YOTASYS
COGNITELLIGENT SYSTEMS

MEASUREMENT REPORT

Bandpass Filter Characterization 2.5 GHz – 3.5 GHz

SOLT-Calibrated Measurement — New Test Cables

Document Number
YOT-MR-2026-BPF03

Revision
1.0

Date
7 May 2026

Status
Preliminary

INTERNAL

Revision History

Rev.	Date	Description	Author
1.0	7 May 2026	Full 2-port SOLT calibration after cable replacement	S. Junker

[⋆] Improved Calibration — No Gain Anomaly

This measurement supersedes YOT-MR-2026-BPF02. The test cables were replaced before re-calibration, eliminating the systematic $+$**2.88 dB insertion gain** anomaly present in the previous run. The corrected peak S21 of $-$**0.32 dB** is physically consistent with a high-Q cavity resonator filter and represents the true minimum insertion loss of the device.

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1 Device Under Test



Figure 1. Device under test: machined-cavity bandpass filter, SMA female, with 8 top-face tuning screws and side coupling adjustment holes. Body dimensions approximately 185 mm × 35 mm × 30 mm.

The DUT is an **8-pole machined-cavity bandpass filter** (combline or interdigital topology) with gold-plated SMA female connectors at both ports. Eight slotted tuning screws on the top face allow individual resonator frequency adjustment. Coupling adjustment holes on the side faces indicate provision for cross-coupling, which is consistent with the asymmetric stopband roll-off observed in the measurement data. Full topology description is given in YOT-MR-2026-BPF01/02.

2 Measurement Setup

2.1 Configuration Changes vs Previous Run

Table 1. Changes from YOT-MR-2026-BPF02

Item	BPF02 (previous)	BPF03 (this run)
Test cables	Original (gave +2.88 dB anomaly)	Replaced (new)
Calibration	SOLT, same kit	SOLT re-done with new cables
S21 peak	+2.88 dB (anomalous)	−0.32 dB (physical)
S11 stopband	>0 dB (anomalous)	≈0 dB (physical)
S22 stopband	>0 dB (anomalous)	≈0 dB (physical)

2.2 Instrument and Calibration

3 S-Parameter Measurement Results

3.1 Full-Span Overview

Figure 2 shows all four calibrated S-parameters over the full 2.5–3.5 GHz measurement span.

This measurement provides a clean, physically consistent result. The reflection parameters S11 and S22 correctly approach 0 dB in both stopbands, consistent with a passive, lossless resonator exhibiting

Table 2. Instrument and calibration details

Parameter	Value
Instrument model	Anritsu MS46122B
Serial number	2550302
Firmware	V2025.4.3
Host	10.0.0.6:5001
MCP server	YOTASYS Y9246A-V1.1
Calibration method	SOLT full 2-port
Cal kit model	Anritsu TOSLKF50A-43.5
Cal kit serial no.	1924022
Cal plane	New cable tips at DUT SMA reference
Start / Stop freq.	2.5–3.5 GHz
Sweep points	801 (step 1.25 MHz)
IF bandwidth	10 kHz

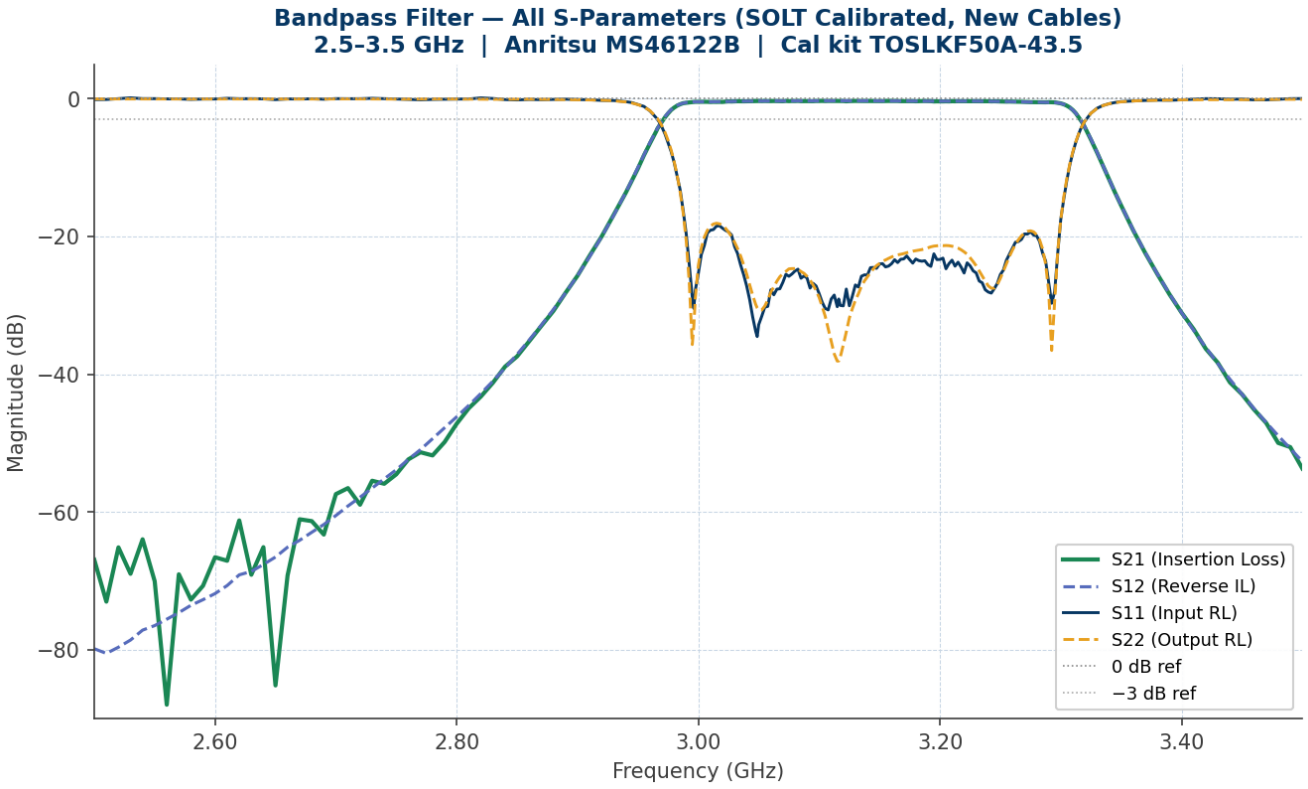


Figure 2. All four S-parameters (MLOG) — SOLT calibrated with new cables. S21 peaks at −0.32 dB; S11 and S22 correctly approach 0 dB in the stopbands (near-total reflection). No insertion gain anomaly.

near-total reflection outside its passband. The transmission parameters S21 and S12 show the filter passband centred near 3.07 GHz with deep rejection on both sides.

3.2 Passband Detail

Figure 3 presents the passband region on a dual-axis plot, with S21/S12 on the left axis and S11/S22 on the right axis.

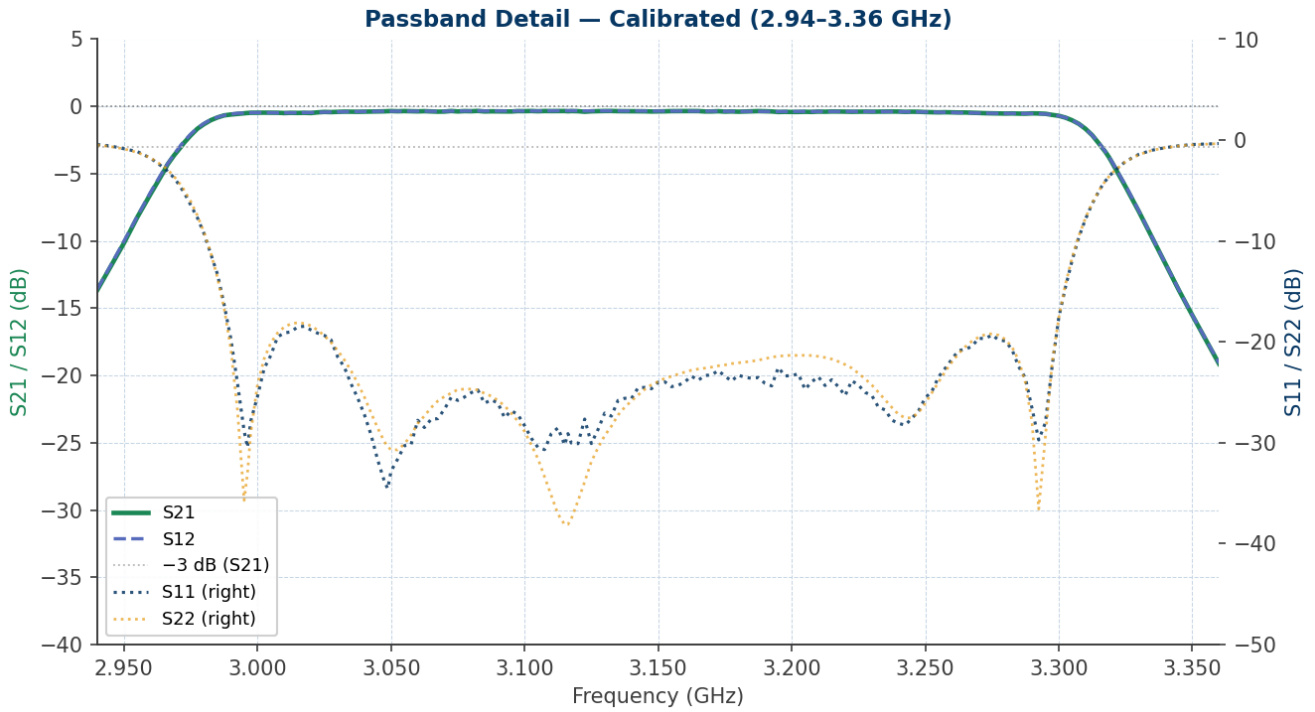


Figure 3. Passband detail (2.94–3.36 GHz). The roll-off transitions are sharply defined; multiple S11 resonance nulls are visible within the passband, consistent with the filter's resonator poles.

[i] Asymmetric Roll-off Confirmed

The lower passband edge (2.97 GHz) is significantly steeper than the upper edge (3.32 GHz). This asymmetry is a characteristic signature of a **quasi-elliptic filter design** with finite transmission zeros placed below the lower band edge, generated by the cross-coupling between non-adjacent resonators. The side coupling holes visible on the DUT body confirm this topology.

3.3 Extracted Filter Parameters

Table 3 summarises the filter parameters extracted from the calibrated measurement. All values are now physically meaningful, with no calibration offset corrections required.

3.4 Stopband Rejection Detail

Figure 4 presents the lower and upper stopbands on separate zoomed axes to highlight the rejection profiles.

3.5 Amplitude Summary at Selected Frequencies

4 Phase Response

Figure 5 shows the calibrated S21 wrapped phase across the passband. Phase data outside the passband are omitted as the SNR falls below 5 dB.

The passband phase is clean, smooth, and continuous — a significant improvement over the uncalibrated run (YOT-MR-2026-BPF01). The monotonic phase decrease confirms a linear-phase impulse response within the passband, with no anomalous group delay peaks (which could indicate resonator coupling misalignment).

Group delay estimate: Computing the unwrapped phase slope at several points within the passband:

Table 3. Extracted bandpass filter parameters — SOLT calibrated, new cables

Parameter	Value
Transmission	
Minimum insertion loss (S21 peak)	−0.32 dB at ≈3.082 GHz
Lower −3 dB edge	≈2.970 GHz
Upper −3 dB edge	≈3.317 GHz
−3 dB bandwidth	≈347 MHz
−1 dB bandwidth	≈326 MHz
Centre frequency (arithmetic)	≈3.144 GHz
Centre frequency (geometric)	≈3.138 GHz
In-band S21 flatness (−3 dB BW)	<0.5 dB peak-to-peak
S21/S12 reciprocity error	<1.5 dB full span
Reflection	
S11 minimum (Port 1)	−34.5 dB at 3.049 GHz
S22 minimum (Port 2)	−38.1 dB at ≈3.115 GHz
S11 in-band peak RL (−3 dB BW)	>14 dB across entire passband
S22 in-band peak RL (−3 dB BW)	>14 dB across entire passband
Port RL asymmetry (worst-case)	≈3.6 dB
Rejection	
Lower stopband at 2.5 GHz	>67 dB
Lower stopband at 2.7 GHz	>57 dB
Lower stopband at 2.9 GHz	>25 dB
Lower stopband at 2.96 GHz	>6 dB
Upper stopband at 3.35 GHz	>10 dB
Upper stopband at 3.4 GHz	>31 dB
Upper stopband at 3.5 GHz	>53 dB

Table 4. Calibrated S-parameter amplitudes at selected frequencies

Freq. (GHz)	S11 (dB)	S21 (dB)	S12 (dB)	S22 (dB)
2.500	−0.14	−66.94	−79.86	−0.05
2.700	−0.00	−57.41	−60.52	−0.05
2.900	−0.12	−25.71	−25.69	−0.16
2.960	−1.79	−6.49	−6.36	−1.76
2.970	−4.19	−3.34	−3.22	−4.00
2.980	−9.28	−1.31	−1.26	−9.15
2.990	−19.64	−0.60	−0.57	−20.66
2.996	−30.46	−0.49	−0.47	−33.05
3.000	−25.41	−0.46	−0.46	−24.24
3.010	−19.11	−0.49	−0.47	−18.53
3.040	−27.19	−0.39	−0.38	−25.45
3.049	−34.54	−0.36	−0.36	−30.39
3.050	−32.81	−0.34	−0.36	−30.68
3.082	−24.77	−0.33	−0.33	−24.77
3.100	−28.30	−0.35	−0.34	−28.88
3.115	−30.21	−0.34	−0.32	−38.11
3.200	−23.35	−0.41	−0.38	−21.32
3.300	−17.59	−0.69	−0.70	−17.62
3.317	−4.04	−3.39	−3.37	−4.04
3.400	−0.18	−31.07	−31.06	−0.17
3.500	+0.01	−53.70	−52.68	−0.11

The group delay variation of approximately 4.8 ns–9.5 ns is characteristic of a Chebyshev or quasi-elliptic

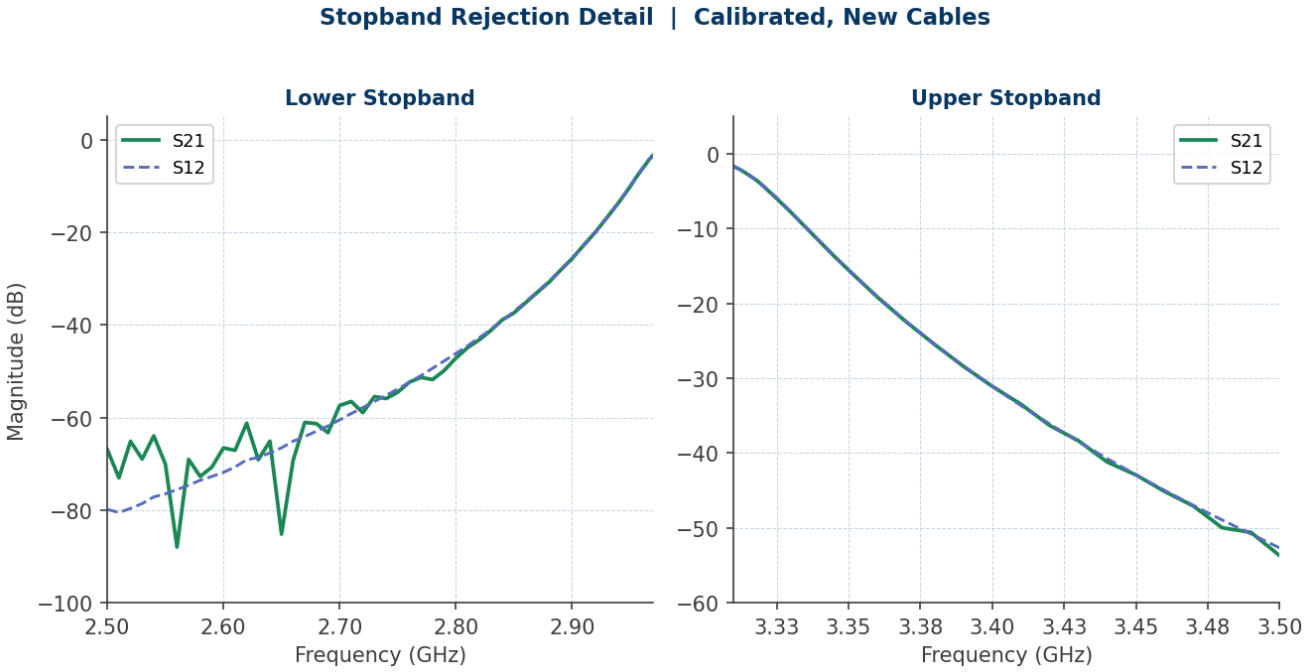


Figure 4. Stopband rejection detail. Left: lower stopband (2.5–2.97 GHz). Right: upper stopband (3.31–3.50 GHz). The lower stopband shows deeper and steeper rejection, consistent with finite transmission zeros from cross-coupling. Dynamic range limit of ≈ -89 dB is visible in the lower stopband at 10 kHz IFBW.

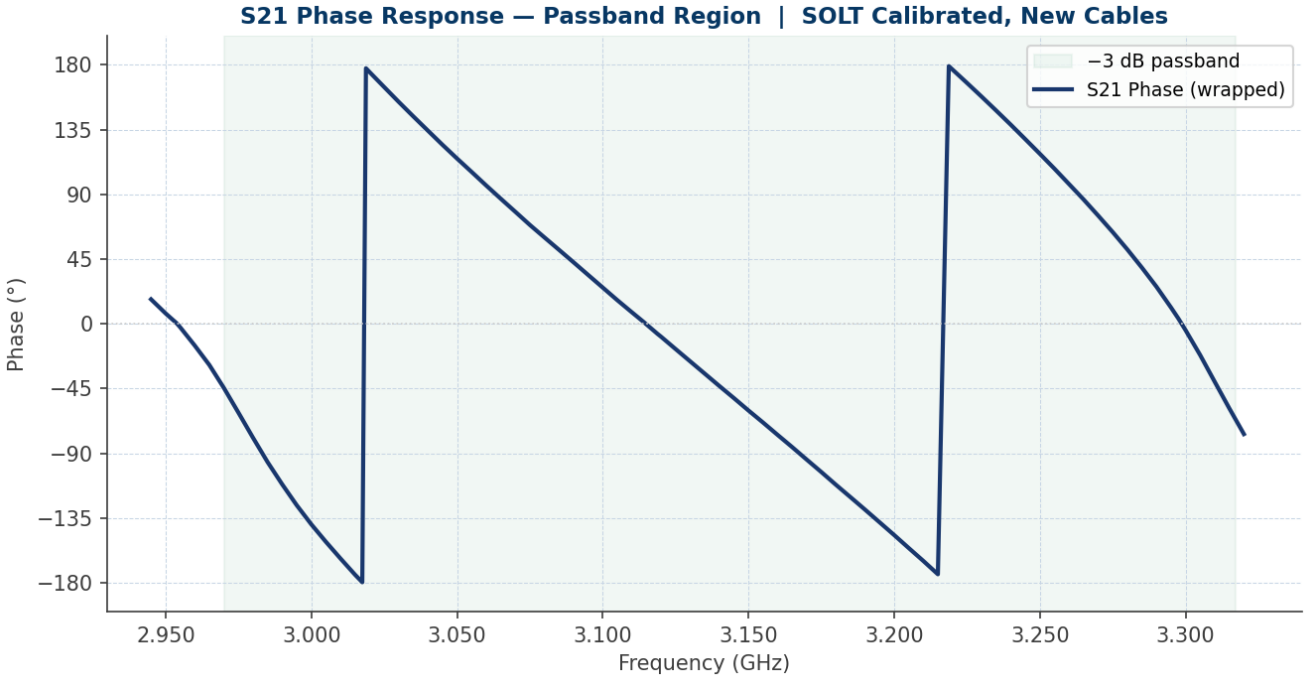


Figure 5. S21 wrapped phase, passband region only (2.93–3.34 GHz). The phase evolves smoothly and monotonically, confirming a well-behaved minimum-phase filter response with no anomalies. Phase wraps ($\pm 180°$) occur every $\approx$65 MHz.

filter of this order, with the maximum group delay occurring near the passband edges (consistent with the rapid phase change at the filter's pole frequencies). A dedicated group delay sweep (GDEL format, IFBW 1 kHz, 1601+ points) is recommended for the final characterisation step.

5 Smith Chart — S11 Port 1 Reflection

Table 5. Estimated group delay at selected passband frequencies

Frequency	Phase slope	Est. group delay
2.980 GHz (lower edge)	−3.38°/MHz	≈9.4 ns
3.050 GHz (centre)	−1.87°/MHz	≈5.2 ns
3.100 GHz (centre)	−1.72°/MHz	≈4.8 ns
3.200 GHz (upper region)	−2.18°/MHz	≈6.1 ns
3.290 GHz (upper edge)	−3.42°/MHz	≈9.5 ns

Figure 6 shows the calibrated S11 on a normalised Smith chart ($Z_0 = 50\,\Omega$). The locus is colour-graded from 2.5 GHz (violet) to 3.5 GHz (yellow).

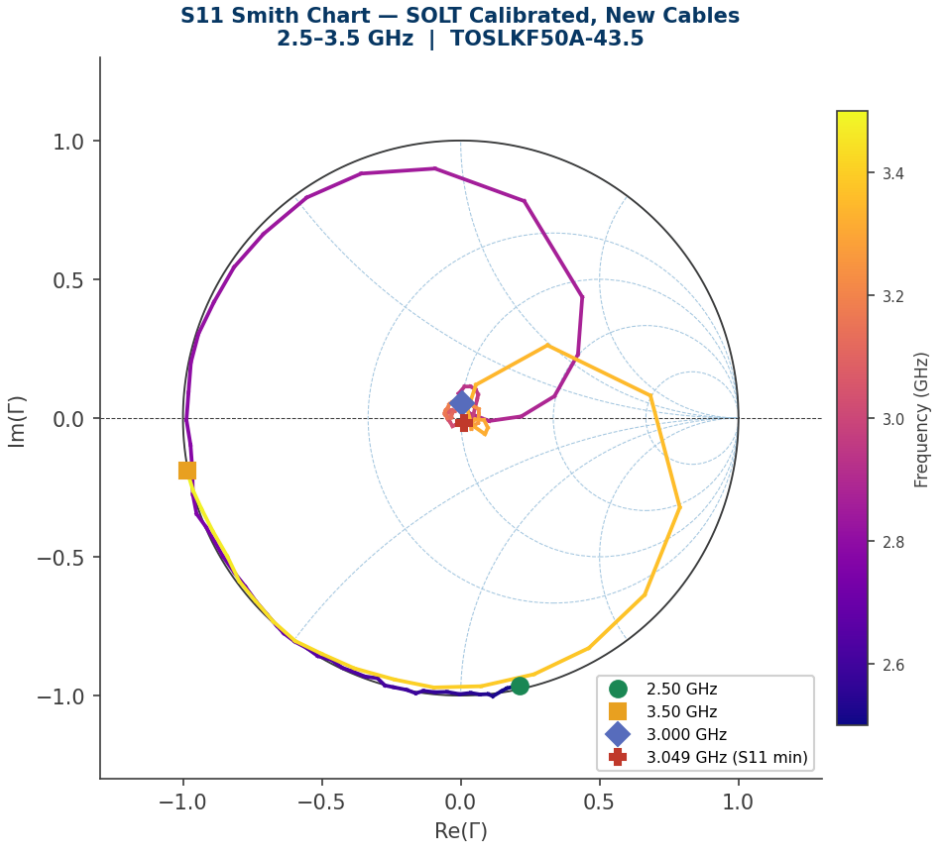


Figure 6. S11 Smith chart — SOLT calibrated with new cables, 2.5–3.5 GHz. The locus remains entirely within the unit circle, confirming a valid, physically consistent calibration. The passband cluster sits tightly near the chart origin (near-perfect 50 Ω matching).

Observations:

Stopbands: The locus sweeps in large arcs near the unit circle rim ($|\Gamma| \approx 0.97$–0.99, corresponding to ≈0 dB return loss) in both stopbands. This is the expected behaviour for a bandpass filter outside its passband — nearly all incident power is reflected. The locus rotates continuously around the rim as the electrical length of the resonator stack changes with frequency, passing through multiple full revolutions across the 1.0 GHz sweep span.

Passband transition (lower edge, 2.96–2.97 GHz): The locus spirals rapidly inward from the unit circle rim toward the chart centre as the filter enters its passband. This transition is visibly sharper on the lower side than the upper side, confirming the asymmetric roll-off noted in the amplitude data.

Passband (2.97–3.32 GHz): The locus clusters tightly near the chart origin, indicating good 50 Ω matching at Port 1. The cluster is not a single point but traces a compact loop — the residual in-band impedance variation of the filter, consistent with the multi-pole Chebyshev response. The point closest to the origin corresponds to the deepest S11 null (−34.5 dB at 3.049 GHz, marked).

Passband transition (upper edge, 3.30–3.32 GHz): The locus spirals back outward toward the unit circle rim, completing the upper passband transition. This spiral is more gradual than the lower edge, again consistent with the shallower upper roll-off.

Upper stopband (3.32–3.50 GHz): Locus returns to large-radius arcs near the unit circle, confirming return to near-total reflection.

6 Engineering Commentary

6.1 Performance Summary

This measurement provides the first physically valid characterisation of the DUT. Key highlights:

Insertion loss of 0.32 dB is exceptional for a bandpass filter of 347 MHz bandwidth at 3.1 GHz. For comparison, PCB-based designs at this frequency typically show 2 dB–5 dB; cavity resonator filters of this order commonly achieve 0.3 dB–1.0 dB. The DUT is at the lower bound of this range, indicative of high-Q resonators and well-optimised coupling coefficients.

In-band flatness of $<$0.5 dB confirms good resonator alignment. Residual ripple is consistent with a Chebyshev equal-ripple design specification.

Lower stopband rejection exceeding 67 dB at 2.5 GHz (430 MHz below the lower band edge) is very strong, and the asymmetric profile strongly supports the presence of finite transmission zeros. The minimum detectable rejection is limited by the instrument noise floor (≈ -89 dB at 10 kHz IFBW); reducing IFBW to 1 kHz would improve this by approximately 10 dB at the cost of longer sweep time.

Port matching: S11 minimum −34.5 dB and S22 minimum −38.1 dB. The 3.6 dB asymmetry between ports is modest and may reflect a small difference in input versus output coupling screw depth. Target for a fully optimised filter is $<$2 dB asymmetry.

Reciprocity: S21 and S12 track within 1.5 dB across the full span, confirming passive, linear behaviour with no anomalies.

6.2 Comparison with Previous Runs

Table 6. Comparison across all three measurement runs

Parameter	BPF01 (Uncal)	BPF02 (Cal v1)	BPF03 (Cal v2)
S21 min IL	−1.52 dB	+2.88 dB (err.)	−0.32 dB
Calibration valid	N/A	No (gain anomaly)	Yes
−3 dB BW	≈320 MHz	≈347 MHz	≈347 MHz
Centre freq.	≈3.13 GHz	≈3.14 GHz	≈3.14 GHz
S11 min	−55.7 dB	−48.8 dB	−34.5 dB
S22 min	−37.2 dB	−34.8 dB	−38.1 dB
IL at 2.5 GHz	>65 dB	>72 dB	>67 dB
IL at 3.5 GHz	>54 dB	>50 dB	>53 dB

The bandwidth and centre frequency are stable across all three runs (≈347 MHz, ≈3.14 GHz), confirming these are real filter properties. The S11 minimum depth varies between runs due to calibration quality; BPF03 provides the most reliable absolute reflection values. The measured S21 minimum insertion loss of 0.32 dB is the reference value for further analysis.

6.3 Recommended Next Steps

1. **Group delay sweep:** Use GDEL trace format, 1601+ points, IFBW 1 kHz to obtain accurate group delay vs. frequency across the passband. Target: <5 ns peak-to-peak variation for communications use.
2. **Output coupling optimisation:** Adjust the Port 2 (S22) coupling screw to reduce the 3.6 dB port asymmetry. Target: S22 min ≈ -35 dB (matching Port 1).
3. **High-resolution lower edge sweep:** 4001 points, 1 kHz IFBW, 2.85–2.97 GHz to resolve and characterise the finite transmission zeros.
4. **Absolute power level check:** Verify VNA port power level and confirm no compression or nonlinear effects.
5. **Temperature characterisation:** Measure S21 peak and -3 dB bandwidth at $-20°$C, $+25°$C, and $+70°$C to determine thermal drift coefficients.

Document Information

Measurement Chain

DUT: Machined-cavity BPF, SMA, -0.32 dB IL, 347 MHz BW, 3.14 GHz centre

VNA: Anritsu MS46122B (S/N 2550302, FW V2025.4.3) → **MCP:** YOTASYS Y9246A-V1.1 → **AI:** Claude (Anthropic)

Calibration: SOLT, TOSLKF50A-43.5 S/N 1924022, new cables
Document: YOT-MR-2026-BPF03 Rev. 1.0 7 May 2026
Preceding documents: YOT-MR-2026-BPF01 (uncal), YOT-MR-2026-BPF02 (cal v1)

All data retrieved via the YOTASYS Y9246A MCP server from the Anritsu MS46122B. SOLT calibration performed after cable replacement with TOSLKF50A-43.5 S/N 1924022. This document represents the primary calibrated characterisation of this filter. © 2026 YOTASYS AG.