August 2023 EK60/80 Calibration Report

NOAA Ship *Okeanos Explorer*

Seascape Alaska 4: Gulf of Alaska Deepwater Mapping (EX2305)

Supporting Document for the NOAA Ship *Okeanos Explorer* Mapping Systems Readiness Report 2023 (https://doi.org/10.25923/cder-qt47)

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Introduction

NOAA Ocean Exploration is dedicated to exploring the unknown ocean, unlocking its potential through scientific discovery, technological advancements, and data delivery. By working closely with partners across public, private, and academic sectors, we are filling gaps in our basic understanding of the marine environment. This allows us, collectively, to protect ocean health, sustainably manage our marine resources, accelerate our national economy, better understand our changing environment, and enhance appreciation of the importance of the ocean in our everyday lives.

With priority placed on exploration of deep waters and the waters of the U.S. Exclusive Economic Zone, NOAA Ocean Exploration applies the latest tools and technologies to explore previously unknown areas of the ocean, making discoveries of scientific, economic, and cultural value. By making collected data publicly available in increasingly innovative and accessible ways, we provide a unique and centralized national resource of critical ocean information. And, through live exploration video, online resources, training and educational opportunities, and public events, we share the excitement of ocean exploration with people around the world and inspire and engage the next generation of ocean scientists, engineers, and leaders.

This document provides information for the August 2023 calibration of the Simrad EK60/80 echosounders on NOAA Ship *Okeanos Explorer* during the EX2305 expedition. This was the first calibration of the EK sonars in the Pacific Ocean, which the ship entered at the end of 2022. EX2208, which operated off the west coast of California, is the first cruise for which these calibrations are applicable and should supersede the calibrations conducted in August 2022 in the Atlantic Ocean. Any future mid-season equipment calibrations or modifications will also be archived as a supporting document with the annual readiness report.

The calibrations occurred on August 5 and August 16, 2023 while drifting in the Gulf of Alaska and the Shelikof Strait, respectively (**Figure 1**). 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 38 and 70 kHz wideband transceivers (WBT) were calibrated in continuous wave (CW) mode at a pulse length of 1.024 ms. The 70 kHz WBT was calibrated at an additional pulse length of 2.048 ms. The frequency-modulated (FM) modes of the 38 and 70 kHz were not calibrated.

Location and Conditions

- The calibrations occurred in the Gulf of Alaska and the Shelikof Strait.
    - Pod starting coordinates: 53° 43.86’ N, 151° 09.948’ W.
    - 18 kHz starting coordinates: 58° 53.19’ N, 153° 03.942 W’.
- The vessel was drifting in waters deeper than 50 meters.
- A CastAway conductivity, temperature, depth (CTD) cast was performed before the calibration each day to obtain the required oceanographic properties; including the temperature and salinity at the depth of the sphere.
- Average speed of sound at the calibration depth (15 meters) for the 38, 70, 120, and 200 kHz transducers on August 5 was 1489.74 meters per second, with an average temperature of 10.80 °C and average salinity of 32 psu (practical salinity units).
- Average speed of sound at the calibration depth (30 meters) for the 18 kHz transducer on August 16 was 1485.78 meters per second, with an average temperature of 10.30 °C and average salinity of 31 psu (practical salinity units).

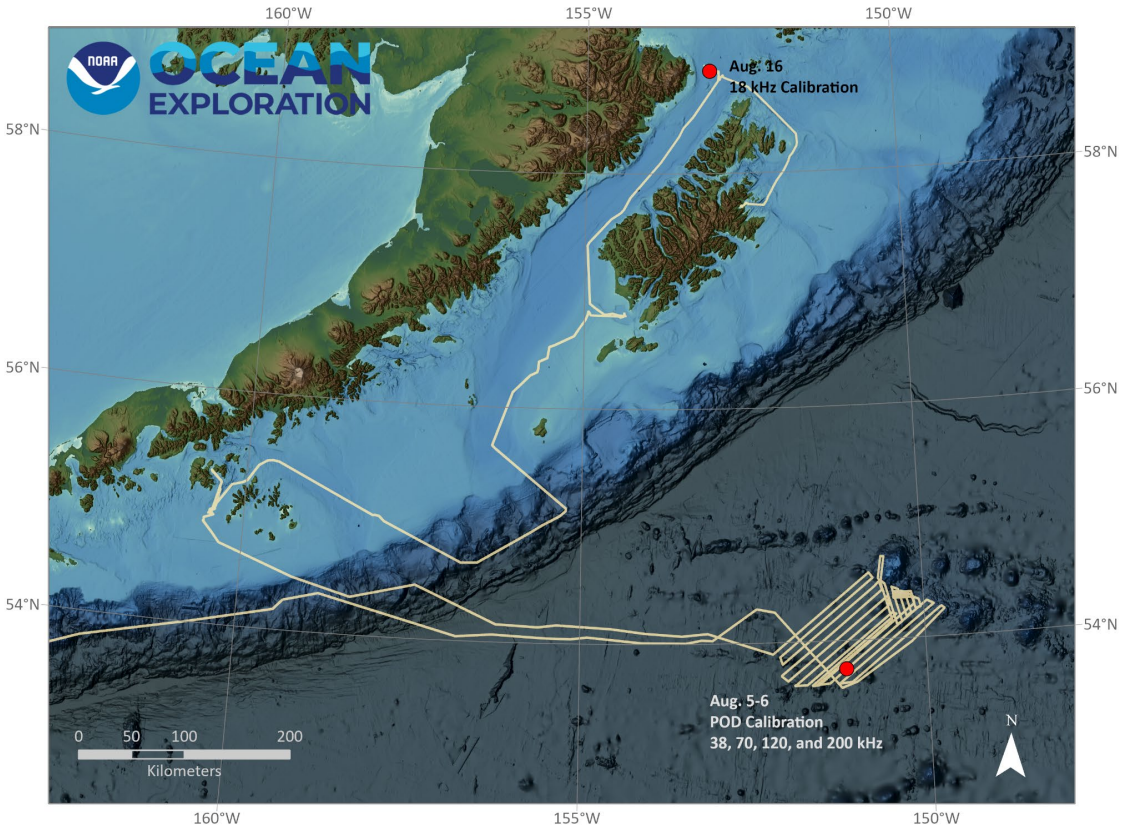

Figure 1. Location of the calibrations on August 5-6 and August 16, 2023.

Calibration Parameters

- All frequencies within the pod (38, 70, 120, 200 kHz) and the 18 kHz were calibrated with a pulse length of 1.024 ms. The 70 kHz CW mode was additionally calibrated with a pulse length of 2.048 ms. Neither the 38 kHz or 70 kHz FM modes were calibrated.
- 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 2023 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**	**120**	**200**
EK 80 software version	21.15.2.0	21.15.2.0	21.15.2.0
Transducer model	ES18	ES120-7C	ES200-7C
Transducer serial number	2097	1256	596
Transducer draft setting (m)	4.99	4.99	4.99
Transmit power (W)	1600	250	150
Pulse length (ms)	1.024	1.024	1.024
Two-way beam angle (dB)	-17.00	-20.70	-20.70
Transducer peak gain (dB)	22.93	26.08	26.27
Sa correction (dB)	-0.69	-0.32	-0.29
Absorption coefficient (dB/km)	0.0024	0.0370	0.0527
Speed of sound (m/s)	1485.78	1489.74	1489.74
3 dB beamwidth (º) alongship/athwartship	9.84/9.95	6.26/6.62	6.50/6.48
Angle offset (º) alongship/athwartship	0.06/0.05	0.05/0.08	0.04/0.16

Table 2. List of relevant parameters and initial settings used during the 2023 calibration of the EK80 Wide Band Transceivers (WBTs) in CW mode. For more information, see **Appendix A,** containing the channel tab for each frequency calibrated.

Frequency (kHz)	**38 (CW)**	**70 (CW)**	**70 (CW)**
Frequency Range (kHz)	38	70	70
GPT/WBT serial number	WBT 748247	WBT 746998	WBT 746998
EK 80 software version	21.15.2.0	21.15.2.0	21.15.2.0
Transducer model	ES38-7	ES70-7C	ES70-7C
Transducer serial number	291	343	343
Transducer draft setting (m)	4.99	4.99	4.99
Transmit power (W)	2000	750	750
Pulse length (ms)	1.024	1.024	2.048
Slope (%)	10.280	2.790	1.395
Two-way beam angle (dB)	-20.70	-20.70	-20.70
Transducer peak gain (dB)	26.61	27.09	27.86
Sa correction (dB)	-0.06	0.00	0.03
Absorption coefficient (dB/km)	0.0092	0.0220	0.0220
Speed of sound (m/s)	1489.74	1489.74	1489.74
3 dB beamwidth (º) alongship/athwartship	6.53/6.94	6.62/6.70	6.62/6.70
Angle offset (º) alongship/athwartship	-0.05/0.00	-0.04/0.06	04/0.06

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 21.15.2.0) 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 Calibration[1]. 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	-34.42	N/A
38 (CW)	N/A	-42.40
70 (CW)	N/A	-41.29
120	N/A	-39.49
200	N/A	-39.27

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 (**Appendix E**). 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 calibrations conducted the previous year on NOAA Ship *Okeanos Explorer*.

Appendix A: Channel Results

18 kHz (CW): 1.024 ms

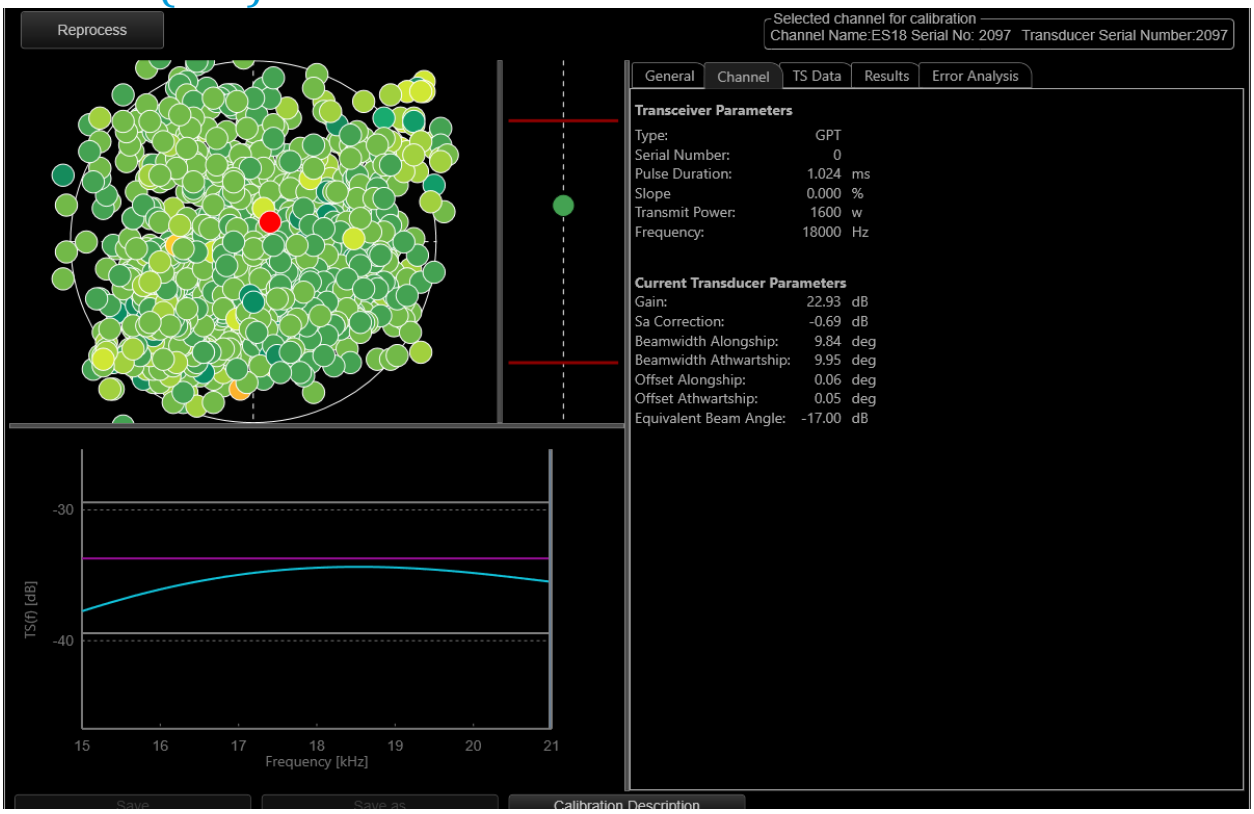

Figure 2. Screenshot of EK80 Calibration Wizard channel results for the 18 kHz calibration at 1.024 ms.

38 kHz (CW): 1.024 ms

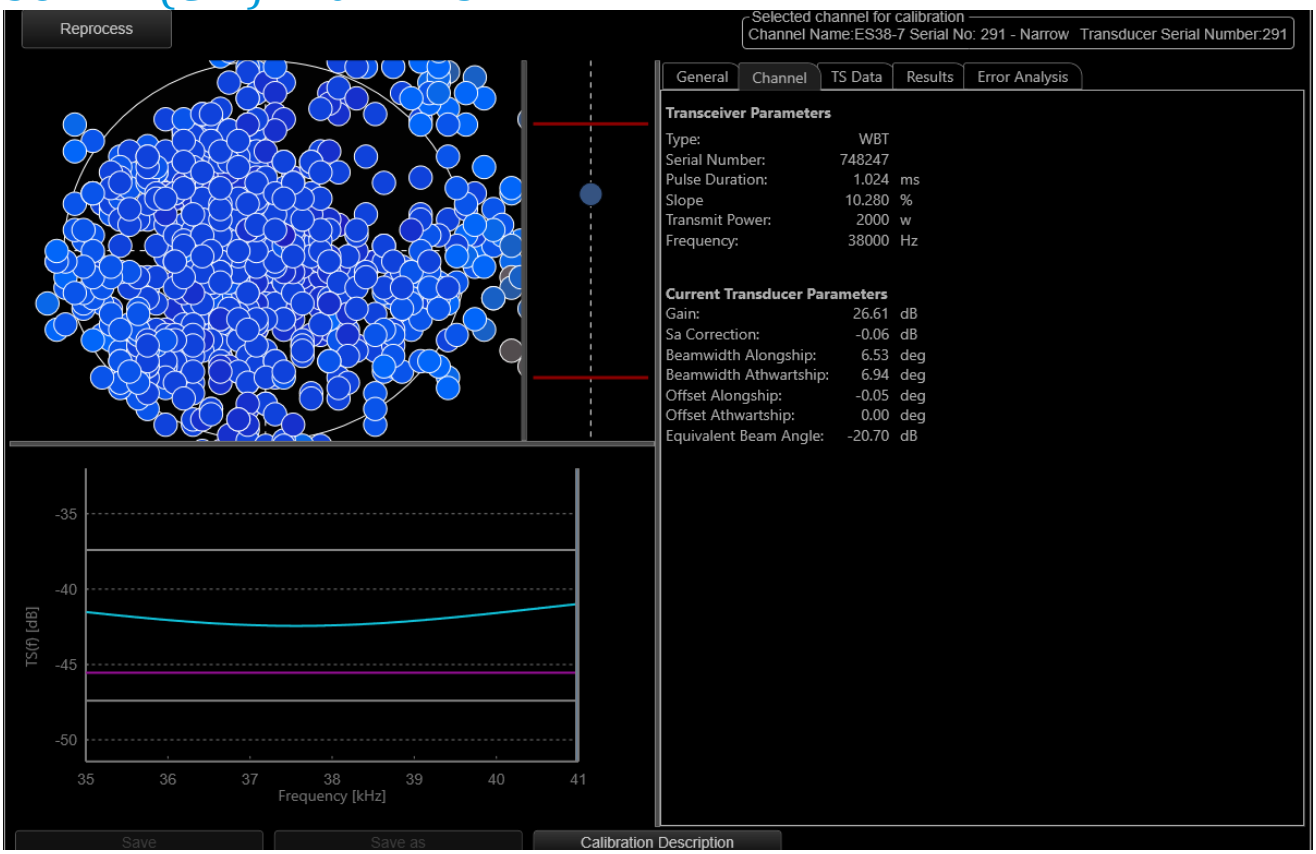

Figure 3. Screenshot of EK80 Calibration Wizard channel results for the 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (CW): 1.024 ms

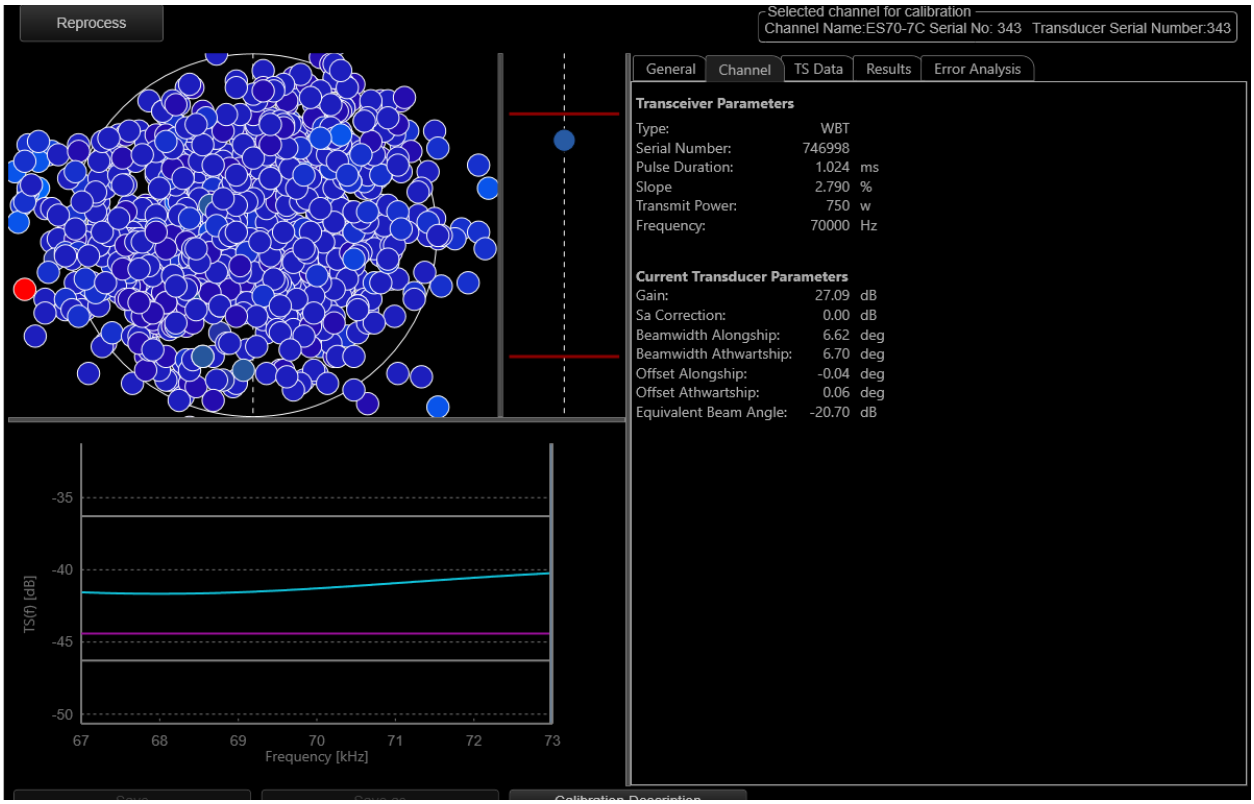

Figure 4. Screenshot of EK80 Calibration Wizard channel results for the 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (CW): 2.048 ms

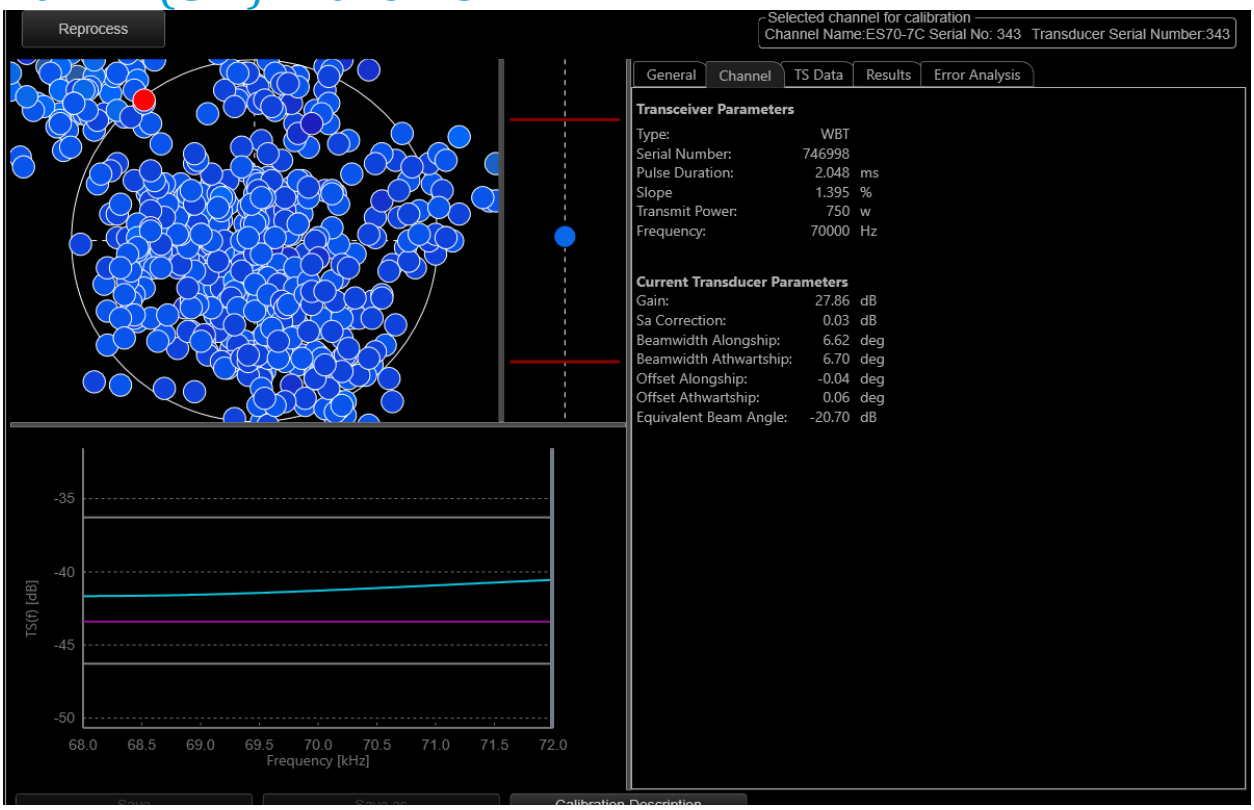

Figure 5. Screenshot of EK80 Calibration Wizard channel results for the 70 kHz calibration at 2.048 ms in continuous wave (CW) mode.

120 kHz: 1.024 ms

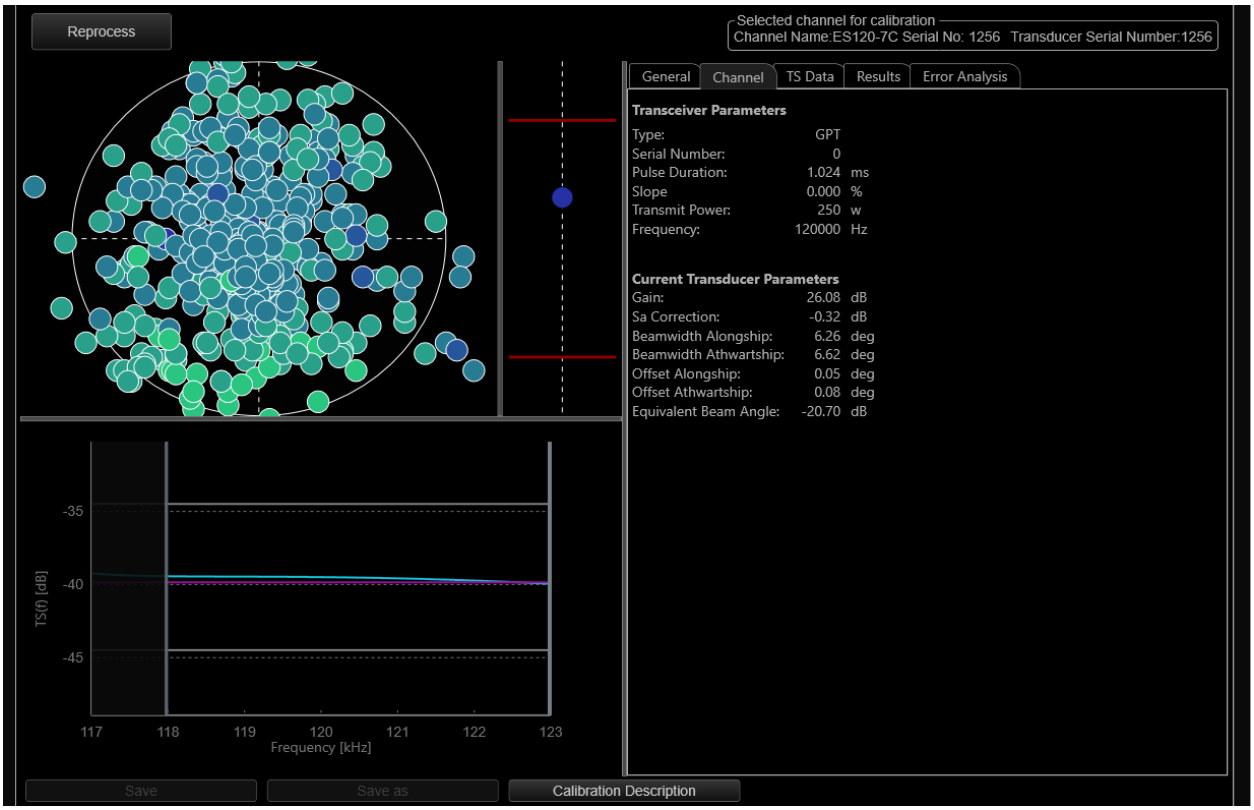

Figure 6. Screenshot of EK80 Calibration Wizard channel results for the 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

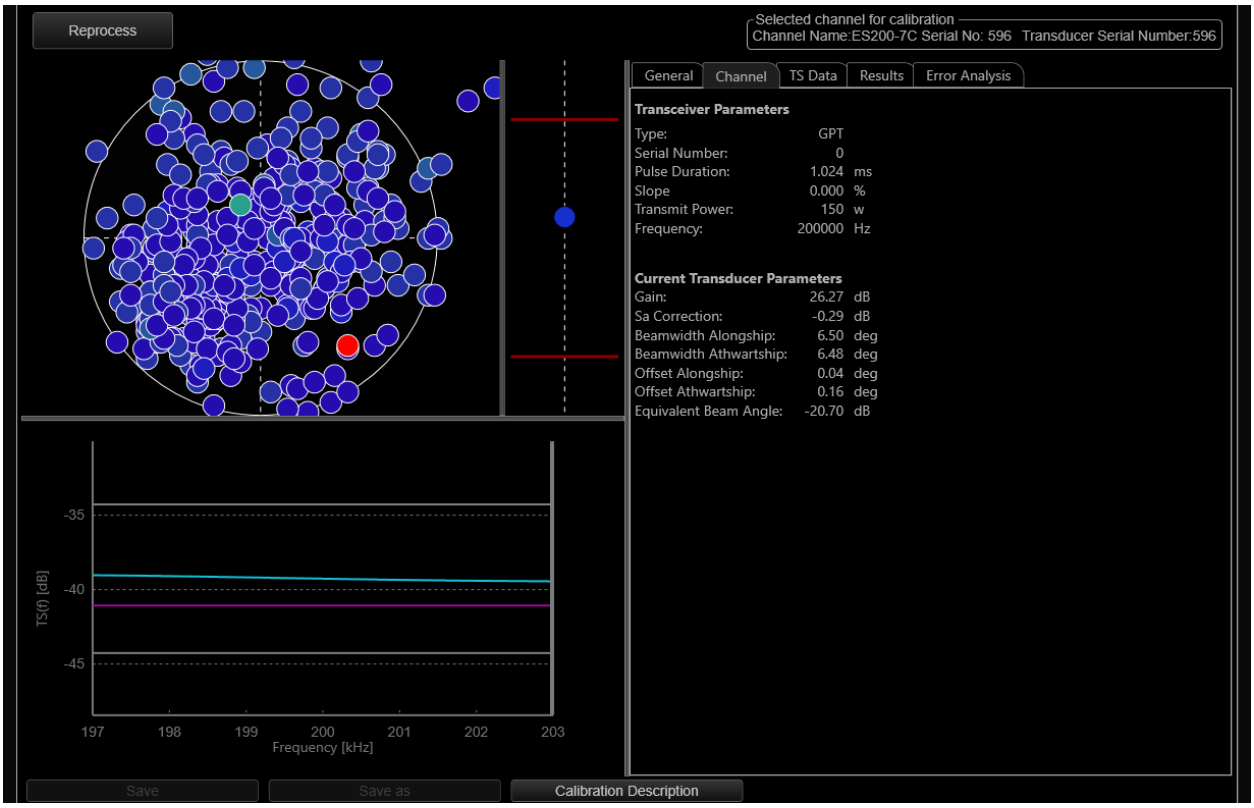

Figure 7. Screenshot of EK80 Calibration Wizard channel results for the 200 kHz calibration at 1.024 ms.

Appendix B: General Results

18 kHz: 1.024 ms

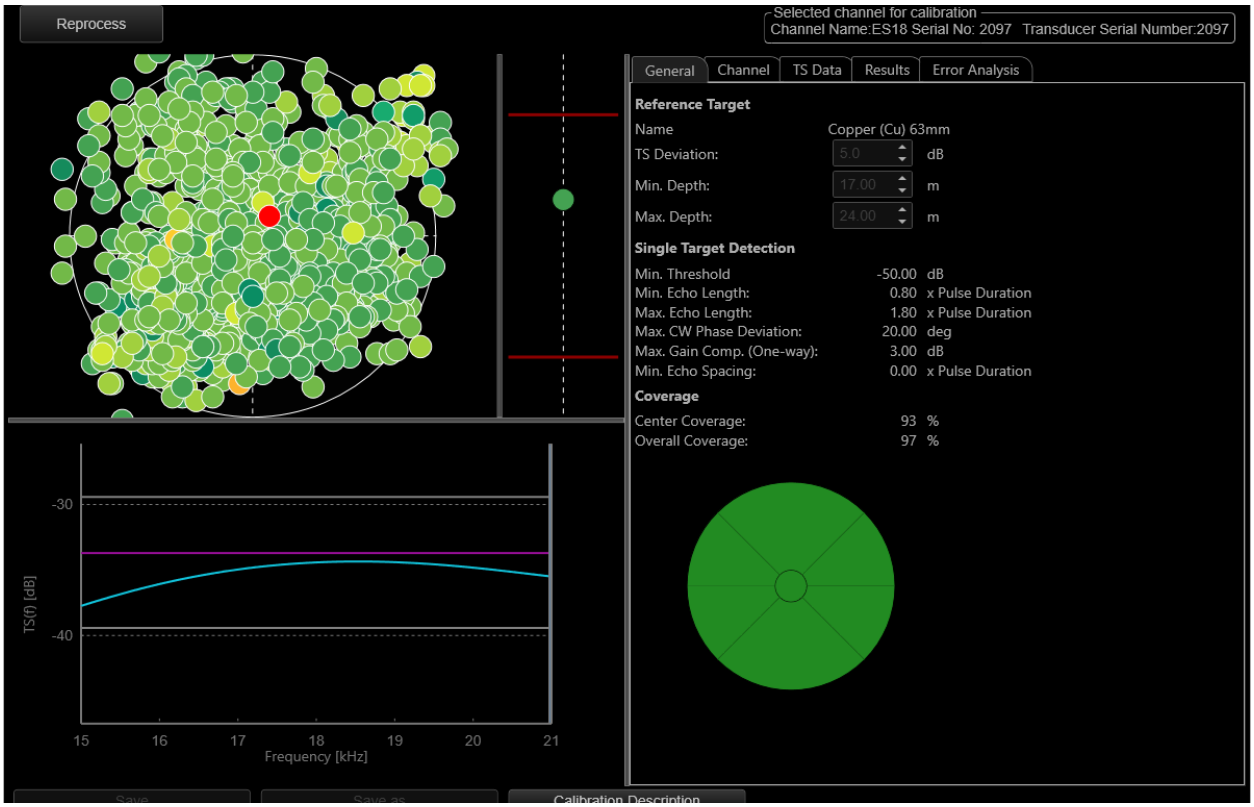

Figure 8. Screenshot of EK80 Calibration Wizard general results for the 18 kHz calibration at 1.024 ms in continuous wave (CW) mode.

38 kHz (CW): 1.024 ms

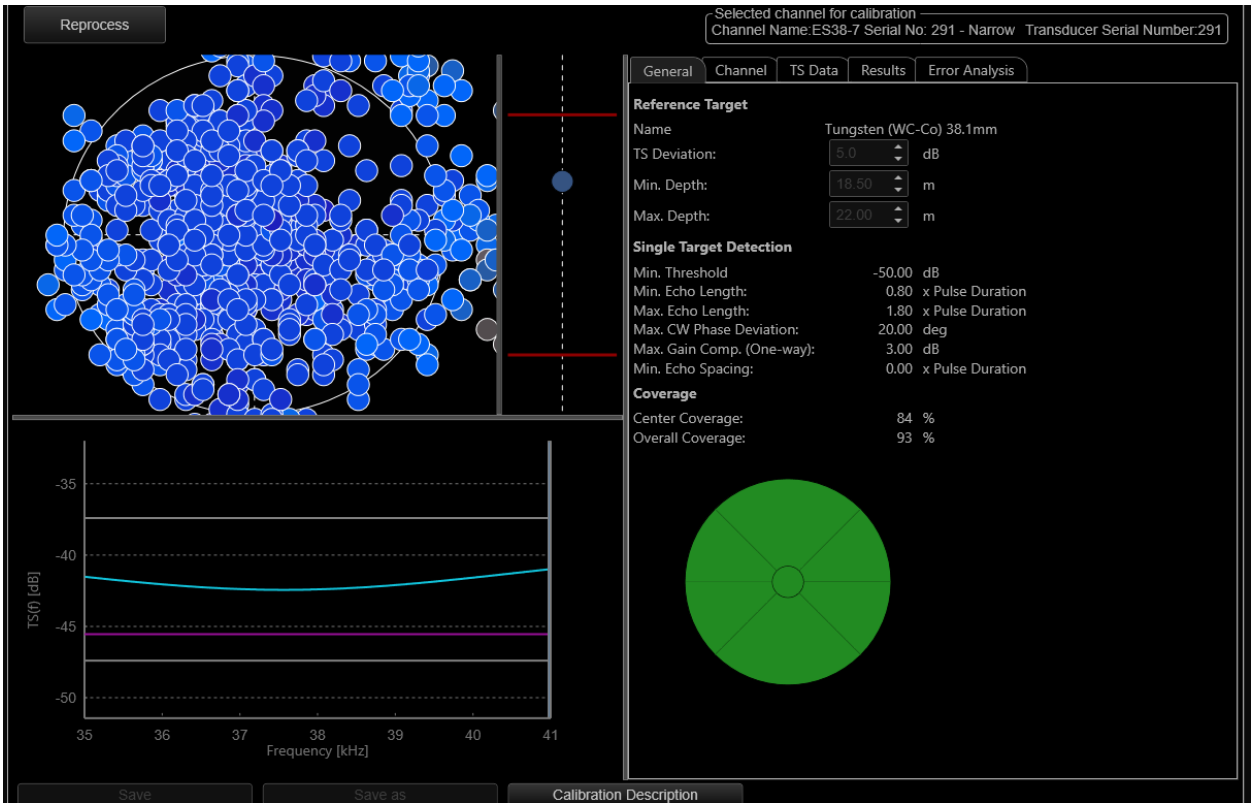

Figure 9. Screenshot of EK80 Calibration Wizard general results for the 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (CW): 1.024 ms

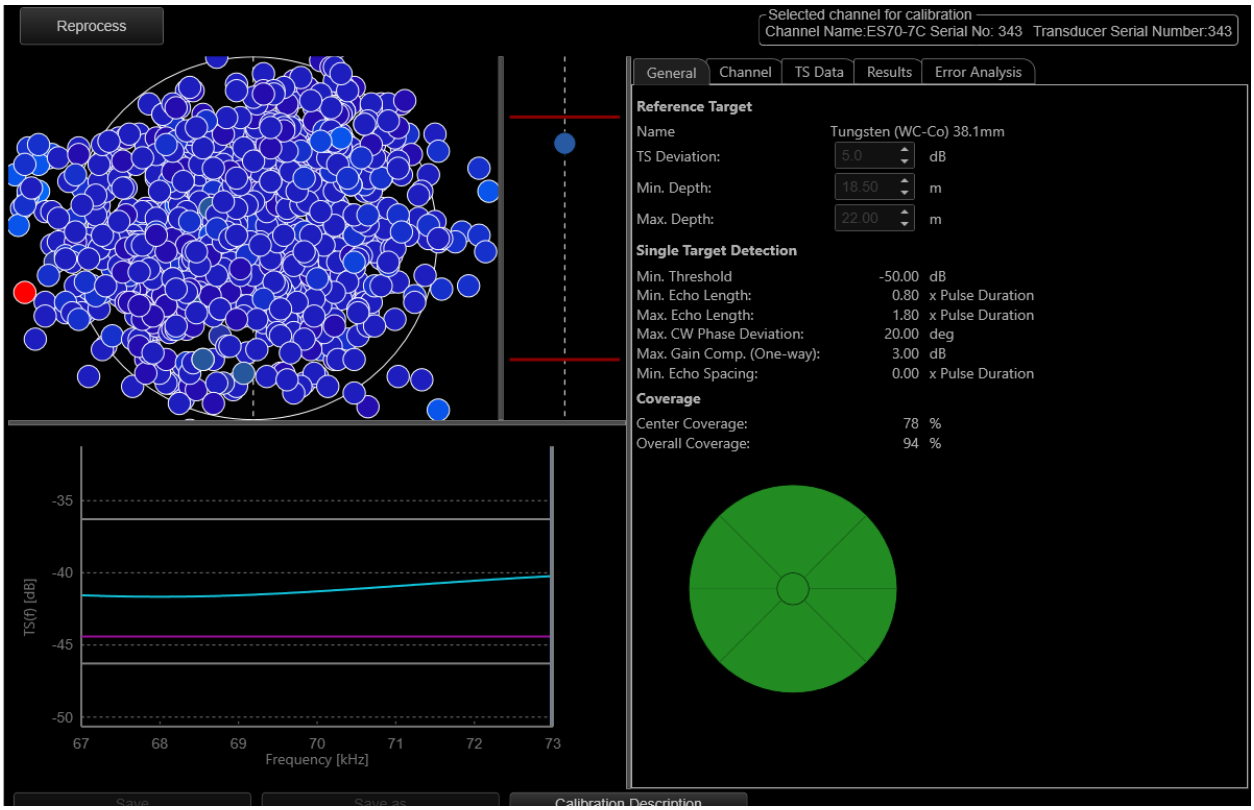

Figure 10. Screenshot of EK80 Calibration Wizard general results for the 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (CW): 2.048 ms

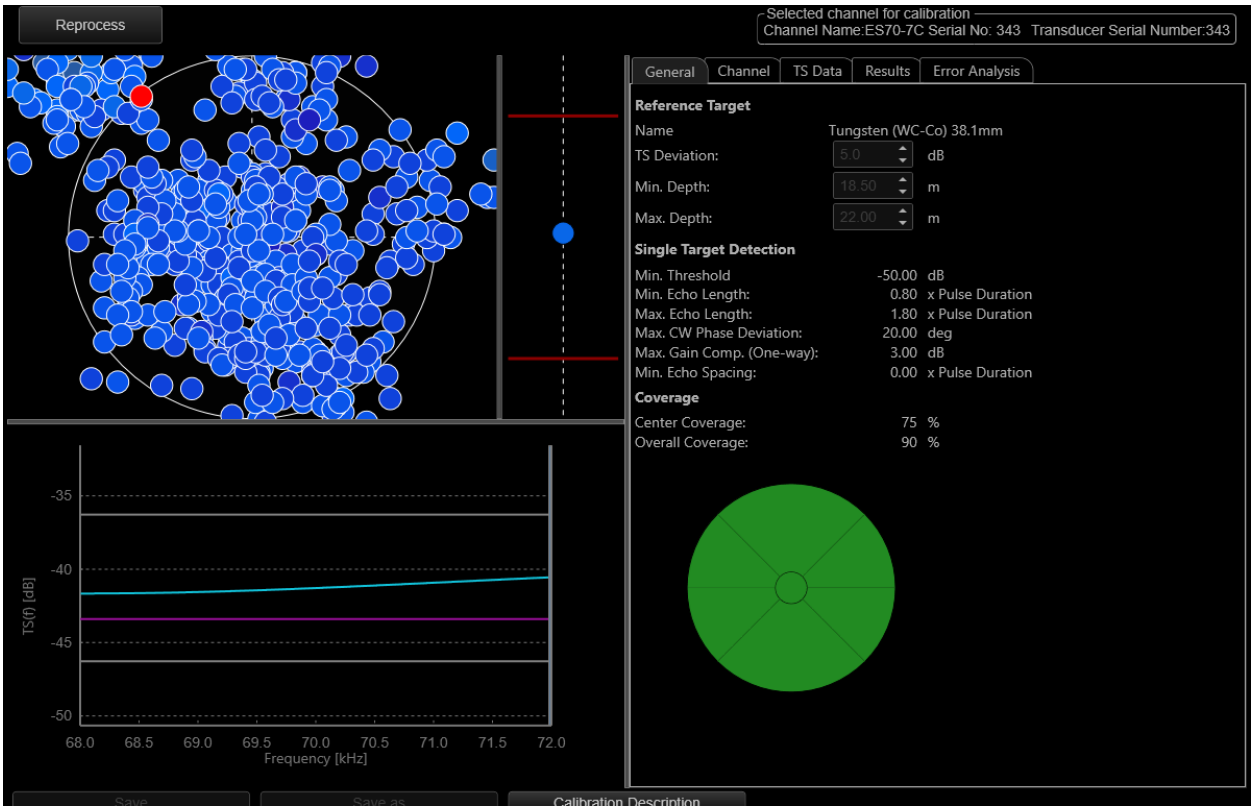

Figure 11. Screenshot of EK80 Calibration Wizard general results for the 70 kHz calibration at 2.048 ms in continuous wave (CW) mode.

120 kHz: 1.024 ms

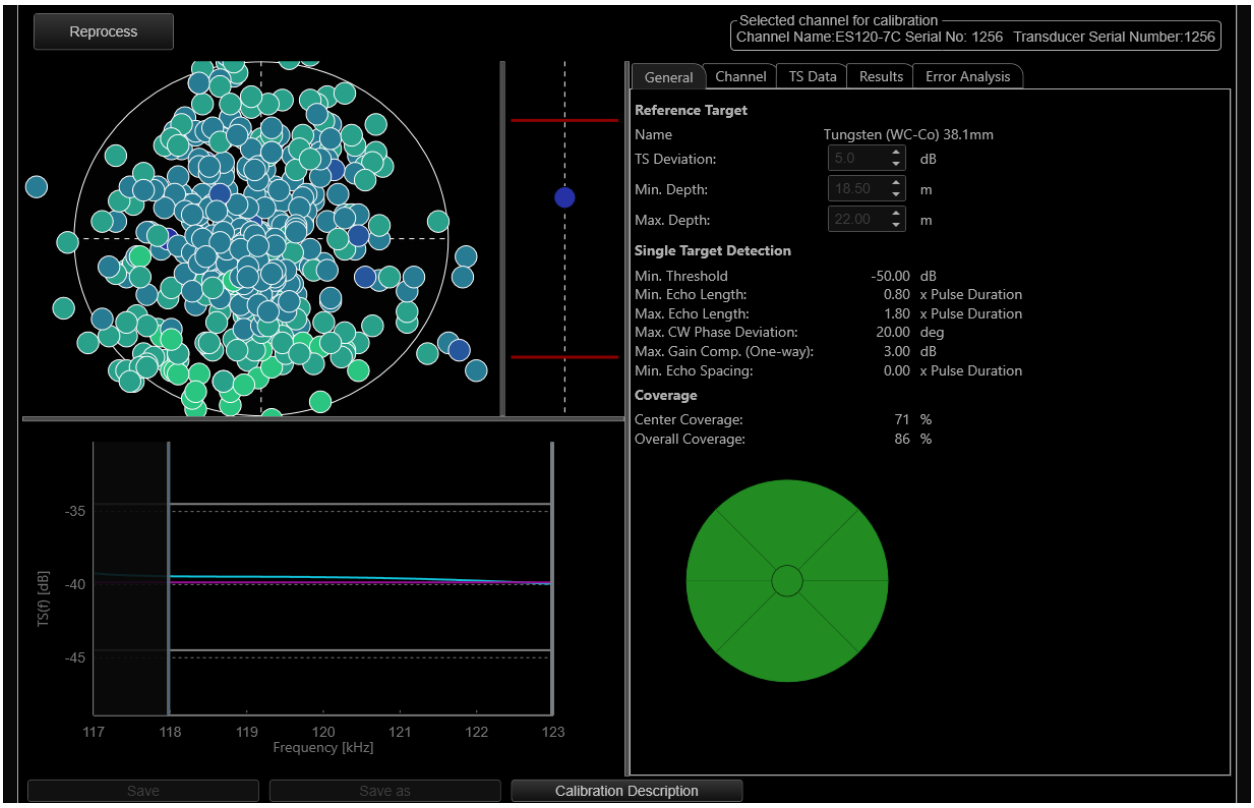

Figure 12. Screenshot of EK80 Calibration Wizard general results for the 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

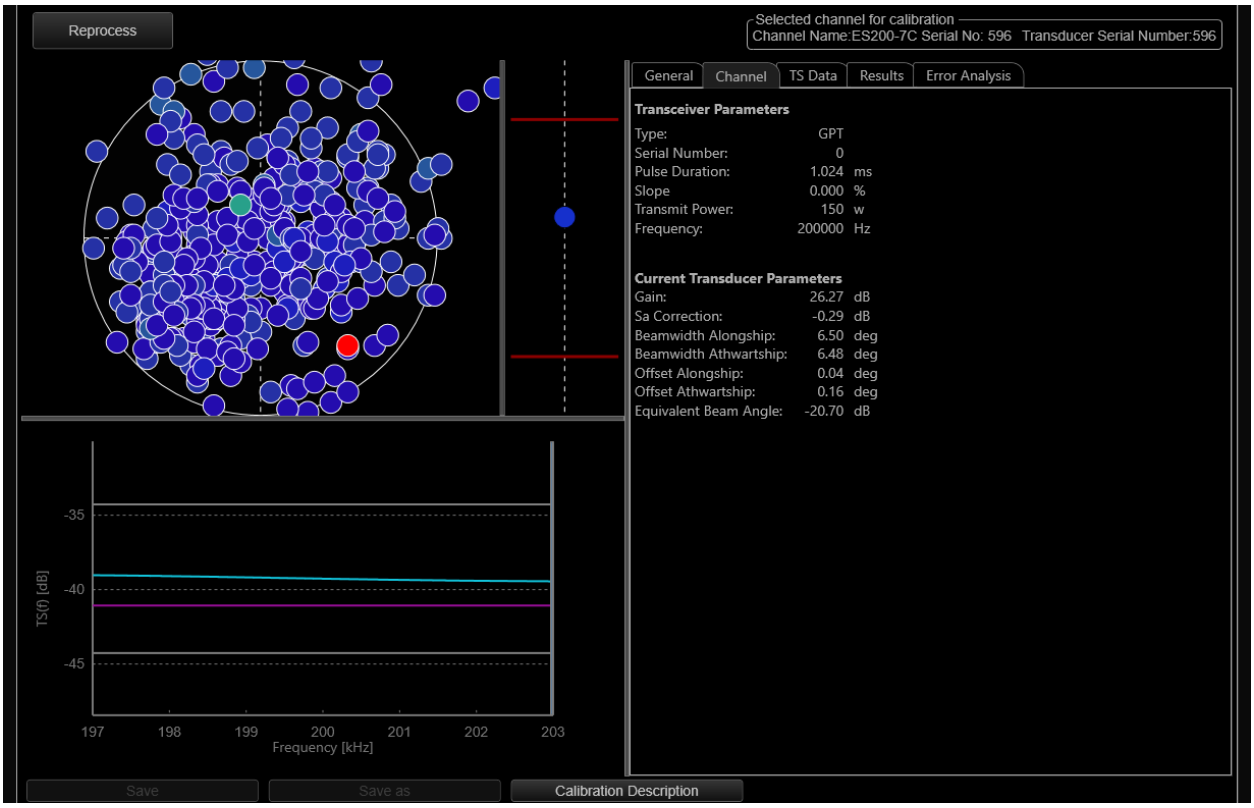

Figure 13. Screenshot of EK80 Calibration Wizard general results for the 200 kHz calibration at 1.024 ms.

Appendix C: TS Results

18 kHz: 1.024 ms

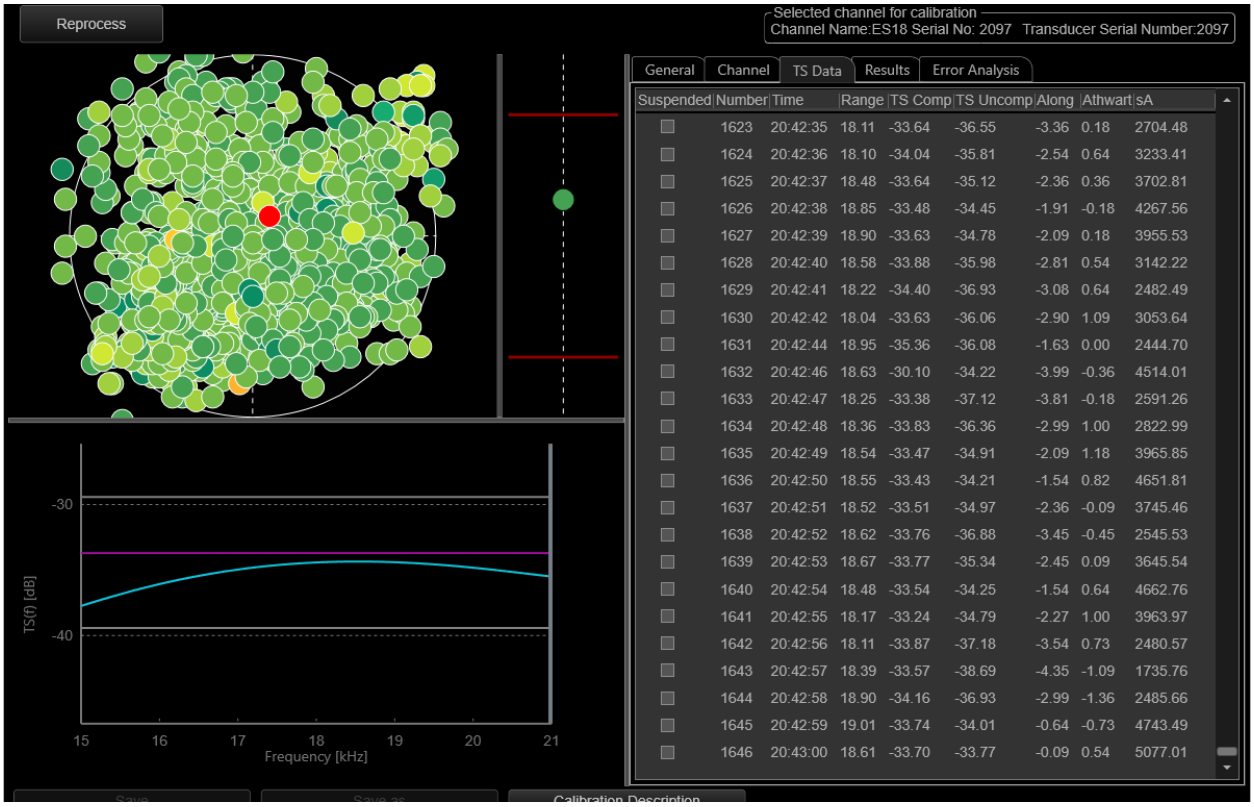

Figure 14. Screenshot of EK80 Calibration Wizard TS data for the 18 kHz calibration at 1.024 ms.

38 kHz (CW): 1.024 ms

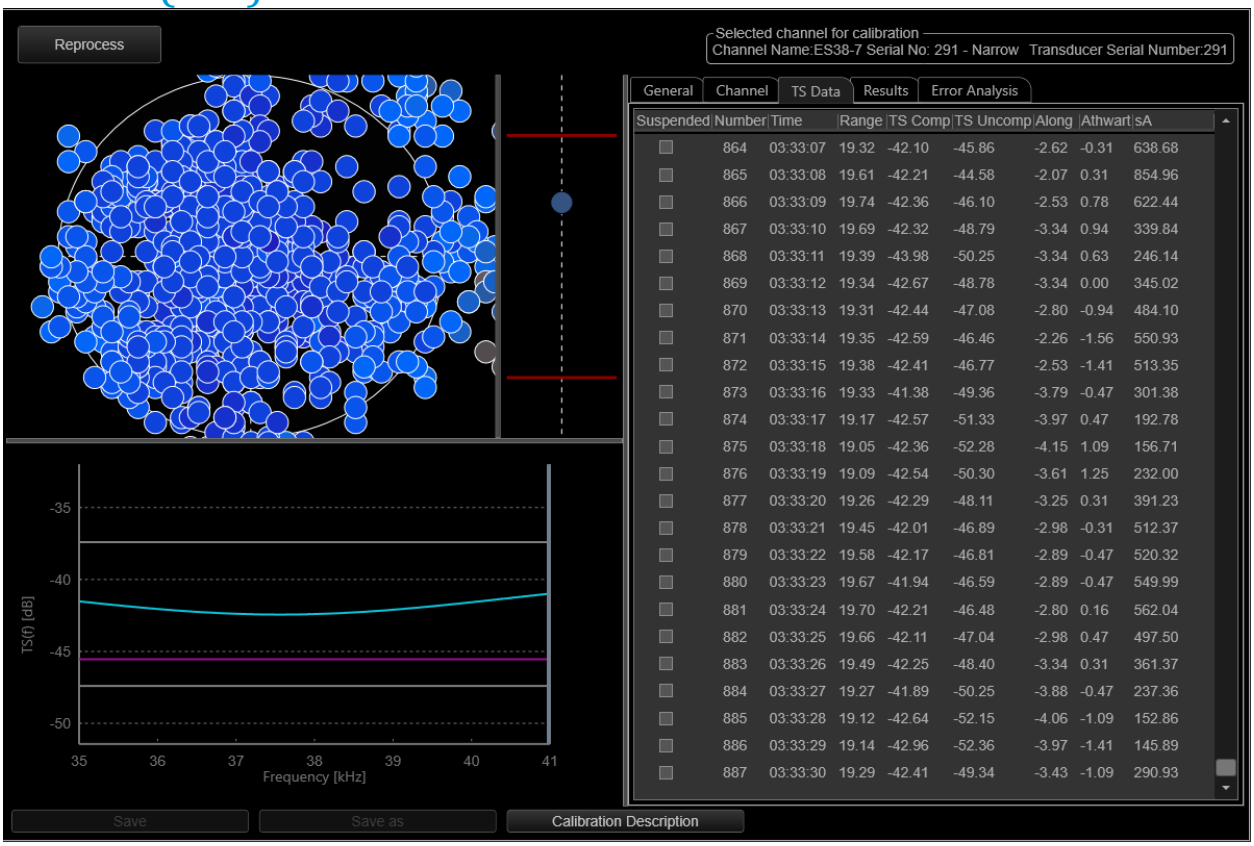

Figure 15. Screenshot of EK80 Calibration Wizard TS data for the 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (CW): 1.024 ms

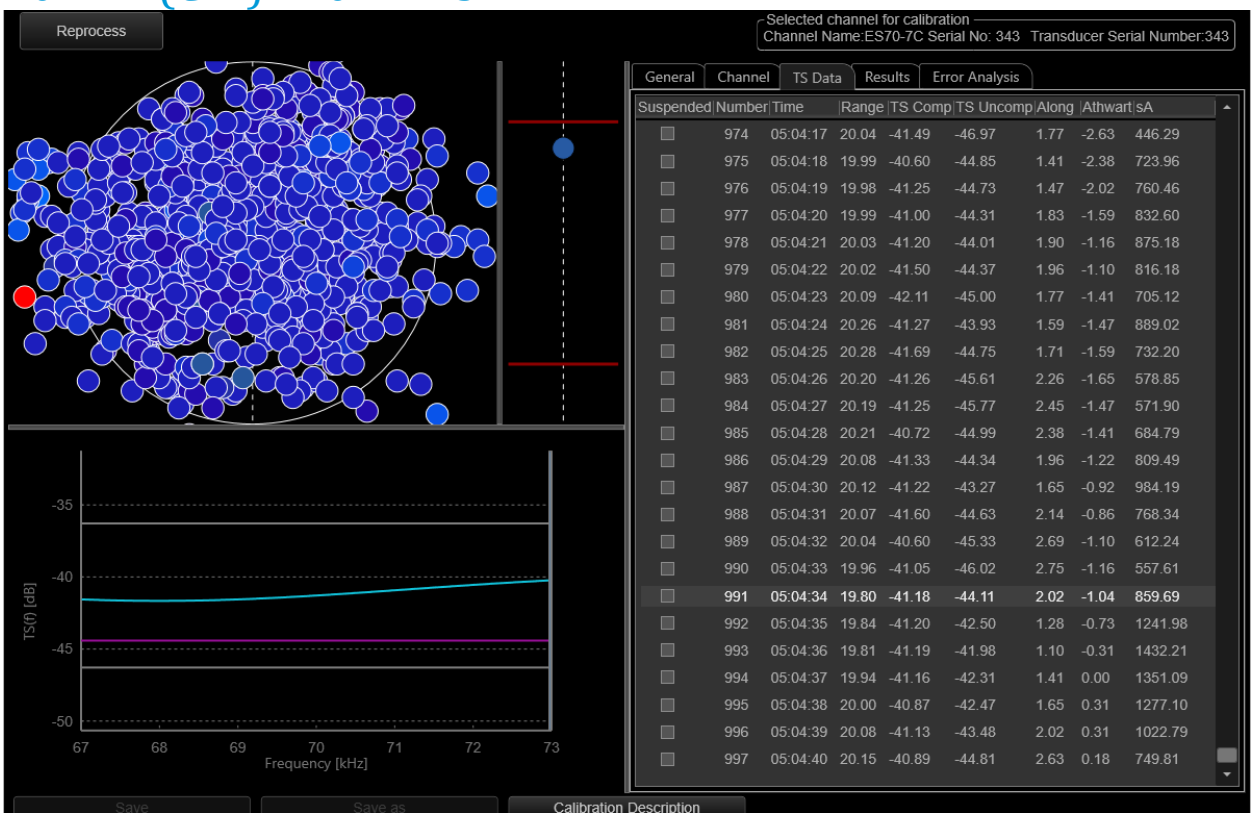

Figure 16. Screenshot of EK80 Calibration Wizard TS data for the 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (CW): 2.048 ms

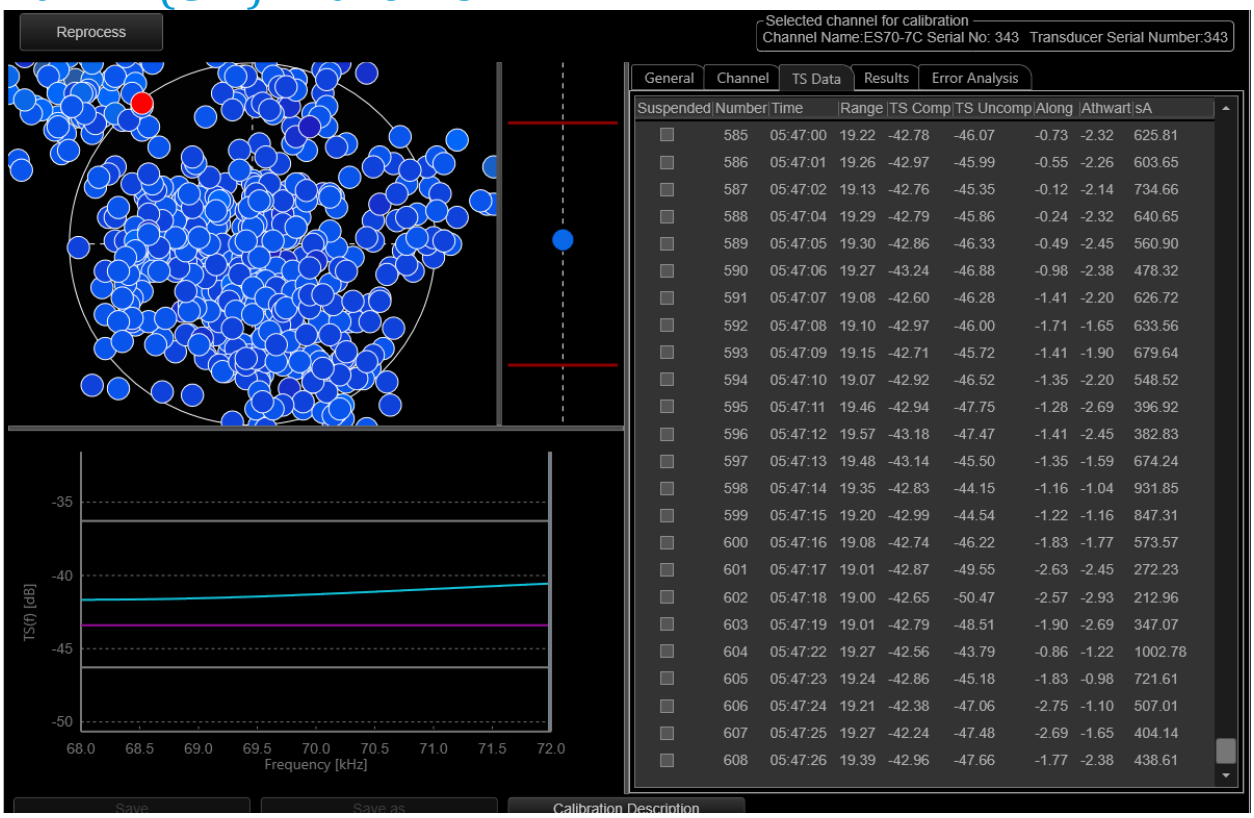

Figure 17. Screenshot of EK80 Calibration Wizard TS data for the 70 kHz calibration at 2.048 ms in continuous wave (CW) mode.

120 kHz: 1.024 ms

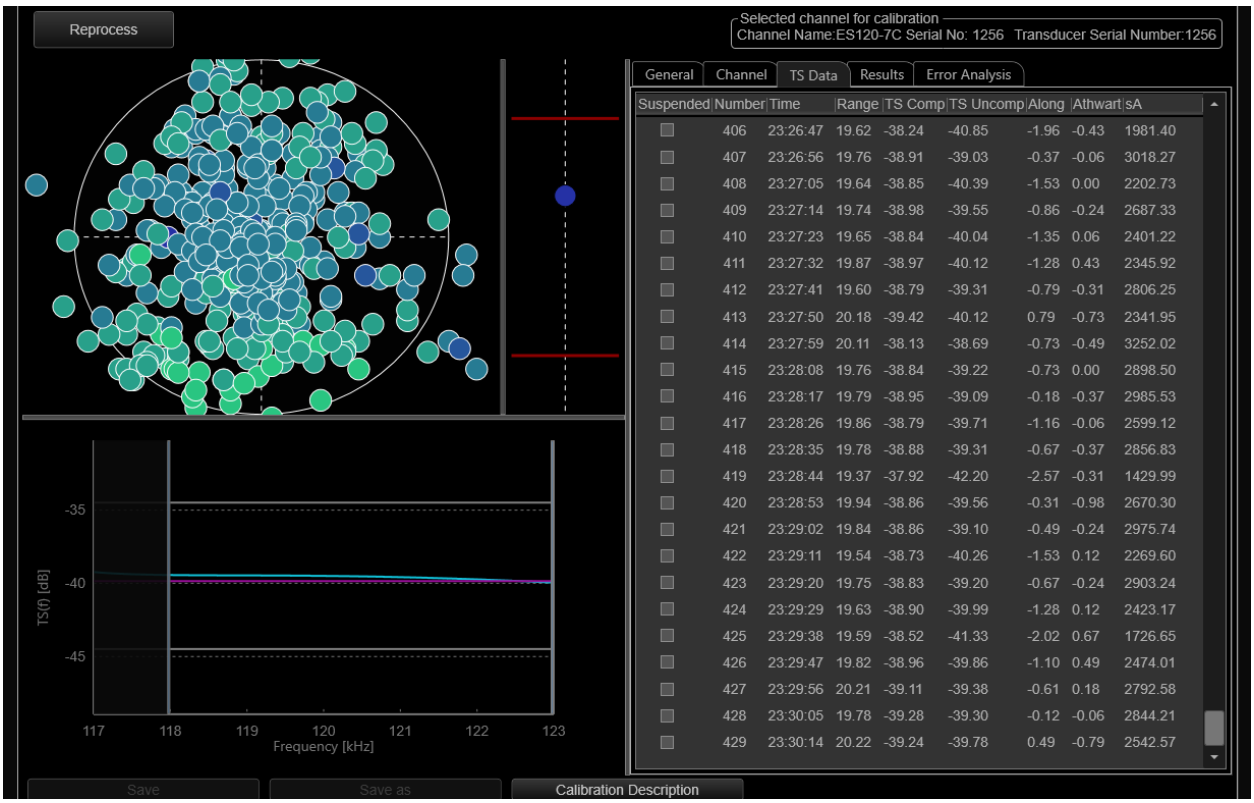

Figure 18. Screenshot of EK80 Calibration Wizard TS data for the 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

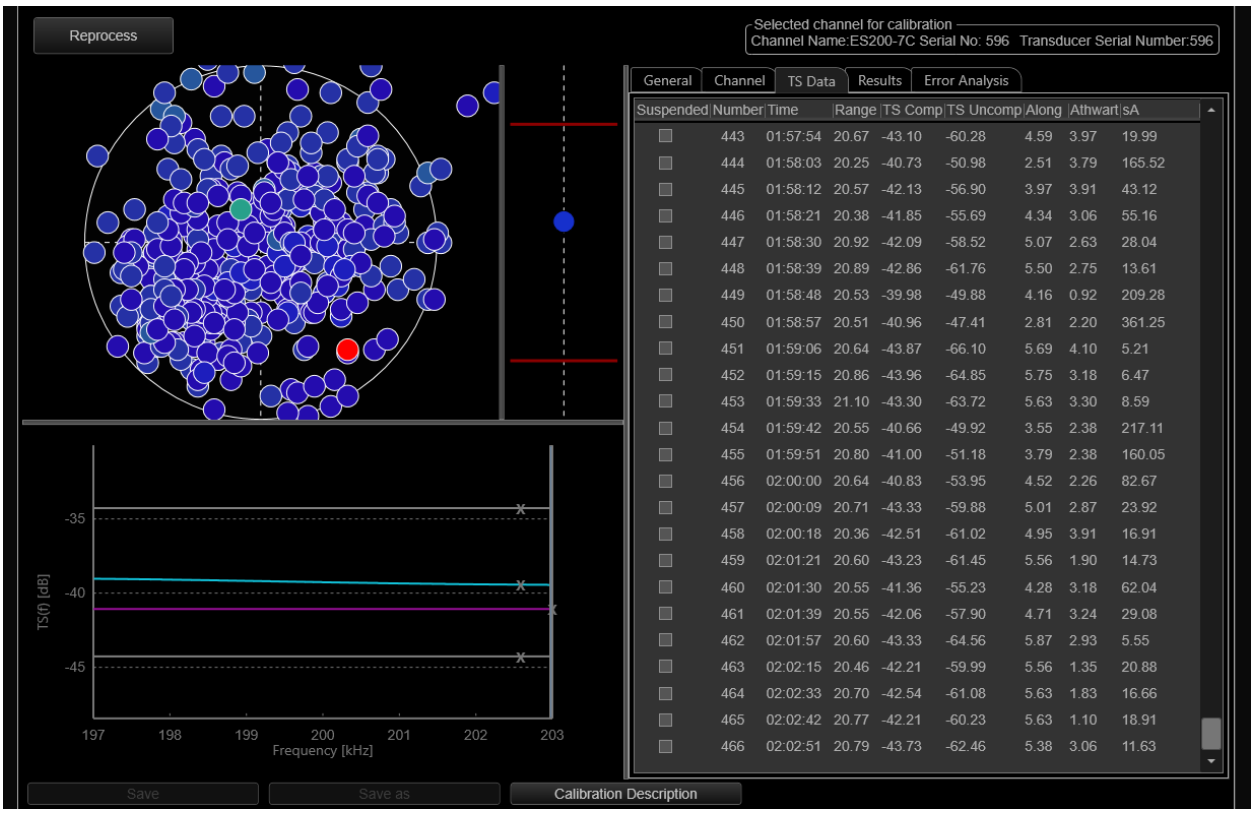

Figure 19. Screenshot of EK80 Calibration Wizard TS data for the 200 kHz calibration at 1.024 ms.

Appendix D: Results

18 kHz: 1.024 ms

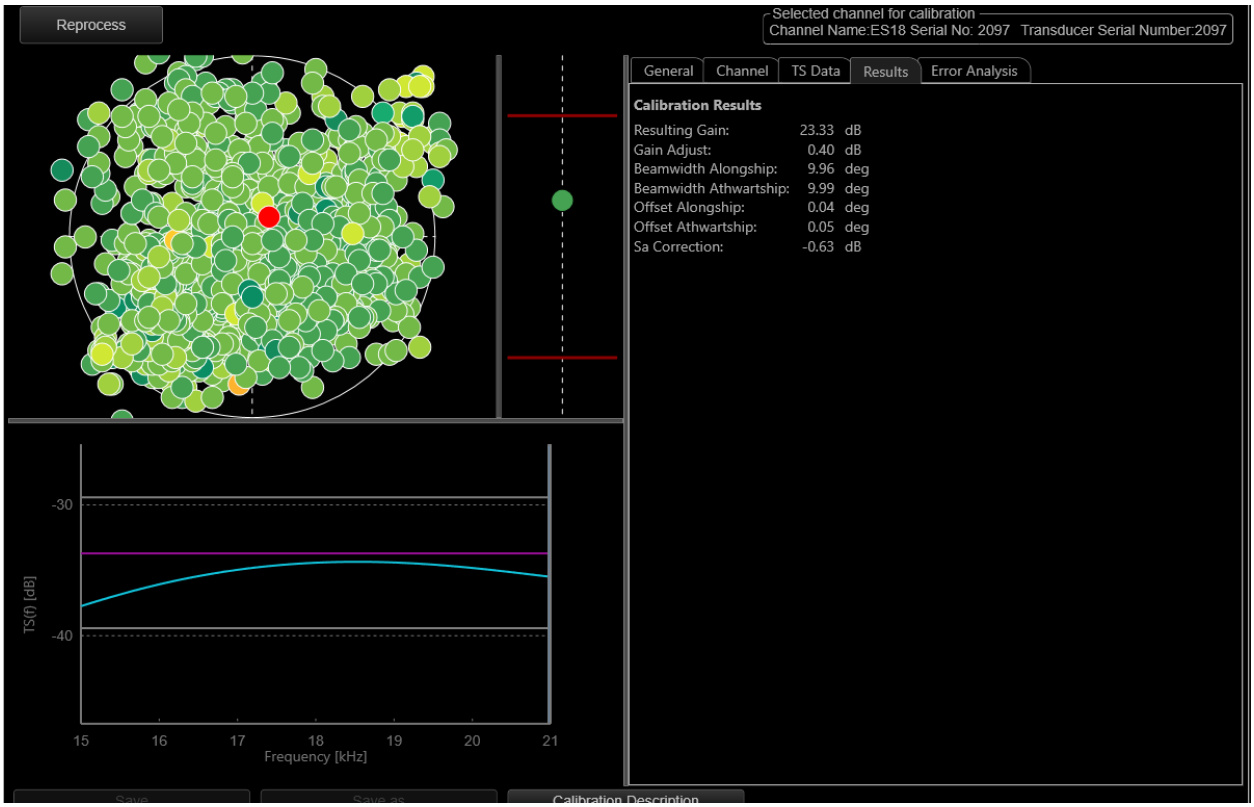

Figure 20. Screenshot of EK80 Calibration Wizard results for the 18 kHz calibration at 1.024 ms.

38 kHz (CW): 1.024 ms

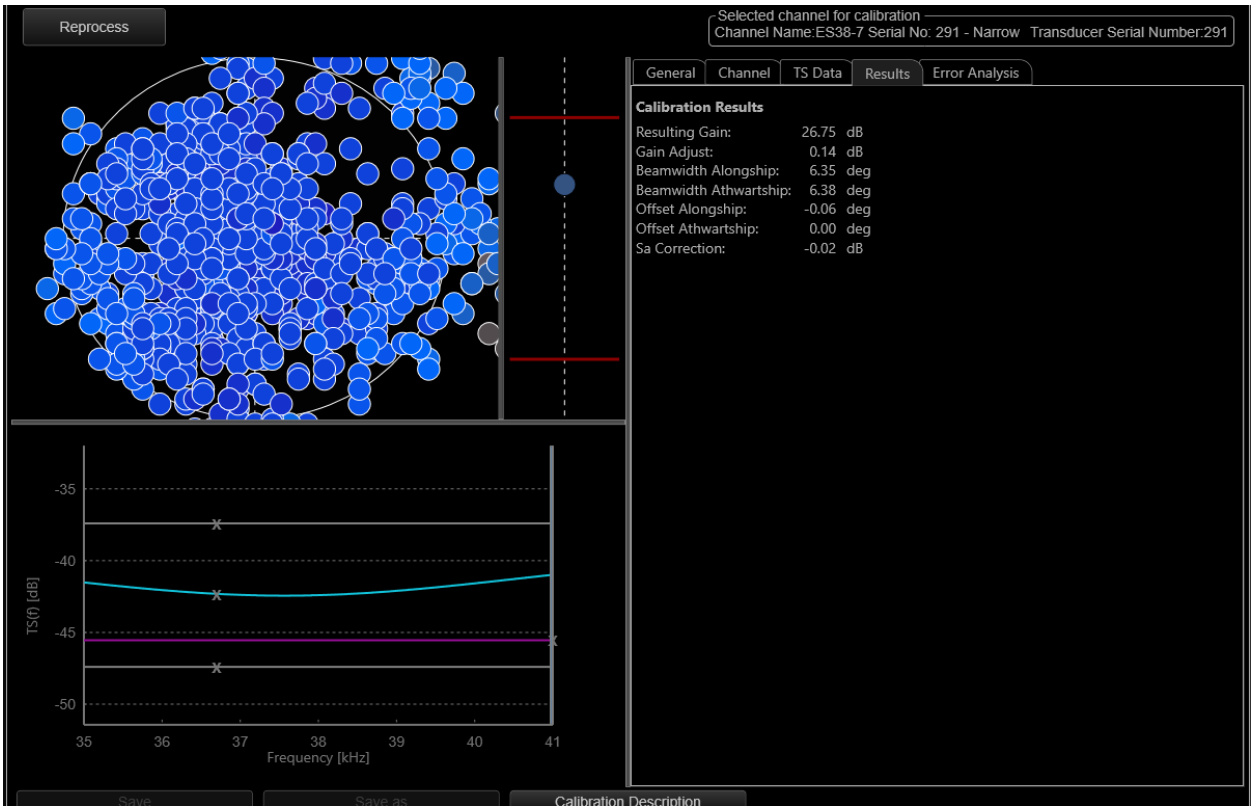

Figure 21. Screenshot of EK80 Calibration Wizard results for the 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (CW): 1.024 ms

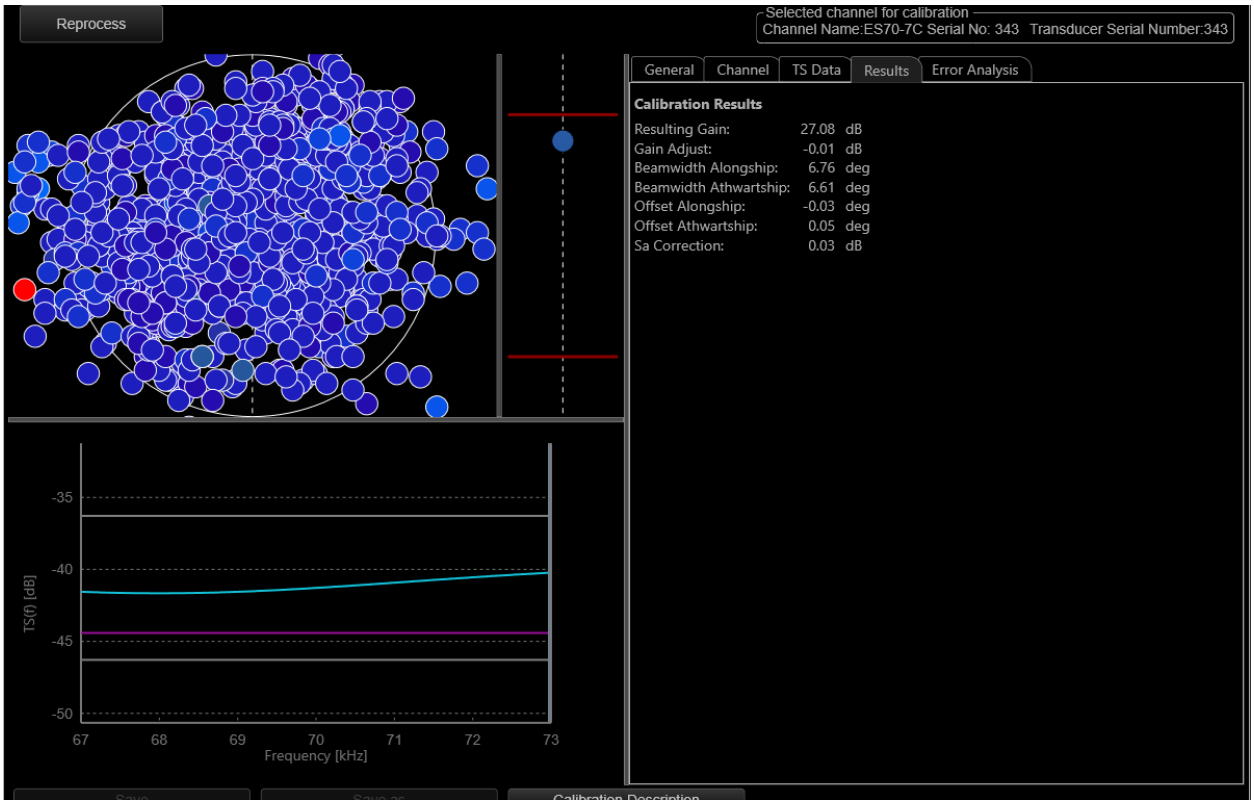

Figure 22. Screenshot of EK80 Calibration Wizard results for the 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (CW): 2.048 ms

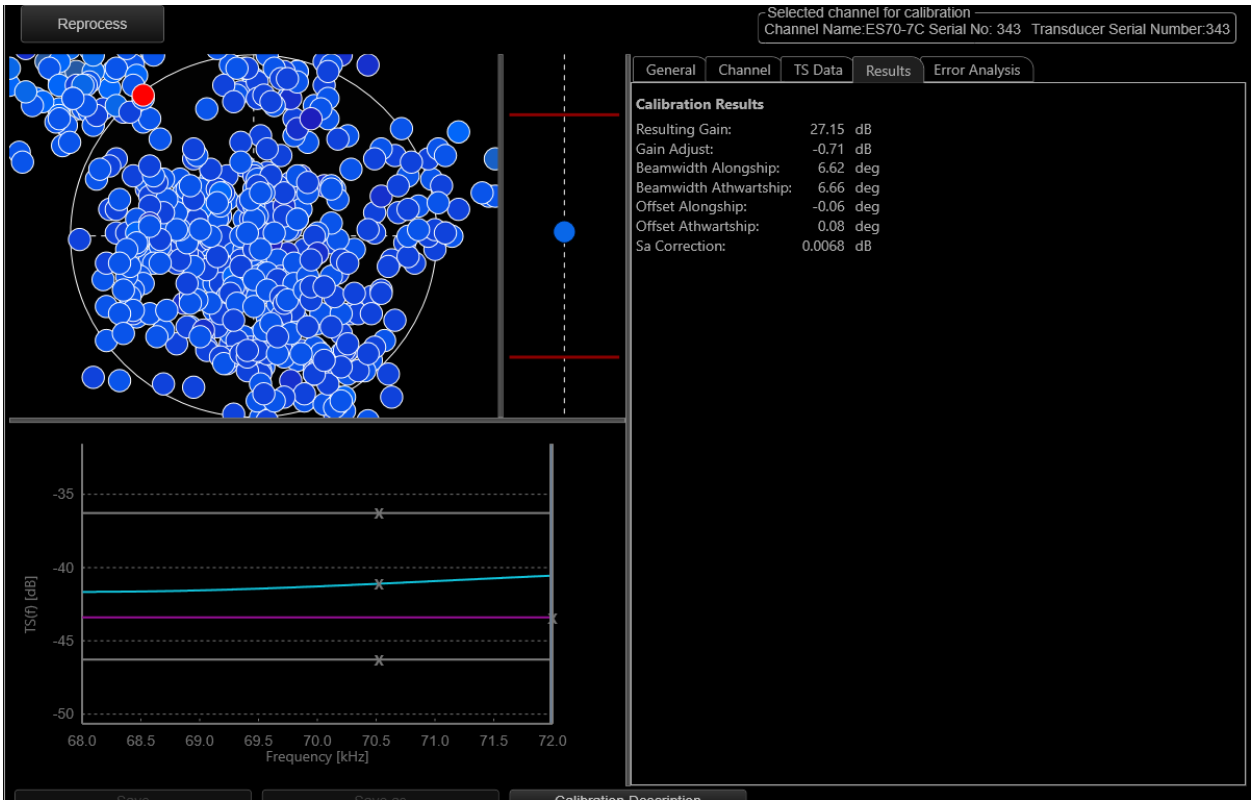

Figure 23. Screenshot of EK80 Calibration Wizard results for the 70 kHz calibration at 2.048 ms in continuous wave (CW) mode.

120 kHz: 1.024 ms

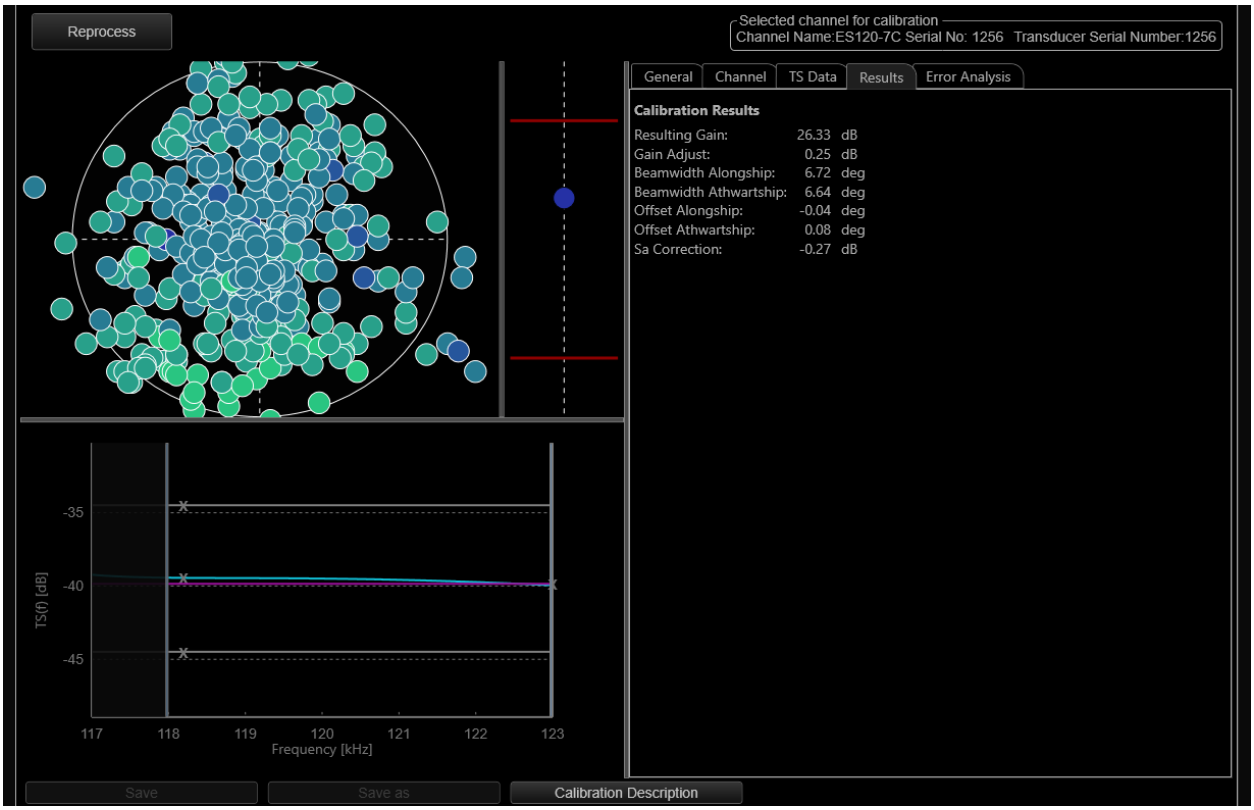

Figure 24. Screenshot of EK80 Calibration Wizard results for the 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

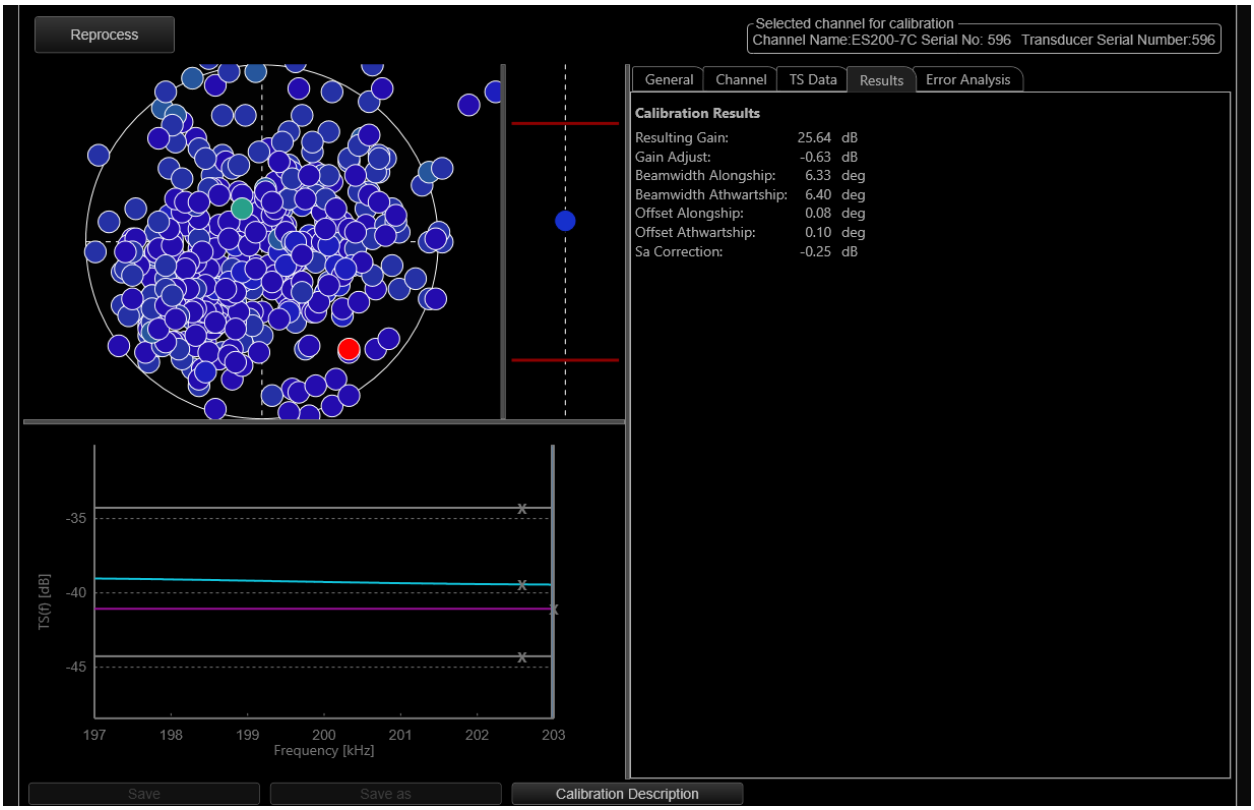

Figure 25. Screenshot of EK80 Calibration Wizard results for the 200 kHz calibration at 1.024 ms.

Appendix E: Error Analysis

18 kHz: 1.024 ms

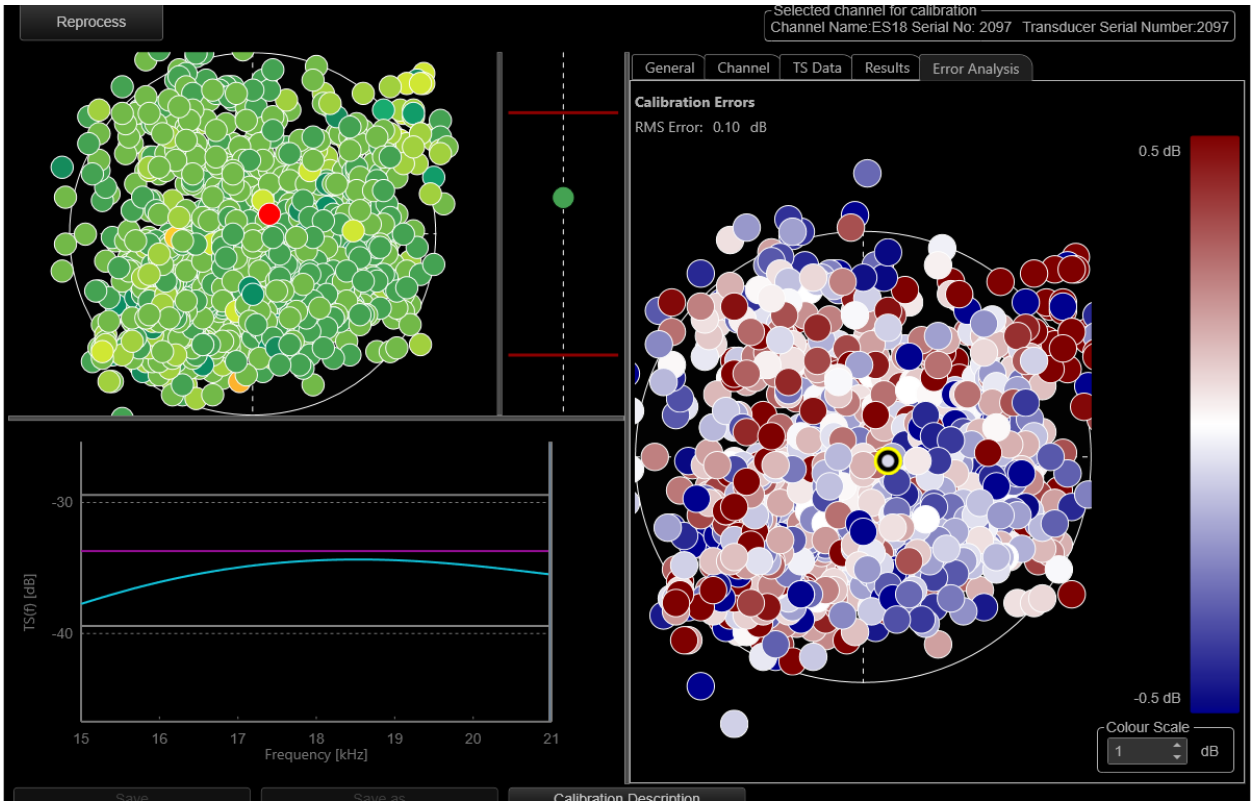

Figure 26. Screenshot of EK80 Calibration Wizard error analysis for the 18 kHz calibration at 1.024 ms.

38 kHz (CW): 1.024 ms

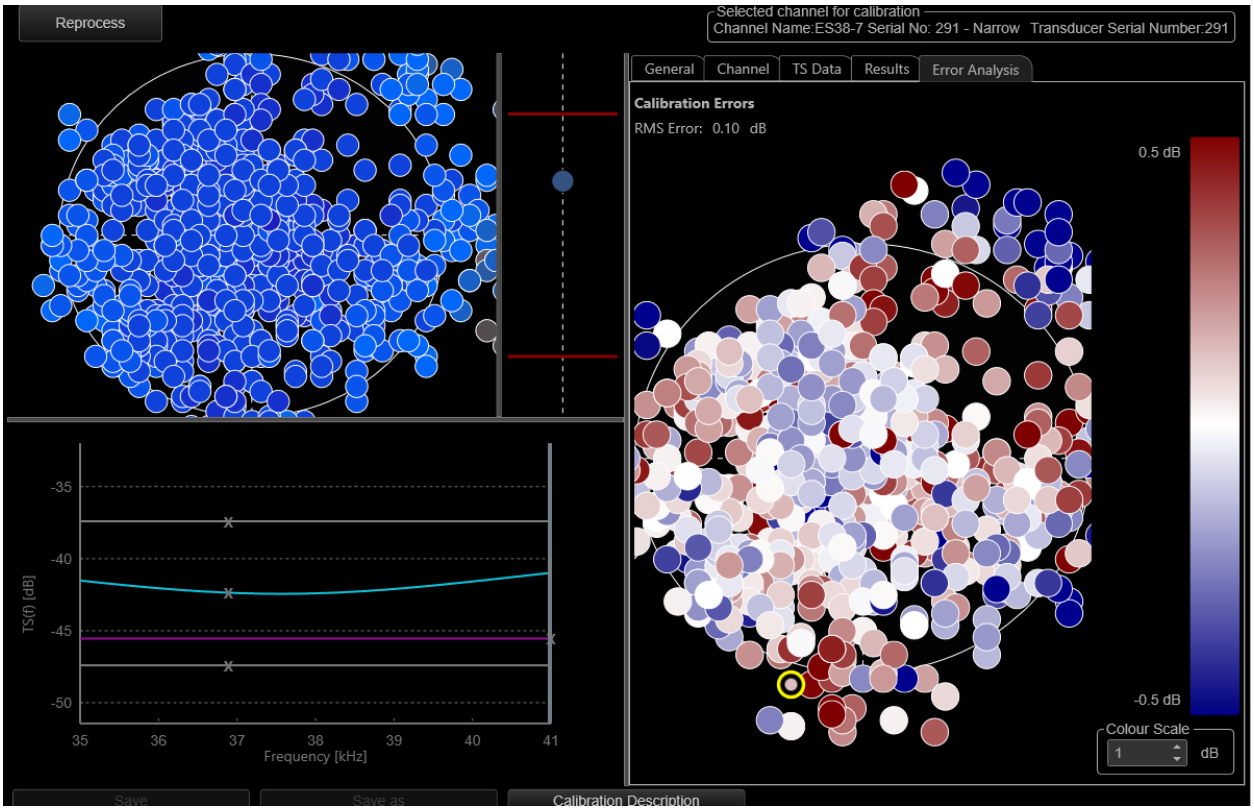

Figure 27. Screenshot of EK80 Calibration Wizard error analysis for the 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (CW): 1.024 ms

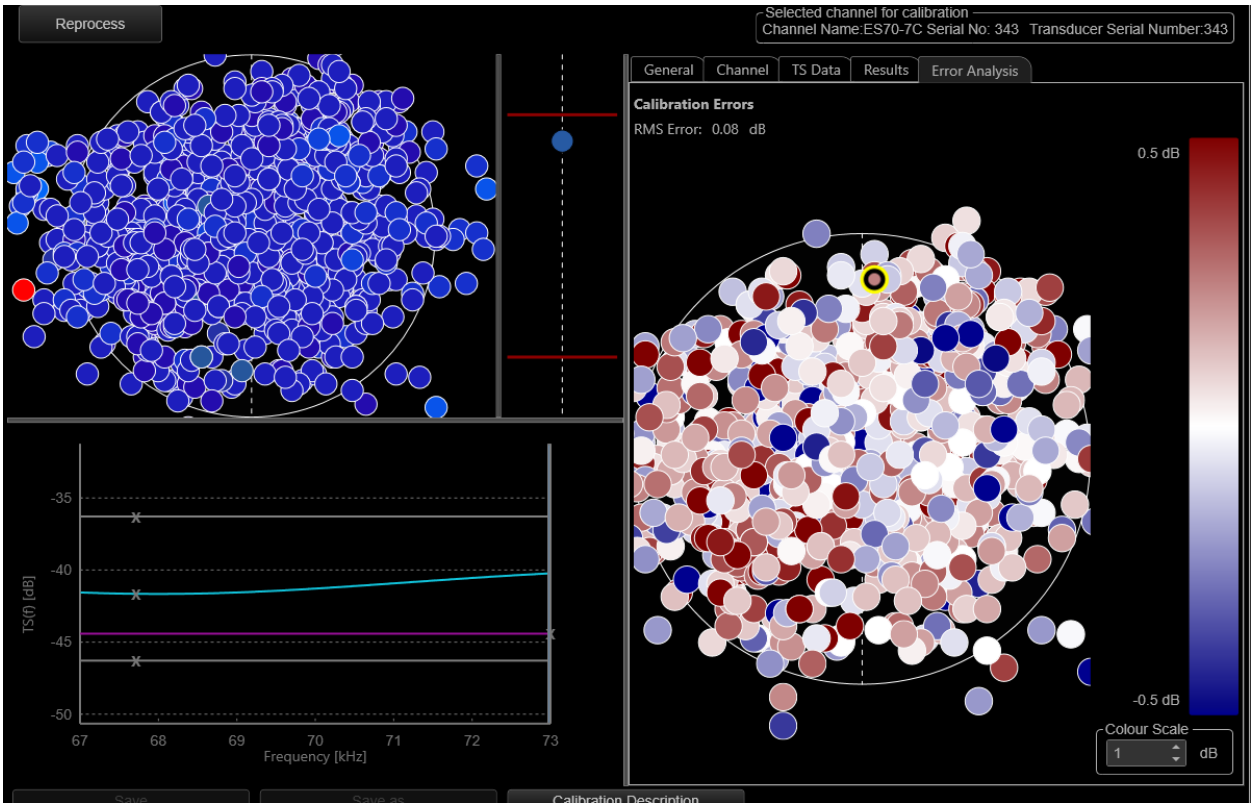

Figure 28. Screenshot of EK80 Calibration Wizard error analysis for the 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (CW): 2.048 ms

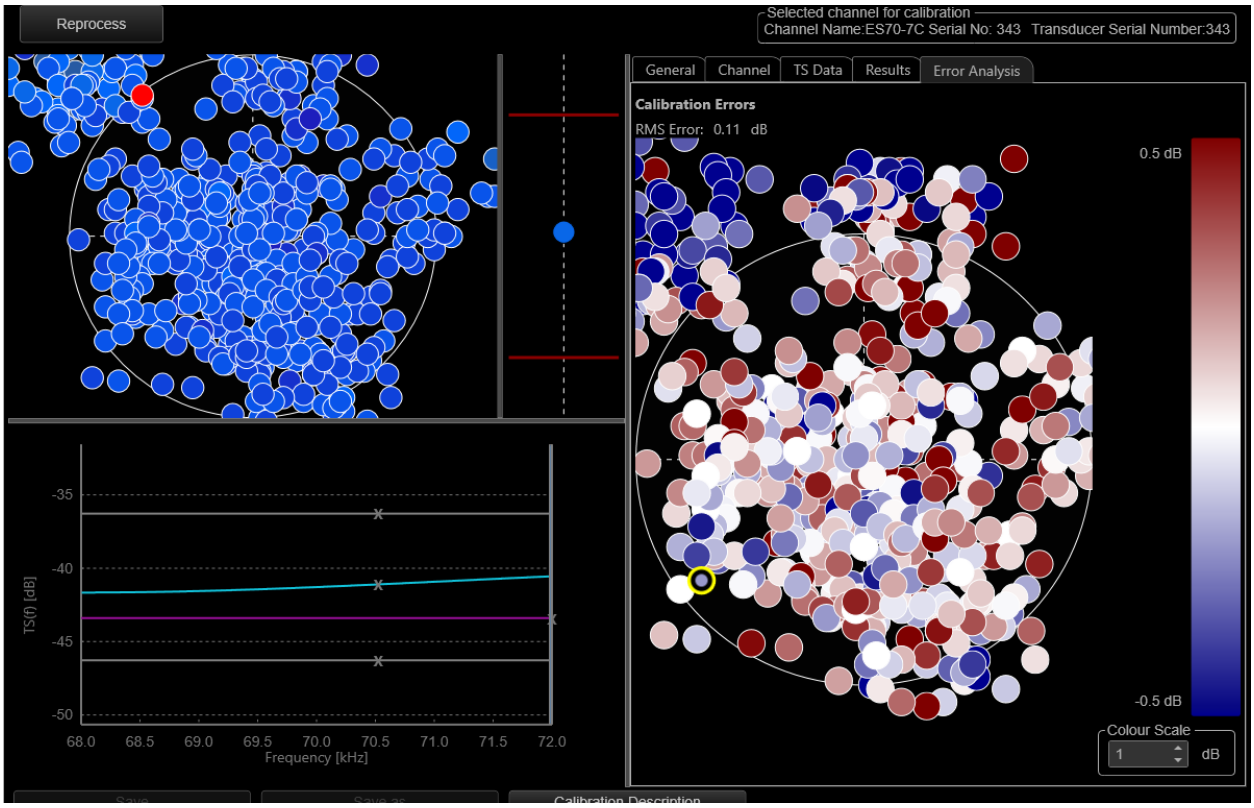

Figure 29. Screenshot of EK80 Calibration Wizard error analysis for the 70 kHz calibration at 2.048 ms in continuous wave (CW) mode.

120 kHz: 1.024 ms

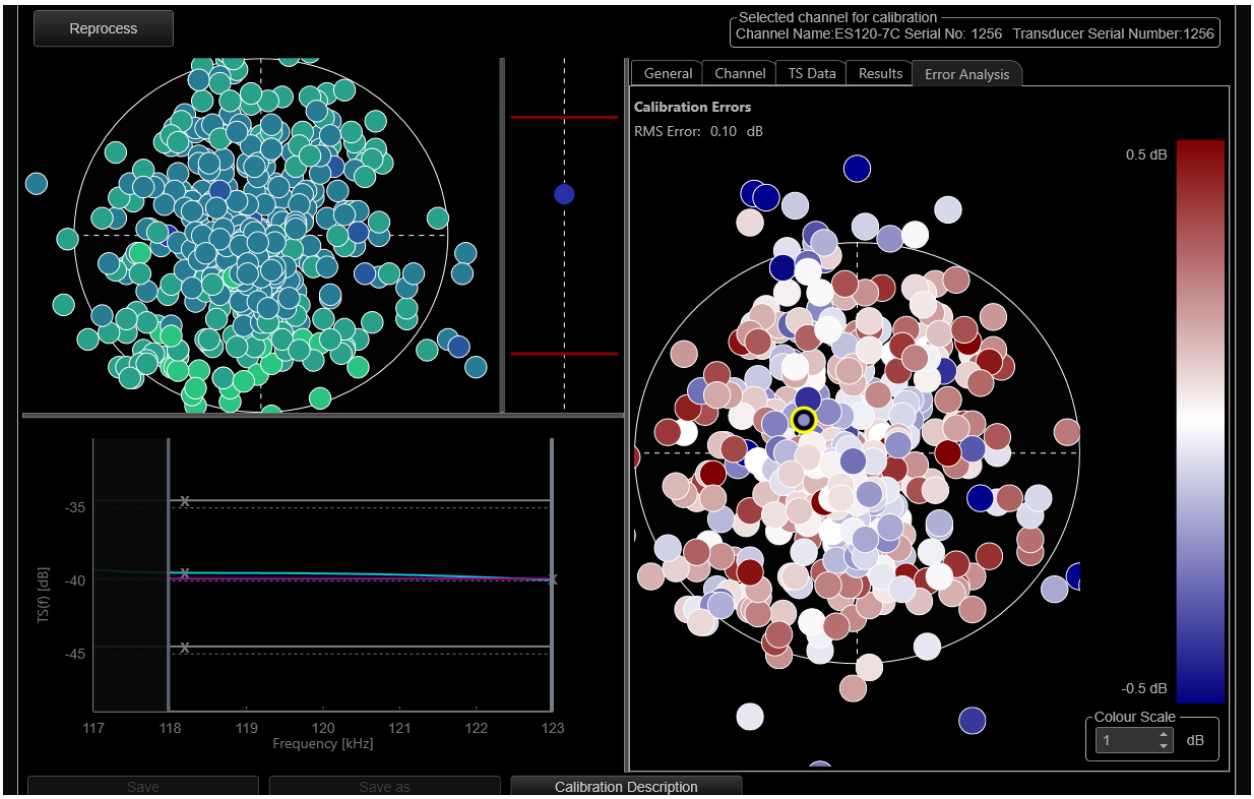

Figure 30. Screenshot of EK80 Calibration Wizard error analysis for the 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

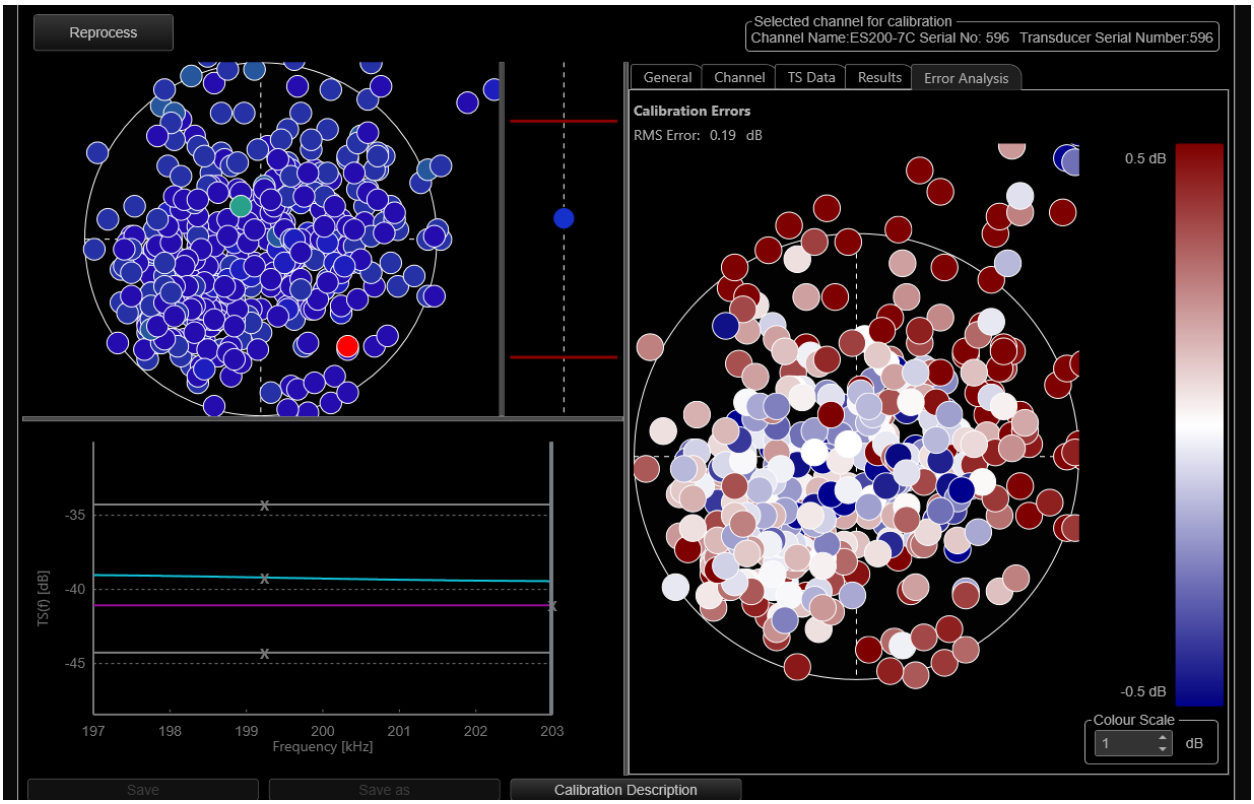

Figure 31. Screenshot of EK80 Calibration Wizard error analysis for the 200 kHz calibration at 1.024 ms.

Appendix F: Detailed List Calibration Files

File name	Date (UTC)	Frequency (pulse length)
EX2305_EK60-D20230805-T213247.idx	08/05/2023	120 kHz (1024 ms)
EX2305_EK60-D20230805-T213247.raw	08/05/2023	120 kHz (1024 ms)
EX2305_EK60-D20230805-T220743.idx	08/05/2023	120 kHz (1024 ms)
EX2305_EK60-D20230805-T220743.raw	08/05/2023	120 kHz (1024 ms)
EX2305_EK60-D20230805-T220945.idx	08/05/2023	120 kHz (1024 ms)
EX2305_EK60-D20230805-T220945.raw	08/05/2023	120 kHz (1024 ms)
EX2305_EK60-D20230805-T222329.idx	08/05/2023	120 kHz (1024 ms)
EX2305_EK60-D20230805-T222329.raw	08/05/2023	120 kHz (1024 ms)
EX2305_EK60-D20230805-T233730.idx	08/05/2023	200 kHz (1024 ms)
EX2305_EK60-D20230805-T233730.raw	08/05/2023	200 kHz (1024 ms)
EX2305_EK60-D20230805-T233757.idx	08/05/2023	200 kHz (1024 ms)
EX2305_EK60-D20230805-T233757.raw	08/05/2023	200 kHz (1024 ms)
EX2305_EK60-D20230805-T233815.idx	08/05/2023	200 kHz (1024 ms)
EX2305_EK60-D20230805-T233815.raw	08/05/2023	200 kHz (1024 ms)
EX2305_EK60-D20230806-T020657.idx	08/06/2023	38 kHz (1024 ms)
EX2305_EK60-D20230806-T020657.raw	08/06/2023	38 kHz (1024 ms)
EX2305_EK60-D20230806-T031716.idx	08/06/2023	38 kHz (1024 ms)
EX2305_EK60-D20230806-T031716.raw	08/06/2023	38 kHz (1024 ms)
EX2305_EK60-D20230806-T034307.idx	08/06/2023	70 kHz (1024 ms)
EX2305_EK60-D20230806-T034307.raw	08/06/2023	70 kHz (1024 ms)
EX2305_EK60-D20230806-T035434.idx	08/06/2023	70 kHz (1024 ms)
EX2305_EK60-D20230806-T035434.raw	08/06/2023	70 kHz (1024 ms)
EX2305_EK60-D20230806-T035701.idx	08/06/2023	70 kHz (1024 ms)
EX2305_EK60-D20230806-T035701.raw	08/06/2023	70 kHz (1024 ms)
EX2305_EK60-D20230806-T042303.idx	08/06/2023	70 kHz (1024 ms)
EX2305_EK60-D20230806-T042303.raw	08/06/2023	70 kHz (1024 ms)
EX2305_EK60-D20230806-T044454.idx	08/06/2023	70 kHz (1024 ms)
EX2305_EK60-D20230806-T044454.raw	08/06/2023	70 kHz (1024 ms)

File name	Date (UTC)	Frequency (pulse length)
EX2305_EK60-D20230806-T051728.idx	08/06/2023	70 kHz (2048 ms)
EX2305_EK60-D20230806-T051728.raw	08/06/2023	70 kHz (2048 ms)
EX2305_EK60-D20230806-T052040.idx	08/06/2023	70 kHz (2048 ms)
EX2305_EK60-D20230806-T052040.raw	08/06/2023	70 kHz (2048 ms)
EX2305_EK60-D20230806-T052924.idx	08/06/2023	70 kHz (2048 ms)
EX2305_EK60-D20230806-T052924.raw	08/06/2023	70 kHz (2048 ms)
EX2304_EK60-D20230816-T184318.raw	08/16/2023	18 kHz (1024 ms)
EX2304_EK60-D20230816-T185000.idx	08/16/2023	18 kHz (1024 ms)
EX2304_EK60-D20230816-T185000.raw	08/16/2023	18 kHz (1024 ms)
EX2304_EK60-D20230816-T185029.idx	08/16/2023	18 kHz (1024 ms)
EX2304_EK60-D20230816-T185029.raw	08/16/2023	18 kHz (1024 ms)
EX2304_EK60-D20230816-T191159.idx	08/16/2023	18 kHz (1024 ms)
EX2304_EK60-D20230816-T191159.raw	08/16/2023	18 kHz (1024 ms)

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