Larrys Matching Lab by AD8M

OPERATING MANUAL • VERSION 3.3

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A practical RF matching workbench for amateur, commercial and experimental antenna systems. Start with a simple match, compare alternatives, and evaluate the electrical and mechanical tradeoffs before building.

Software use and support notice

Provided free of charge for educational and experimental use, AS IS, without warranty. All results are model-based estimates and must be independently verified before construction or operation. Users are responsible for RF safety, component ratings and applicable regulations.

NO INDIVIDUAL TECHNICAL SUPPORT IS PROVIDED. Please do not contact the developer for email or telephone assistance, troubleshooting, equipment configuration, VNA compatibility, drivers or individual antenna designs. No live VNA connection is provided. Future file import, if offered, will be limited to documented formats.

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Application: Larrys_Matching_v3_3 by AD8M.html. This manual supersedes the v2.8 manual and v3.0 supplement.

1 Quick start

Save the HTML file locally and open it in a current desktop browser. No installation, internet connection or instrument driver is needed. The DISCLAIMER / NO SUPPORT button in the banner opens the full notice.

Your first match

1. Select Lumped L/C matching — original lab in Design category.

2. Enter frequency 7.200 MHz, source R = 50 Ω, X = 0 Ω, available power = 100 W. Enter load R = 100 Ω, X = −50 Ω. These are demonstration values, not measurements.

3. Choose π: shunt C1 → series L → shunt C2. Select NORMAL and press AUTO MATCH. If the solver reports out of range, open Capacitor travel limits and try a larger maximum, or compare another network.

4. Read Actual Z in, Generalized SWR and |Γ|. Open Peak RF voltage across active components and Component Q and estimated losses to review stress and power.

5. Turn a dial or drag a slider to detune the network. Observe the change; press AUTO MATCH to solve again.

The six design categories

Category	Use it for
Lumped L/C matching	π and L networks; advisor and design comparisons
Transmission Line Lab	Compare cable impedance, loss and voltage/current
Coax stub / single L-C / quarter-wave	Alternative matching circuits and physical lengths
Feed-point de-embedding	Recover antenna impedance from a shack-end measurement
Optimum Feedline Length	Compare cable lengths with or without a π tuner
Air-core Coil Designer	Estimate coil dimensions, resistance and Q

Operating conditions are shared. Changing categories preserves the lumped tuner settings. Optional workspaces within the lumped lab can be opened or closed independently. Compare operations are read-only; USE and other explicit apply controls can change settings.

2 Lumped matching and frequency response

Source and load

Enter frequency in MHz; R and X in ohms. Positive X is inductive; negative X is capacitive. Source and load resistance must be positive. Available source power is the maximum available from the modeled Thevenin source, not necessarily power accepted by the tuner. The target is the complex conjugate of the source: a source of 25 + j40 Ω targets 25 − j40 Ω.

Network and tuning controls

Control	Operation
π	Input shunt C1, series L, output shunt C2.
Series C → shunt L	Capacitor in series; inductor shunts output.
Shunt L → series C	Inductor shunts input; capacitor in series.
NORMAL / AUTO MATCH	Find component settings at fixed F_o.
REVERSE / FIND FREQUENCY	Hold components fixed; search entered frequency limits for minimum mismatch. Select a candidate frequency.
Reset dials	Return component controls to starting values; not a full system reset.

Capacitor maxima are selectable from 300, 500, 1000, 1500 and 3000 pF; default maxima are 300 pF. Initial dials are 200 pF, 1.5 µH, 200 pF. Inductance range is 0.05–40 µH. The π solver may report no feasible ideal match; the two L arrangements can offer a labeled best-found compromise. Finite Q can leave residual mismatch.

Smith chart and frequency sweep

The chart is normalized to source resistance. Orange is the complete network input sweep; gray points represent measured-frequency samples. Show matching stages at F_o displays antenna, transformed load, input and target markers. In a reactive-source case the chart center is not necessarily the conjugate target.

Open Frequency sweep limits and band presets. CUSTOM accepts arbitrary positive start/stop MHz; U.S. amateur presets extend through 70 cm, with adjustable margins. The default custom range is 6.950–7.350 MHz. Components remain fixed during a sweep.

Analyzer readings

Open Analyzer measurements, choose Analyzer readings (interpolated), select Use 4 readings or Use 5 readings, and enter strictly increasing frequencies with R > 0 and signed X. Keep all measurements at the same reference plane. F_o must be within the measured range. The sweep uses those endpoints; linear interpolation of R and X does not extrapolate. Source impedance remains constant. Restore example restores illustrative data.

3 Interpreting and comparing designs

Live results

Reading	Interpretation
Rectangular / polar	R ± jX; magnitude $\sqrt{(R^2 + X^2)}$, angle atan2(X,R). Example: 100 − j50 Ω = 111.80 Ω ∠−26.57°.
|Γ| and phase	Source power-wave mismatch coefficient; zero is conjugate match.
Generalized SWR	(1 + |Γ|)/(1 − |Γ|); 1.00:1 is ideal. For reactive source it is not literal cable SWR.
Reflected / available	$\|\Gamma\|^2 \times 100\%$; source mismatch fraction, not necessarily a physical reflected wave.
Return loss	$-20 \log_{10}\|\Gamma\|$ dB; larger is better.
Delivered power	Load real watts; delivered/available includes mismatch and modeled losses.

Compare before choosing

Network choices → COMPARE NETWORKS evaluates the three topologies with the active transformation. Matching Advisor → COMPARE OPTIONS tests direct, 4:1, 9:1 and 16:1 in both directions, plus a nonduplicate custom ratio. A 9:1 reduction turns 1800 − j450 Ω into 200 − j50 Ω. Both R and X scale. Remove transformer returns to direct operation; retune if necessary.

Design Evaluation → COMPARE DESIGNS compares the current settings and 12 candidate combinations. Inspect SWR, delivered power, tuner losses, peak voltage, rating use, sweep coverage and construction review. Press USE only to install a chosen result. Transformer losses are not modeled; a balun is for balanced/unbalanced conversion, not simply an impedance ratio.

Component Q and peak voltage

Default Q: L1 = 150, C1/C2 = 2000. The coil series resistance is $R = 2\pi \cdot F_0 \cdot L/Q$ and is held constant across a sweep. Capacitor loss is represented by conductance with constant Q. Lower Q increases modeled heat.

Enter actual RF peak voltage ratings for capacitors (initially 1000 V each). Peak is √2·RMS for sinusoidal RF, not peak-to-peak. The display emphasizes peak; 80% of rating triggers caution and 100% triggers over-limit. These are indicators, not guaranteed safety margins. Check component current, spacing, thermal limits and actual manufacturer data.

Power accounting: available power = mismatch power + accepted power; accepted power = load watts + modeled tuner losses. A matched system can still be inefficient. Load watts are not radiated watts.

4 Coax matching and line evaluation

Coax stub / single L-C / quarter-wave

1. Enter the raw antenna impedance and F_0 in shared Operating conditions. The category ignores the active lumped transformer.

2. Choose main coax Z_0 and velocity factor, stub coax Z_0 and velocity factor, and quarter-wave line Z_0 to test. Standard options are 50, 75 and 93 Ω.

3. Choose a reasonable match threshold (1.10:1 through 3.00:1). Press COMPARE COAX OPTIONS. Green rows meet the chosen criterion.

4. Compare series and shunt L/C arrangements, open and shorted shunt stubs, and quarter-wave alternatives. VIEW CIRCUIT shows the topology and calculated lengths.

Main-line length runs from the antenna reference plane to the matching junction; do not add it blindly to an existing cable. Open stubs leave the far end open; shorted stubs join inner conductor to shield at the far end. A series element goes in the signal path; a shunt element goes to return. The model is ideal and lossless at F_0.

Quarter-wave example

For a 50 Ω source and 100 Ω resistive antenna, the ideal quarter-wave Z_0 is √(50·100) = 70.71 Ω. Use commercially available 75 Ω cable instead: the input is 56.25 Ω and ideal SWR is 1.13:1. At 7.2 MHz and VF 0.66, physical length is about 22.54 ft. The mathematical ideal is a reference, not a custom cable construction recommendation.

Transmission Line Lab

1. Set physical length in feet and match threshold. Enter velocity factor and matched attenuation in dB/100 ft at F_0 separately for 50, 75 and 93 Ω cable. Use datasheet values; defaults are illustrative.

2. Press COMPARE LINES. Compare input impedance, SWR, delivered power, cable loss, maximum peak voltage, RMS current and sweep coverage.

3. Press VIEW for a candidate to inspect voltage/current versus distance and source-referenced SWR versus frequency.

The uniform line model includes attenuation but holds it and VF constant across the sweep. It excludes connector and common-mode effects. A lossless line changes input impedance but not SWR relative to its own Z_0. Loss may reduce apparent SWR while wasting power.

5 Feed-point and feedline length

Feed-point de-embedding

Use this category when an analyzer measures at the shack end of a known cable, and you need the antenna impedance rather than the transformed shack-end value.

1. Set F_0 in Operating conditions. In the de-embedding category enter measured R and X, coax Z_0, VF, physical length, matched attenuation and length uncertainty (± ft).

2. Press CALCULATE FEED-POINT. Compare shorter, nominal and longer assumptions, electrical lengths, rectangular/polar feed-point impedances and forward-calculation checks.

3. If the nominal result is physically plausible, press USE NOMINAL AS LOAD to transfer it into the lumped lab. Recalculate the match.

A matched 50 Ω line measured as 50 + j0 Ω should return 50 + j0 Ω. Inverting a long, lossy or highly mismatched line can amplify measurement errors. A forward check is algebraic consistency, not independent measurement validation. Use accurate cable length, VF and calibration; invalid non-passive results are rejected.

Optimum Feedline Length

1. Enter antenna feed-point impedance, not the shack-end reading, in Operating conditions. Select standard coax Z_0, VF and attenuation.

2. Enter minimum and maximum practical lengths and increment. Choose acceptable source SWR and Direct + re-tuned π, Direct coax only, or Re-tuned π only.

3. Press COMPARE LENGTHS. Compare the ranked candidates and shorter/longer alternatives. The π network is re-solved for each sampled cable length within existing component limits and Q.

4. Use VIEW to inspect cable stress and suggested π values. Open Optional Smith chart — see what the line length does for the pre-tuner impedance trace.

Ranking prioritizes meeting the SWR threshold and capacitor ratings, then delivered power. Results are at F_0, sampled over the entered length increment, and use no extra transformer. Compare leaves the tuner unchanged. The Smith chart is normalized to coax Z_0, and its center is a match to that cable, not necessarily the source.

Practical tip: cable length can make a tuner easier to match, but cannot remove a lossless line's own mismatch. Prefer a design that meets electrical requirements with practical cable length, low loss and adequate voltage/current margin.

6 Air-core Coil Designer

Adapted from Larry's LC Resonance Lab V14, this optional category connects the required matching inductance to a proposed single-layer copper winding.

Design a coil

1. Select Air-core Coil Designer. Follow tuner L1 uses the current inductance and shared frequency; Independent target lets you enter another inductance in µH.

2. Enter mean winding diameter (mm), winding length/diameter ratio, copper AWG and insulation thickness per side (mm). The diameter is measured at the centerline of the wire, not the bare form.

3. Press COMPARE COILS. Review five designs: Selected, Larger diameter, Longer winding, Heavier wire and Lighter wire. VIEW shows a schematic and further winding information.

4. For a fitting design in Follow tuner L1 mode, press USE Q to transfer its skin-effect-only Q into the tuner. The component dials remain unchanged. Reset geometry restores the geometry inputs.

Read the comparison

Column	Meaning
Turns / length / pitch	Estimated turns, axial winding length and pitch (mm).
Wire m / Rdc Ω	Estimated helical conductor length and DC resistance.
Rac Ω / Est. Q	Skin-effect-only RF resistance and unloaded coil Q.
Fit	Checks insulated wire diameter versus pitch and at least one turn.
VIEW / USE Q	Inspect geometry; apply Q only for the current tuner L1.

Model and example

Wheeler approximation: $L(\mu H) = r^2 \cdot N^2/(9r + 10\ell)$, where radius r and winding length ℓ are in inches. Copper skin depth $\delta = \sqrt{(\rho/(\pi \cdot f \cdot \mu))}$; $Q = 2\pi \cdot f \cdot L/Rac$. For 1.5 µH at 7.2 MHz, 25 mm mean diameter, length/diameter 1 and AWG 22, the model gives about 9.4 turns, 0.74 m wire and Q ≈ 265.

This is an optimistic estimate, not a measured Q or a thermal rating. Proximity effect, leads, contacts, self-capacitance and dielectric/core loss are omitted. Fractional turns require adjustment; insulation fit does not establish RF breakdown spacing. Verify actual inductance, Q and self-resonance, particularly at VHF/UHF.

7 Practice tests and reference notes

Suggested self-guided checks

Test	Expected observation
50 Ω source / 50 Ω load, matched line	With zero attenuation, 100 W available gives 100 W delivered and 1.00:1 SWR. With 1 dB total loss, about 79.43 W delivered.
High impedance load: 1800 − j450 Ω	9:1 reduction gives 200 − j50 Ω at tuner side. Compare direct and transformed designs.
Short antenna: 5 − j200 Ω	Compare topology and component limits. A good SWR does not ensure low loss or radiation efficiency.
Lower L1 Q from 150 to 50	Observe loss, SWR and delivered watts; retune if needed.
Analyzer mode	Use example readings; move F_0 inside range and inspect sweep. Outside range, correct F_0 or data.
Coil designer	Compare five geometries; USE Q only when following tuner L1 and fit permits.

Troubleshooting

No match: check positive R and frequency, C maxima, L limits, active transformer and topology. Try COMPARE NETWORKS or the advisor; a compromise is not an exact match. Invalid analyzer data: fill all selected cells, order frequencies and keep F_0 inside the measured span. Stale comparison: rerun after changing operating conditions.

Printing: in the lumped lab open Matching Advisor and press PRINT REPORT. The print stylesheet favors white paper and suppresses controls/dark plots. Review browser print preview; record optional-category results separately if needed.

Release boundaries

v3.3 has no live VNA connection, Touchstone import, double-stub solver or broadband multisection transformer design. It does not model actual antenna radiation efficiency, full transformer losses, or verified component safety. Coax matching options are lossless at F_0; the separate line lab models attenuation. All results must be independently checked before applying RF power.

Source: Larrys_Matching_v3_3 by AD8M.html, version 3.3; control names and model limits reviewed against the application. Coil design adapted from Larry's LC Resonance Lab V14. No individual technical support provided.