.raw	05/01/2021	18 kHz (4.096 ms)
EX2101_EK60_calibration_-D20210501-T170216.idx	05/01/2021	18 kHz (4.096 ms)
EX2101_EK60_calibration_-D20210501-T170216.raw	05/01/2021	18 kHz (4.096 ms)
EX2101_EK60_calibration_-D20210501-T172408.idx	05/01/2021	18 kHz (4.096 ms)
EX2101_EK60_calibration_-D20210501-T172408.raw	05/01/2021	18 kHz (4.096 ms)
EX2101_EK60_calibration_-D20210501-T173126.idx	05/01/2021	18 kHz (8.192 ms)
EX2101_EK60_calibration_-D20210501-T173126.raw	05/01/2021	18 kHz (8.192 ms)
EX2101_EK60_calibration_-D20210501-T175331.idx	05/01/2021	18 kHz (8.192 ms)
EX2101_EK60_calibration_-D20210501-T175331.raw	05/01/2021	18 kHz (8.192 ms)
EX2101_EK60_calibration_-D20210501-T181536.idx	05/01/2021	18 kHz (8.192 ms)
EX2101_EK60_calibration_-D20210501-T181536.raw	05/01/2021	18 kHz (8.192 ms)

.xml file name	Date (UTC)
CalibrationDataFile-D20210426-T204745-38kHz-2048.xml	04/26/2021
CalibrationDataFile-D20210426-T200505-38kHz_1024.xml	04/26/2021
CalibrationDataFile-D20210426-T223612-38kHz_FM-4096.xml	04/26/2021
CalibrationDataFile-D20210426-T213750-38kHz-FM-1024.xml	04/26/2021
CalibrationDataFile-D20210427-T023506-70kHz_CW_2048.xml	04/27/2021
CalibrationDataFile-D20210427-T020152-70kHz-CW-1024.xml	04/27/2021
CalibrationDataFile-D20210427-T032513-70kHz-FM-2048.xml	04/27/2021
CalibrationDataFile-D20210427-T040908-70kHz-FM-1024.xml	04/27/2021
CalibrationDataFile-D20210427-T010652-120kHz_1024.xml	04/27/2021
CalibrationDataFile-D20210427-T002252-200kHz-1024.xml	04/27/2021
CalibrationDataFile-D20210501-T173145-18kHz-8192.xml	05/01/2021
CalibrationDataFile-D20210501-T164031-18kHz-4096.xml	05/01/2021
CalibrationDataFile-D20210501-T153255-18kHz-1024.xml	05/01/2021

Appendix G: Vessel Offsets for Transducer Hull Locations

Vessel Offsets (meters)			
Transducer	X	Y	Z
ES18 (18 kHz)	-0.5234	1.7793	6.7833
ES38-B (38 kHz)	5.7288	3.3967	6.7955
ES70-7C (70 kHz)	6.5095	3.3939	6.7903
ES120-7C (120 kHz)	5.2481	3.3954	6.7895
ES200-7C (200 kHz)	6.1682	3.2258	6.7920