

August 2022 EK60/80 Calibration Report

NOAA Ship *Okeanos Explorer*

EX-22-06: Voyage to the Ridge 3 (ROV/Mapping)

Supporting Document for the NOAA Ship *Okeanos Explorer* Mapping Systems Readiness Report 2022 (<https://doi.org/10.25923/g2ep-ae34>)

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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 2022** calibration of the Simrad EK60/80 echosounders on NOAA Ship *Okeanos Explorer* during EX-22-06, to account for any potential changes as a result of the emergency drydock period following EX-22-04, June 26 - July 1, 2022. These calibrations supersede those conducted prior to the emergency drydock for all data collected during the remainder of the field season (unless a need for another calibration is identified). Any future mid-season equipment calibrations or modifications will also be archived as a supporting document with the annual readiness report.

The calibrations occurred August 11-12, 2022 while drifting on the Azores Plateau, Portugal. 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 length of 2.048 ms.

The 38 and 70 kHz wideband transceivers (WBT) were calibrated in continuous wave (CW) mode at a pulse length of 1.024 ms. The 38 kHz WBT was calibrated at an additional pulse length of 2.048 ms. The FM mode for the 38 kHz was calibrated at the 1.024 ms pulse length. The 38 kHz

Location and Conditions

- The calibrations occurred on the Azores Plateau, Portugal.
 - Pod starting coordinates: 38° 26.37' N, 28° 45.57' W.
 - 18 kHz starting coordinates: 38° 16.43' N, 28° 7.60 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 11 was 1525.93 meters per second, with an average temperature of 21.108 °C and average salinity of 36.068 psu (practical salinity units).
- Average speed of sound at the calibration depth (30 meters) for the 18 kHz transducer on August 12 was 1524.24 meters per second, with an average temperature of 20.464 °C and average salinity of 35.948 psu (practical salinity units).

Calibration Parameters

- All frequencies within the pod (38, 70, 120, 200 kHz) were calibrated with a pulse length of 1.024 ms. The 38 kHz and 70 kHz CW modes were additionally calibrated with a pulse length of 2.048 ms. The 38 kHz FM mode was calibrated with a pulse length of 1.024 ms. The 18kHz was calibrated with pulse lengths of 1.024 ms and 2.048 ms.
- 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 2022 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	120	200
EK 80 software version	21.15.0.0	21.15.0.0	21.15.0.0	21.15.0.0
Transducer model	ES18	ES18	ES120-7C	ES200-7C
Transducer serial number	2097	2097	1256	596
Transducer draft setting (m)	4.99	4.99	4.59	4.59
Transmit power (W)	1600	1600	250	150
Pulse length (ms)	1.024	2.048	1.024	1.024
Two-way beam angle (dB)	-17.00	-17.00	-20.70	-20.70
Transducer peak gain (dB)	22.93	23.30	26.08	26.27
Sa correction (dB)	-0.69	-0.62	-0.32	-0.29
Absorption coefficient (dB/km)	0.00	0.00	0.00	0.00
Speed of sound (m/s)	1524.24	1524.24	1525.93	1525.93
3 dB beamwidth (°) alongship/athwartship	10.02/10.02	9.84/9.95	6.26/6.62	6.50/6.48
Angle offset (°) alongship/athwartship	0.04/0.04	0.06/0.05	0.05/0.08	0.04/0.16

Table 2. List of relevant parameters and initial settings used during the 2022 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)	70 (CW)
Frequency Range (kHz)	38	38	34 to 45	70
GPT/WBT serial number	WBT 748247	WBT 748247	WBT 748247	WBT 746998
EK 80 software version	21.15.0.0	21.15.0.0	21.15.0.0	21.15.0.0
Transducer model	ES38-7	ES38-7	ES38-7	ES70-7C
Transducer serial number	291	291	291	343
Transducer draft setting (m)	4.59	4.59	4.59	4.59
Transmit power (W)	2000	2000	2000	750
Pulse length (ms)	1.024	2.048	1.024	1.024
Slope (%)	10.280	5.140	11.489	2.790
Two-way beam angle (dB)	-20.70	-20.70	-20.70	-20.70
Transducer peak gain (dB)	26.61	26.62	25.55 - 29.13	27.09
Sa correction (dB)	-0.06	-0.06	0.000	0.004
Absorption coefficient (dB/km)	0.0000	0.0000	0.0000	0.0000
Speed of sound (m/s)	1525.93	1525.93	1525.93	1525.93
3 dB beamwidth (°) along/athwart	6.67/6.56	6.53/6.94	see XML file	6.69/6.57
Angle offset (°) along/athwart	-0.06/-0.02	-0.05/0.00	-0.03/-0.02	-0.07/0.16

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).

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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
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 (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 prior to the emergency drydock on NOAA Ship *Okeanos Explorer*.

Appendix A: Channel Results

18 kHz (CW): 1.024 ms

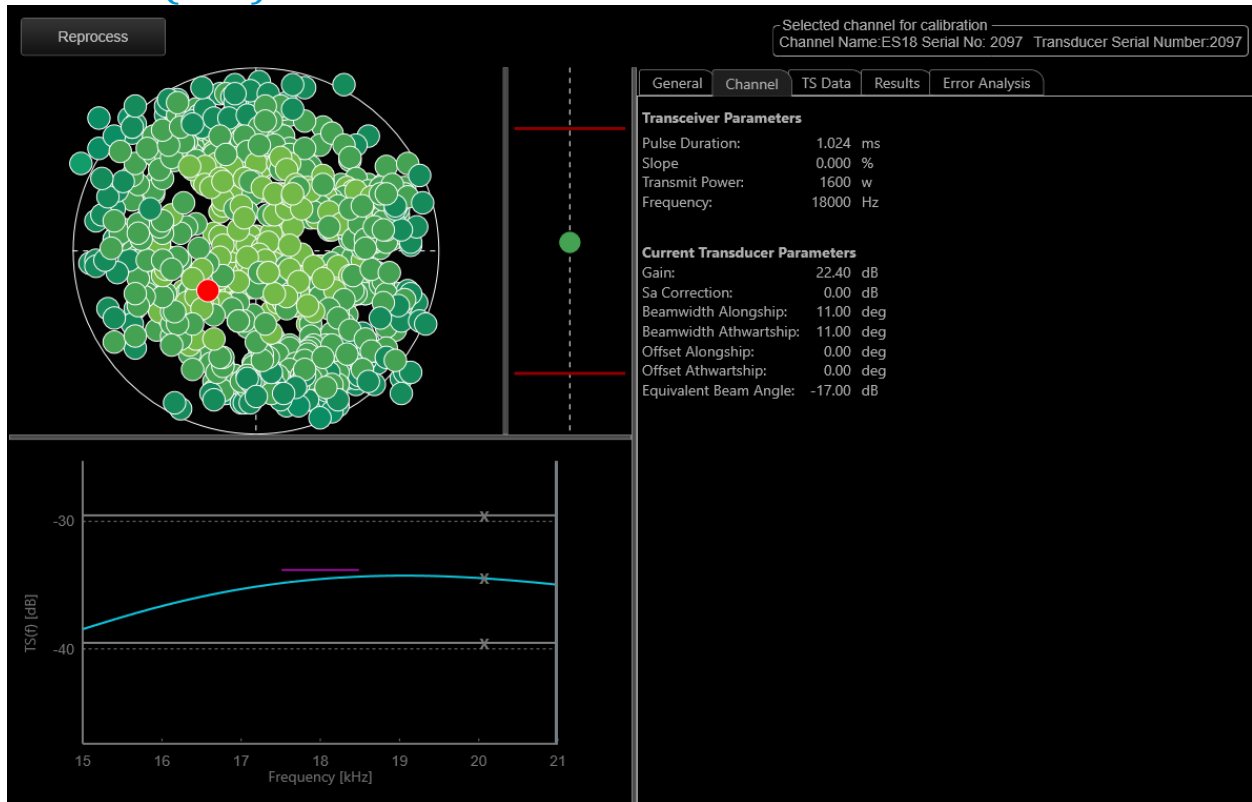


Figure 1. Screenshot of EK80 Calibration Wizard channel results for the 18 kHz calibration at 1.024 ms.

18 kHz (CW): 2.048 ms

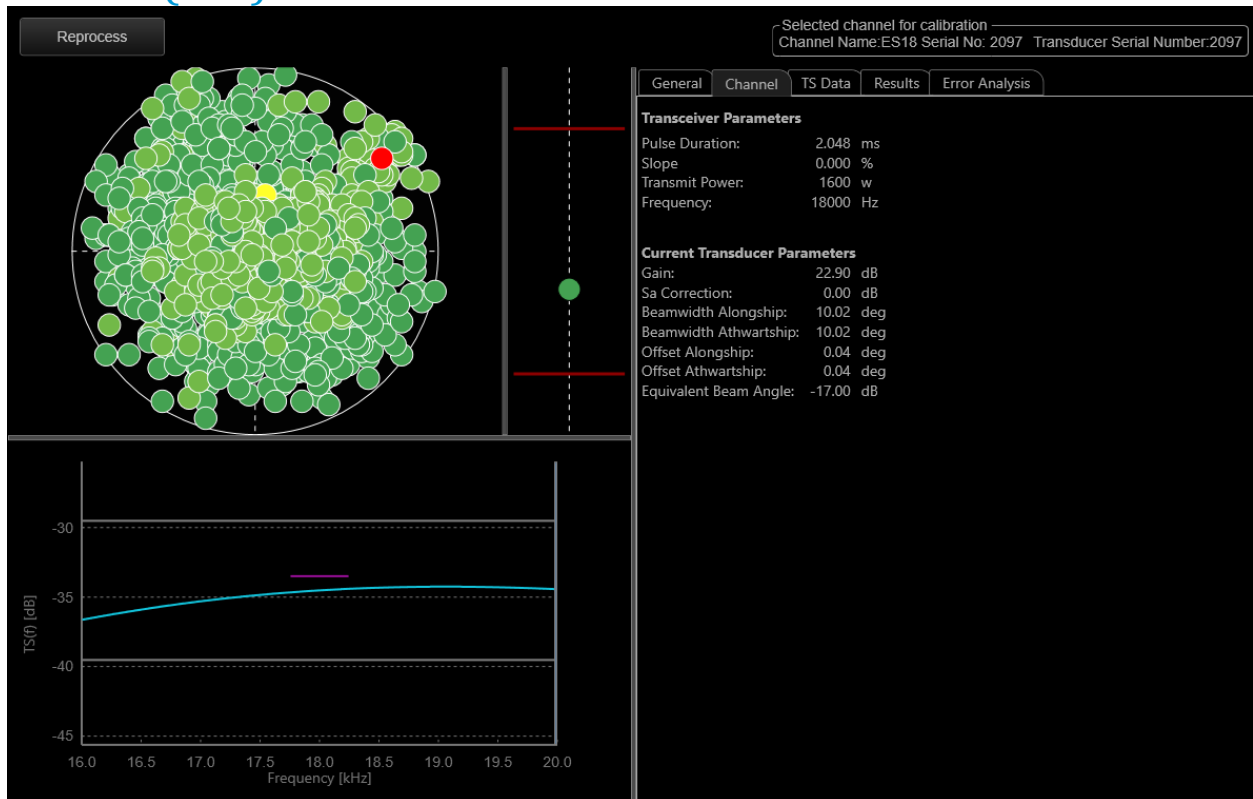


Figure 2. Screenshot of EK80 Calibration Wizard channel results for the 18 kHz calibration at 2.048 ms.

38 kHz (CW): 1.024 ms

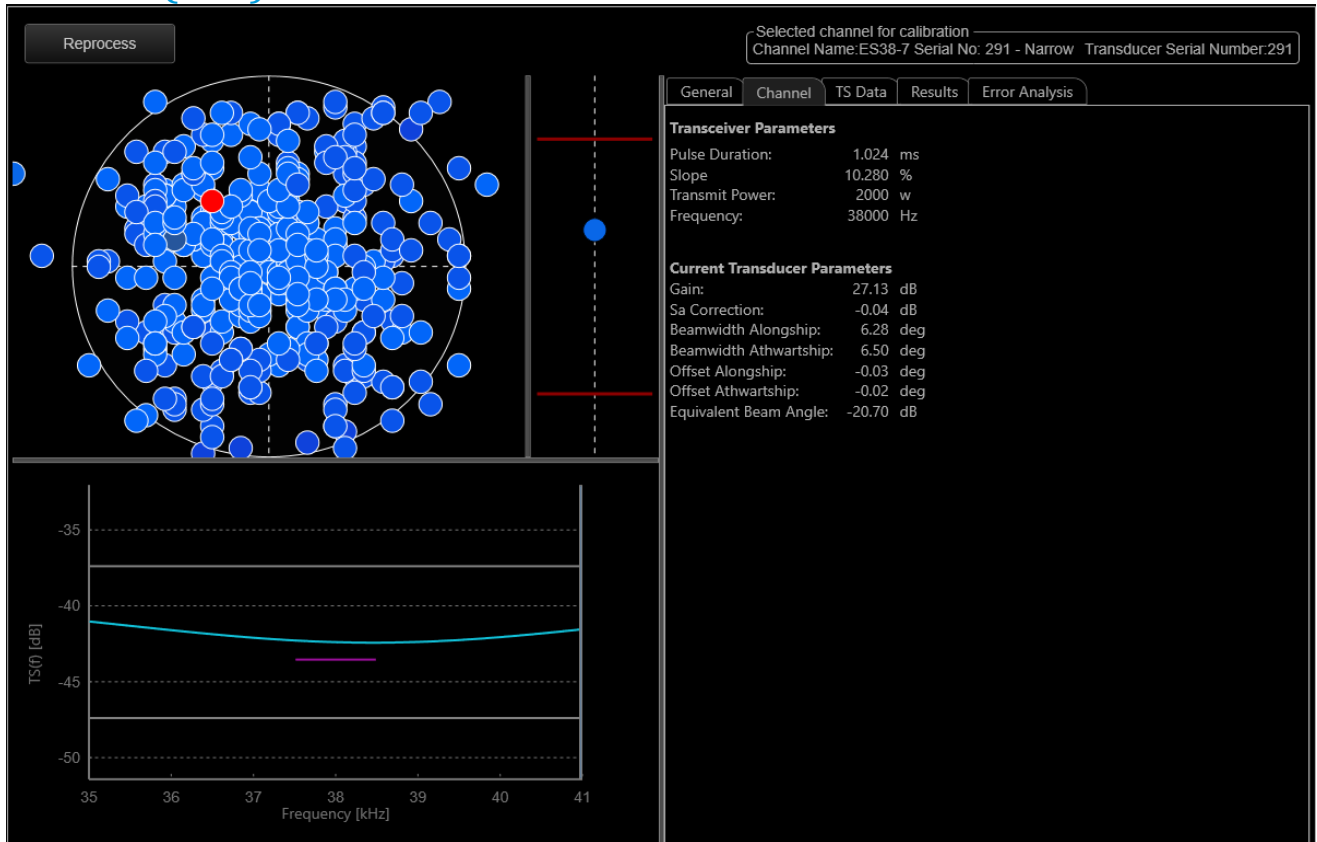


Figure 3. Screenshot of EK80 Calibration Wizard channel results for the 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

38 kHz (CW): 2.048 ms

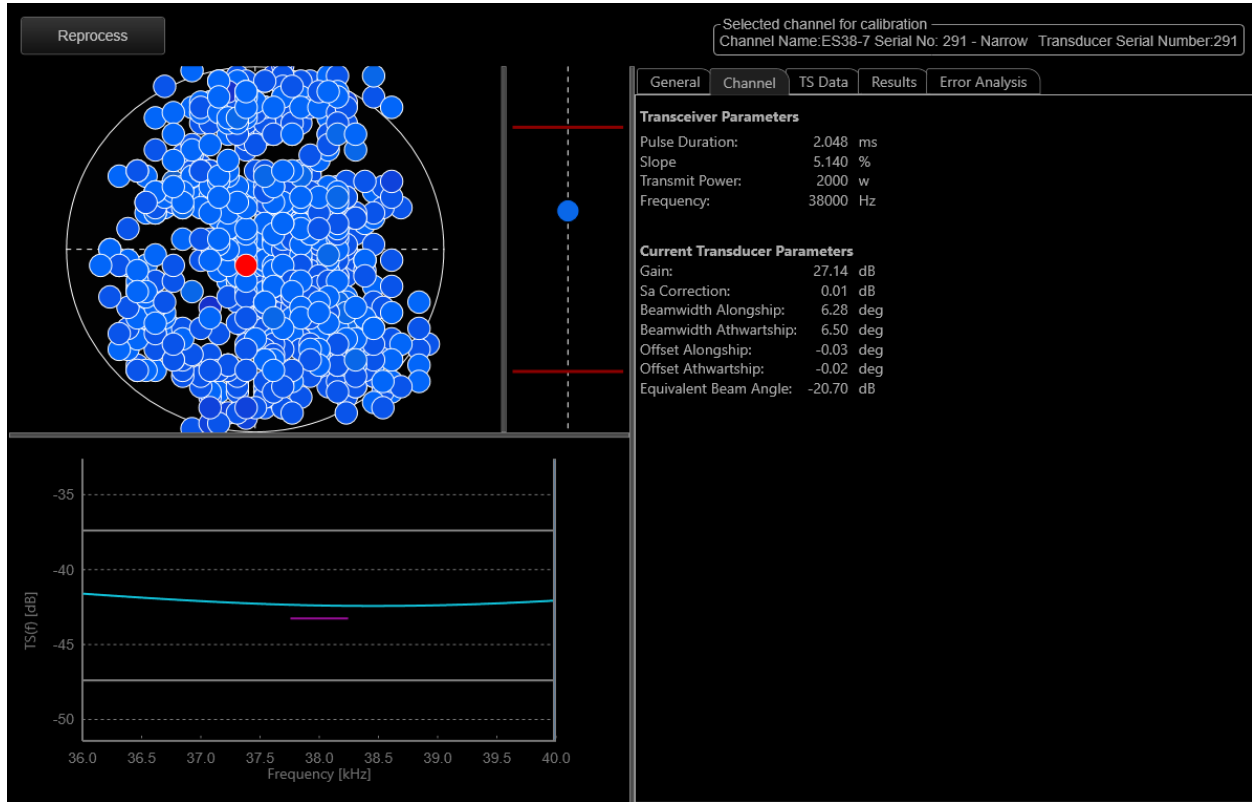


Figure 4. Screenshot of EK80 Calibration Wizard channel results for the 38 kHz calibration at 2.048 ms in continuous wave (CW) mode.

38 kHz (FM): 1.024 ms

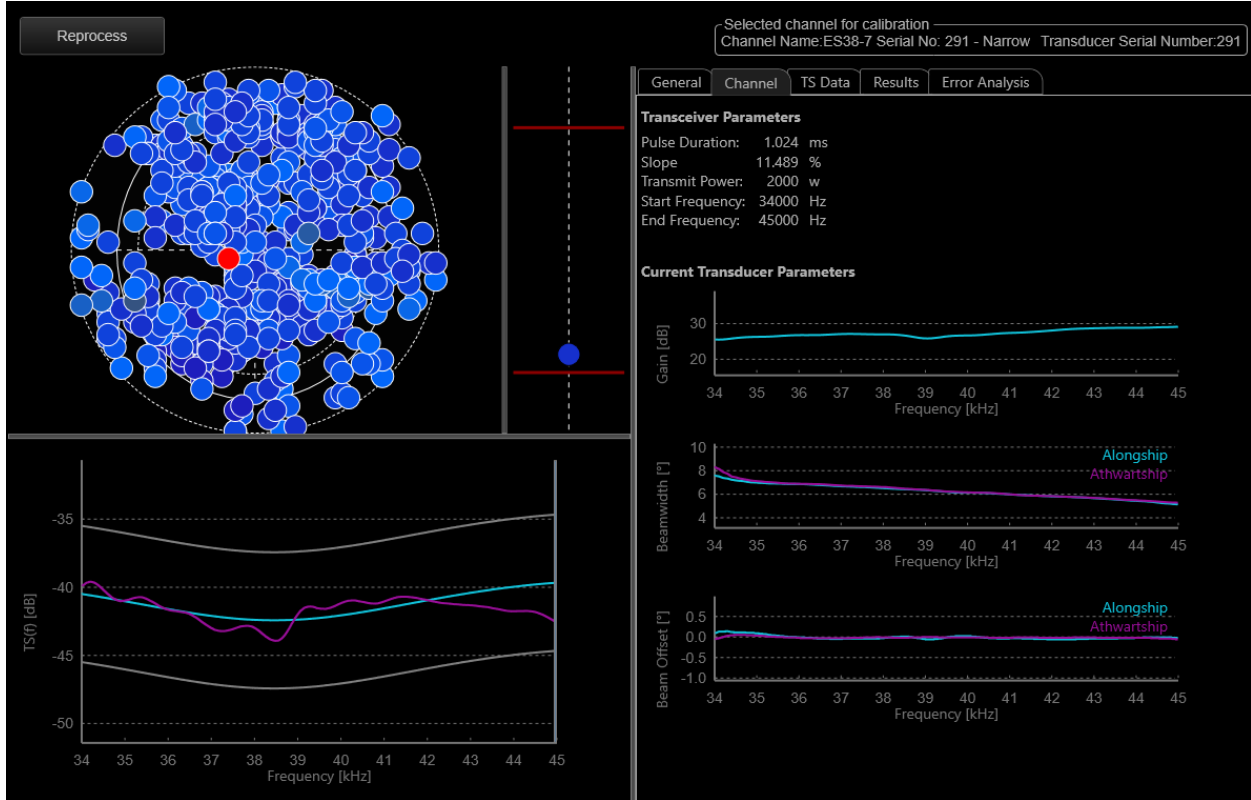


Figure 5. Screenshot of EK80 Calibration Wizard channel results for the 38 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

70 kHz (CW): 1.024 ms

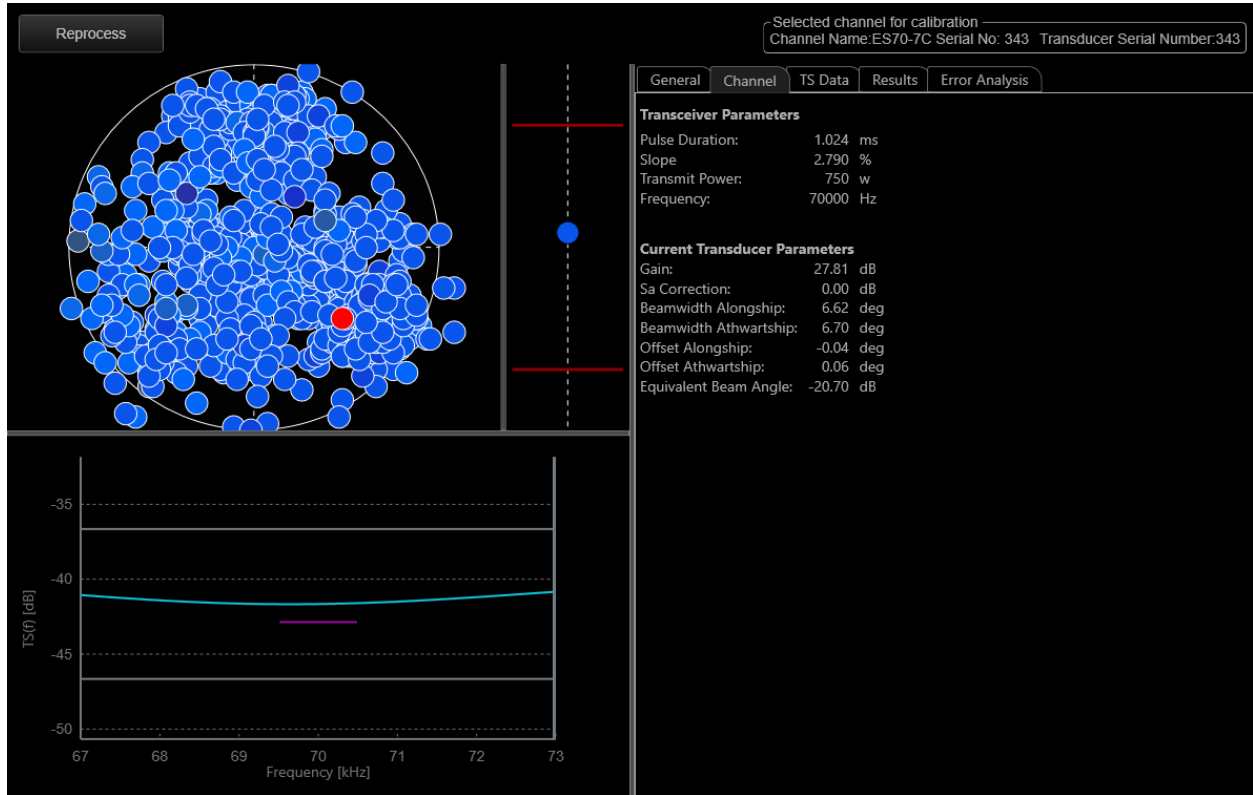


Figure 6. Screenshot of EK80 Calibration Wizard channel results for the 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

120 kHz: 1.024 ms

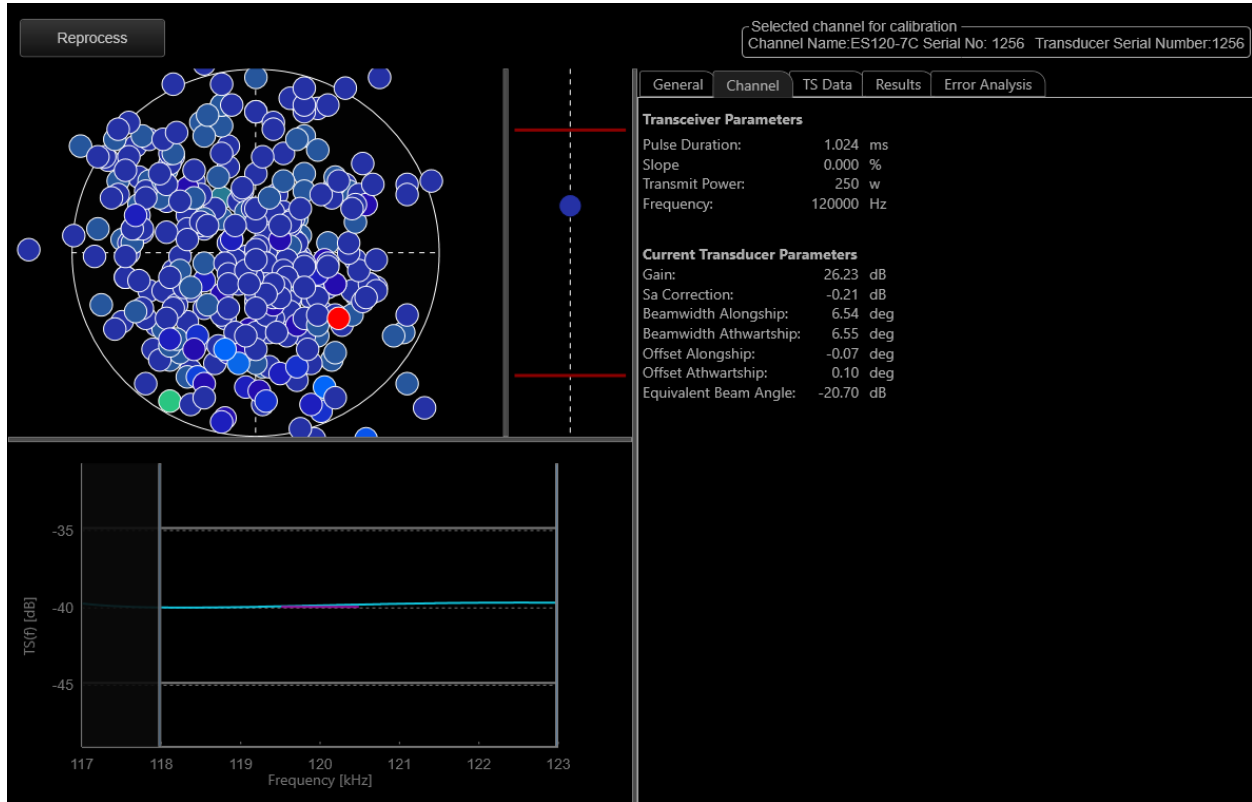


Figure 7. Screenshot of EK80 Calibration Wizard channel results for the 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

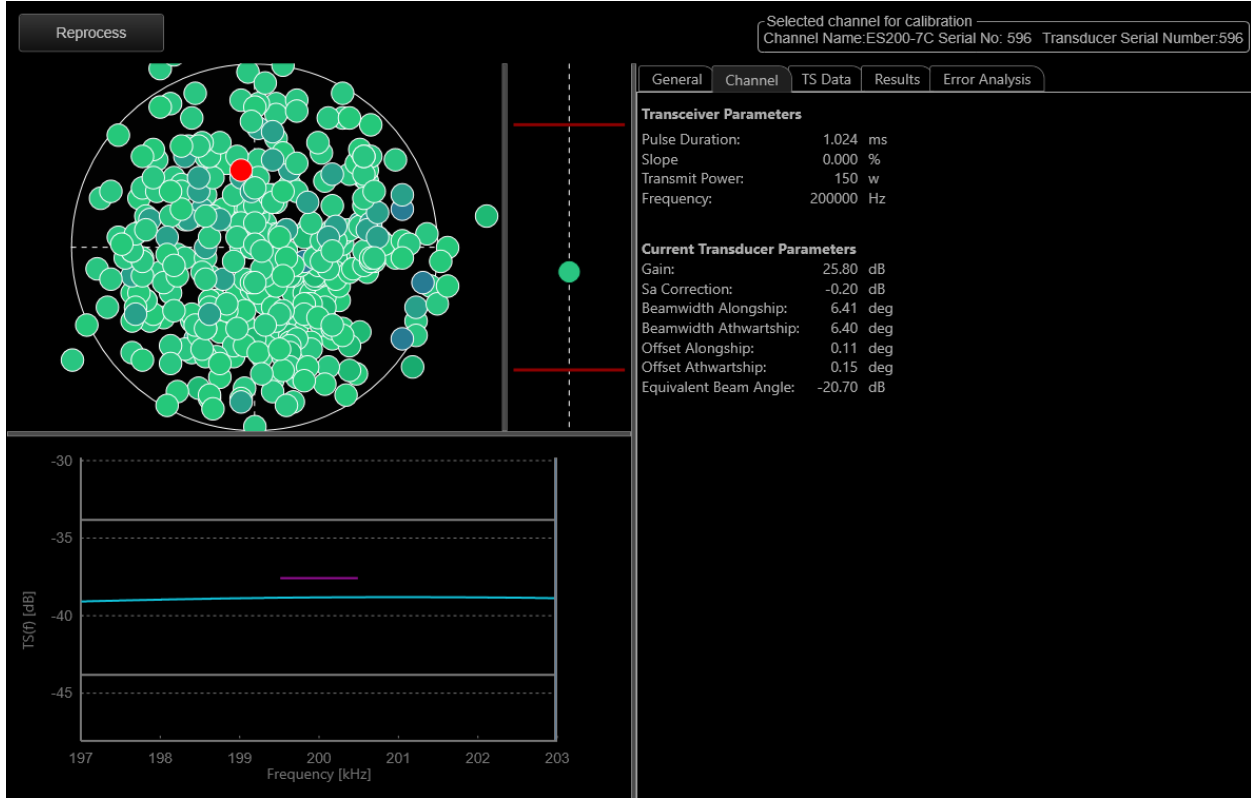


Figure 8. Screenshot of EK80 Calibration Wizard channel results for the 200 kHz calibration at 1.024 ms.

Appendix B: General Results

18 kHz: 1.024 ms

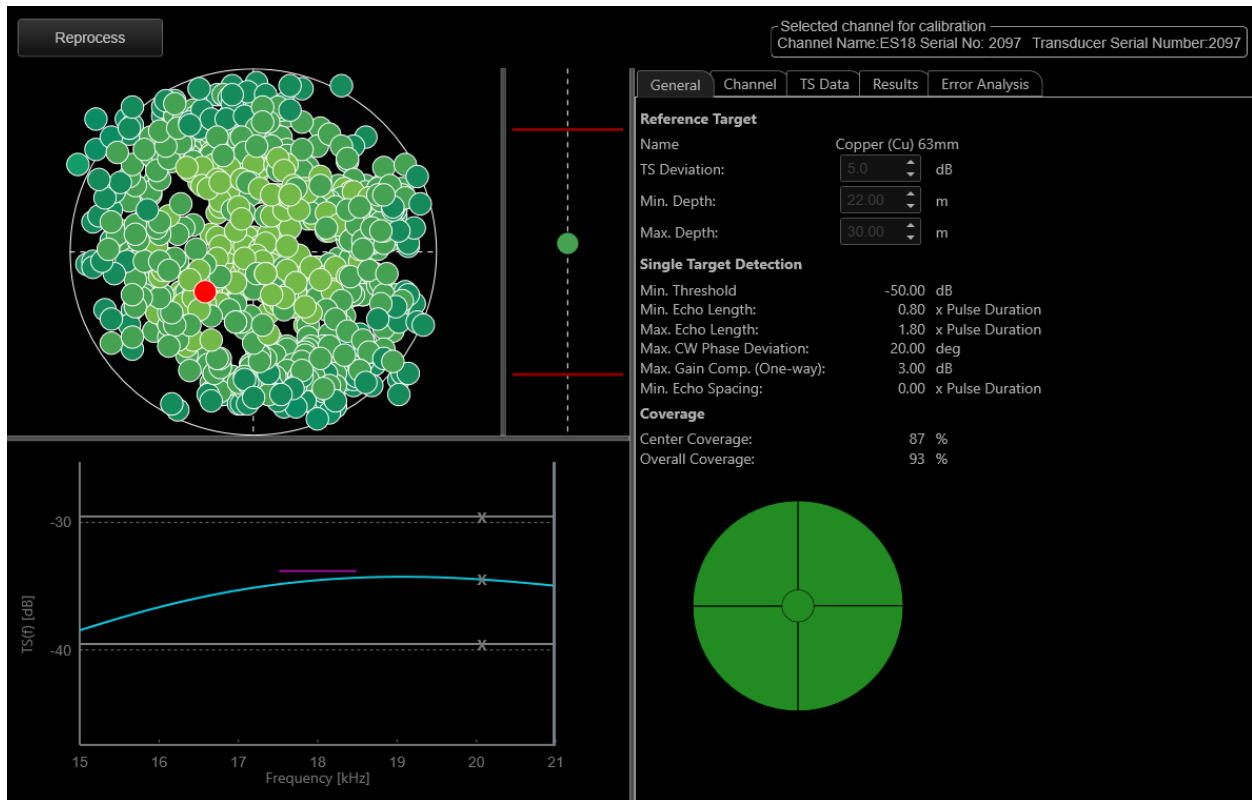


Figure 9. Screenshot of EK80 Calibration Wizard general results for the 18 kHz calibration at 1.024 ms in continuous wave (CW) mode.

18 kHz (CW): 2.048 ms

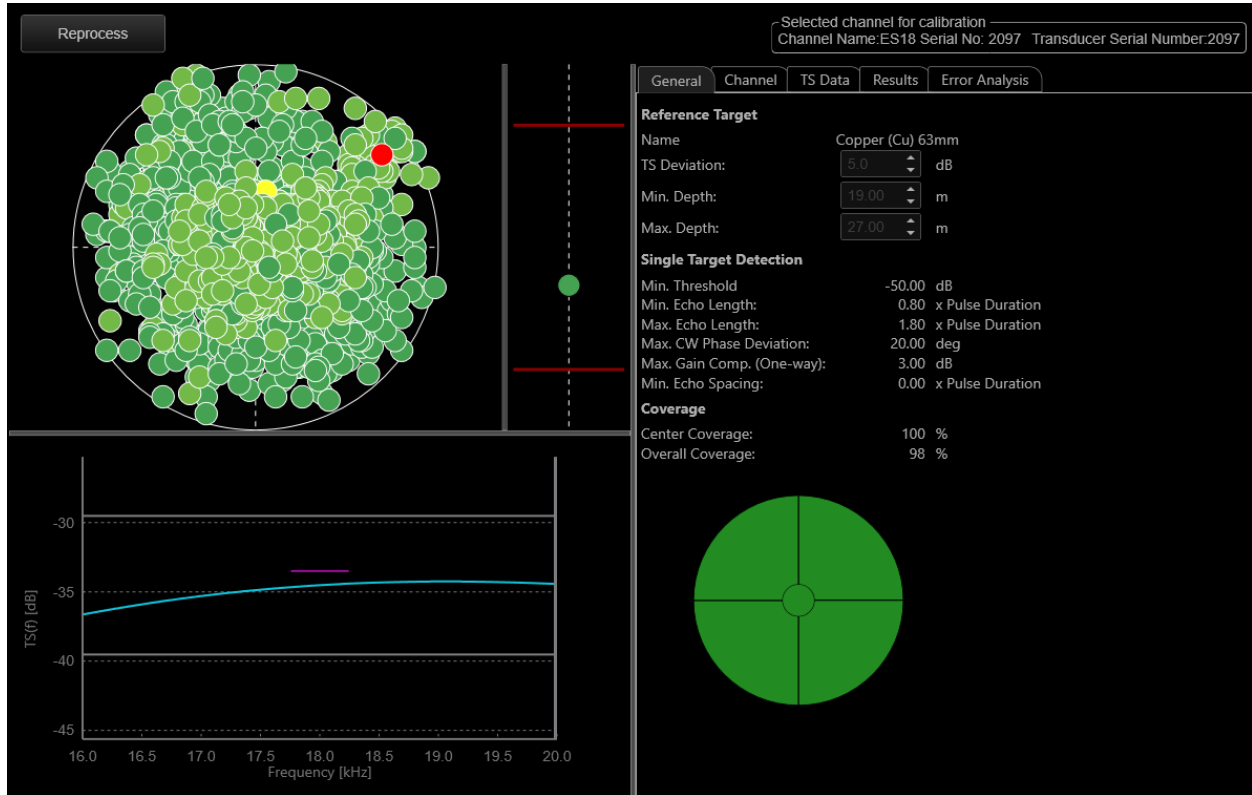


Figure 10. Screenshot of EK80 Calibration Wizard general results for the 18 kHz calibration at 2.048 ms in continuous wave (CW) mode.

38 kHz (CW): 1.024 ms

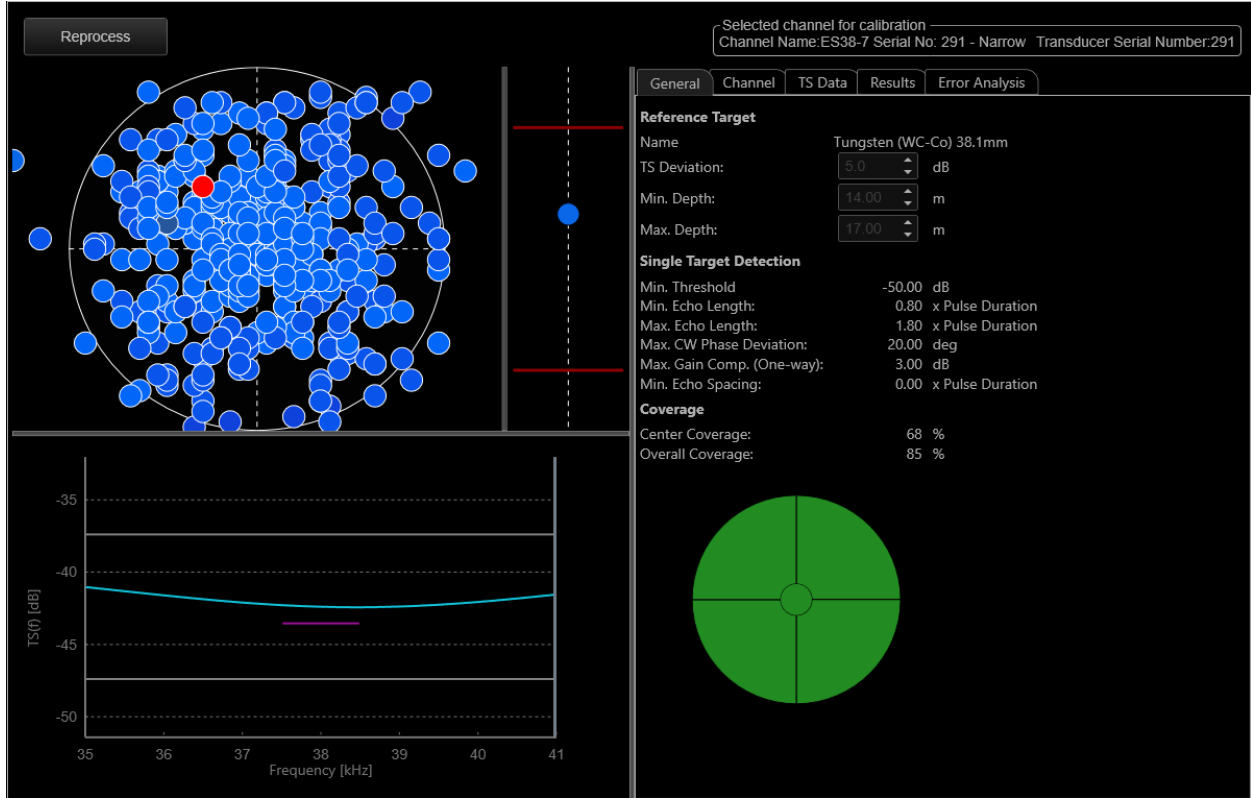


Figure 11. Screenshot of EK80 Calibration Wizard general results for the 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

38 kHz (CW): 2.048 ms

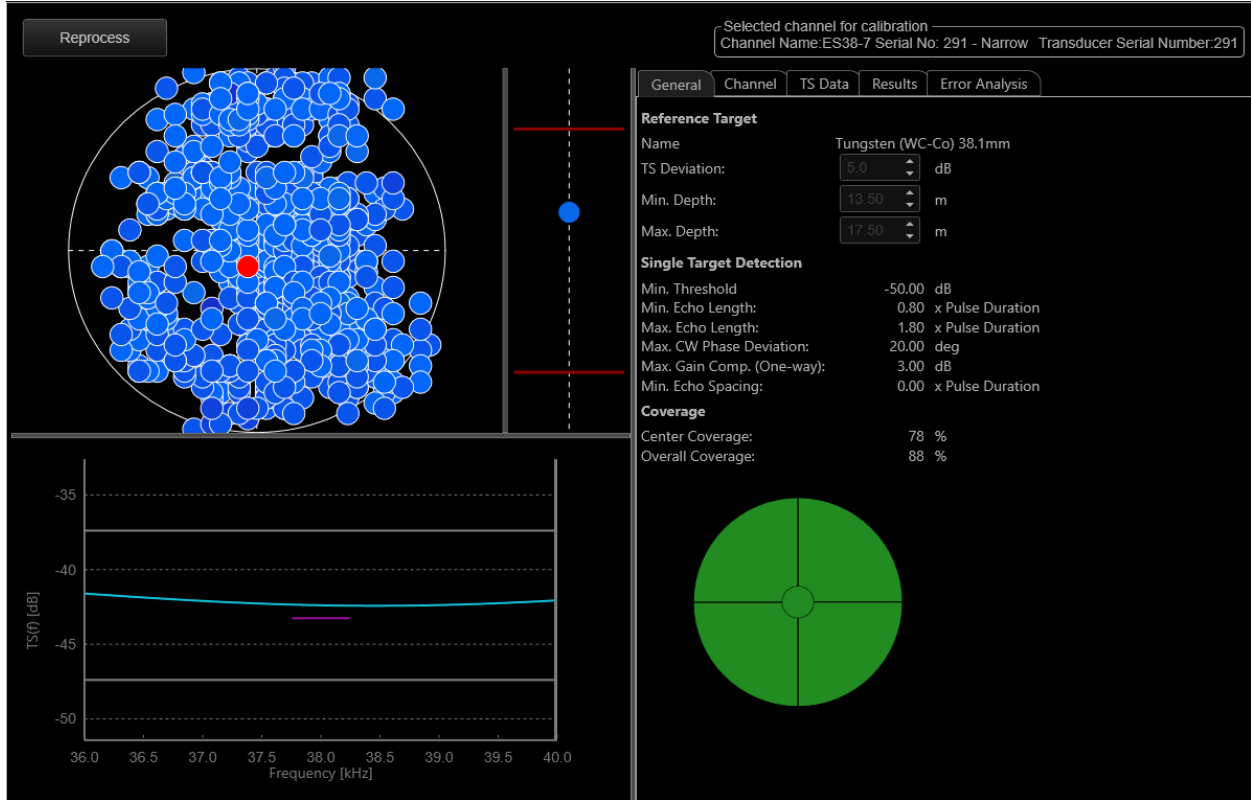


Figure 12. Screenshot of EK80 Calibration Wizard general results for the 38 kHz calibration at 2.048 ms in continuous wave (CW) mode.

38 kHz (FM): 1.024 ms

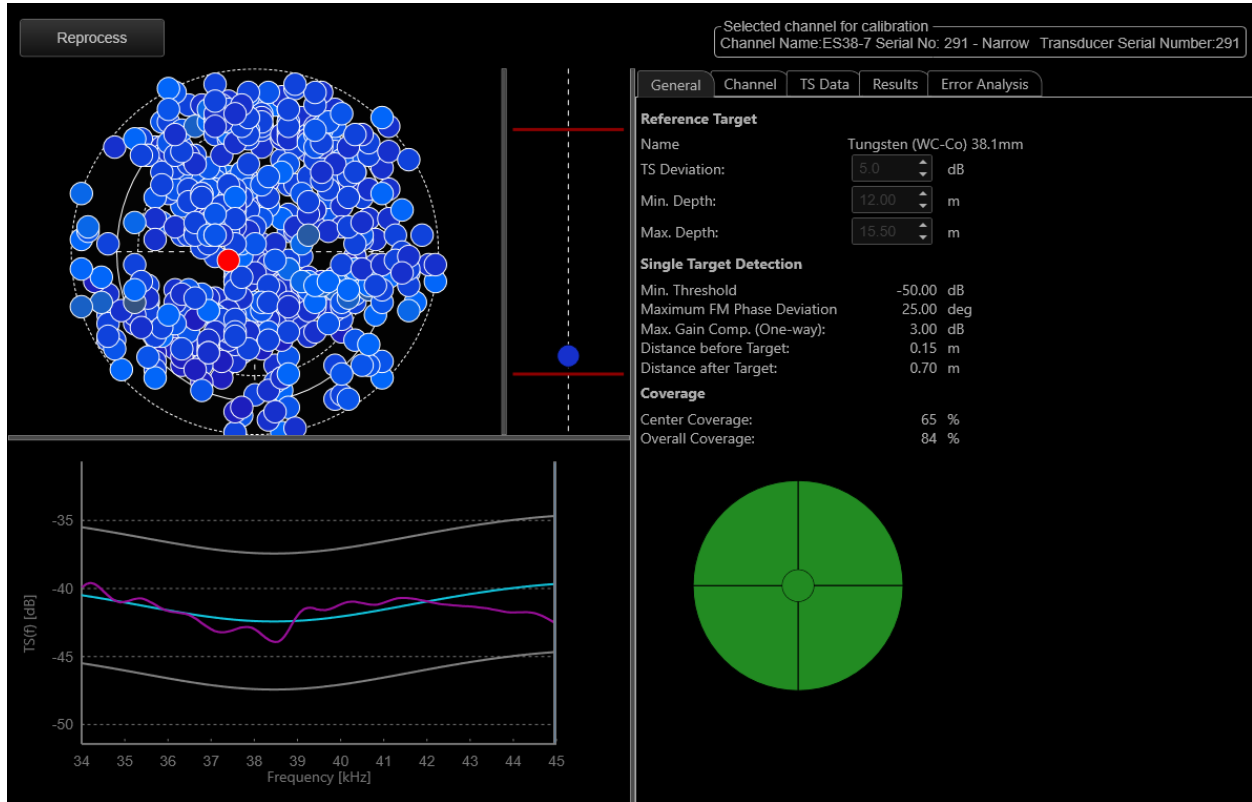


Figure 13. Screenshot of EK80 Calibration Wizard general results for the 38 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

70 kHz (CW): 1.024 ms

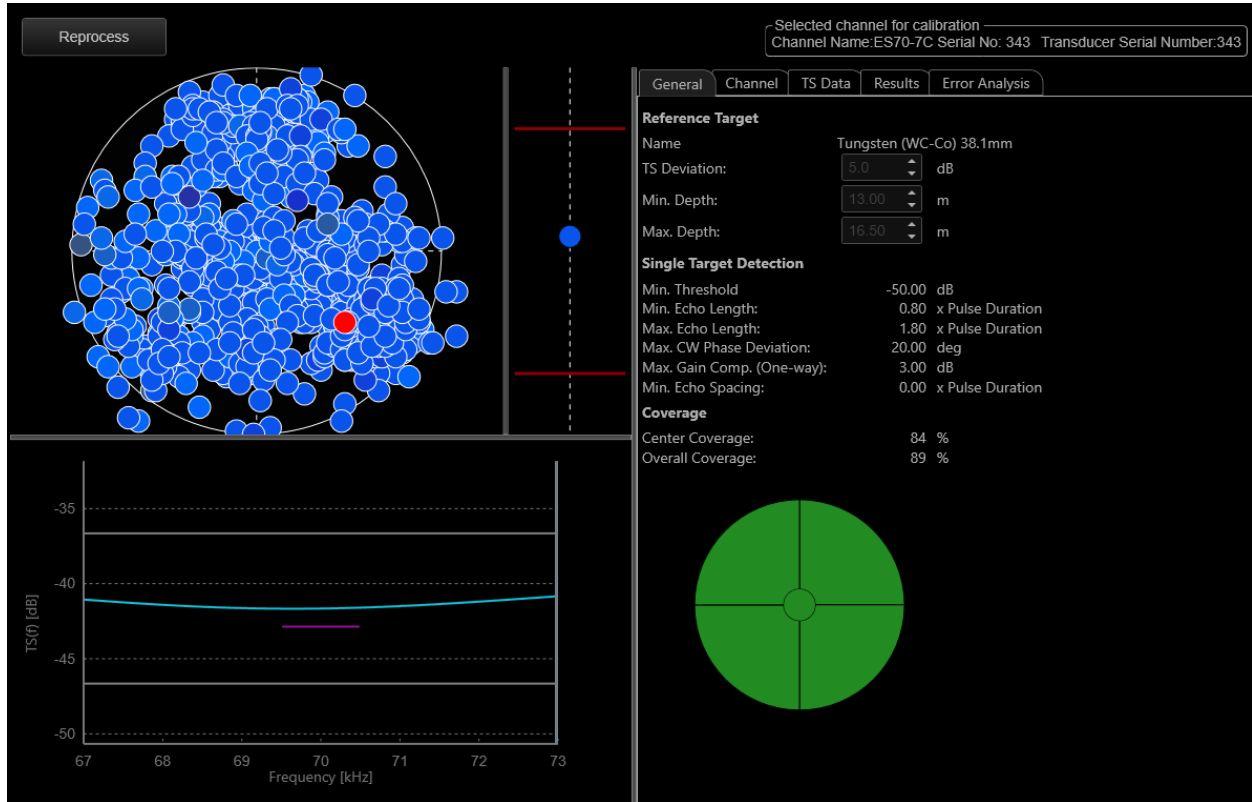


Figure 14. Screenshot of EK80 Calibration Wizard general results for the 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

120 kHz: 1.024 ms

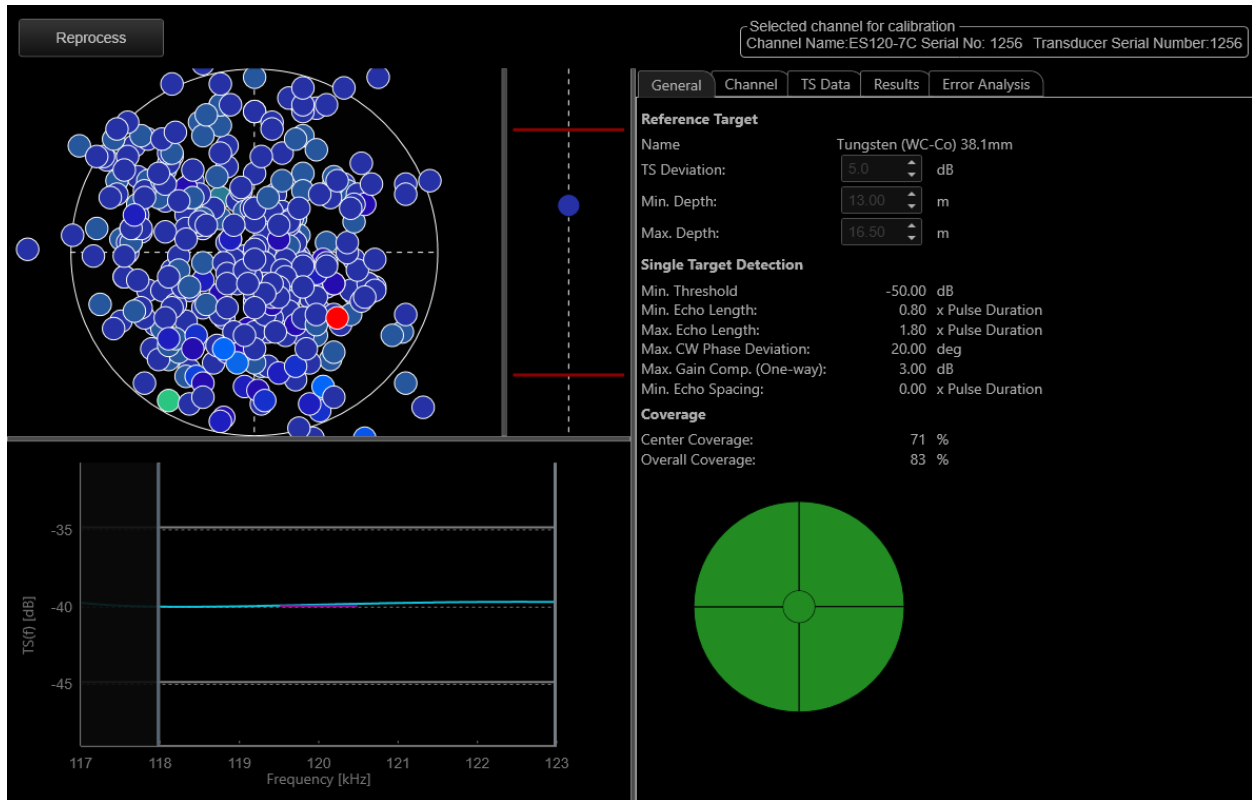


Figure 15. Screenshot of EK80 Calibration Wizard general results for the 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

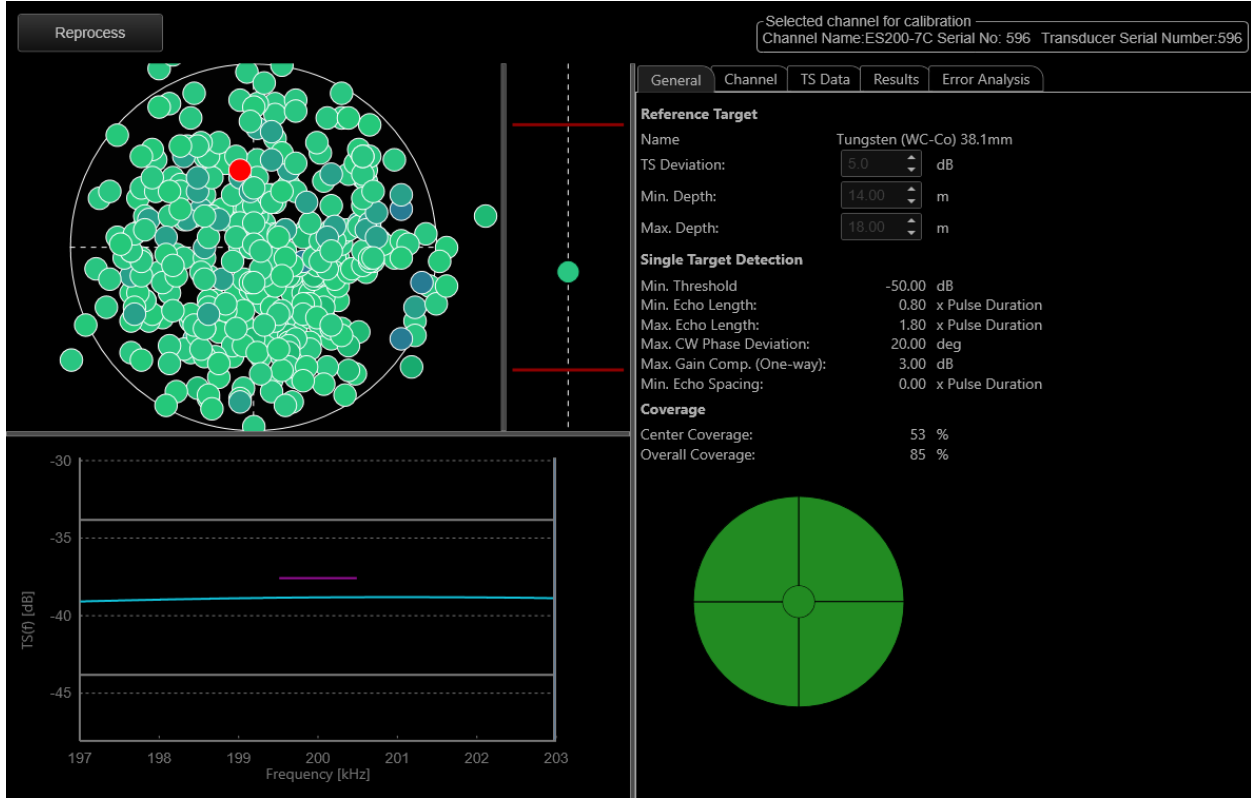


Figure 16. Screenshot of EK80 Calibration Wizard general results for the 200 kHz calibration at 1.024 ms.

Appendix C: TS Results

18 kHz: 1.024 ms

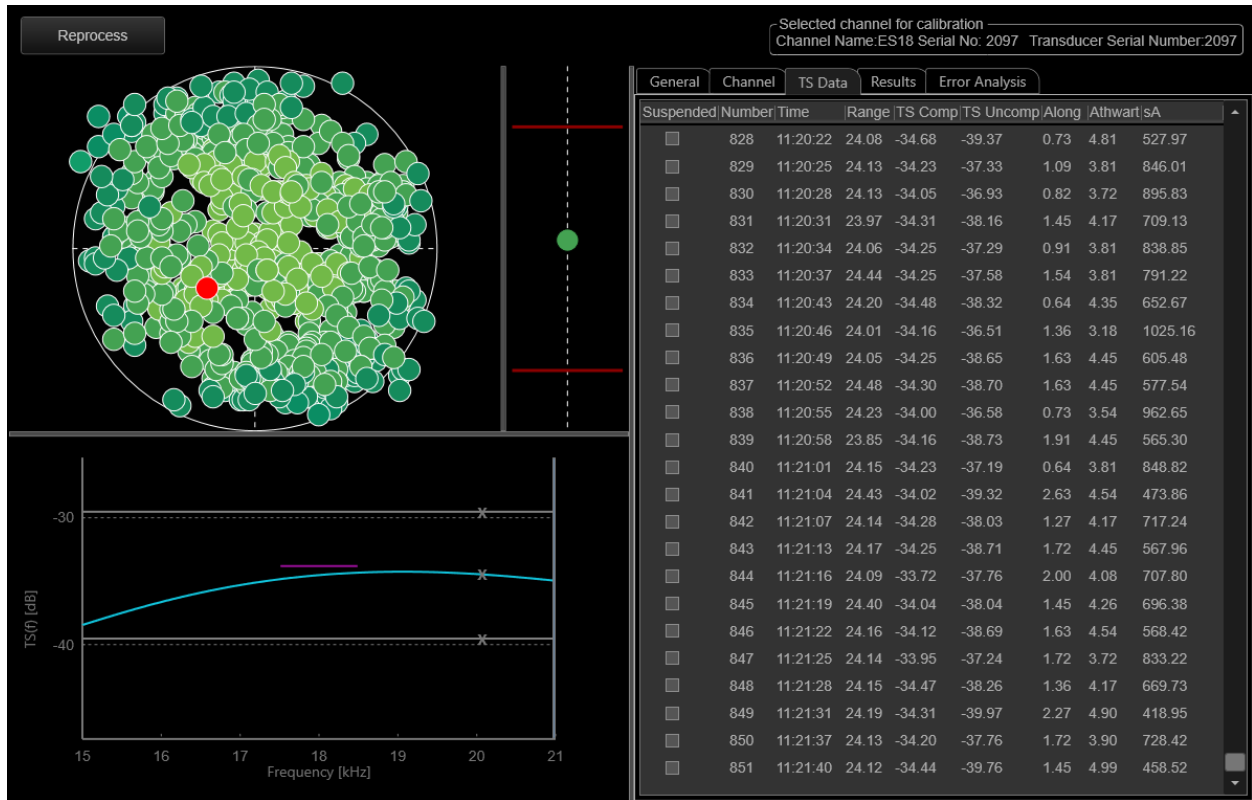


Figure 17. Screenshot of EK80 Calibration Wizard general results for the 18 kHz calibration at 1.024 ms.

18 kHz: 2.048 ms

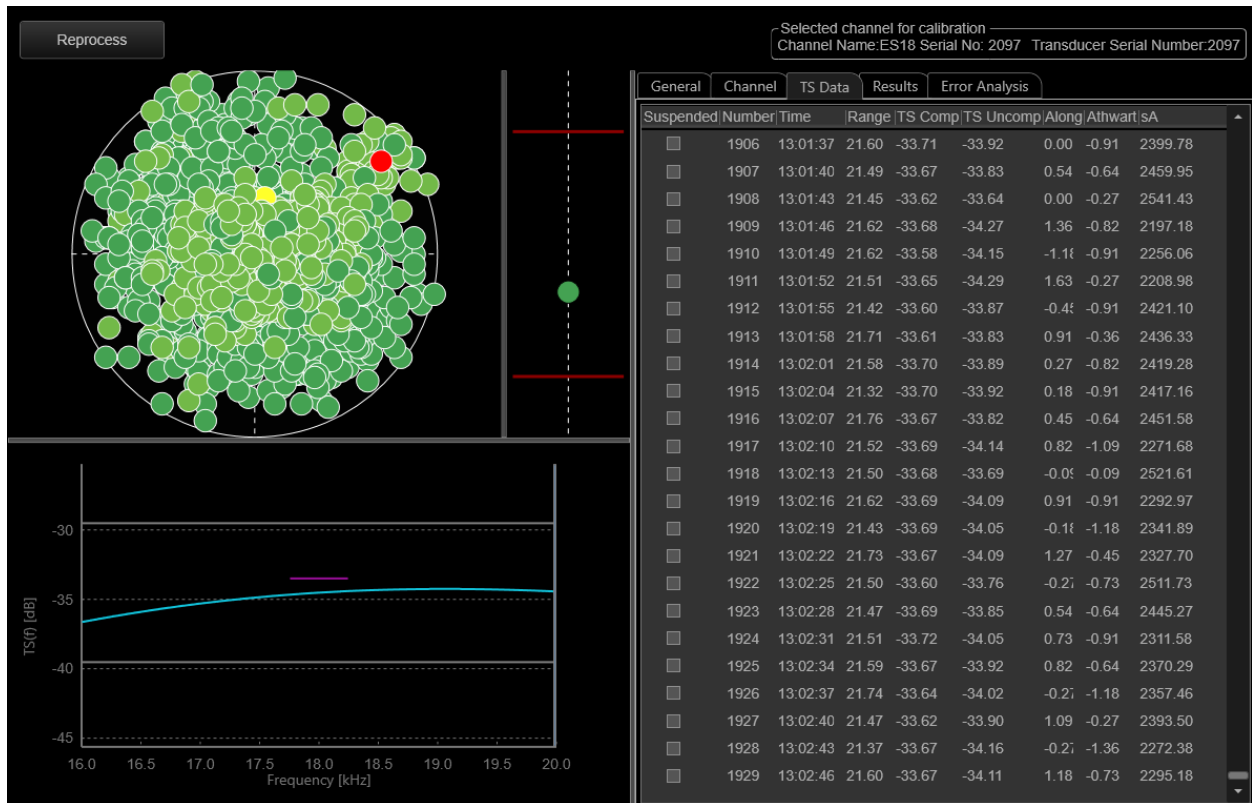


Figure 18. Screenshot of EK80 Calibration Wizard general results for the 18 kHz calibration at 2.048 ms.

38 kHz (CW): 1.024 ms

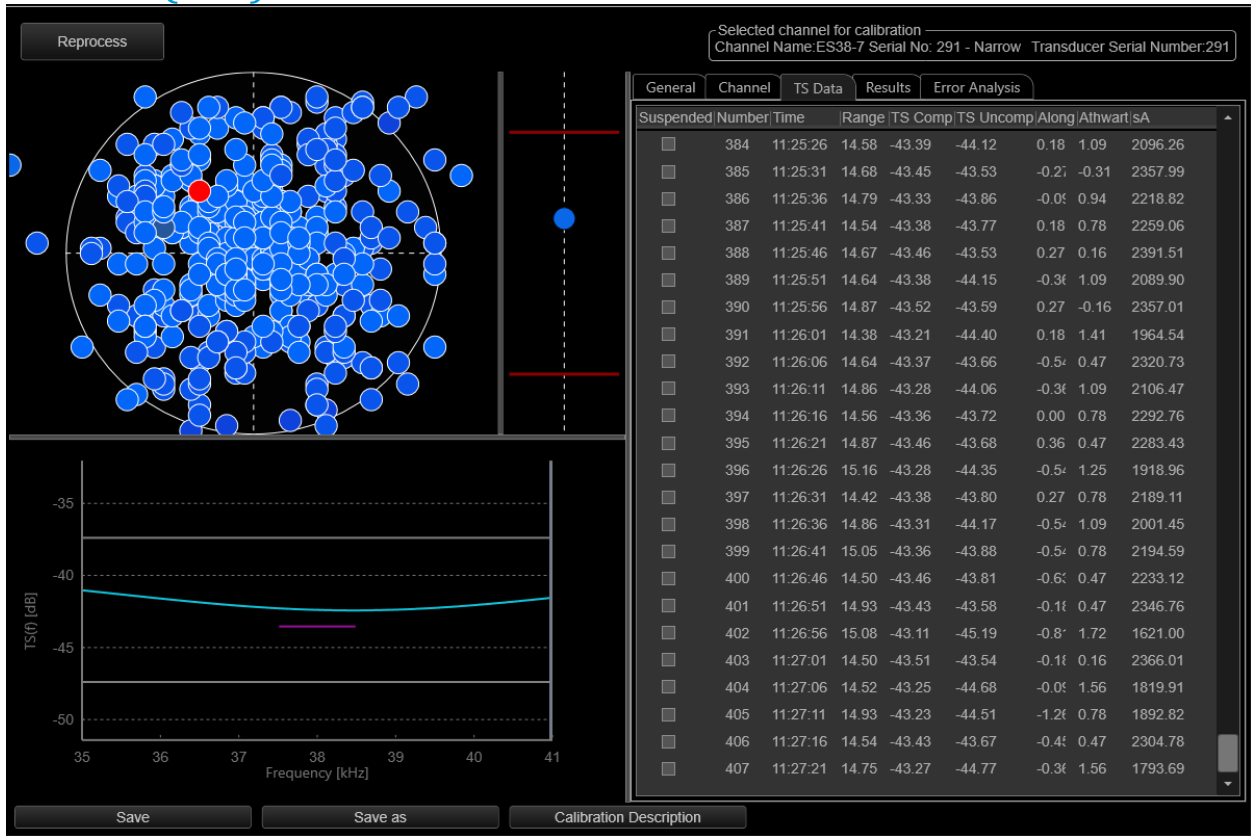


Figure 19. Screenshot of EK80 Calibration Wizard general results for the 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

38 kHz (CW): 2.048 ms

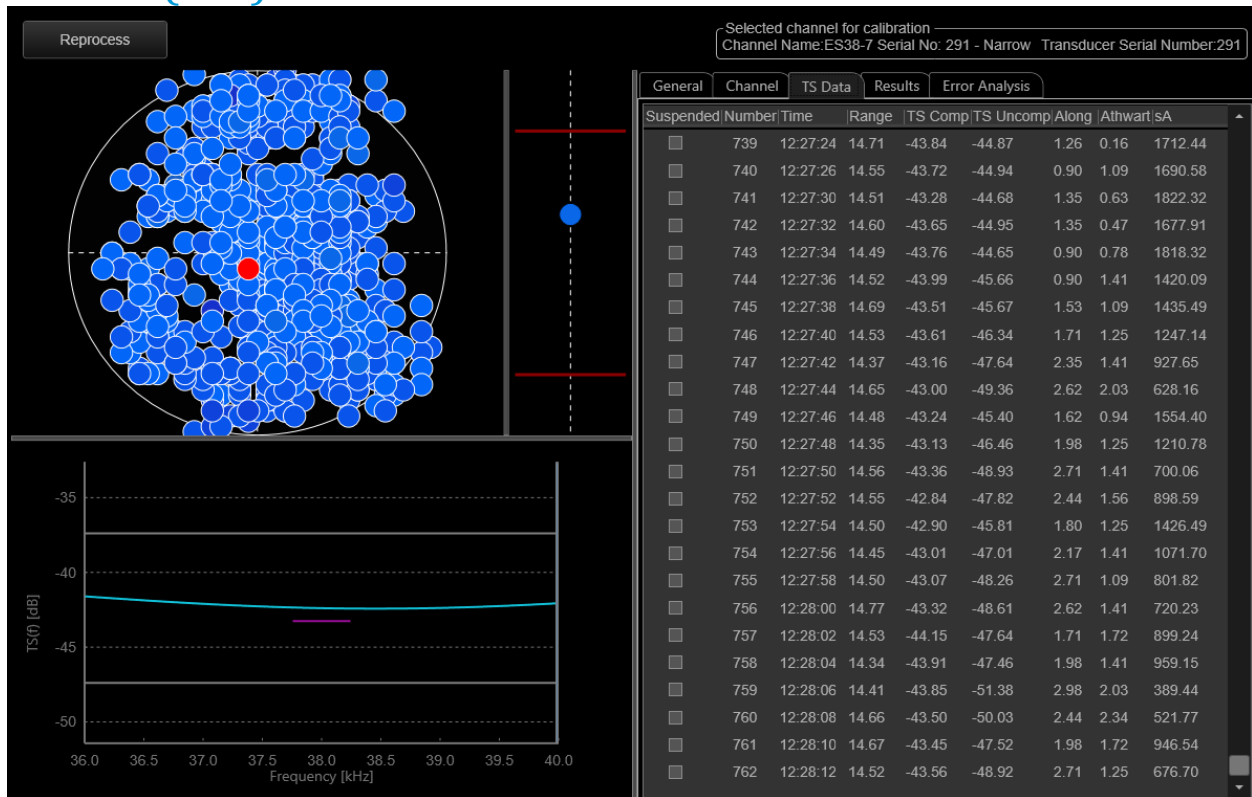


Figure 20. Screenshot of EK80 Calibration Wizard general results for the 38 kHz calibration at 2.048 ms in continuous wave (CW) mode.

38 kHz (FM): 1.024 ms

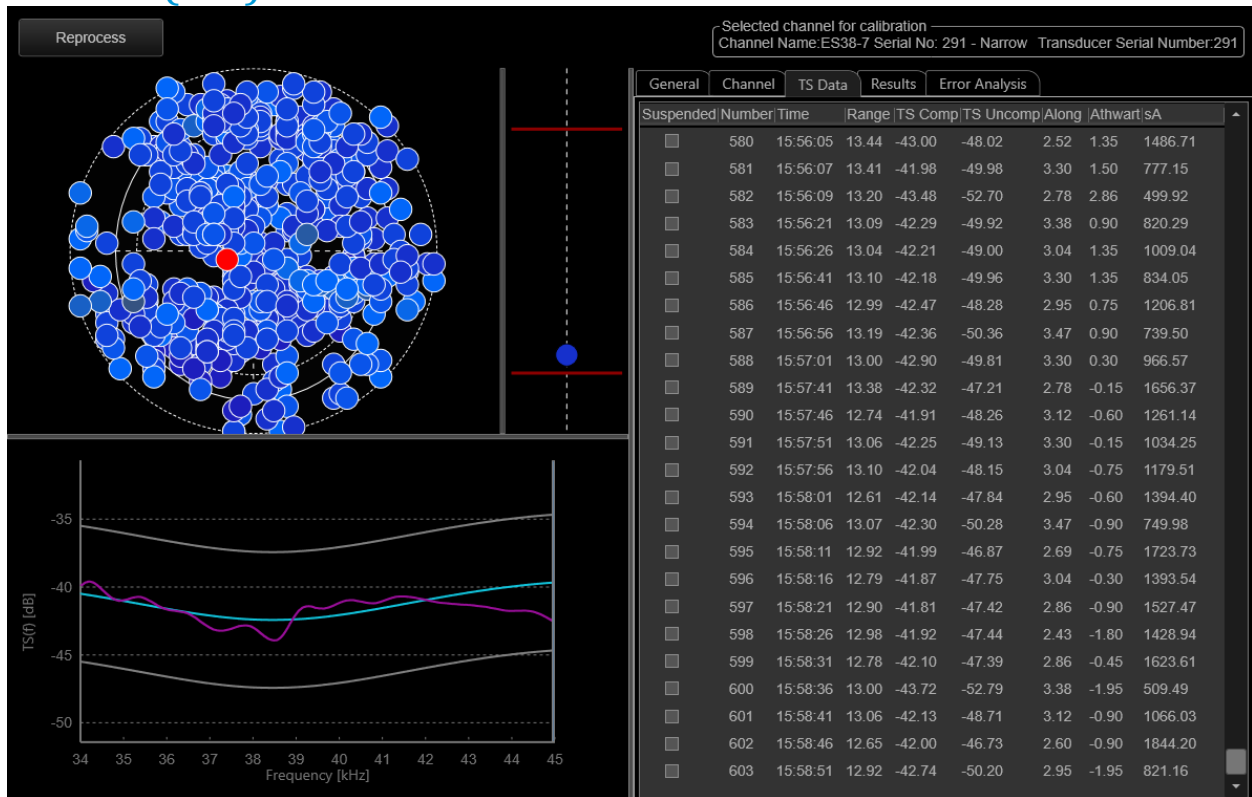


Figure 21. Screenshot of EK80 Calibration Wizard general results for the 38 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

70 kHz (CW): 1.024 ms

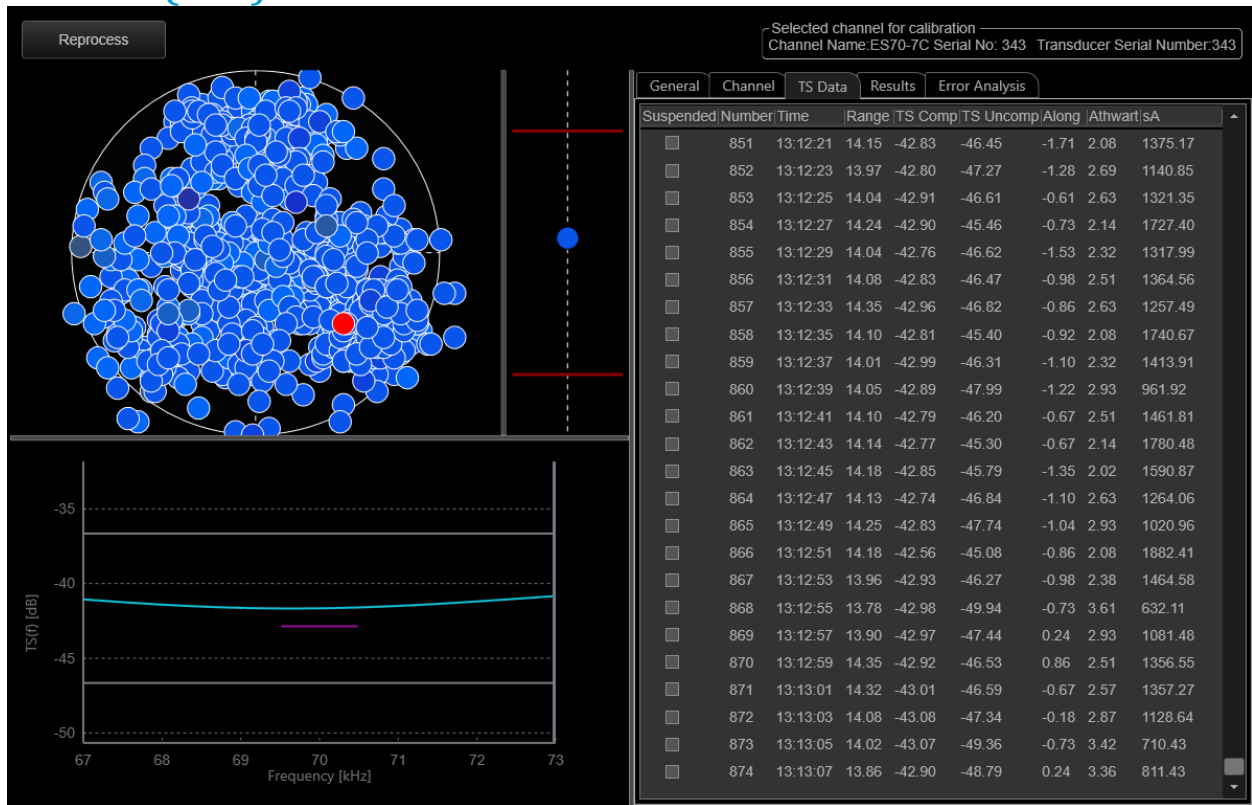


Figure 22. Screenshot of EK80 Calibration Wizard general results for the 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

120 kHz: 1.024 ms

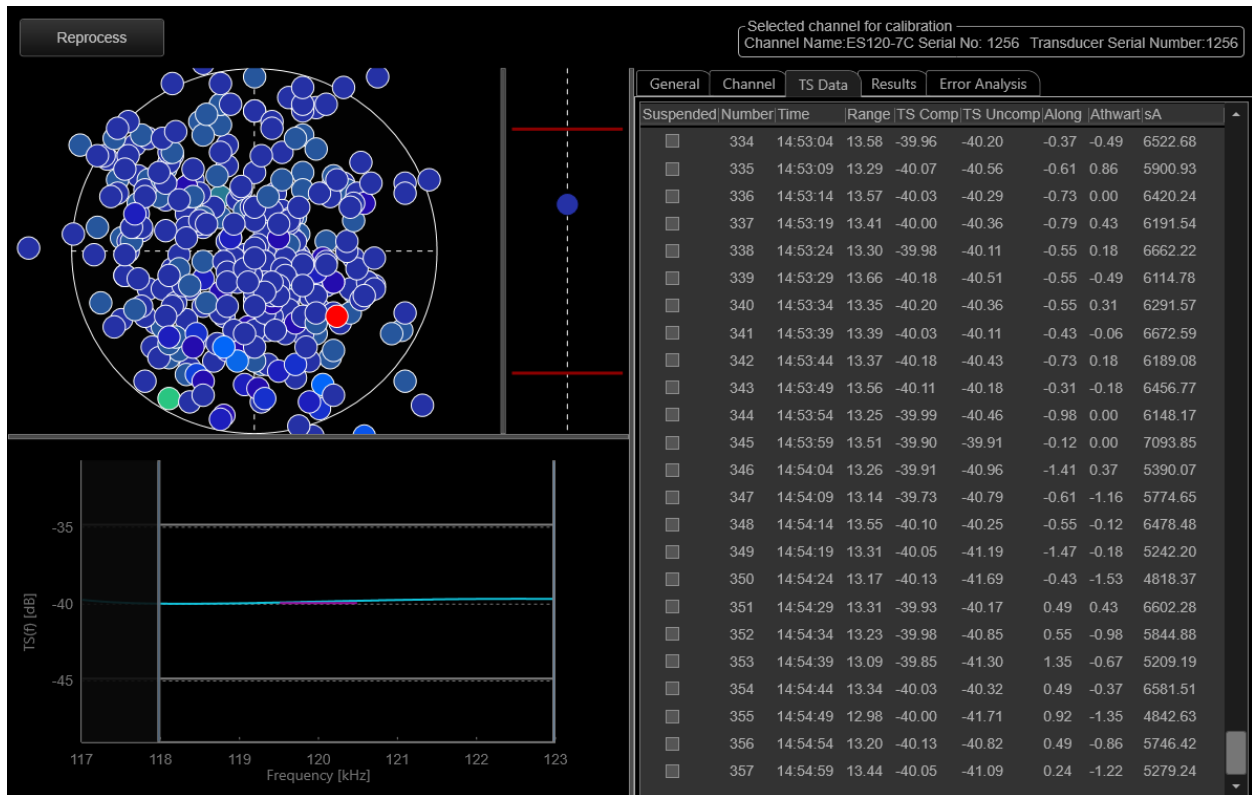


Figure 23. Screenshot of EK80 Calibration Wizard general results for the 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

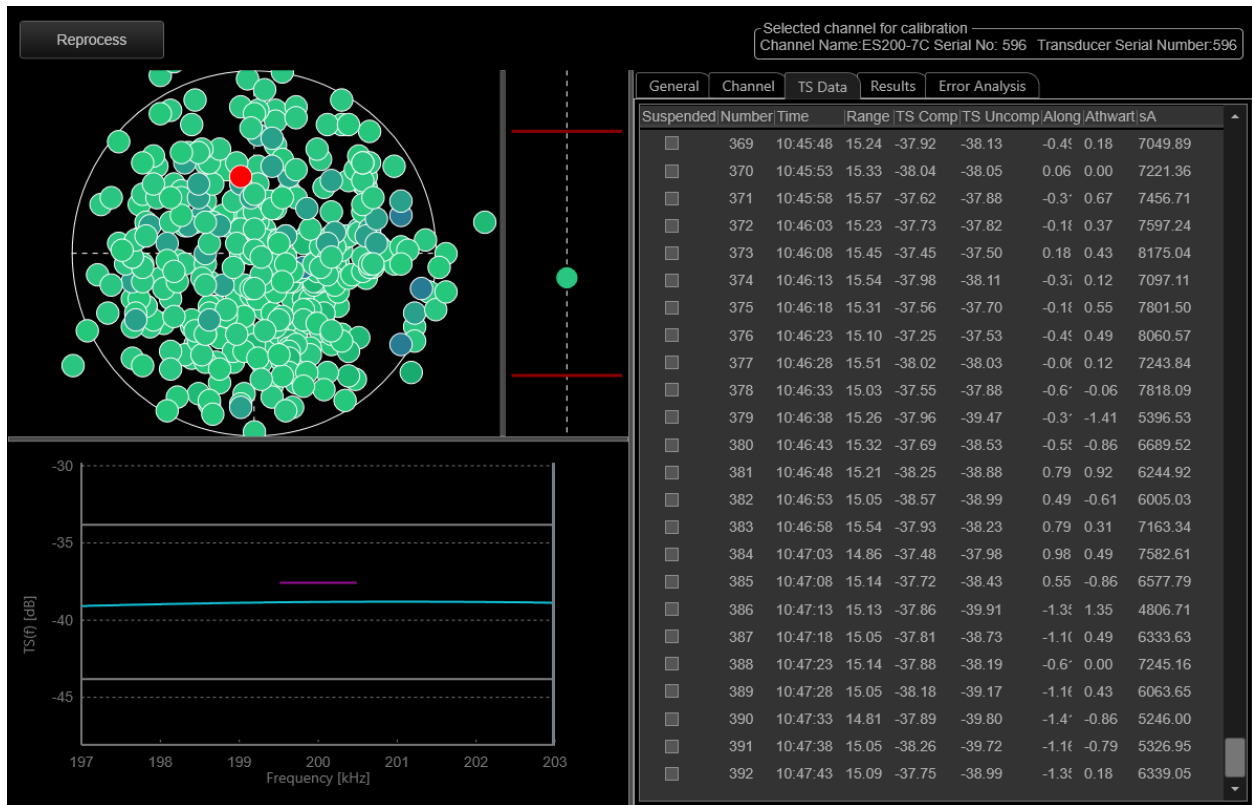


Figure 24. Screenshot of EK80 Calibration Wizard general results for the 200 kHz calibration at 1.024 ms.

Appendix D: Results

18 kHz: 1.024 ms

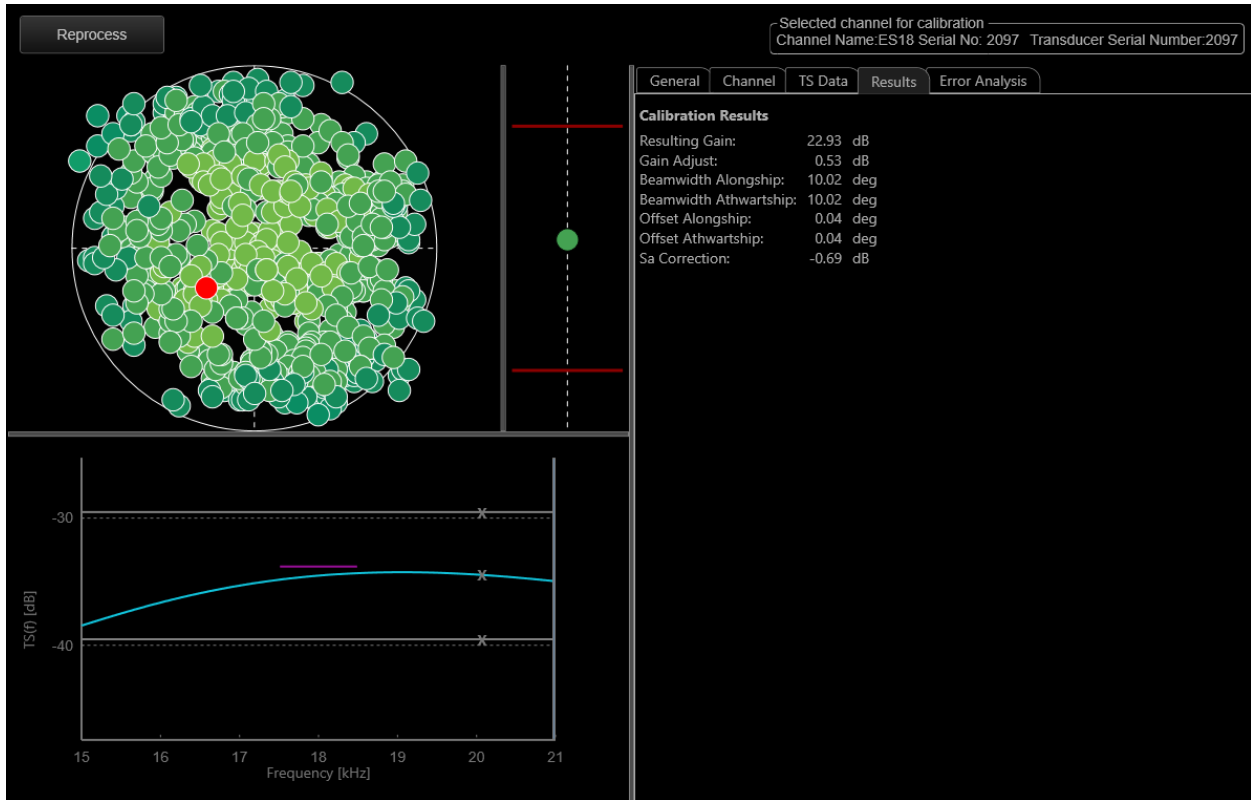


Figure 25. Screenshot of EK80 Calibration Wizard results for the 18 kHz calibration at 1.024 ms.

18 kHz: 2.048 ms

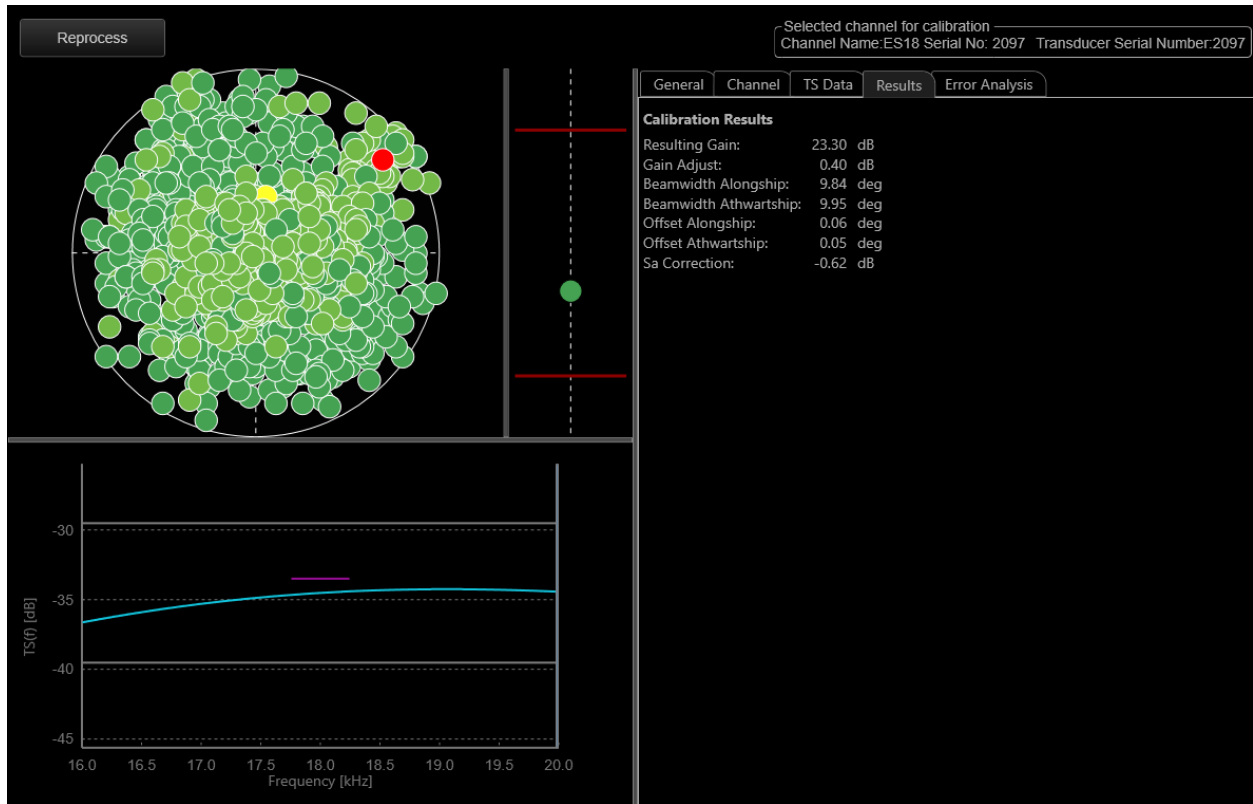


Figure 26. Screenshot of EK80 Calibration Wizard results for the 18 kHz calibration at 2.048 ms.

38 kHz (CW): 1.024 ms

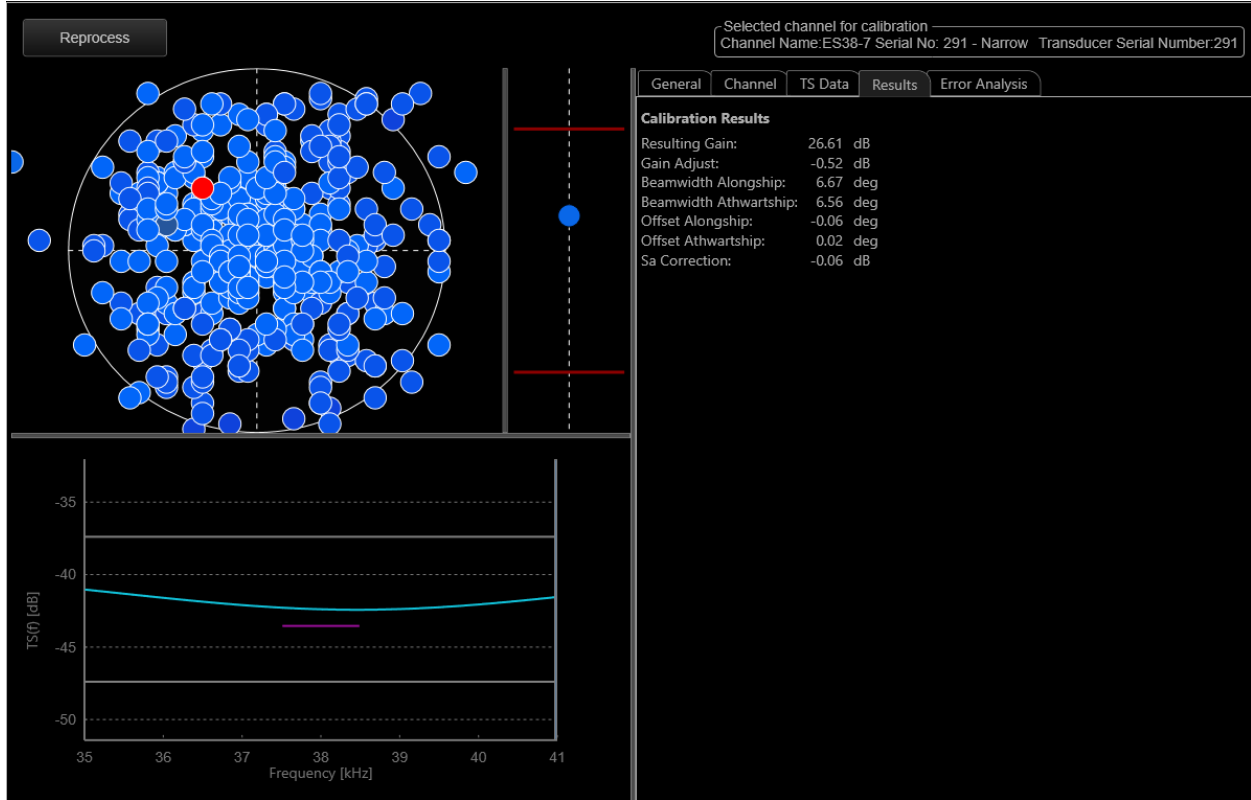


Figure 27. Screenshot of EK80 Calibration Wizard results for the 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

38 kHz (CW): 2.048 ms

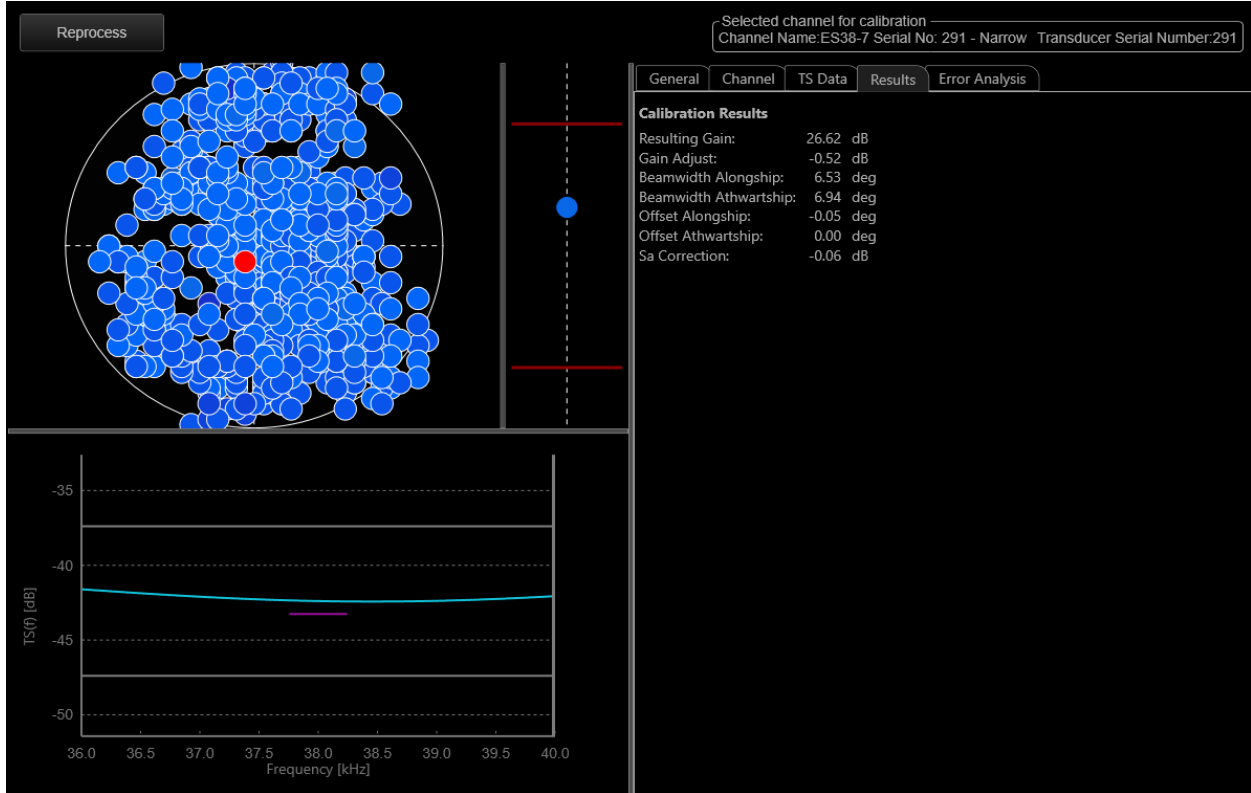


Figure 28. Screenshot of EK80 Calibration Wizard results for the 38 kHz calibration at 2.048 ms in continuous wave (CW) mode.

38 kHz (FM): 1.024 ms

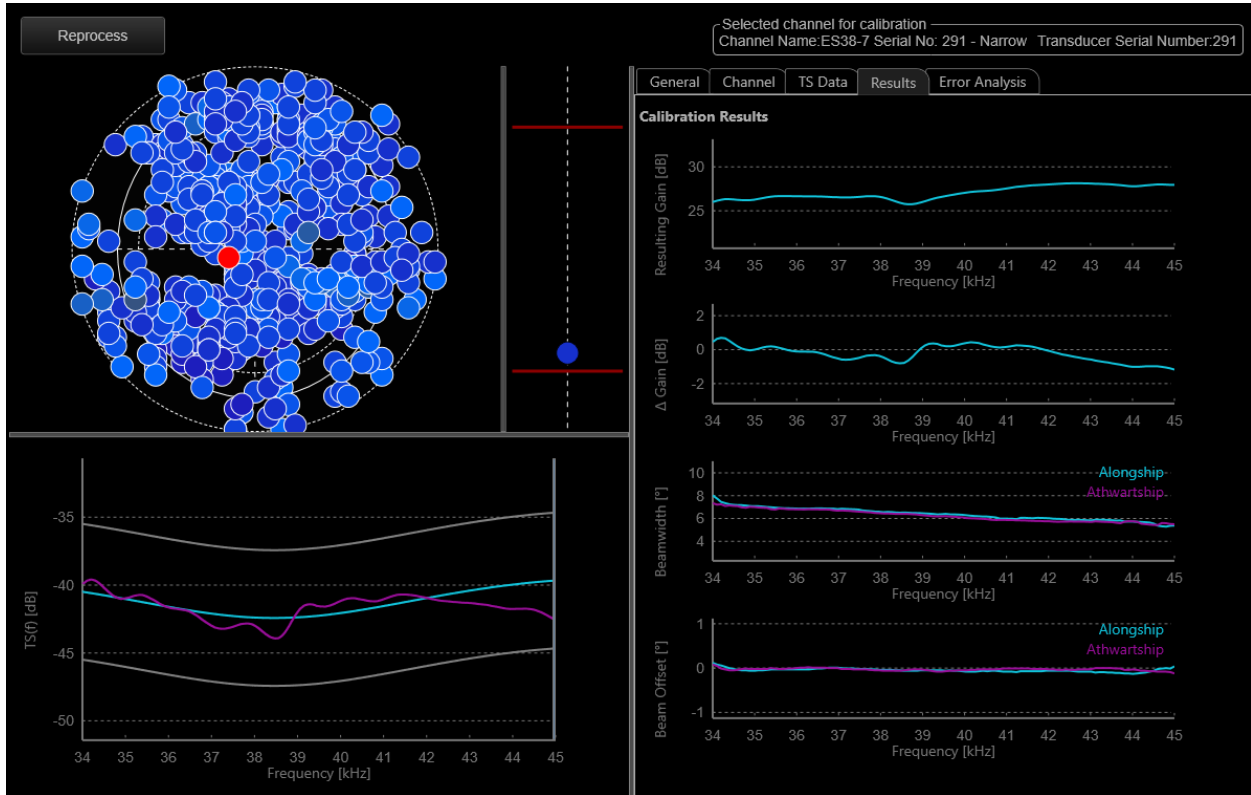


Figure 29. Screenshot of EK80 Calibration Wizard results for the 38 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

70 kHz (CW): 1.024 ms

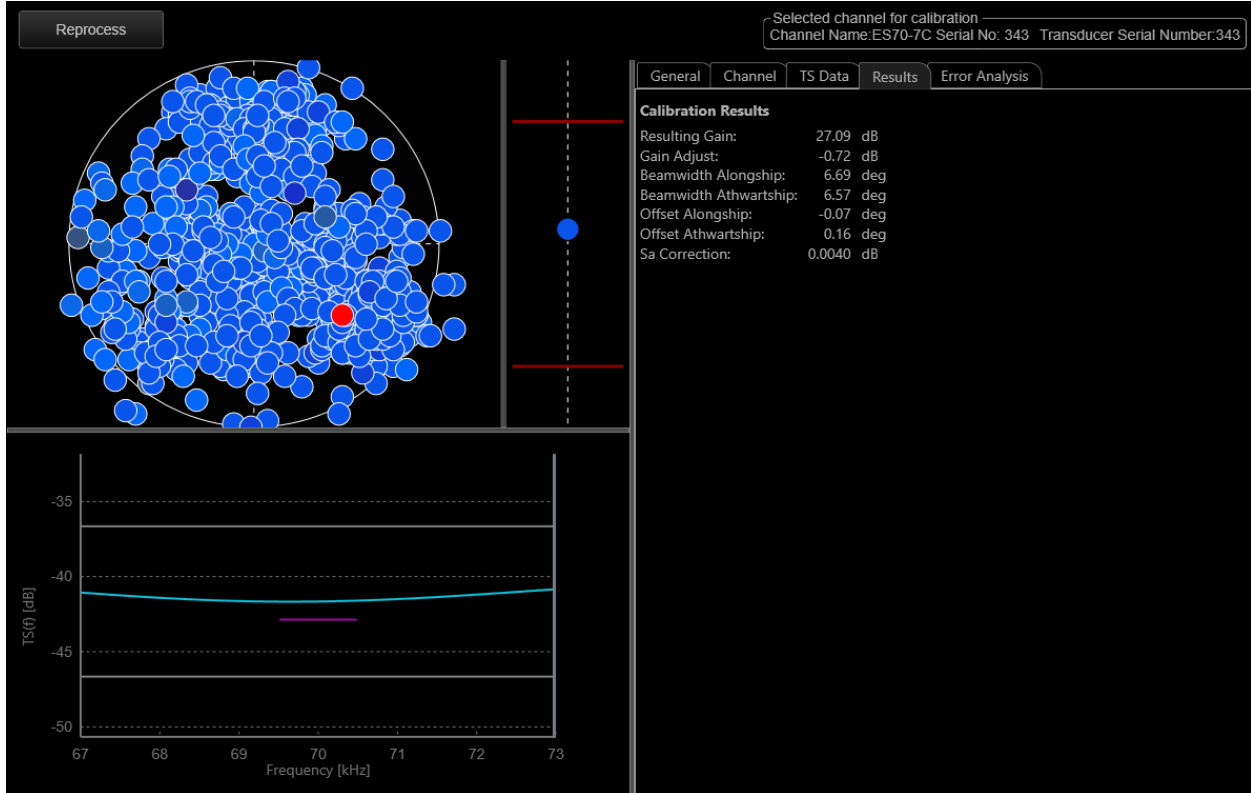


Figure 30. Screenshot of EK80 Calibration Wizard results for the 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

120 kHz: 1.024 ms

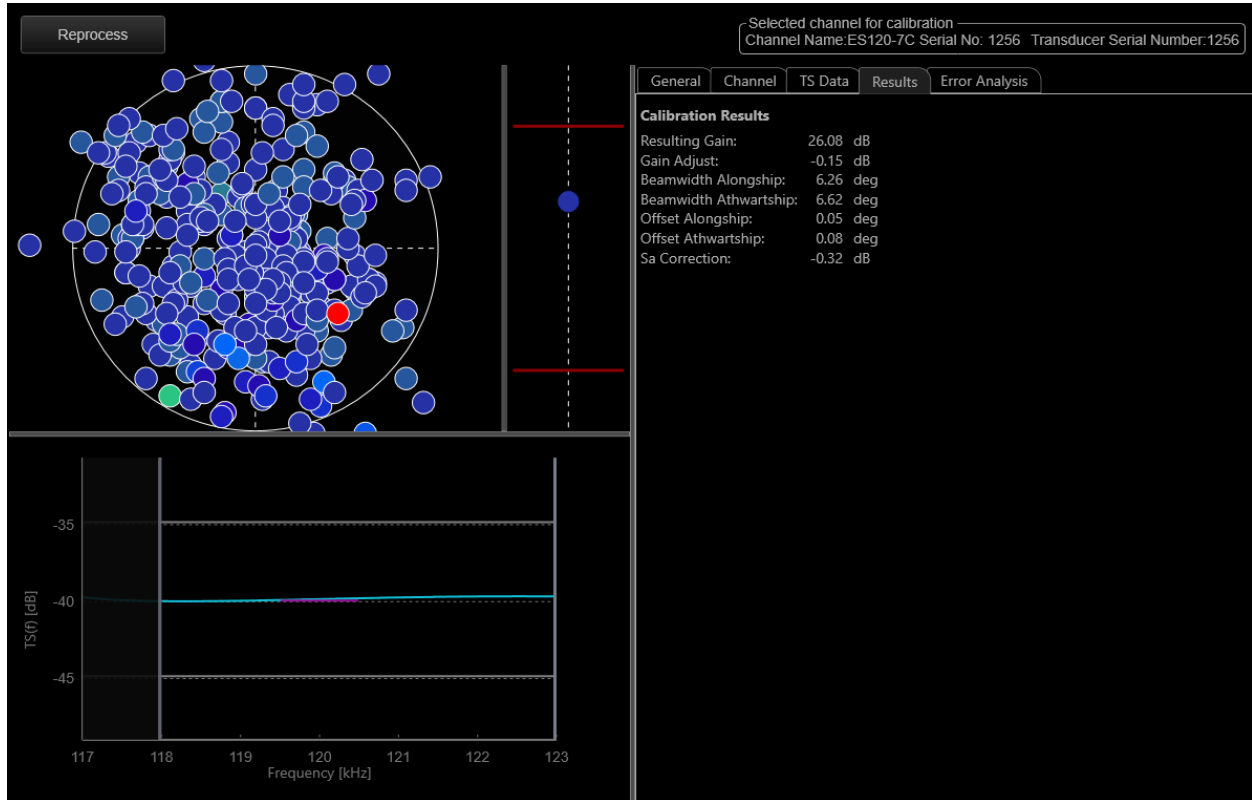


Figure 31. Screenshot of EK80 Calibration Wizard results for the 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

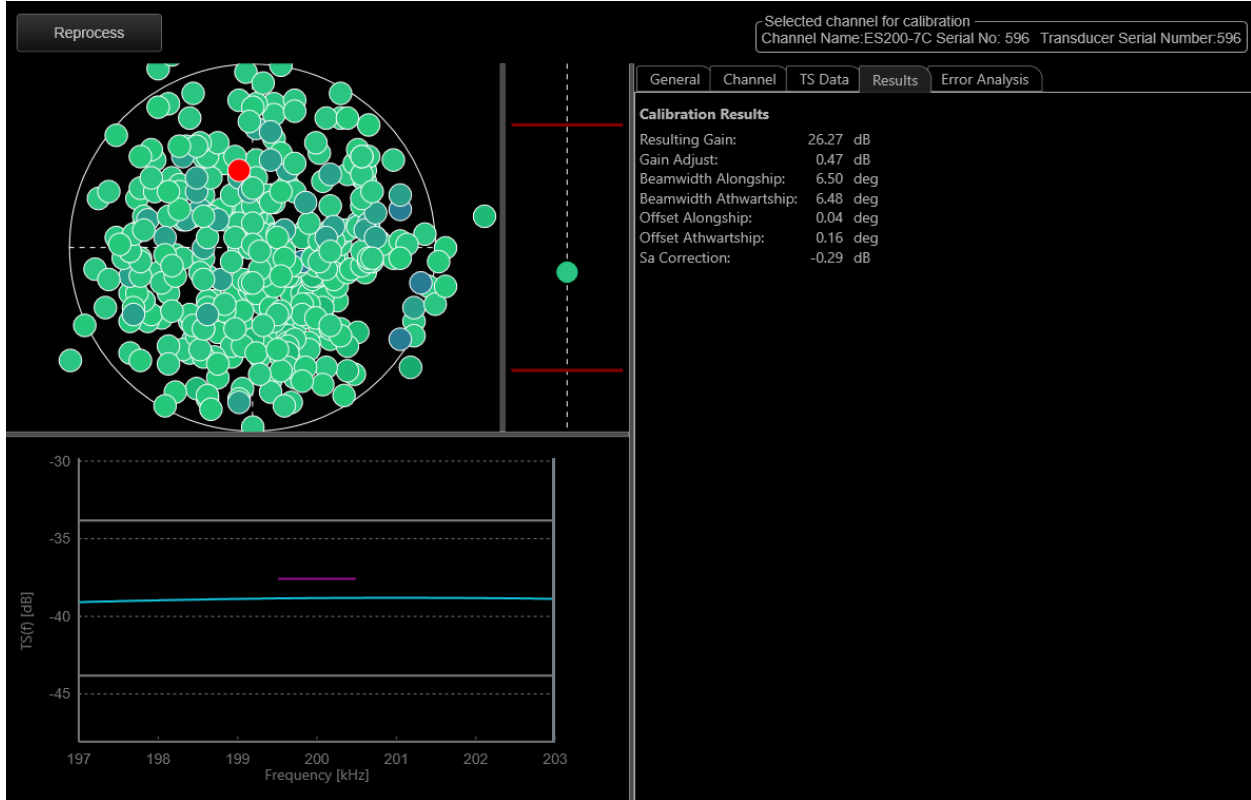


Figure 32. Screenshot of EK80 Calibration Wizard results for the 200 kHz calibration at 1.024 ms.

Appendix E: Error Analysis

18 kHz: 1.024 ms

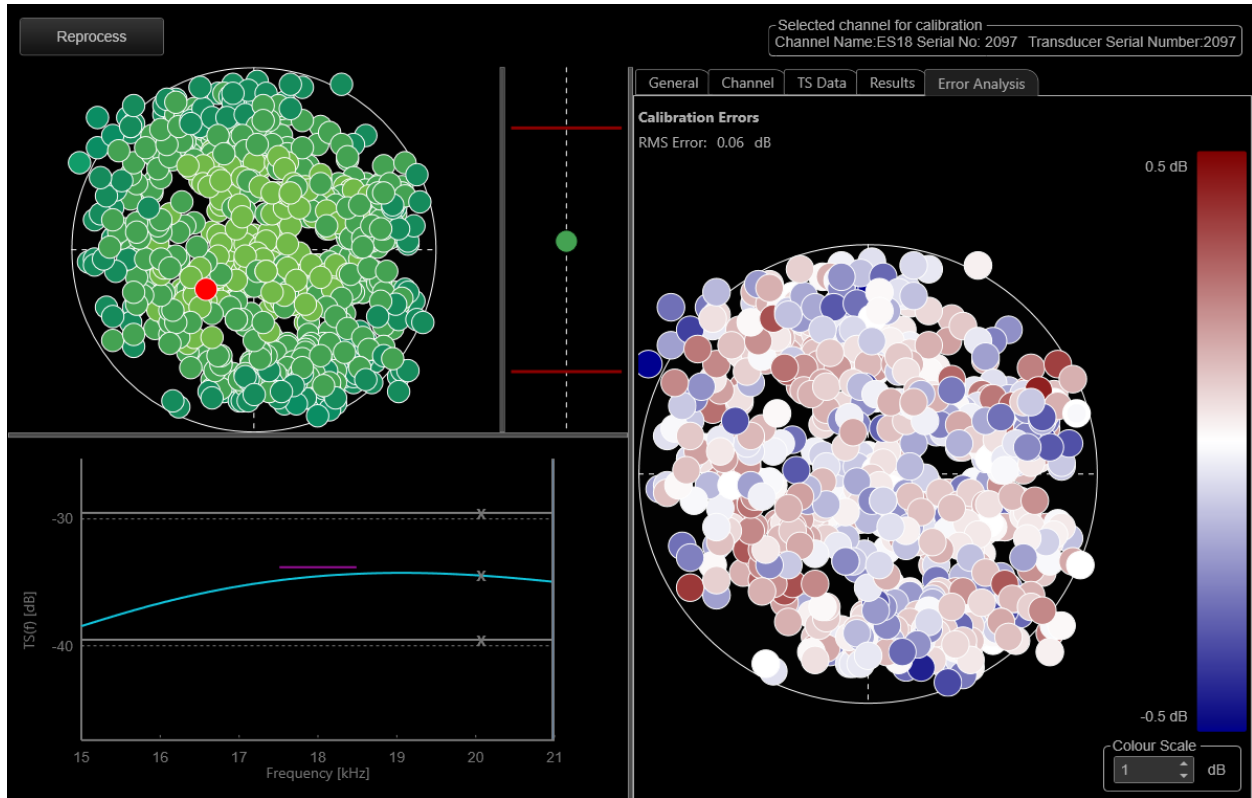


Figure 33. Screenshot of EK80 Calibration Wizard error analysis for the 18 kHz calibration at 1.024 ms.

18 kHz: 2.048 ms

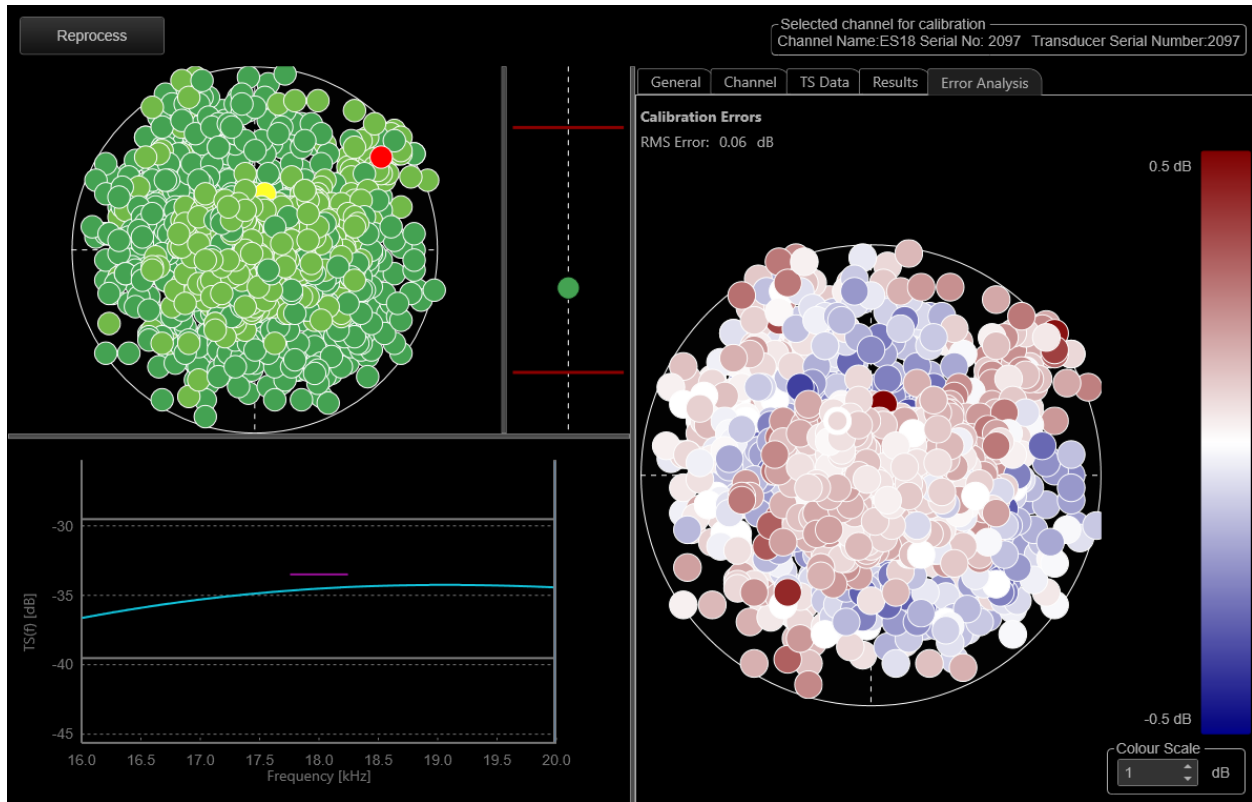


Figure 34. Screenshot of EK80 Calibration Wizard error analysis for the 18 kHz calibration at 2.048 ms.

38 kHz (CW): 1.024 ms

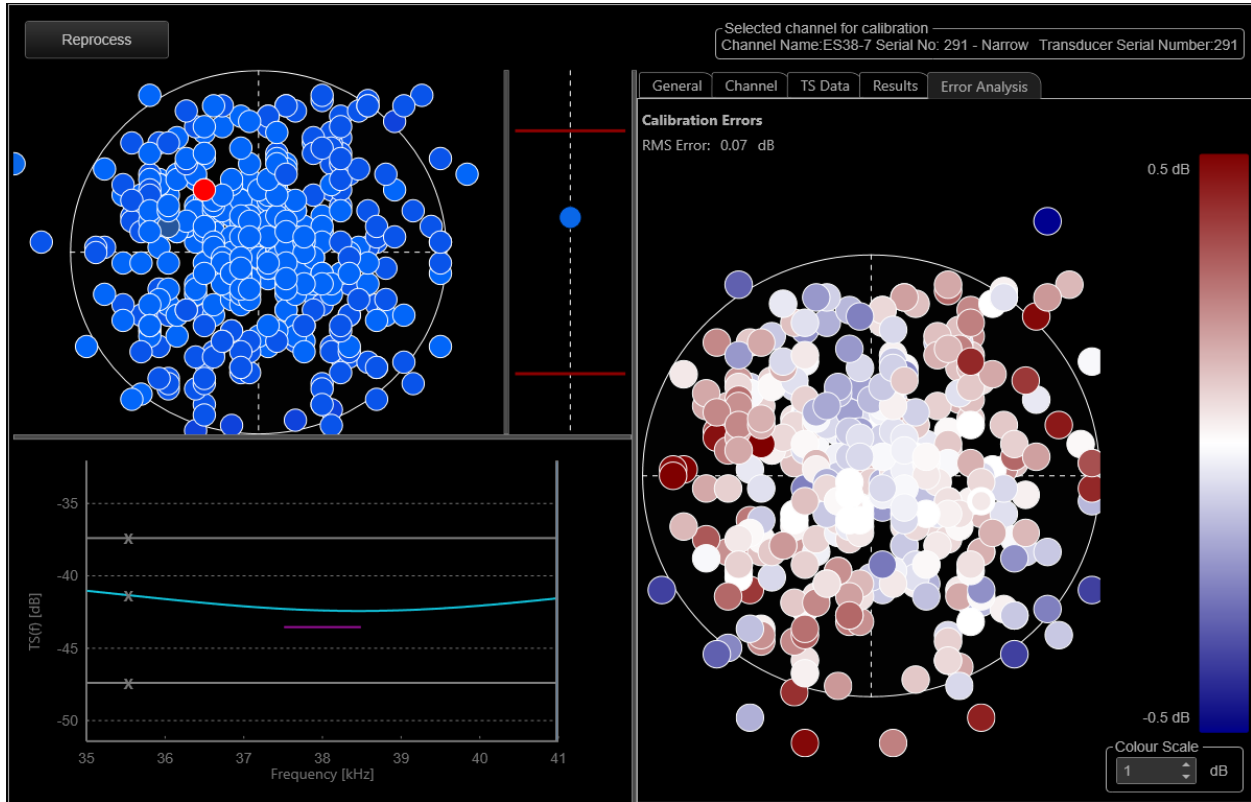


Figure 35. Screenshot of EK80 Calibration Wizard error analysis for the 38 kHz calibration at 1.024 ms in continuous wave (CW) mode.

38 kHz (CW): 2.048 ms

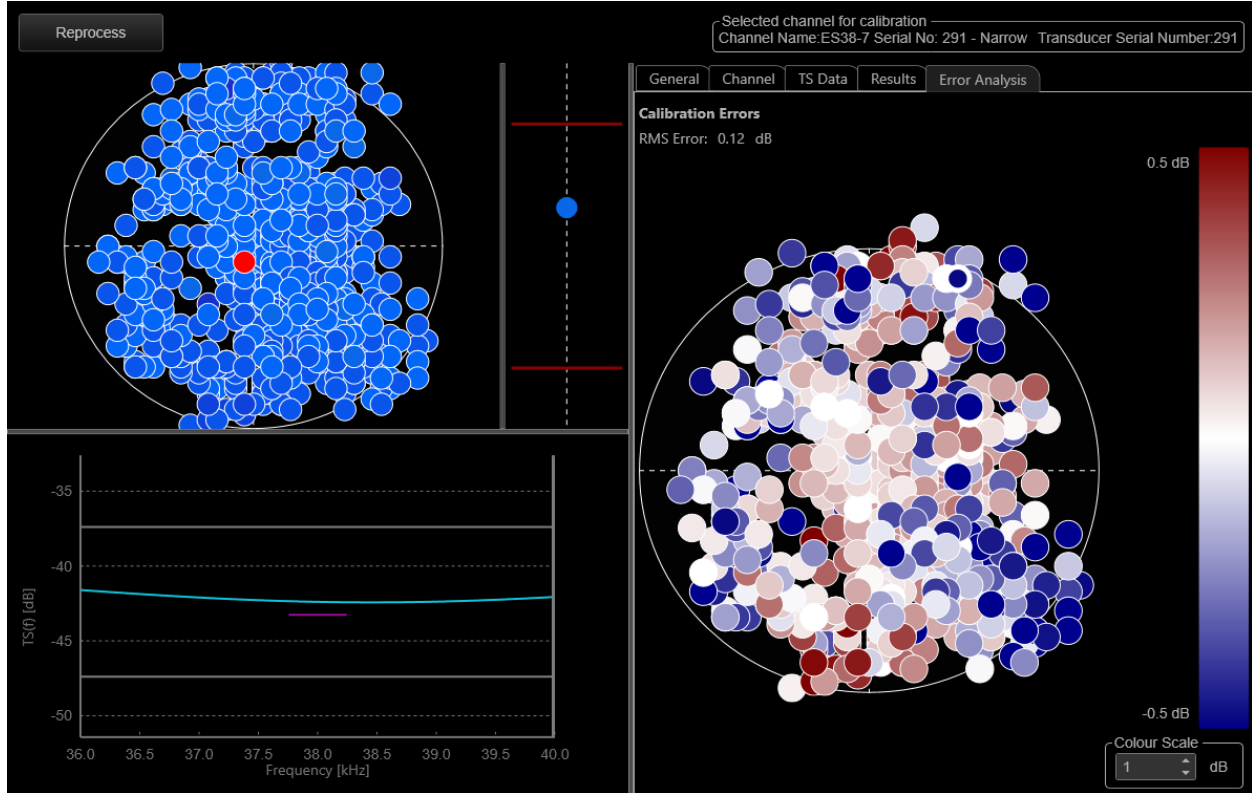


Figure 36. Screenshot of EK80 Calibration Wizard error analysis for the 38 kHz calibration at 2.048 ms in continuous wave (CW) mode.

38 kHz (FM): 1.024 ms

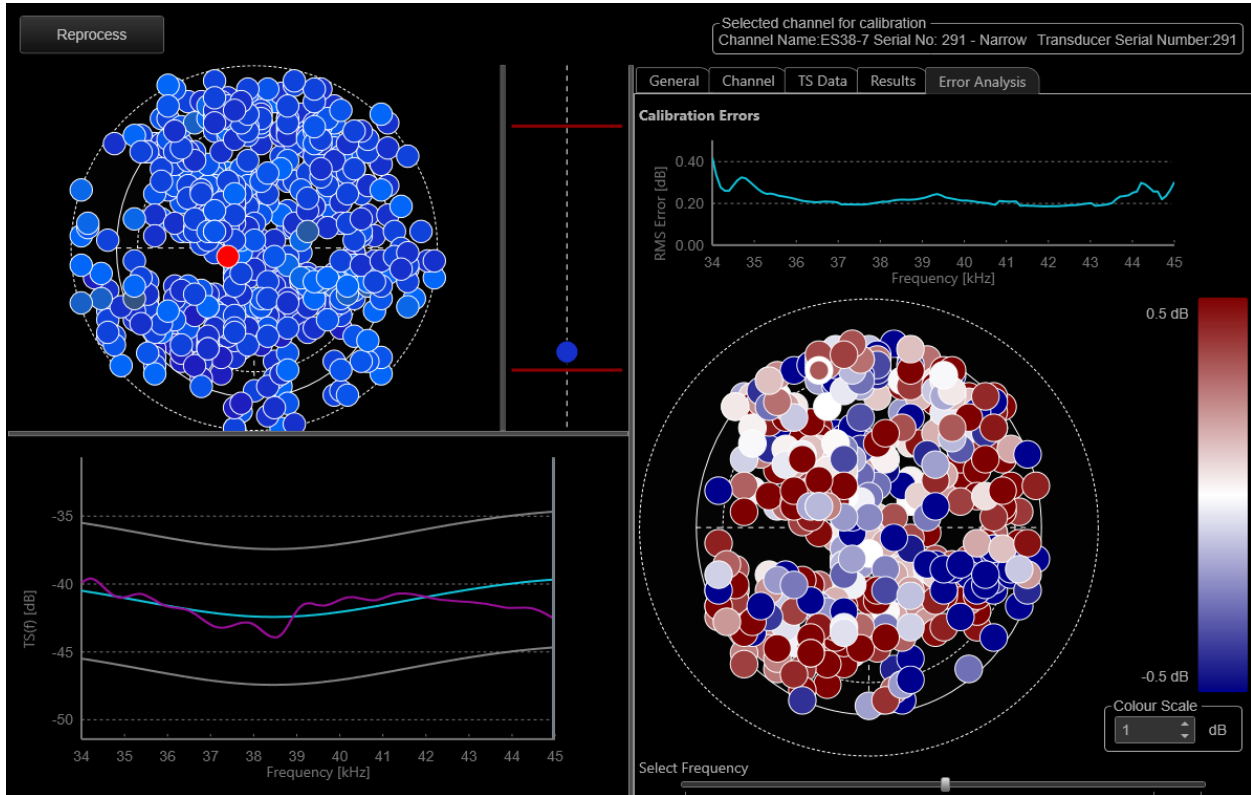


Figure 37. Screenshot of EK80 Calibration Wizard error analysis for the 38 kHz calibration at 1.024 ms in frequency modulated (FM) mode.

70 kHz (CW): 1.024 ms

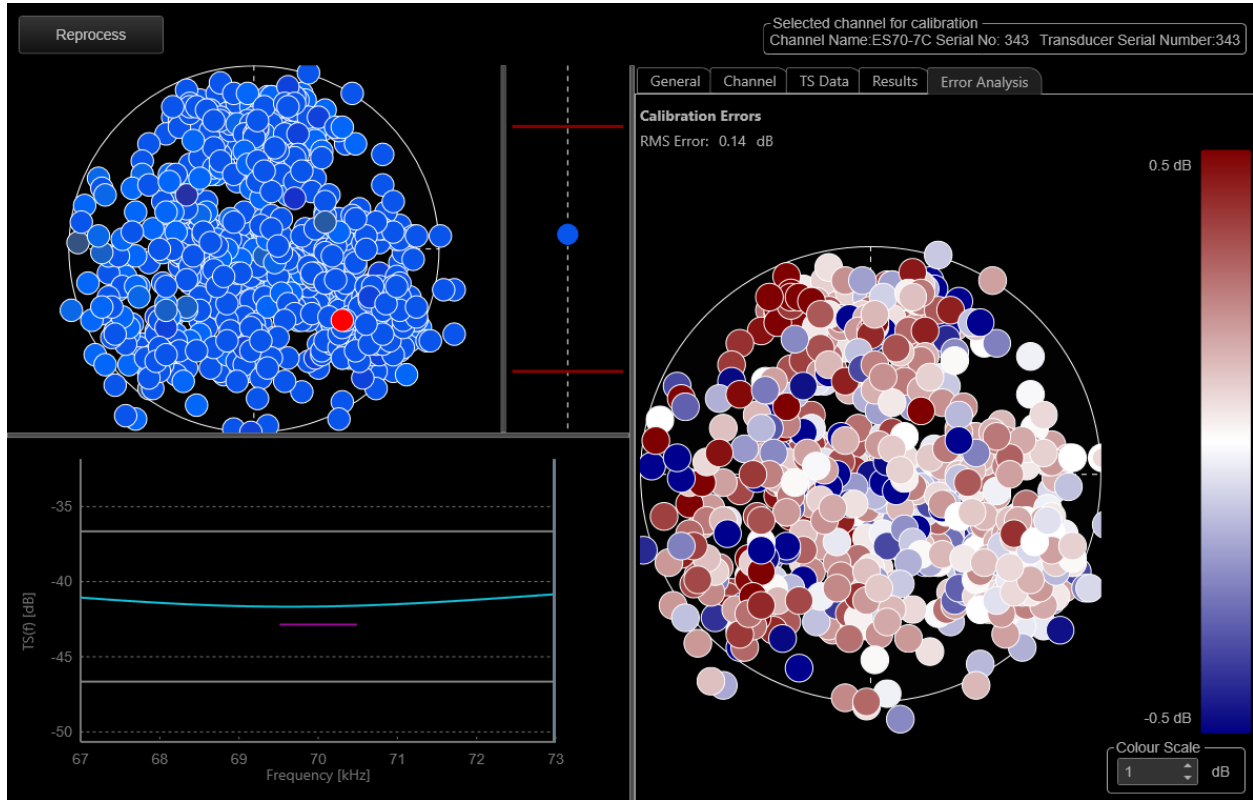


Figure 38. Screenshot of EK80 Calibration Wizard error analysis for the 70 kHz calibration at 1.024 ms in continuous wave (CW) mode.

120 kHz: 1.024 ms

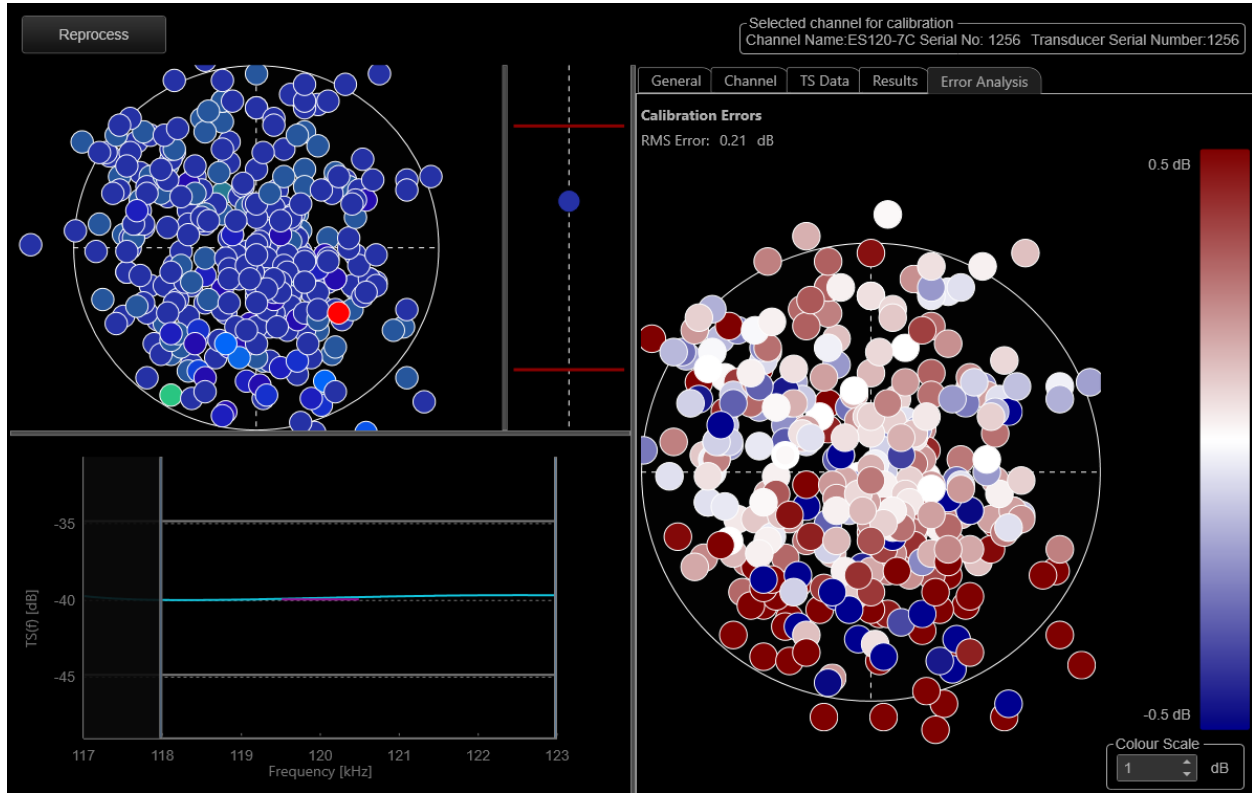


Figure 39. Screenshot of EK80 Calibration Wizard error analysis for the 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

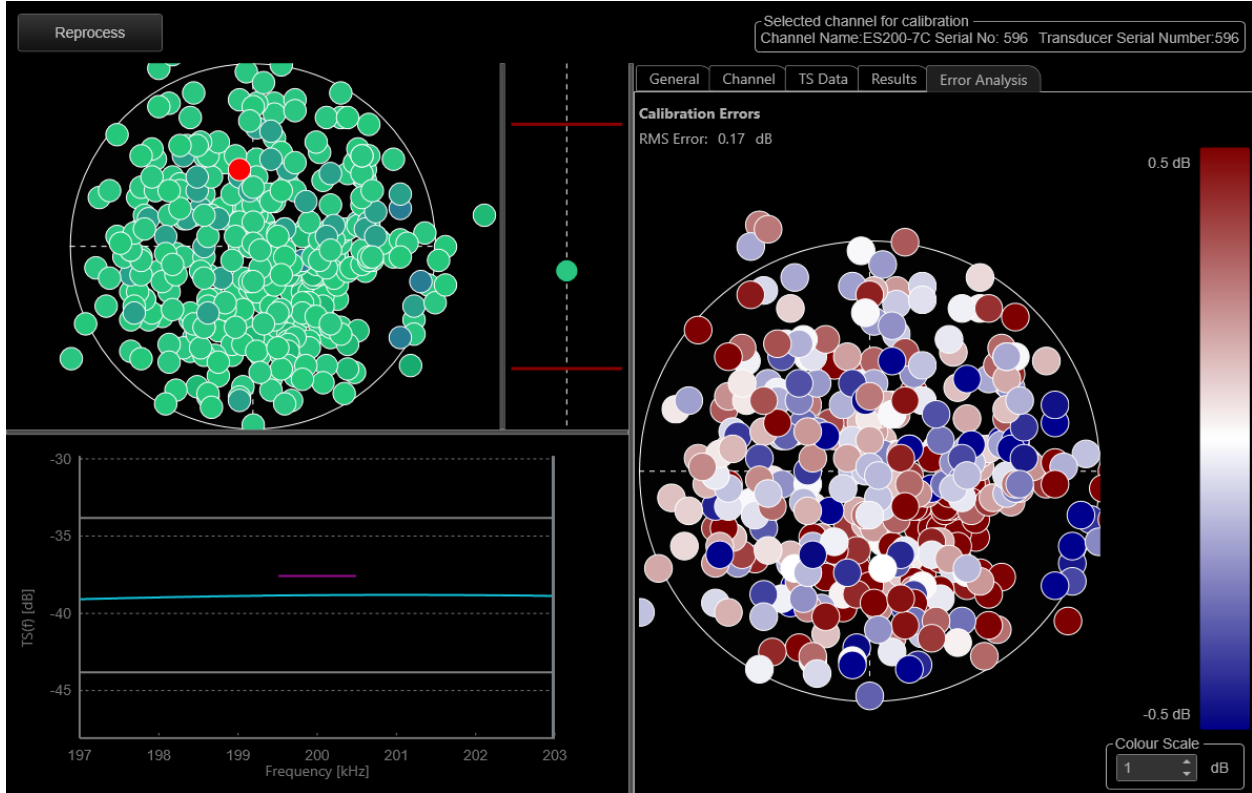


Figure 40. Screenshot of EK80 Calibration Wizard error analysis for the 200 kHz calibration at 1.024 ms.

Appendix F: Detailed List Calibration Files

File name	Date (UTC)	Frequency (pulse length)
EX2206_EK60-D20220811-T141338.raw	08/11/2022	200 kHz (1.024 ms)
EX2206_EK60-D20220811-T141338.idx	08/11/2022	200 kHz (1.024 ms)
EX2206_EK60-D20220811-T145251.raw	08/11/2022	38 kHz - CW (1.024 ms)
EX2206_EK60-D20220811-T145251.idx	08/11/2022	38 kHz - CW (1.024 ms)
EX2206_EK60-D20220811-T153236.raw	08/11/2022	38 kHz - CW (2.048 ms)
EX2206_EK60-D20220811-T153236.idx	08/11/2022	38 kHz - CW (2.048 ms)
EX2206_EK60-D20220811-T163206.raw	08/11/2022	70 kHz - CW (1.024 ms)
EX2206_EK60-D20220811-T163206.idx	08/11/2022	70 kHz - CW (1.024 ms)
EX2206_EK60-D20220811-T181904.raw	08/11/2022	120 kHz - CW (1.024 ms)
EX2206_EK60-D20220811-T181904.idx	08/11/2022	120 kHz - CW (1.024 ms)
EX2206_EK60-D20220811-T185800.raw	08/11/2022	38 kHz - FM (1.024 ms)
EX2206_EK60-D20220811-T185800.idx	08/11/2022	38 kHz - FM (1.024 ms)
EX2206_EK60-D20220812-T140742.raw	08/12/2022	18 kHz - (1.024 ms)
EX2206_EK60-D20220812-T140742.idx	08/12/2022	18 kHz - (1.024 ms)
EX2206_EK60-D20220812-T163004.raw	08/12/2022	18 kHz - (2.048 ms)
EX2206_EK60-D20220812-T163004.idx	08/12/2022	18 kHz - (2.048 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