April 2024 EK60/80 Calibration Report

NOAA Ship *Okeanos Explorer*

EX2401: 2024 Mapping Shakedown + High Seas Mapping

Supporting Document for the NOAA Ship *Okeanos Explorer* Mapping Systems Readiness Report 2024 (https://doi.org/10.25923/j7ab-w612)

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Introduction

This document provides information for the April 2024 calibration of the Simrad EK60/80 echosounders on NOAA Ship *Okeanos Explorer* during the EX2401 expedition. 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 April 29-30 while drifting off the west coast of the island of Hawai'i (**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 frequency-modulated (FM) modes of the 38 and 70 kHz were not calibrated.

Location and Conditions

- The calibrations occurred west of Hawai'i, with a starting coordinate of 19.4687° N, 156.0641° 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 April 29 was 1533.9 meters per second, with an average temperature of 24.8 °C and average salinity of 35 psu (practical salinity units).
- Average speed of sound at the calibration depth (30 meters) for the 18 kHz transducer on April 30 was 1534.6 meters per second, with an average temperature of 24.9 °C and average salinity of 35 psu (practical salinity units).

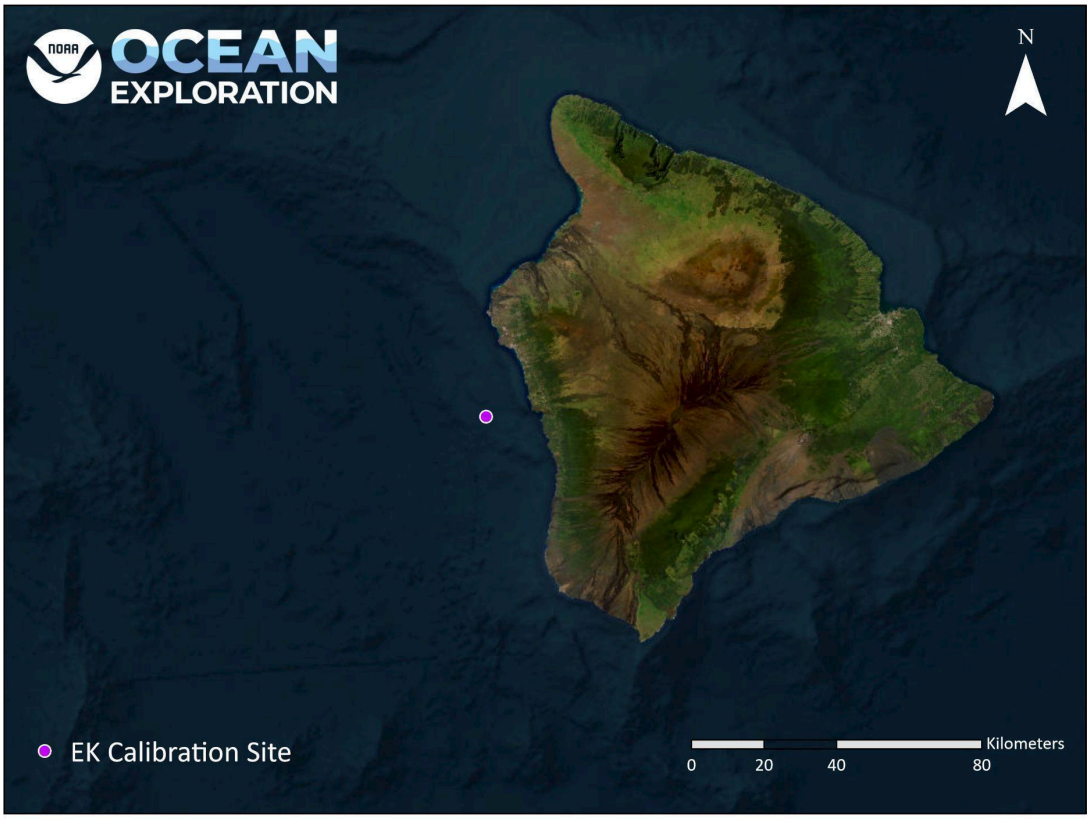

Figure 1. Location of the calibrations on April 29-30, 2024. The coordinates are 19.4687° N, 156.0641° W.

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. 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 2024 calibration of the EK60 General Purpose Transceivers (GPTs). For more information, see **Appendix B,** containing the channel tab for each frequency calibrated.

Frequency (kHz)	**18**	**120**	**200**
EK 80 software version	23.6.2	23.6.2	23.6.2
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)	23.33	26.33	25.64
Sa correction (dB)	-0.63	-0.27	-0.25
Speed of sound (m/s)	1534.6	1533.9	1533.9
3 dB beamwidth (º) alongship/athwartship	9.84/9.95	6.72/6.64	6.33/6.40
Angle offset (º) alongship/athwartship	0.06/0.05	-0.04/0.08	0.08/0.10

Table 2. List of relevant parameters and initial settings used during the 2024 calibration of the EK80 Wide Band Transceivers (WBTs) in CW mode. For more information, see **Appendix B,** containing the channel tab for each frequency calibrated.

Frequency (kHz)	**38 (CW)**	**70 (CW)**
Frequency Range (kHz)	38	70
GPT/WBT serial number	WBT 748247	WBT 746998
EK 80 software version	21.15.2.0	21.15.2.0
Transducer model	ES38-7	ES70-7C
Transducer serial number	291	343
Transducer draft setting (m)	4.99	4.99
Transmit power (W)	2000	750
Pulse length (ms)	1.024	1.024
Slope (%)	10.280	2.790
Two-way beam angle (dB)	-20.70	-20.70
Transducer peak gain (dB)	26.75	27.08
Sa correction (dB)	-0.02	0.03
Speed of sound (m/s)	1533.9	1533.9
3 dB beamwidth (º) along/athwart	6.53/6.94	6.62/6.66
Angle offset (º) along/athwart	-0.05/0.00	-0.06/0.08

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 F** for the X, Y, and Z hull locations for each of the transducers.

Calibrations were performed using Simrad's EK80 calibration software (version 23.6.2) 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, a manual method was utilized by tying the sphere to the center of a line, and pulling it by hand in the direction necessary. 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).

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 50% 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 D**). See **Appendix C** (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 E** 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: General Results

18 kHz: 1.024 ms

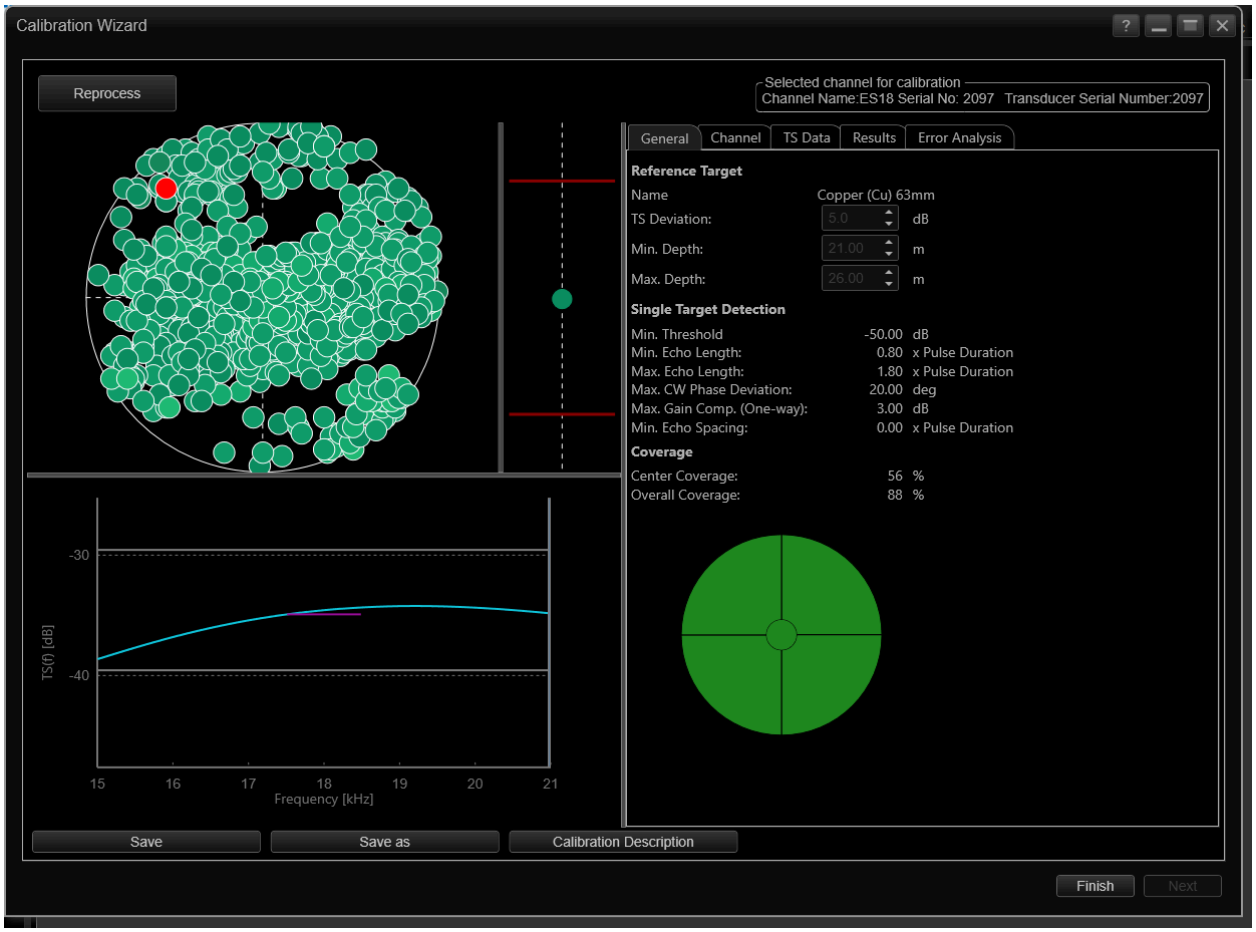

Figure 2. Screenshot of EK80 Calibration Wizard general results for the 18 kHz calibration at 1.024 ms in continuous wave (CW) mode.

38 kHz (CW): 1.024 ms

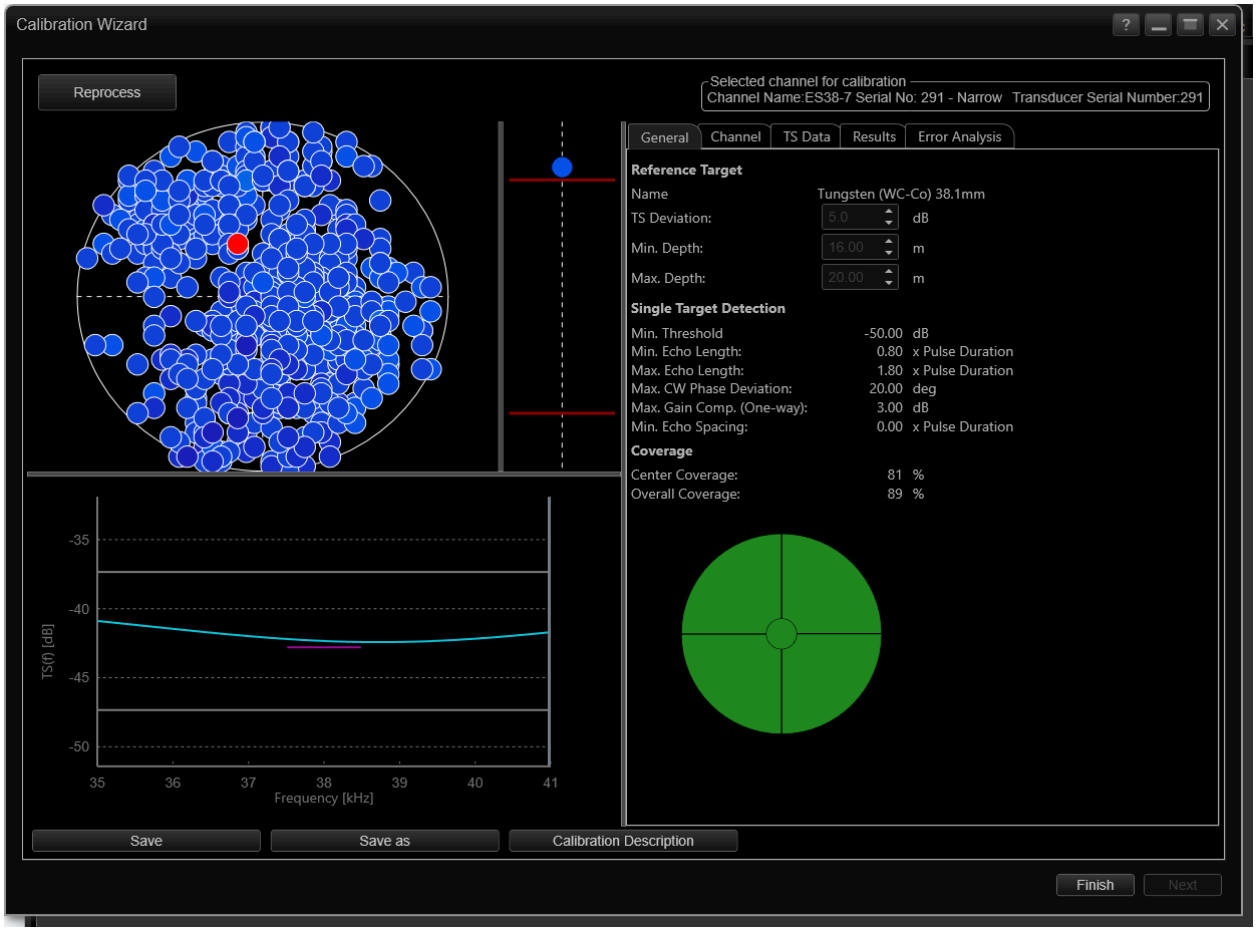

Figure 3. Screenshot of EK80 Calibration Wizard general results for the 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (CW): 1.024 ms

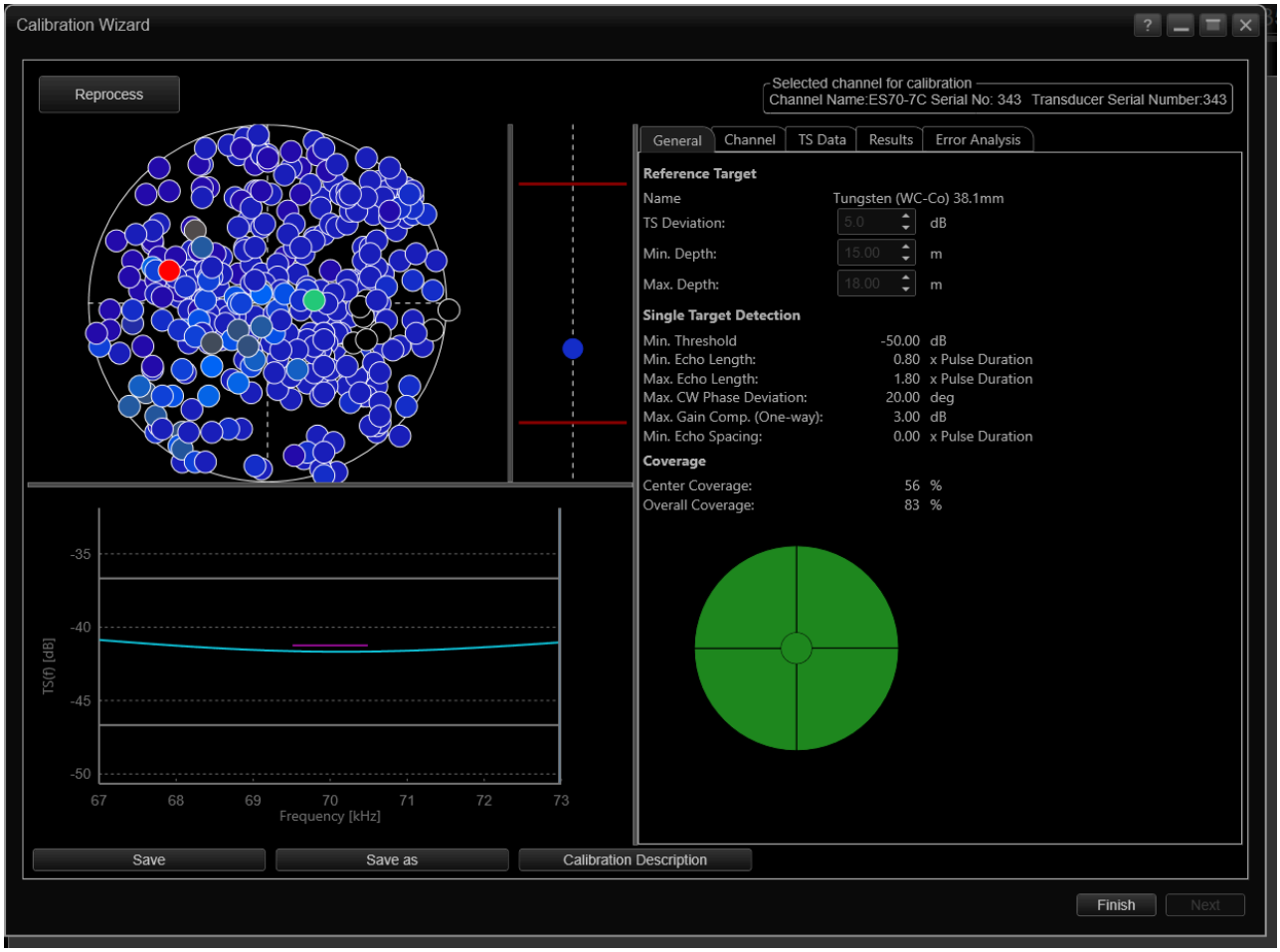

Figure 4. Screenshot of EK80 Calibration Wizard general results for the 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

120 kHz: 1.024 ms

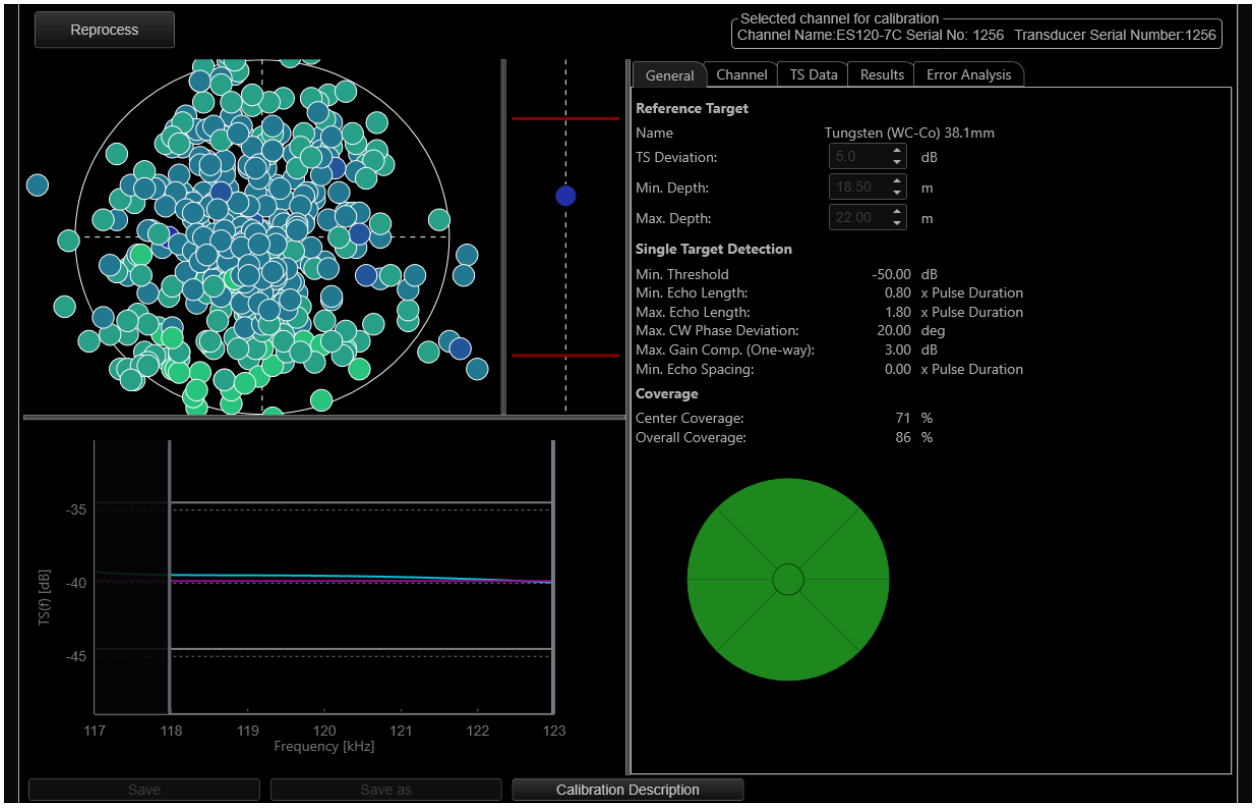

Figure 5. Screenshot of EK80 Calibration Wizard general results for the 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

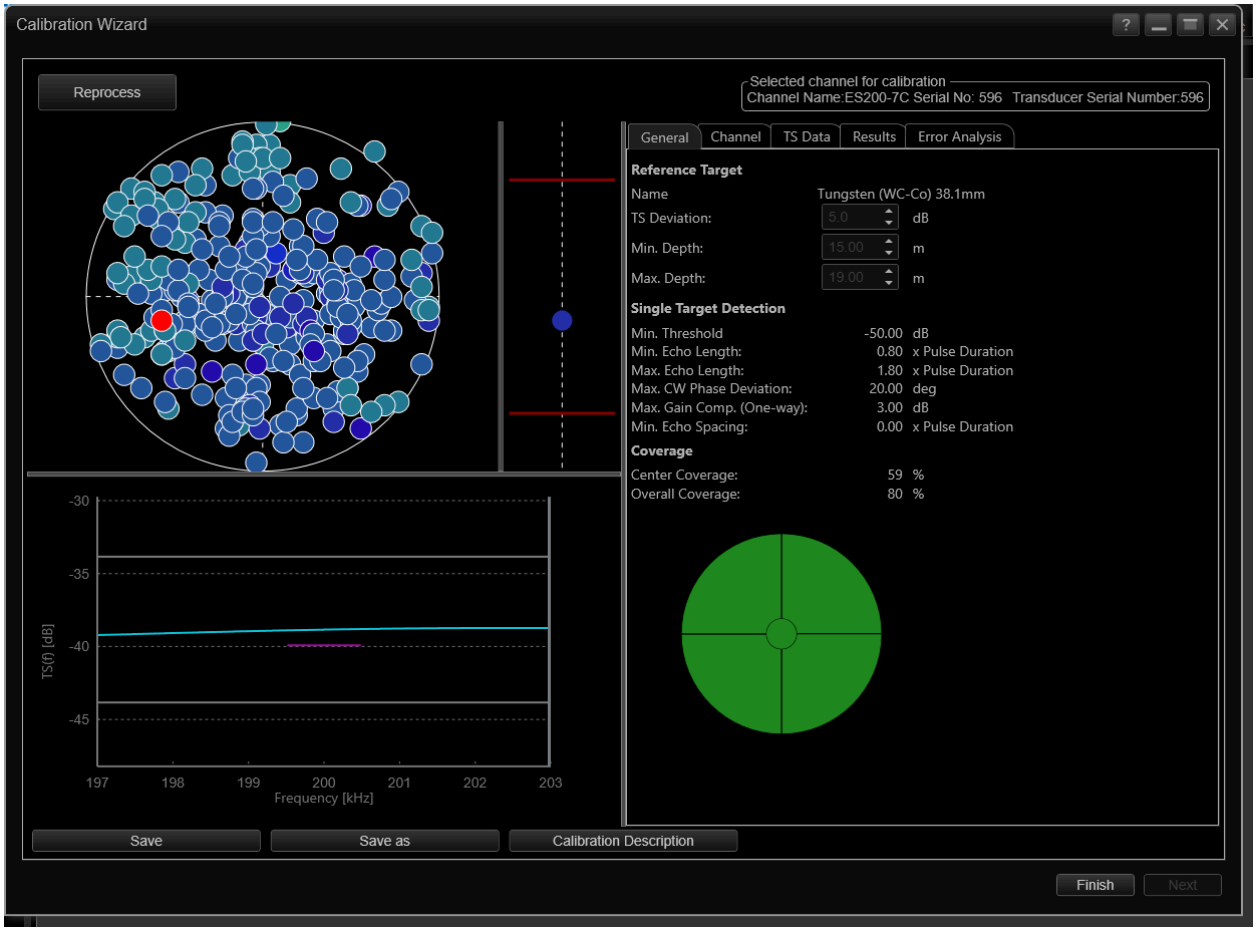

Figure 6. Screenshot of EK80 Calibration Wizard general results for the 200 kHz calibration at 1.024 ms.

Appendix B: Channel Results

18 kHz (CW): 1.024 ms

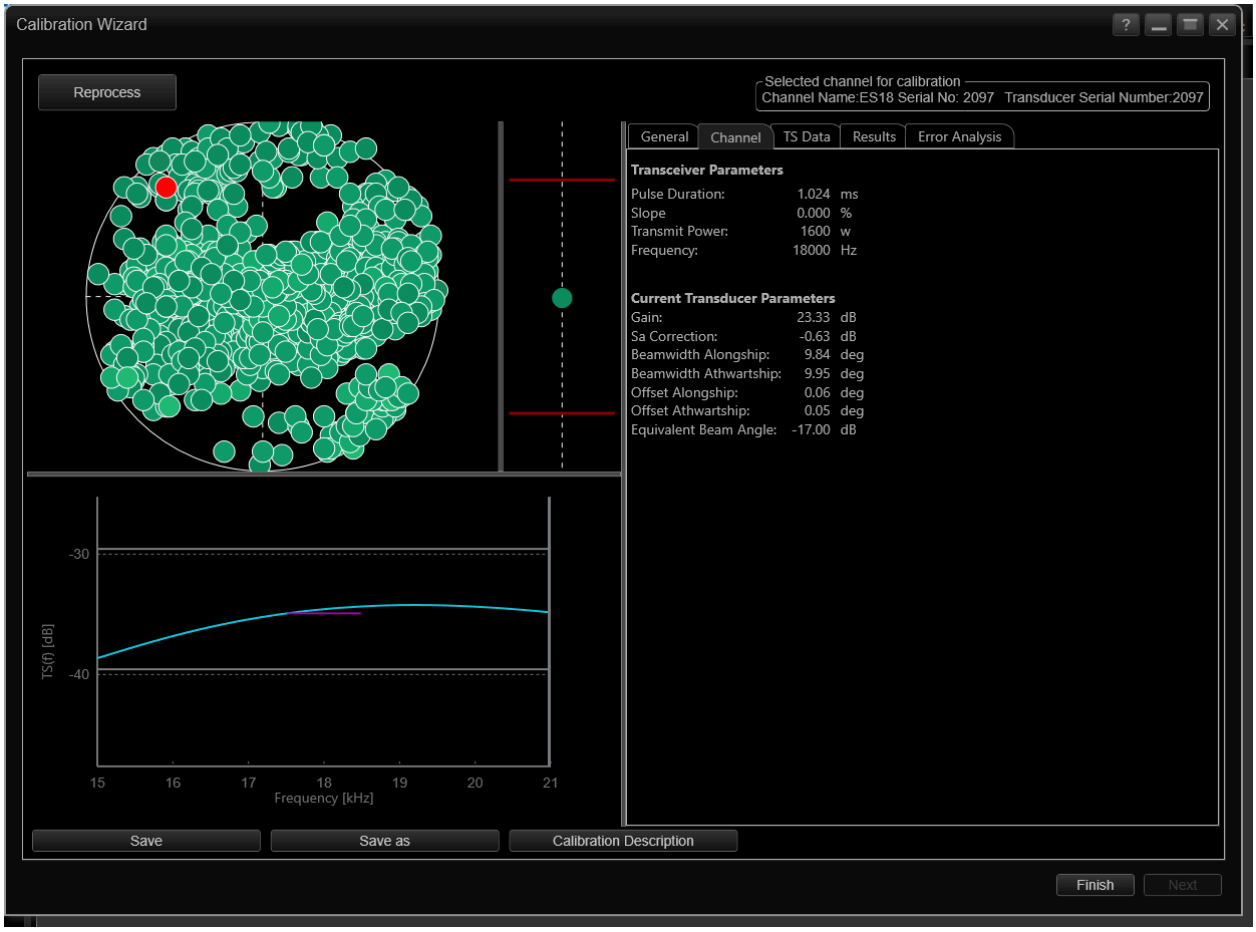

Figure 7. Screenshot of EK80 Calibration Wizard channel results for the 18 kHz calibration at 1.024 ms.

38 kHz (CW): 1.024 ms

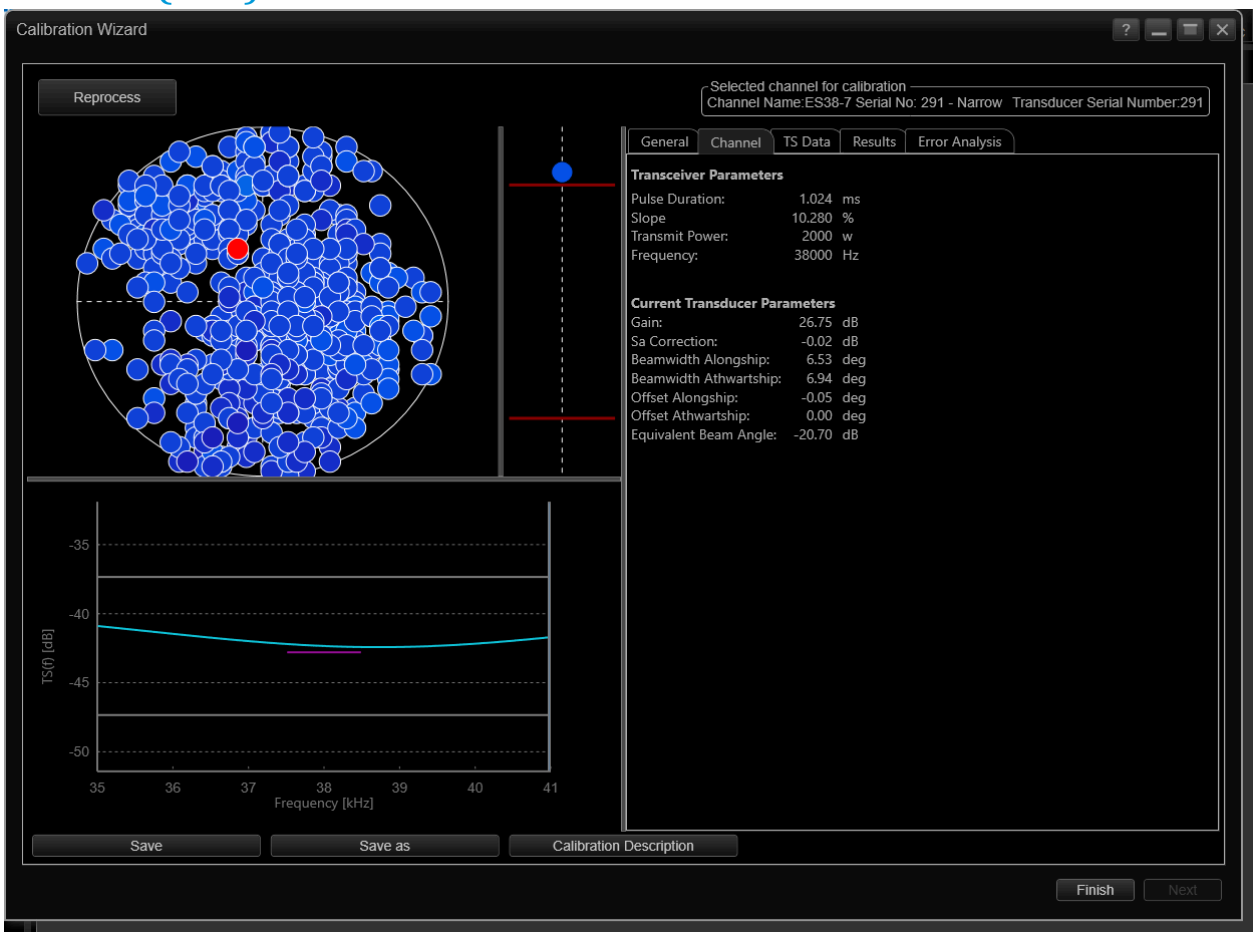

Figure 8. Screenshot of EK80 Calibration Wizard channel results for the 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (CW): 1.024 ms

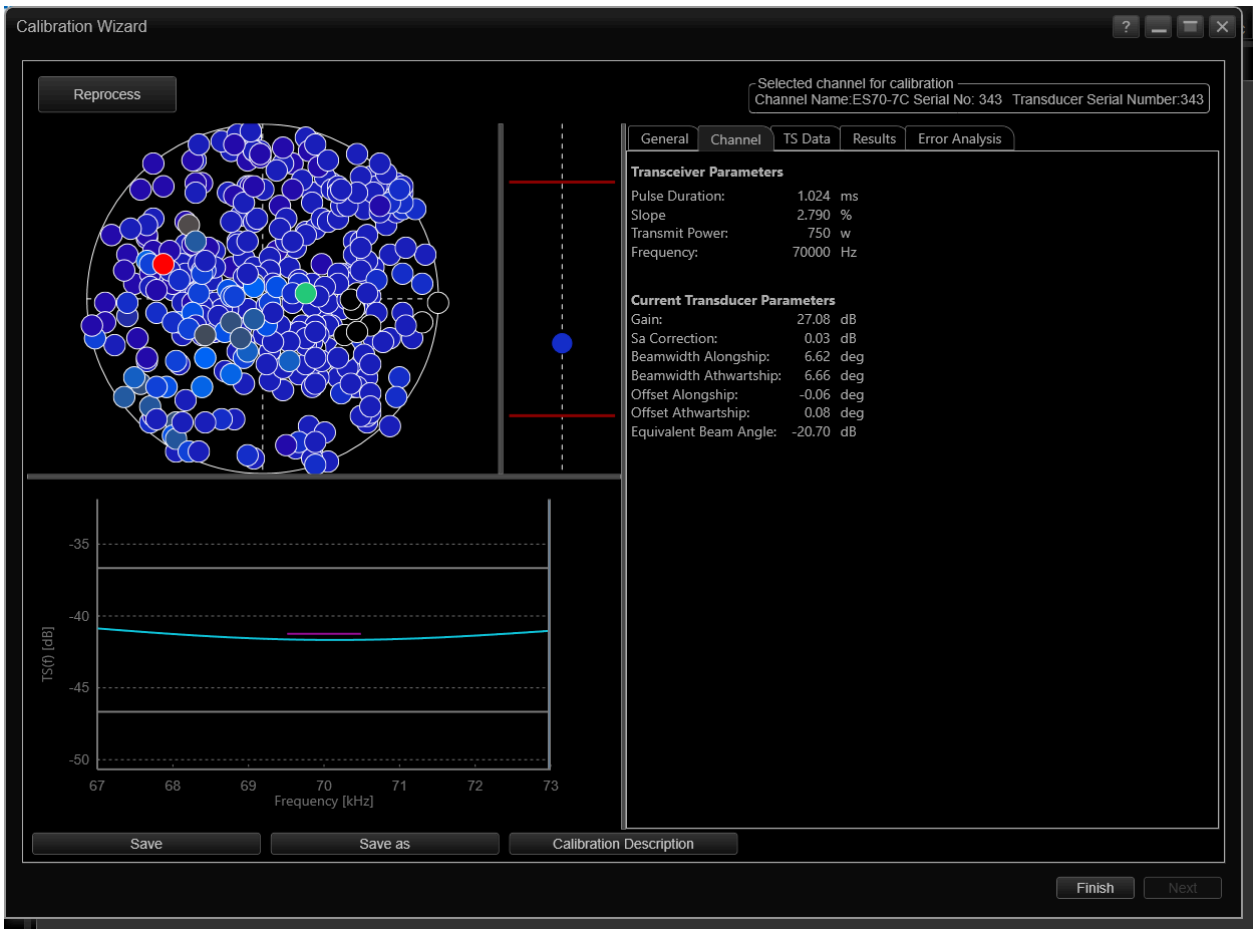

Figure 9. Screenshot of EK80 Calibration Wizard channel results for the 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

120 kHz: 1.024 ms

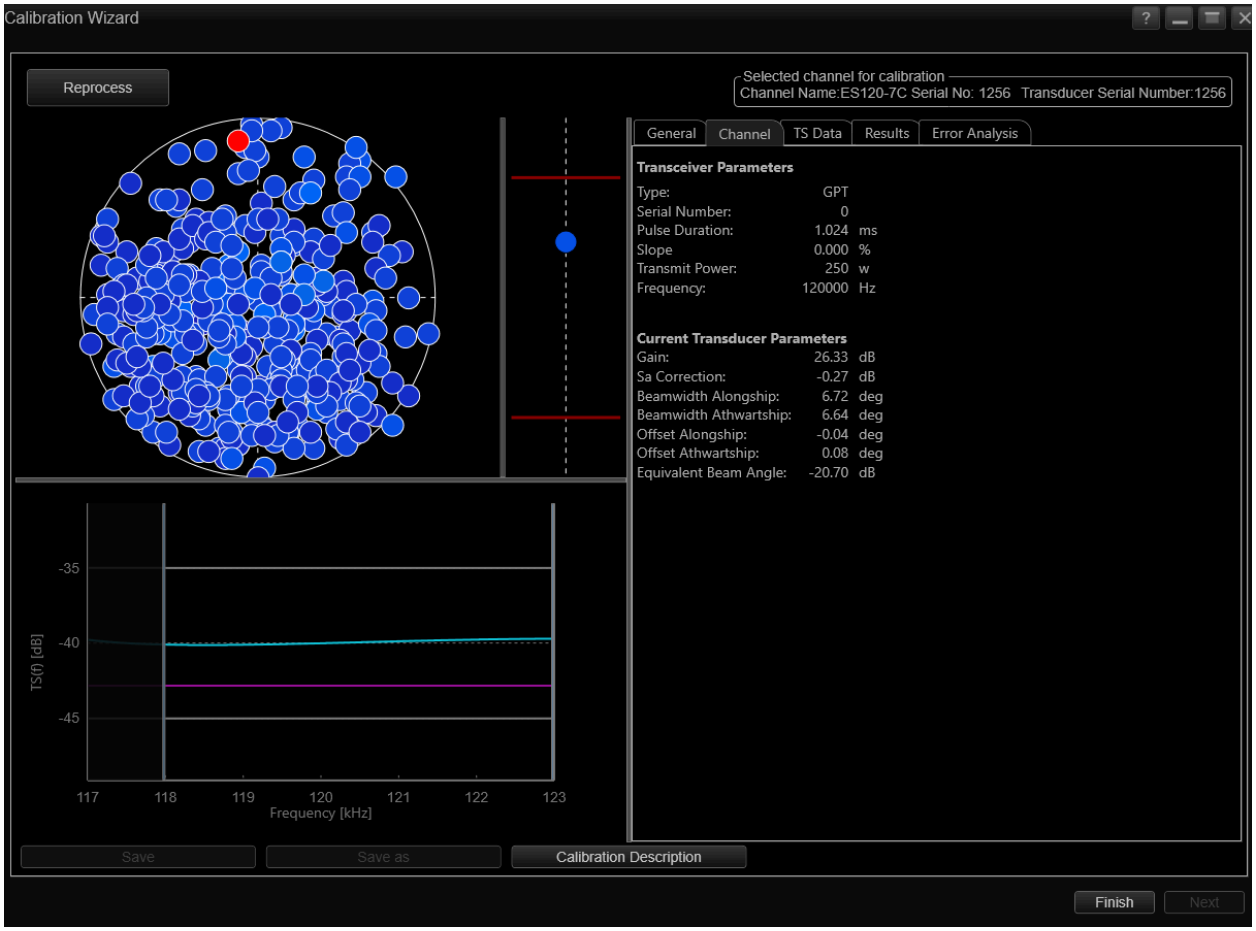

Figure 10. Screenshot of EK80 Calibration Wizard channel results for the 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

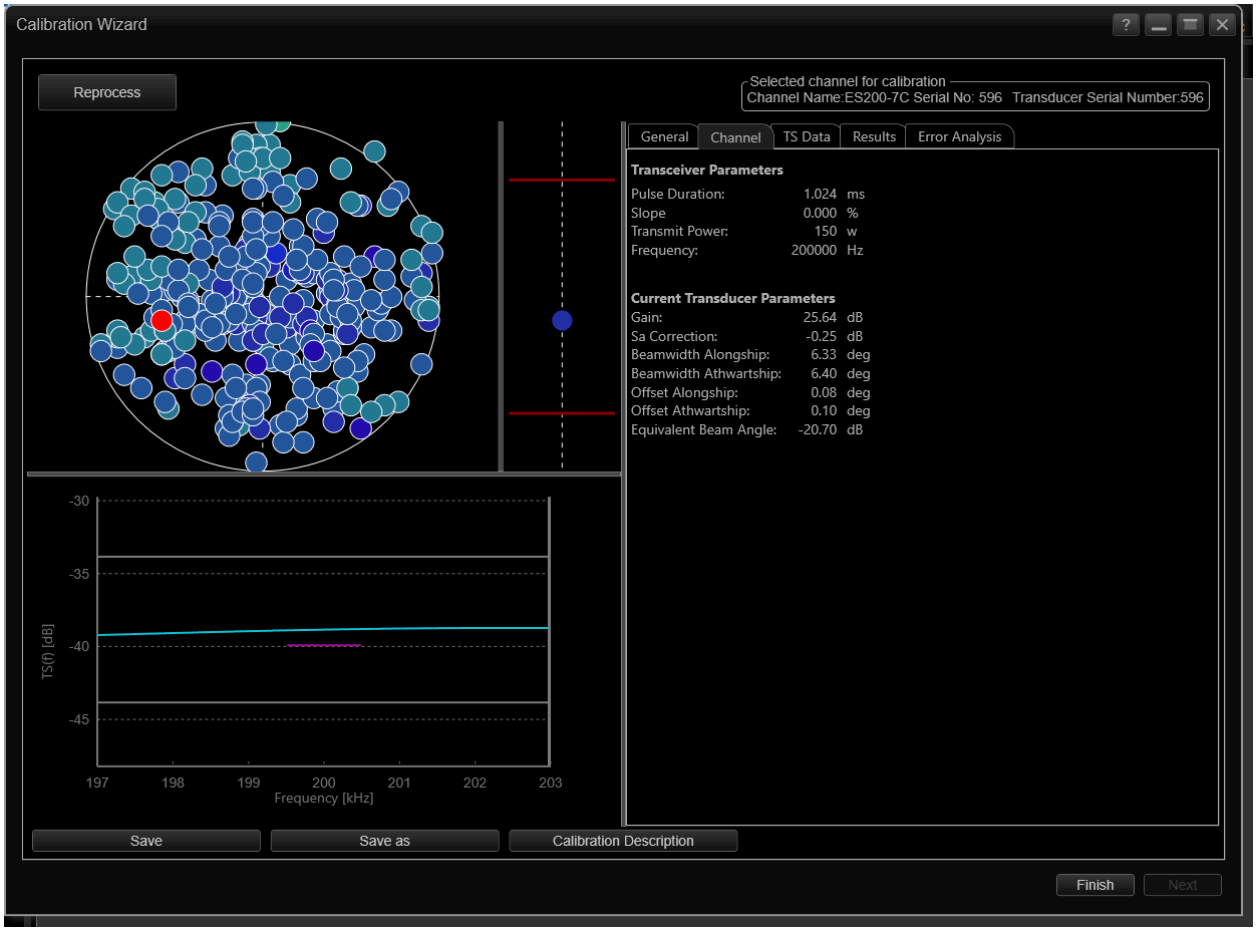

Figure 11. Screenshot of EK80 Calibration Wizard channel results for the 200 kHz calibration at 1.024 ms.

Appendix C: Results

18 kHz: 1.024 ms

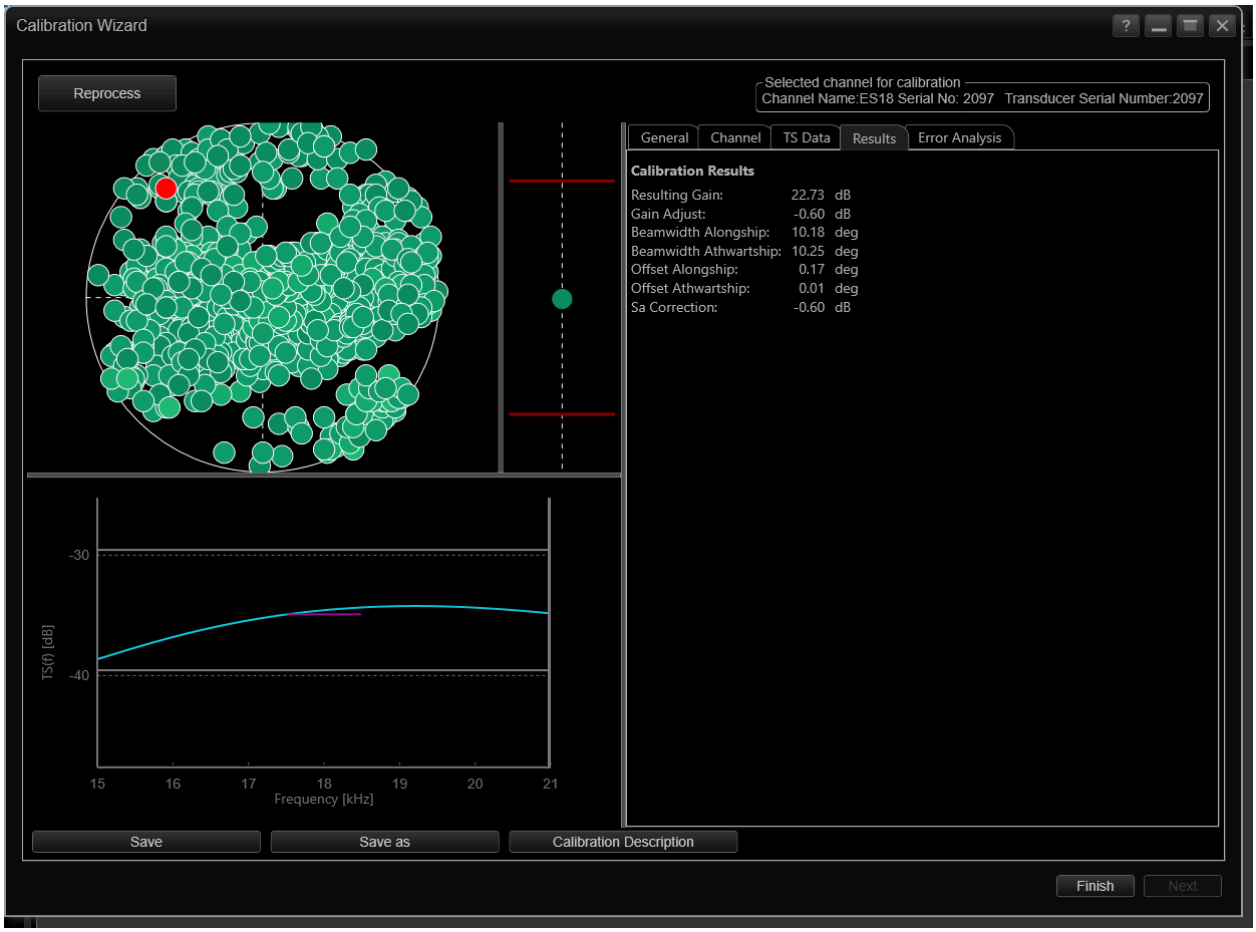

Figure 12. Screenshot of EK80 Calibration Wizard results for the 18 kHz calibration at 1.024 ms.

38 kHz (CW): 1.024 ms

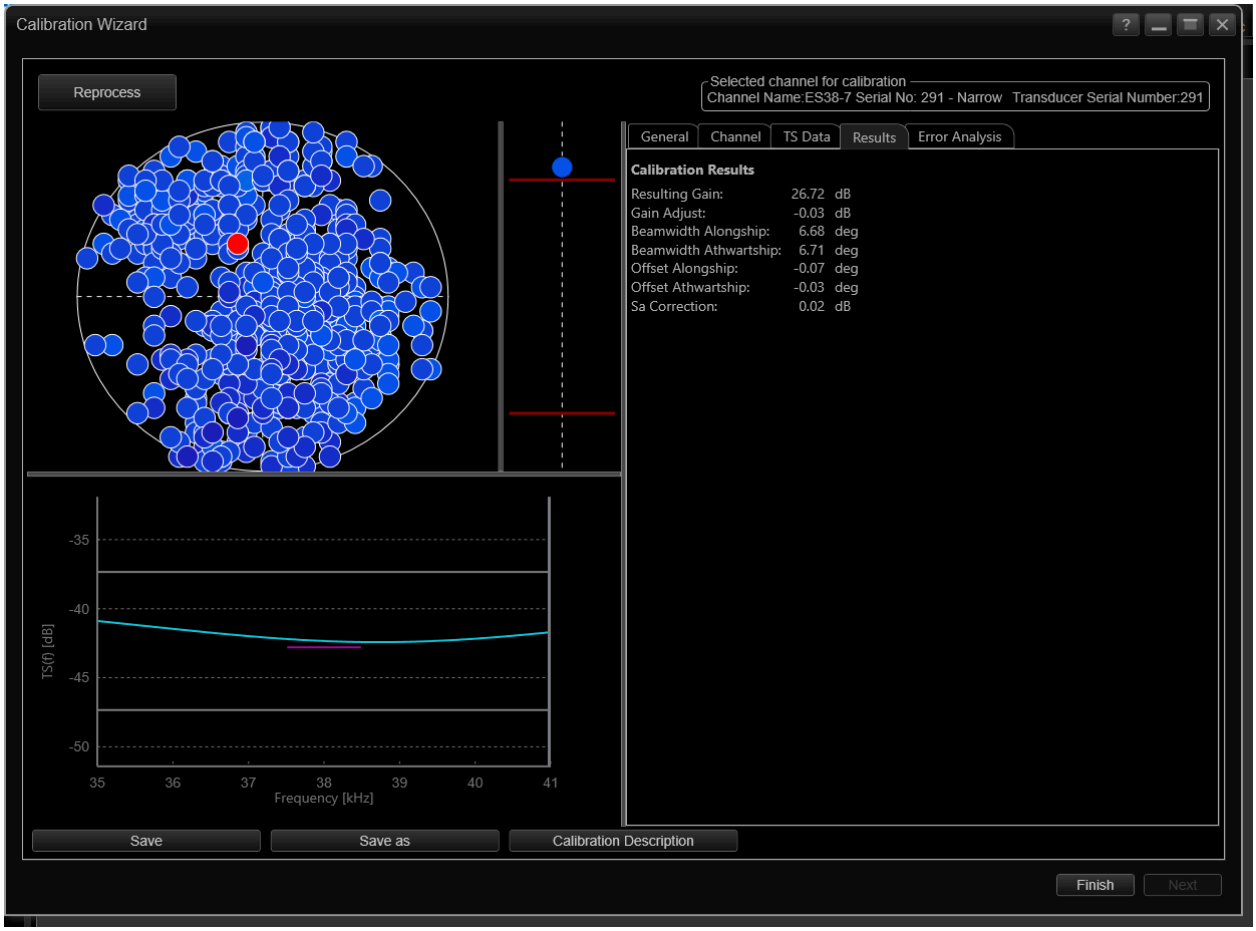

Figure 13. Screenshot of EK80 Calibration Wizard results for the 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (CW): 1.024 ms

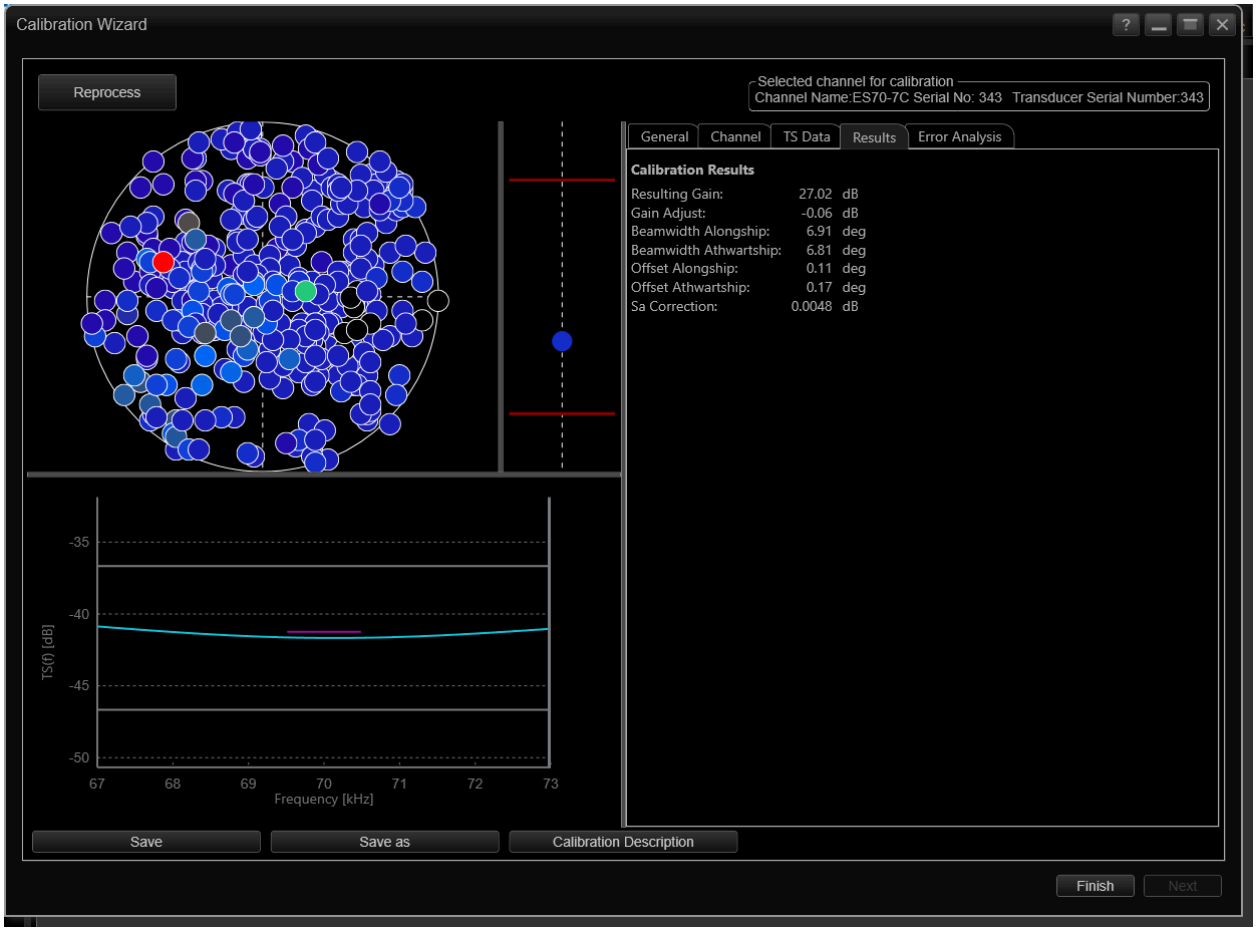

Figure 14. Screenshot of EK80 Calibration Wizard results for the 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

120 kHz: 1.024 ms

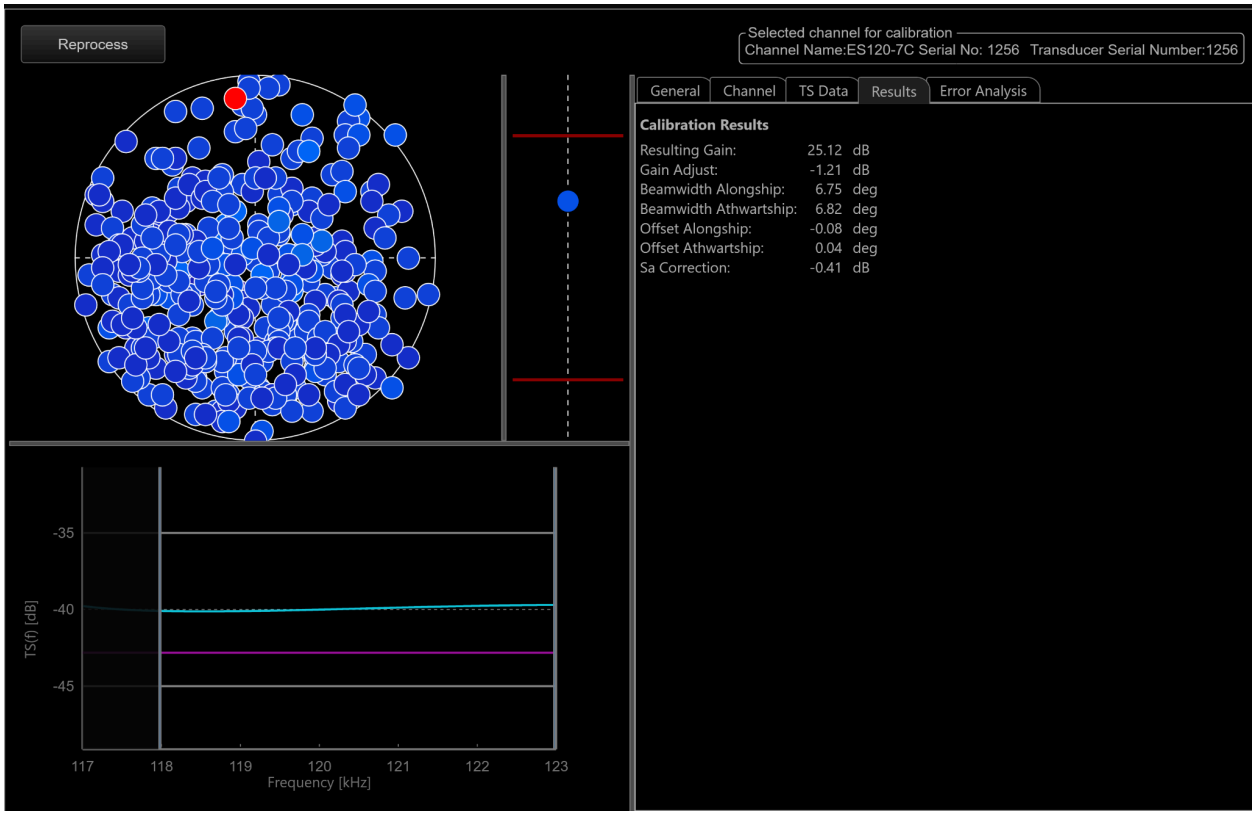

Figure 15. Screenshot of EK80 Calibration Wizard results for the 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

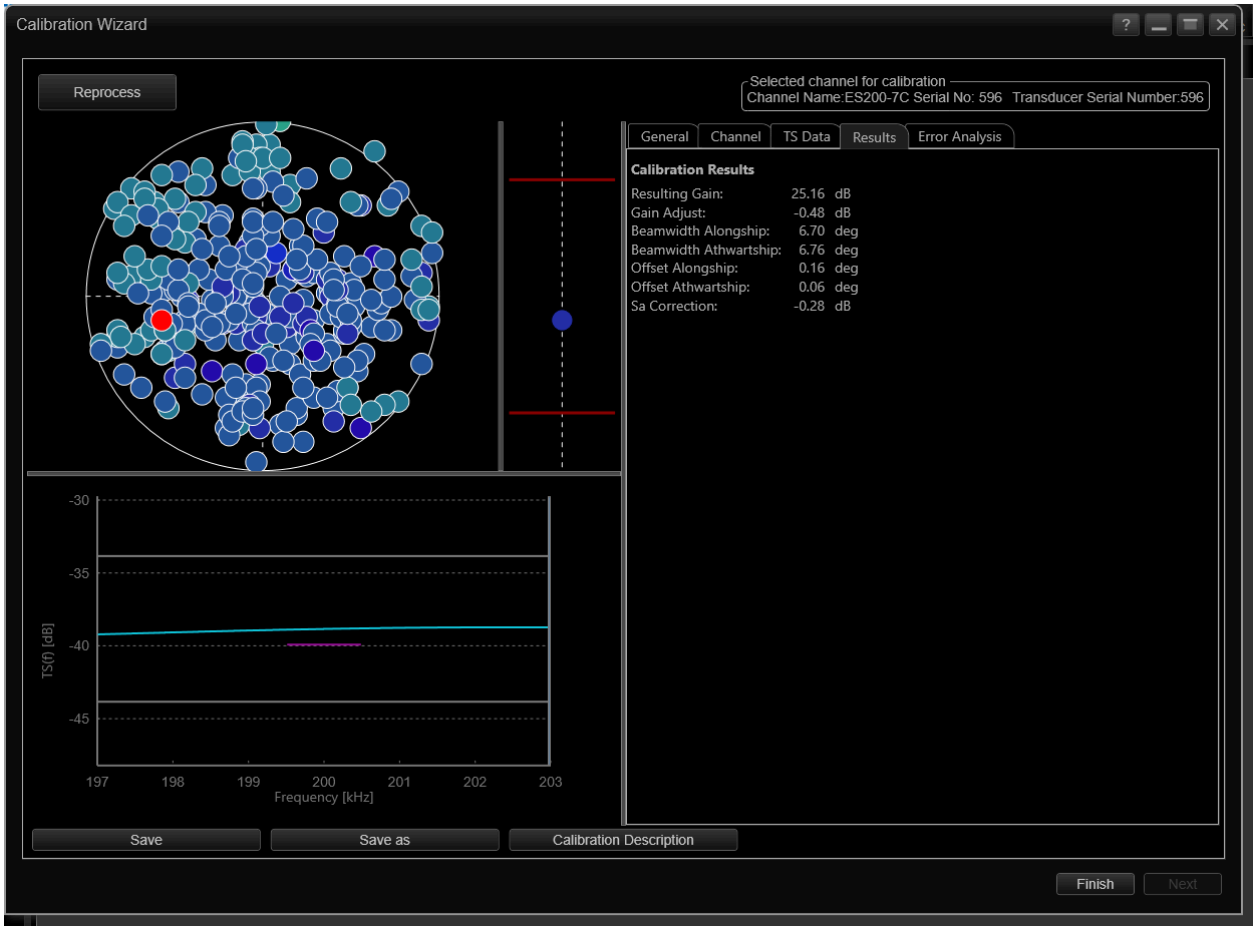

Figure 16. Screenshot of EK80 Calibration Wizard results for the 200 kHz calibration at 1.024 ms.

Appendix D: Error Analysis

18 kHz: 1.024 ms

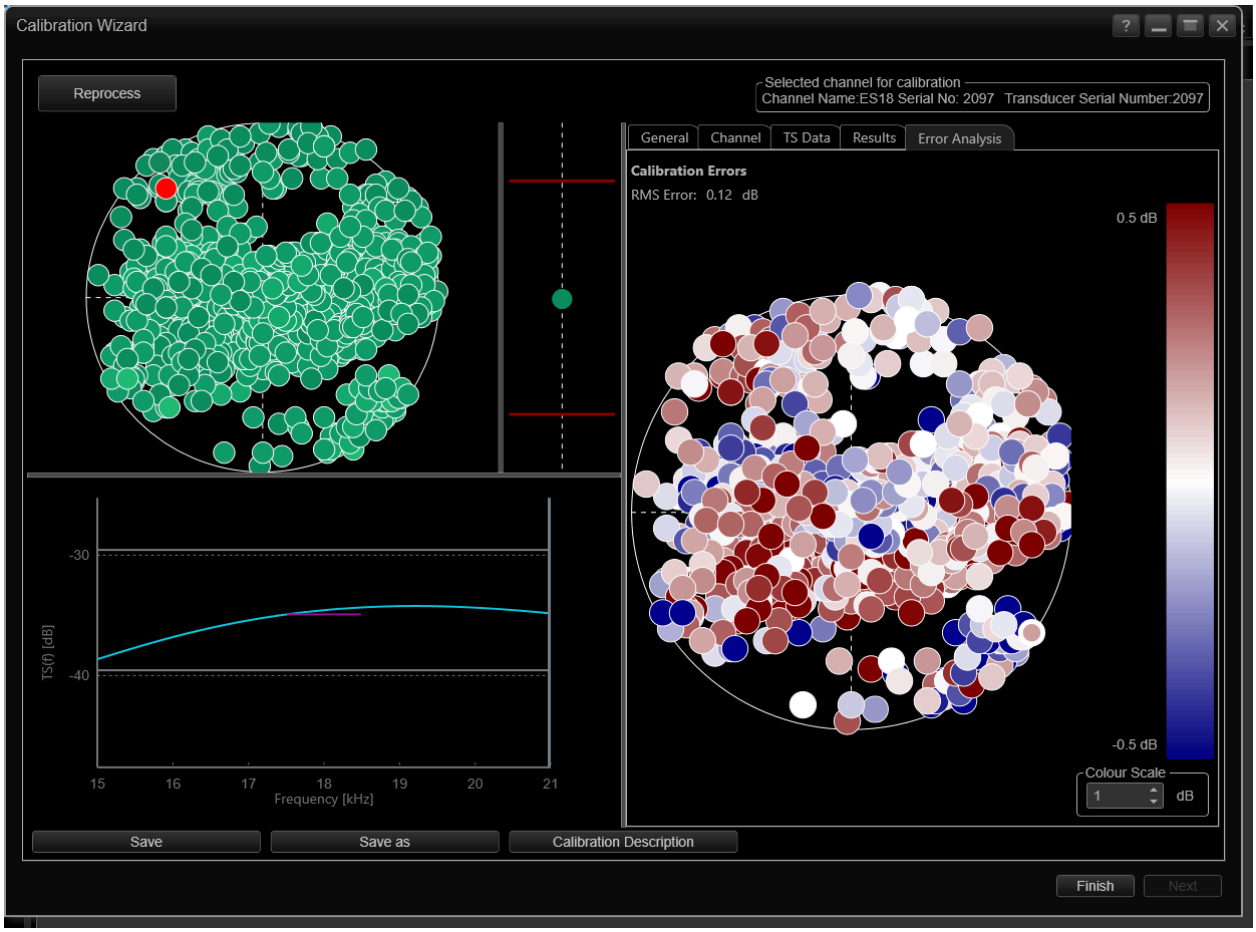

Figure 17. Screenshot of EK80 Calibration Wizard error analysis for the 18 kHz calibration at 1.024 ms.

38 kHz (CW): 1.024 ms

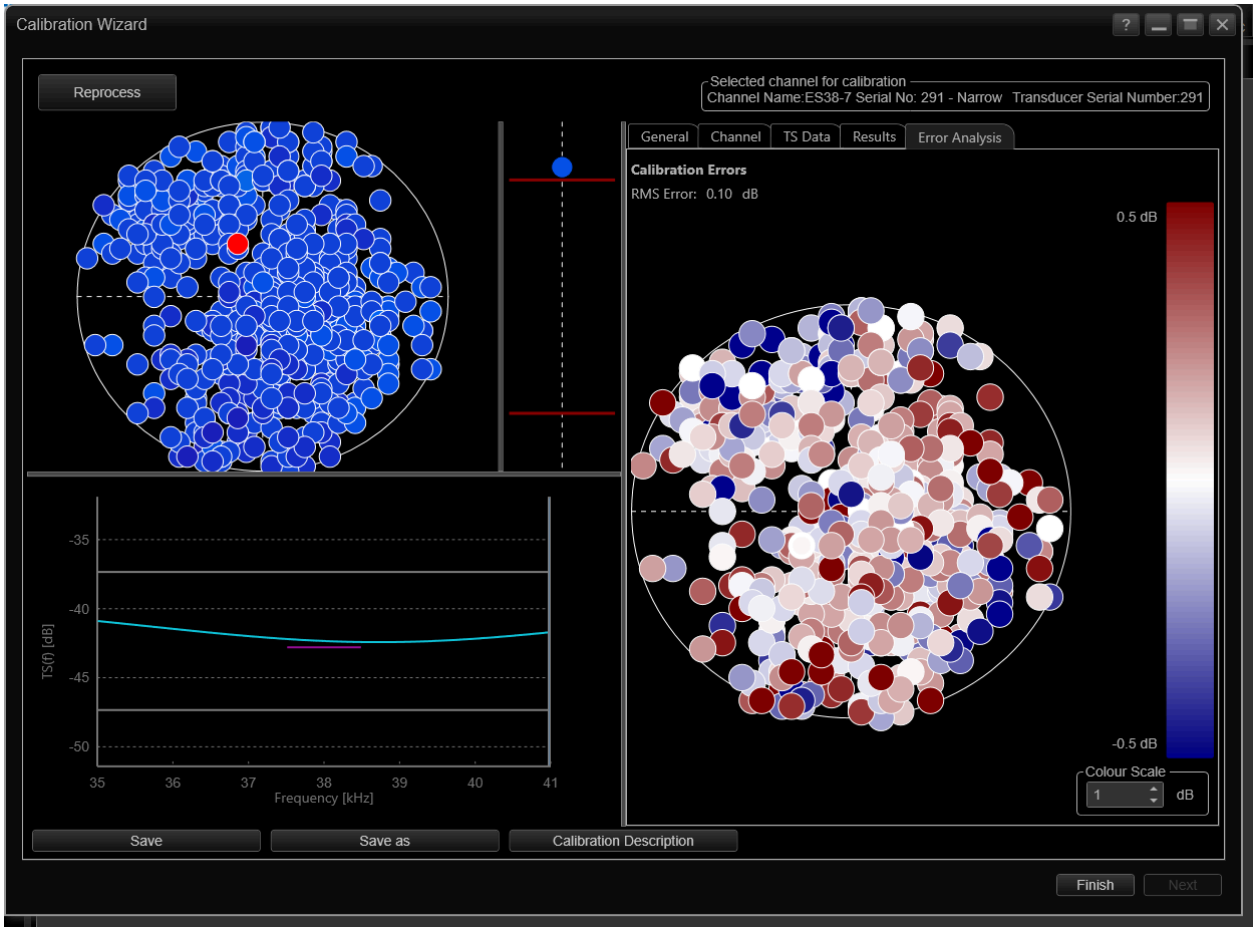

Figure 18. Screenshot of EK80 Calibration Wizard error analysis for the 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

70 kHz (CW): 1.024 ms

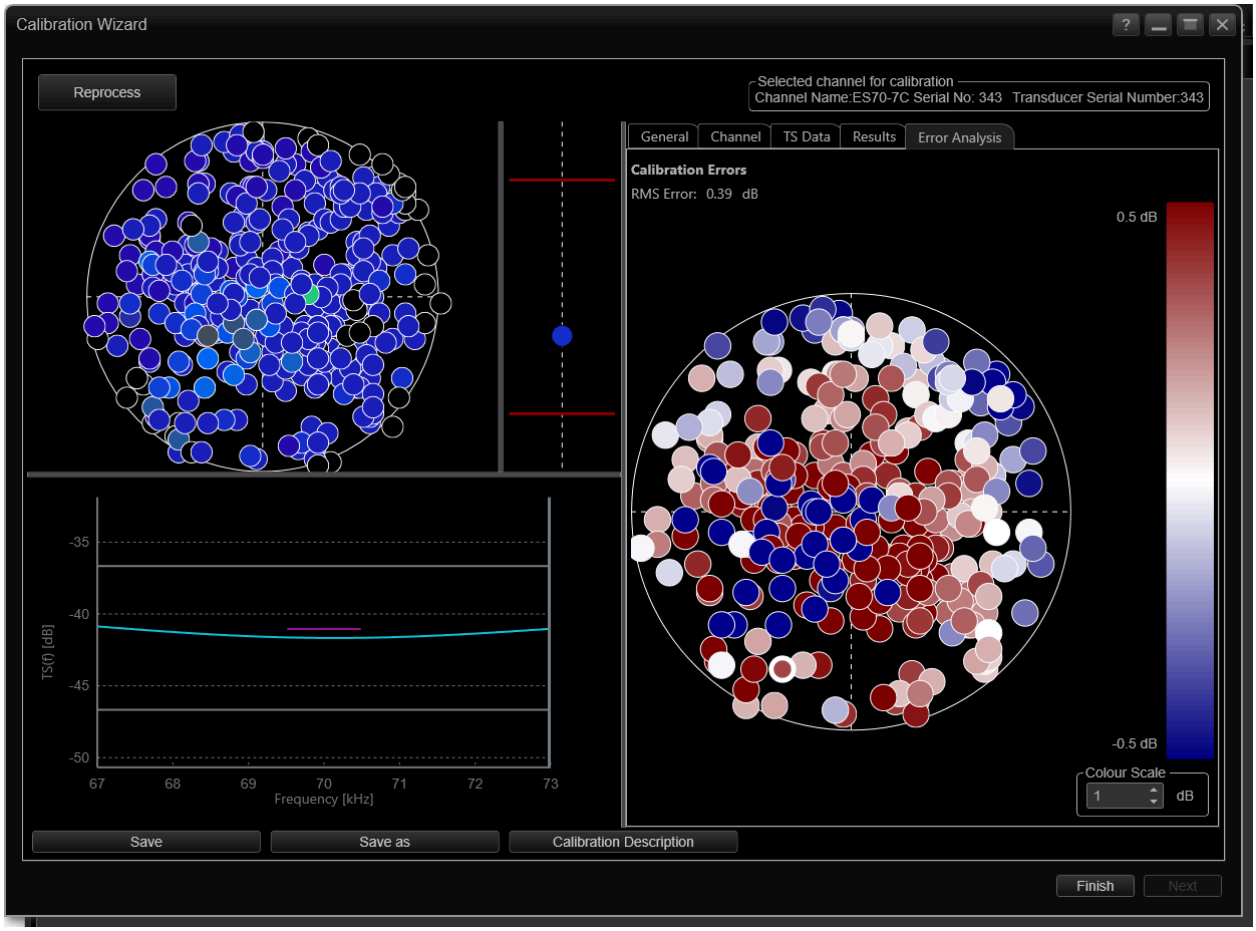

Figure 19. Screenshot of EK80 Calibration Wizard error analysis for the 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

120 kHz: 1.024 ms

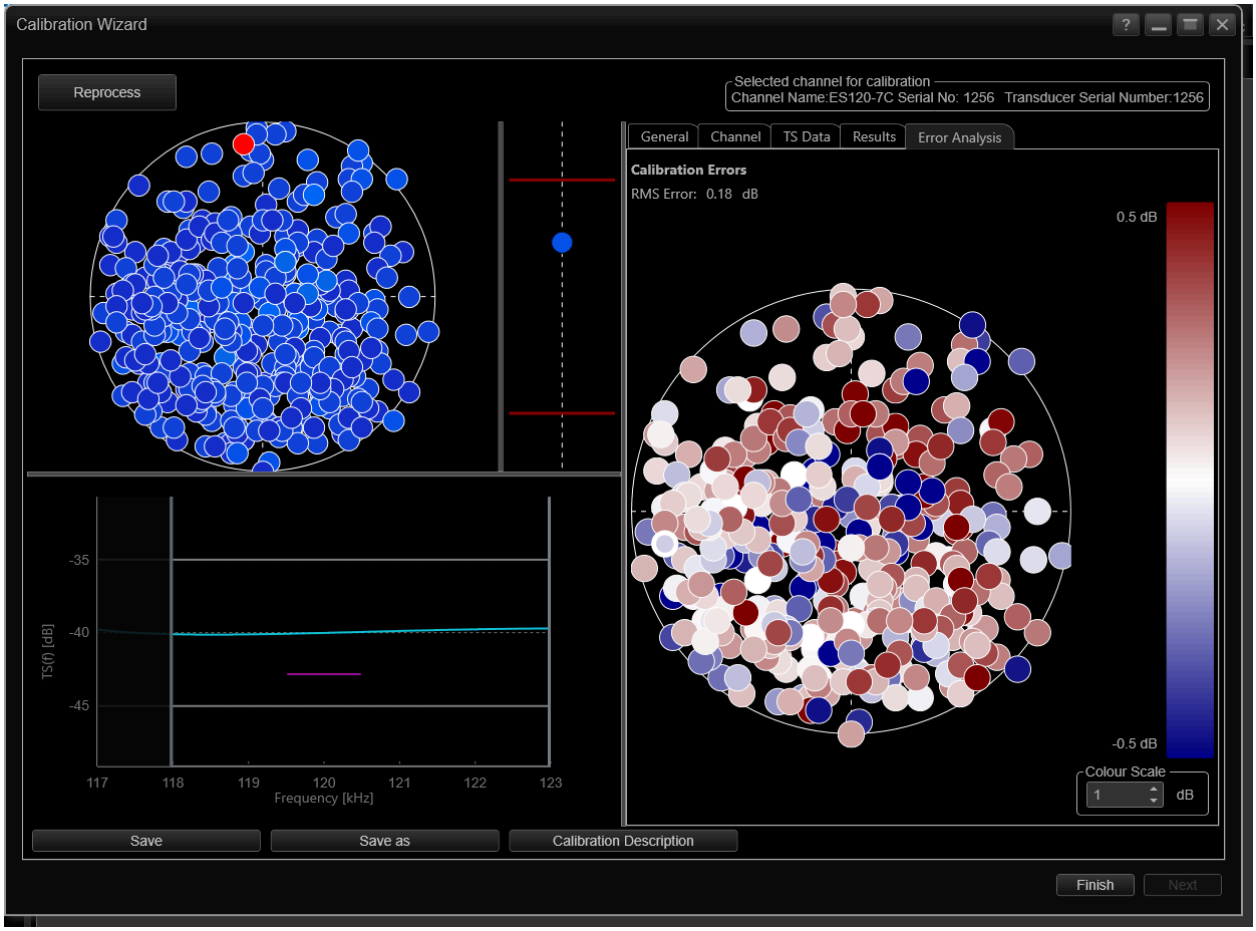

Figure 20. Screenshot of EK80 Calibration Wizard error analysis for the 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

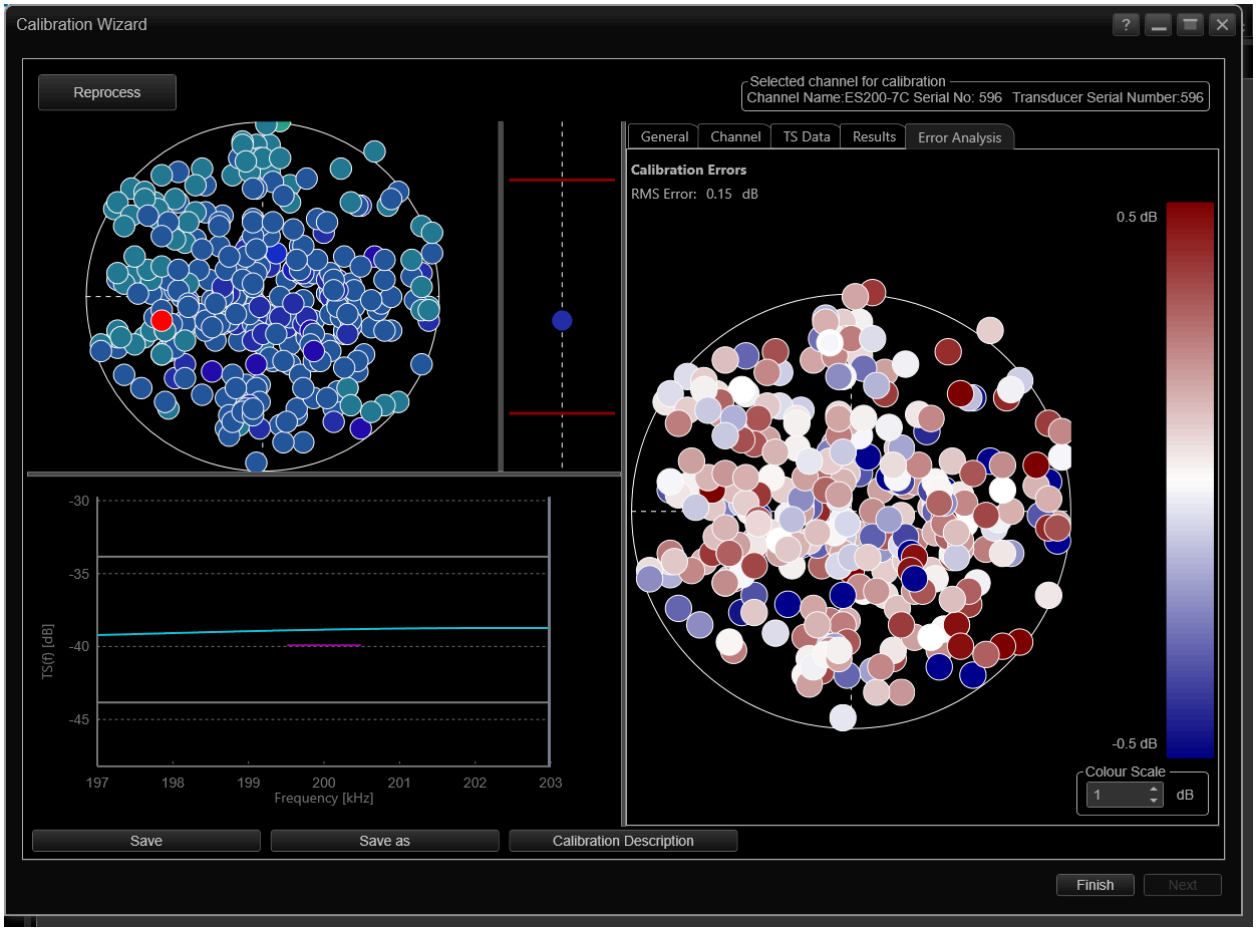

Figure 21. Screenshot of EK80 Calibration Wizard error analysis for the 200 kHz calibration at 1.024 ms.

Appendix E: Detailed List Calibration Files

File name	Date (UTC)	Frequency (pulse length)
EX2401_EK60-D20240429-T204943	4/29/2024	38 kHz (1.024 ms)
EX2401_EK60-D20240429-T220359	4/29/2024	70 kHz (1.024 ms)
EX2401_EK60-D20240429-T220451	4/29/2024	70 kHz (1.024 ms)
EX2401_EK60-D20240429-T220836	4/29/2024	70 kHz (1.024 ms)
EX2401_EK60-D20240429-T225448	4/29/2024	120 kHz (1.024 ms)
EX2401_EK60-D20240429-T234455	4/29/2024	200 kHz (1.024 ms)
EX2401_EK60-D20240501-T032827	5/1/2024	18 kHz (1.024 ms)
EX2401_EK60-D20240501-T040334	5/1/2024	18 kHz (1.024 ms)
EX2401_EK60-D20240501-T043827	5/1/2024	18 kHz (1.024 ms)
EX2401_EK60-D20240501-T051311	5/1/2024	18 kHz (1.024 ms)

Appendix F: 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