AE VarioMatch™ Match Network, VM 1000/1500 Platform

User Manual

October 2009 57020080-00D

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AE VarioMatch™ Match Network, VM 1000/1500 Platform

57020080-00D

ADVANCED ENERGY®

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PRODUCT USAGE STATEMENT

⚠ WARNING:

Read this entire manual and all other publications pertaining to the work to be performed before you install, operate, or maintain this equipment. Practice all plant and product safety instructions and precautions. Failure to follow instructions can cause personal injury and/or property damage. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. All personnel who work with or who are exposed to this equipment must take precautions to protect themselves against serious or possibly fatal bodily injury.

Advanced Energy Industries, Inc., (AE) provides information on its products and associated hazards, but it assumes no responsibility for the after-sale operation of the equipment or the safety practices of the owner or user. NEVER DEFEAT INTERLOCKS OR GROUNDS.

TRADEMARKS

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Advanced Energy's technical writing staff has carefully developed this manual using research-based document design principles. However, improvement is ongoing, and the writing staff welcomes and appreciates customer feedback. Please send any comments on the content, organization, or format of this user manual to:

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Chapter 1

Safety and Product Compliance Guidelines

IMPORTANT SAFETY INFORMATION

To ensure safe installation and operation of the Advanced Energy® VarioMatch match network, read and understand this manual before attempting to install and operate this unit. At a minimum, read and follow the safety instructions and practices documented under "Safety Guidelines" on page 1-2.

DANGER, WARNING, AND CAUTION BOXES IN THE MANUAL

This symbol represents important notes concerning potential harm to people, this unit, or associated equipment. Advanced Energy® includes this symbol in Danger, Warning, and Caution boxes to identify specific levels of hazard seriousness.

DANGER:

DANGER indicates an imminently hazardous situation that, if not avoided, will result in death or serious injury. DANGER is limited to the most extreme situations.

WARNING:

WARNING indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury, and/or property damage.

CAUTION:
CAUTION indicates a potentially hazardous situation that, if not avoided, could result in minor or moderate injury, and/or damage to property. CAUTION is also used for property-damage-only accidents.

SAFETY GUIDELINES

Review the following information before attempting to install and operate the product.

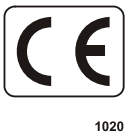
Rules for Safe Installation and Operation

Please note the following rules:

- Do not attempt to install or operate this equipment without proper training.
- Ensure that this unit is properly grounded (see also "Grounding the Unit" on page 5-5).
- Ensure that all cables are properly connected.
- Verify that input line voltage and current capacity are within specifications before turning on the power supplies (see "Electrical Specifications" on page 3-10).
- Use proper electrostatic discharge (ESD) precautions.
- Always be careful around this equipment.

Interpreting Product Labels

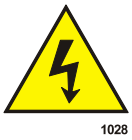
The following labels may appear on your unit:



CE label

Protective Earth Ground

Further information found in this guide.



High voltage

PRODUCT COMPLIANCE

The following sections include information about unit compliance and certification, including the conditions of use required to be in compliance with the standards and directives.

Product Certification

Certain options of this product may be certified by:

- CE Marking – Self-declaration, assessed by AE Corporate Compliance
- EMC measurements – Verified by the AE Corporate Compliance Lab and/or an accredited third party lab

For more information, refer to the Certificate or Letter of Conformity (US) or Declaration of Conformity (EU) accompanying the product.

Safety and Compliance Directives and Standards

Certain options of this unit have been tested for and comply with the following electromagnetic compatibility (EMC) and safety directives and standards and industry guidelines.

Note: This device must be installed and used only in compliance with the directives and standards listed in addition to EN 60204 (IEC 60204) and applicable requirements.

Note: This equipment must be installed and used in accordance with the Conditions of Use described in this manual. If this equipment is expanded, modified, or installed into a larger system, the user is responsible to guarantee the compliance of the overall system. If this equipment is used with external components, the user must ensure that the Safety and EMC requirements are not violated.

ELECTROMAGNETIC COMPATIBILITY (EMC) DIRECTIVES AND STANDARDS

- **89/336/EEC**

  EC Council directive on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive)

- **EN 55011**

  Limits and methods of measurement of radio disturbance characteristics of industrial, scientific, medical (ISM) radio frequency equipment (Class A, Group 2) (CISPR 11)

- **EN 61000-6-2**

  Electromagnetic Compatibility (generic immunity standard— industrial)

- **47 CFR Part 18**

  Code of Federal Regulations—Limits and methods of measurement of radio interference characteristics of industrial, scientific, and medical equipment

SAFETY DIRECTIVES AND STANDARDS

- **2006/95/EC**

  EC Council directive on the harmonization of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits (LVD - Low Voltage Directive)

- **IEC/EN 61010-1**

Safety requirements for electrical equipment for measurement, control, and laboratory use

INDUSTRY GUIDELINES

- **SEMI S2-0706**

  Environmental, Health, and Safety Guidelines for Semiconductor Manufacturing Equipment

Conditions of Use

To comply with the stated directives and standards, you must meet the following conditions of use:

- Before making any other connection to this device, either connect the unit to ground through mounting to a grounded tool or connect the secondary Protective Earth (ground) terminal to a local earth (ground) terminal with a copper wire that is sized according to the applicable requirements.
- Install and operate this device only in accordance with the listed safety guidelines and all other applicable directives and standards specific to your process and application.
- Install and operate this device in an overvoltage category II installation only.
- Install and operate this device only with an RF generator which is installed in an overvoltage category II or better environment.
- Install and operate this device only in a pollution degree 2 or better environment, which means an indoor location such as a computer room, office, or factory floor where only nonconductive pollution occurs during operation. Occasionally, condensation causes temporary conductivity when the device is not operating.
- Operate this device under the ambient temperature and water specifications declared in the specification.
- To prevent against condensation, install and operate this device with an external water solenoid valve so that water flow is interrupted when the device is not operating.
- Use only shielded cables on the remote control **INTERFACE** port connector.
- Install this device so that the output power connection is inaccessible to the user.
- Dispose of this product as directed by applicable laws and regulations.

INTERLOCKS AND LIMITS

WARNING:
Advanced Energy® products only include interlocks when required by product specification. Interlocks in AE products are *not* intended to meet or satisfy safety requirements. Where interlocks exist, you must still meet and satisfy safety requirements. The presence of interlocks does *not* imply operator protection.

The VarioMatch match network does not have an interlock. Ensure that you meed your local safety standards.

Chapter 2

Product Overview and Theory

This chapter describes the AE VarioMatch™ Match Network, VM 1000/1500 Platform, including its theory of operation.

PRODUCT DESCRIPTION

A match network transforms the impedance of the load to 50 Ω to avoid reflected power and to ensure that the generator's full power is delivered to the load.

The VarioMatch match network provides rapid, accurate, and reliable impedance matching across a defined load range. Most VarioMatch match networks use a basic L-type match topology. This configuration allows a very wide tuning range.

The VarioMatch match network matches a load to an RF power generator with its nominal output impedance of 50 Ω. The load is typically a plasma chamber or CO_2-laser system.

Most VarioMatch match networks are optimized for capacitively coupled plasma and CO_2-laser loads, VarioMatch match networks have an excellent ability to match even low impedances (real part). Typical applications include CVD, PVD, sputtering, RIE, and CO_2-laser excitation. Some VarioMatch match networks (ICP options) have been optimized for inductive loads.

Employing vacuum variable capacitors for tuning ensures greater resistance to high voltage breakdown (which often occurs with air gap capacitors) and large RF current carrying capability (up to a 67 A rating). In addition, the vacuum variable capacitors permit a much finer tuning resolution, allowing faster and more accurate matching than air gap capacitors and resulting in the lowest possible reflected power levels.

To achieve the quickest and most reliable matching, VarioMatch match networks use phase and magnitude detection. This is faster than trial-and-error matching and can typically achieve a matched condition between ½ second and 5 seconds from the start of tuning. The match network accurately and reliably tunes with RF levels as little as 1% of the maximum transfer power (see Chapter 3, “Specifications”).

VarioMatch match networks are designed for operation under the demanding conditions presented by low resistance plasma loads with their resultant high RF currents. All components and connections inside the network are designed to withstand very large RF currents and high current pulses.

A DC bias measurement circuit (available on most units) permits the DC self bias voltage created in the load to be monitored. The bias voltage is scaled down by a factor of 1:400 (if not otherwise stated) to a safe, convenient value. The DC bias test voltage delivered by the VarioMatch match network always is positive, even if the actual self bias voltage in the chamber is negative.

VarioMatch match networks are completely self contained and require no additional external components; all that is required for operation is an AC **MAINS** connection. No additional controller is required if the network is operated in conjunction with an AE RF generator; manual controls for the network are incorporated in the generator itself. An additional controller is necessary only if manual operation without an AE RF generator is desired.

OPERATING MODES

The match network can operate in the following modes:

- Automatic tune mode

  AE recommends automatic tune mode for standard operation. In automatic tune mode, a fast analog control signal measures amplitude and phase, and automatically drives the capacitors to transform the impedance of the chamber to the impedance that the generator requires.

  Automatic tune mode requires no user interface.

- Manual tune mode

  In manual tune mode, the automatic tuning feature is disabled, and the capacitor positions are controlled only through the **INTERFACE** port.

THEORY OF OPERATION

Figure 2-1 describes the VarioMatch match network's theory of operation.

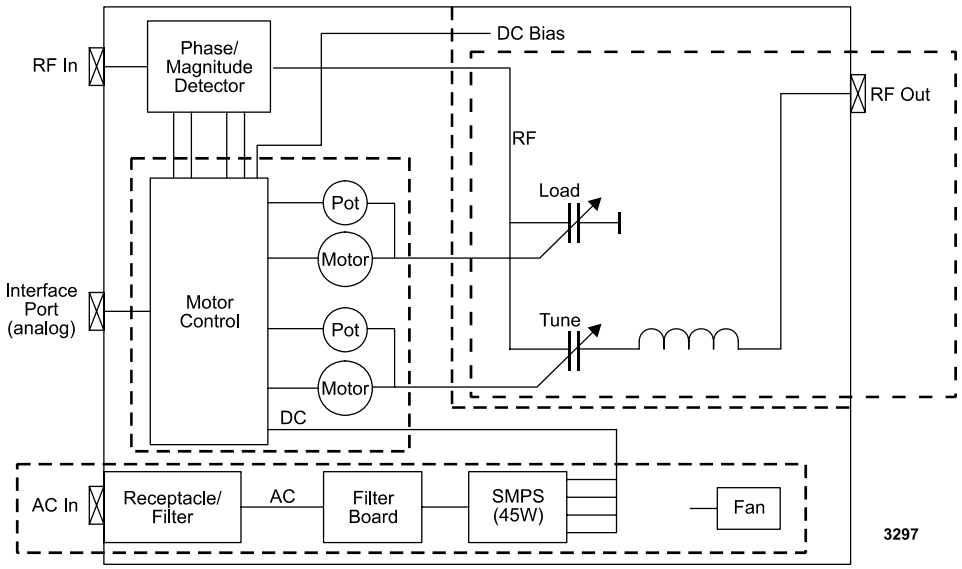


Figure 2-1. *Theory of operation*

Table 2-1. *Theory of operation description*

Section	Description
AC In	The VarioMatch match network converts 100 VAC to 240 VAC, single-phase, to the DC voltages used in the match. The 45 W SMPS (switched mode power supply) supplies ±15 VDC and +5 VDC. The cooling fan is powered from the +15 V supply.
Phase/Magnitude Detector	The RF power enters the VarioMatch match network via the **RF-GENERATOR** connector mounted directly on the Phase/Magnitude detector module. The Phase/Magnitude module provides the phase and magnitude signals to the Motor Control section. The magnitude signal controls the load capacitor, while the phase signal controls the tune capacitor.

Table 2-1. *Theory of operation description*

Section	Description
Motor Control	The Motor Control section generates the signals needed to drive the capacitor motors using the phase and magnitude signals, and provides for the manual control interface. The motors are DC motors and use potentiometers to provide feedback as to the capacitor positions. To keep the capacitors and the feedback potentiometers from reaching their mechanical limits, the motors automatically reverse directions before the mechanical limits are reached.
DC Bias	DC Bias voltage feedback is provided by the DC bias PCB and the motor driver control board. The DC bias board provides the voltage divider, whereas the motor driver board buffers and rectifies the DC bias voltage so that the DC bias voltage at the interface port is always positive.
Load and Tune	The VarioMatch match network uses either the L match topology or Gamma topology (see "Topologies" on page 2-4). The tuning elements may consist of: • Variable load capacitor • Variable tune capacitor • Load coil • Tune coil Tapped or replacable coils are used to produce the impedance range desired.

TOPOLOGIES

The VarioMatch match network uses one of the following topologies:

- L match topology (some ICP units and most non-ICP units)
- Gamma topology (most ICP units and some non-ICP units)

If you purchased an ICP unit, see Chapter 3, "Specifications" to see the topology for your unit.

L Match Topology

Figure 2-1 shows a basic L match network circuit.

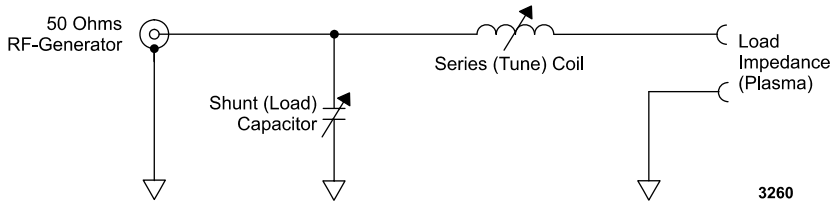


Figure 2-2. *L match network circuit*

The L match network received its name because of the configuration of the capacitor and coil used. The L match network is simple, and requires only two tuning elements—a series (or tune) coil and a shunt (or load) capacitor.

In practice a quality variable coil cannot be economically constructed because a sliding tap to the coil cannot withstand a high RF current. The typical 5 A RF rating for a highly variable coil isn't suitable for plasma loads with their high associated RF currents.

As a result of these limitations, the traditional L match network is modified by the installation of a variable capacitor connected in series with a fixed or tapped coil.

Figure 2-1 shows a typical VarioMatch L match network circuit.

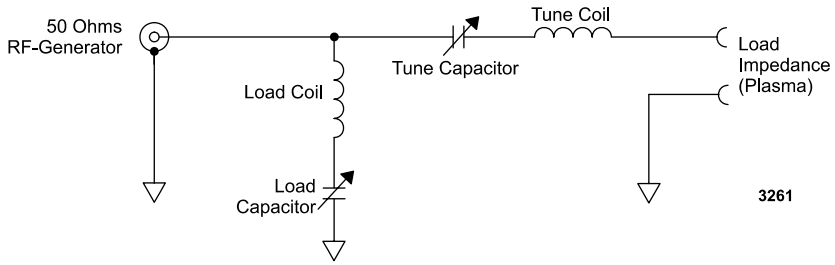


Figure 2-3. *VarioMatch L match network circuit*

In principle, the L match network is a good choice when the load impedance is not known and must be determined by experimentation. If the match network uses inductors and capacitors with very wide tuning range, nearly any impedance can be properly matched.

The tune coil is connected in series with the wiring to the load. The inductance of the wire connecting the match network to the load must be considered to be a part of the tune coil. Because of this, ensure that this wiring is as short as possible and low inductance. Short connection leads will help to reduce EMI. The VarioMatch match network must be well grounded to the load.

The major practical problem of the L match network is the need for very large tuning capacitors when matching low impedances – a typical situation with plasma chambers. The following table provides an idea of the load capacitor's capacity. The load capacitor must provide for different load resistances:

Table 2-2. *Load capacitor capacity by load*

R_{load}	Load capacitor
0.5 Ω	2335 pF
1.0 Ω	1640 pF
2.0 Ω	1150 pF
3.0 Ω	929 pF
4.0 Ω	796 pF
5.0 Ω	704 pF
6.0 Ω	635 pF
7.0 Ω	581 pF
8.0 Ω	537 pF

At load resistances lower than 3 Ω a capacity of larger than 900 pF is required.

The VarioMatch match network uses a load coil to extend the capacitance range of the load capacitor without the negative side effects described above. For more information, see "Set Up the Match for Your Load" on page 5-16.

Gamma Topology

In addition to the L match topology, AE produces match networks that use the Gamma topology. Gamma topology matches allow loads of very low impedances to be matched. This can be advantageous for ICP loads.

Some VarioMatch match network ICP units can be operated in two different configurations, which allow two different load impedance ranges. Other VarioMatch match networks use only Gamma topology. See Chapter 3, "Specifications".

In configuration A (Gamma topology) the tune (series) capacitor comes first from the generator's point of view while in configuration B (L match topology) the load (shunt) capacitor comes first.

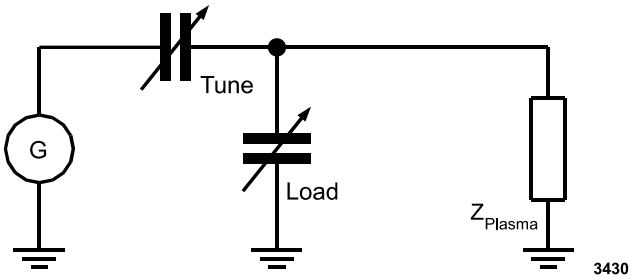


Figure 2-4. *Gamma topology*

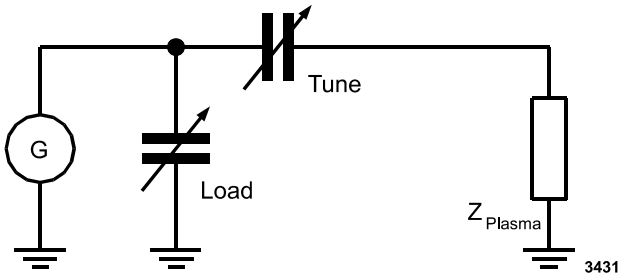


Figure 2-5. *L match topology*

Specifications

This chapter lists specifications for the VarioMatch match network.

PHYSICAL SPECIFICATIONS

Unit Dimensions

Figure 3-1 through Figure 3-4 illustrate the physical dimensions.

The **PLASMA/LOAD** connector can be located on either the rear panel or the bottom panel, depending on your model.

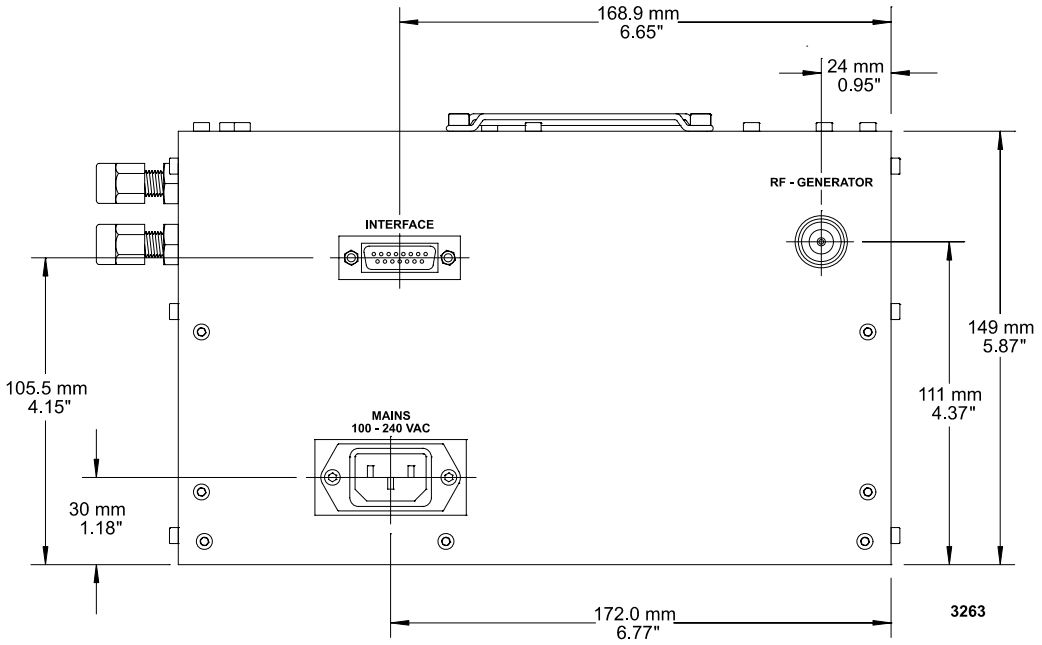


Figure 3-1. *VM 1000/1500 platform front panel*

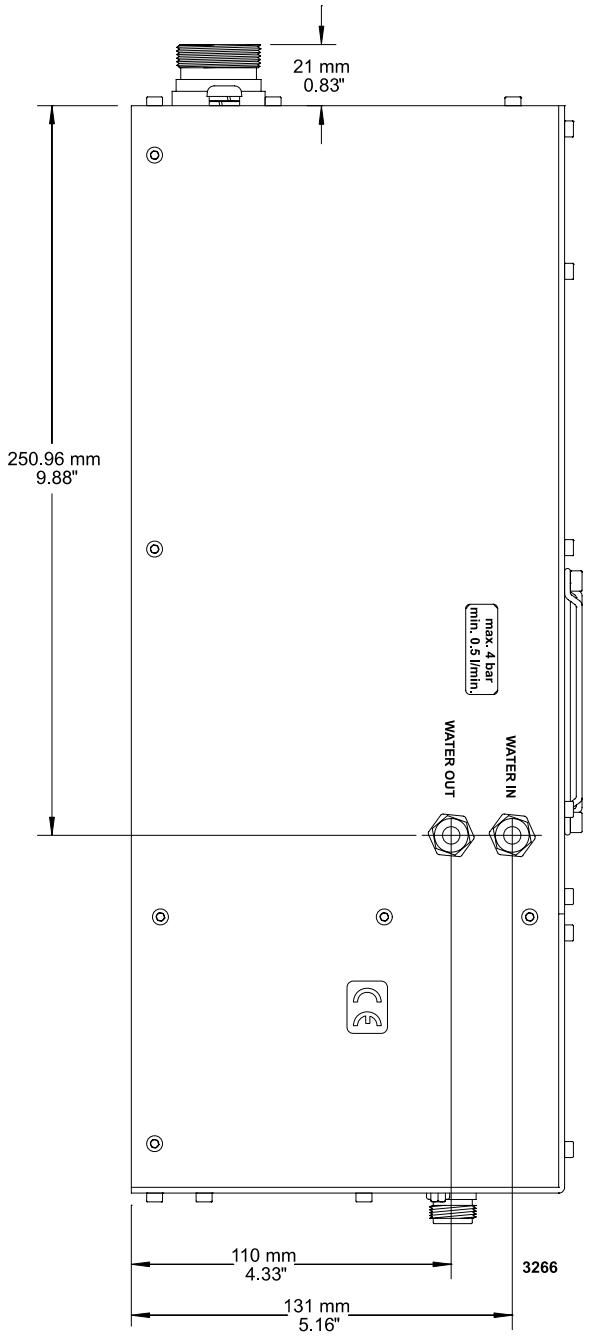


Figure 3-2. *VM 1000/1500 platform left side panel*

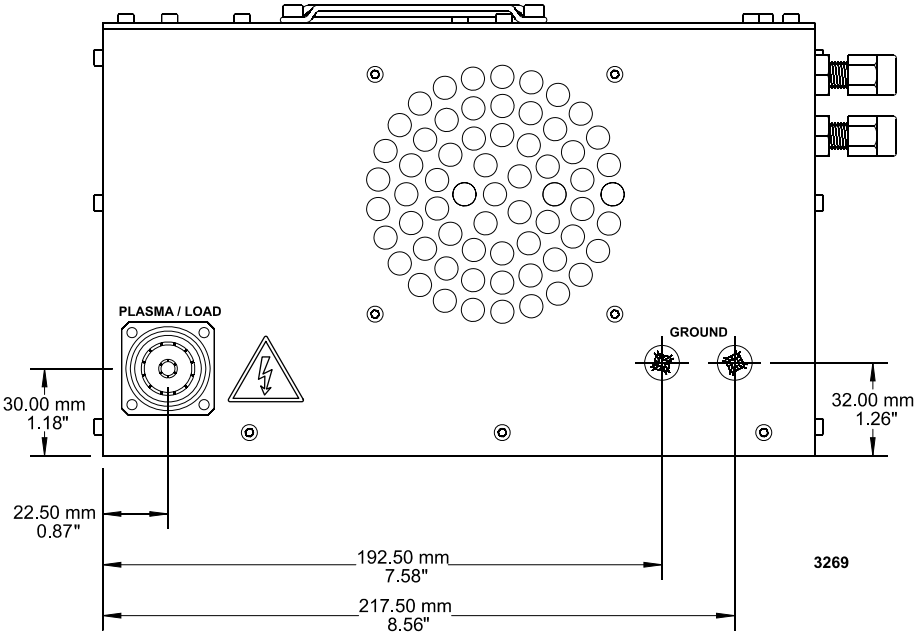


Figure 3-3. *VM 1000/1500 platform rear panel*

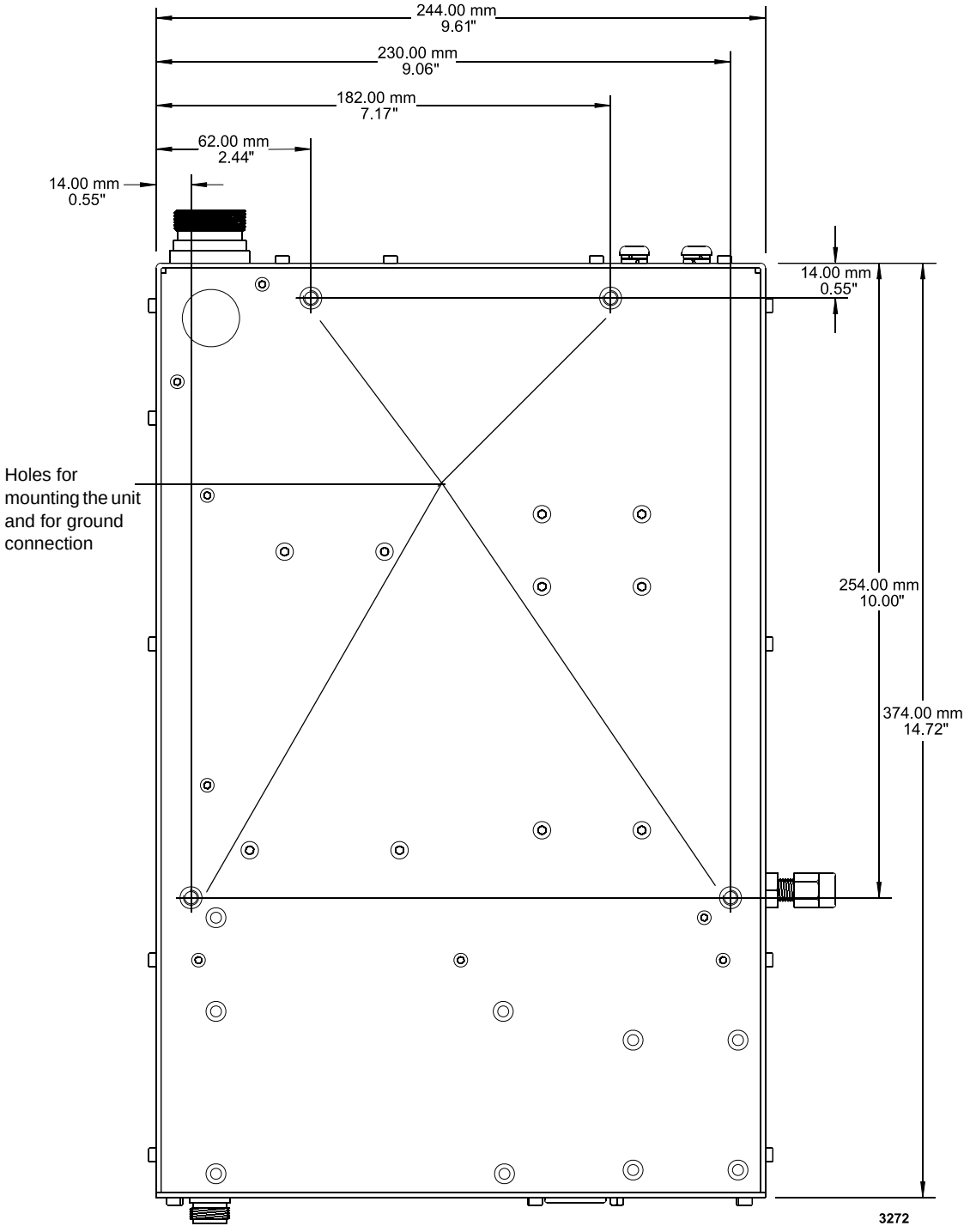


Figure 3-4. *VM 1000/1500 platform bottom panel*

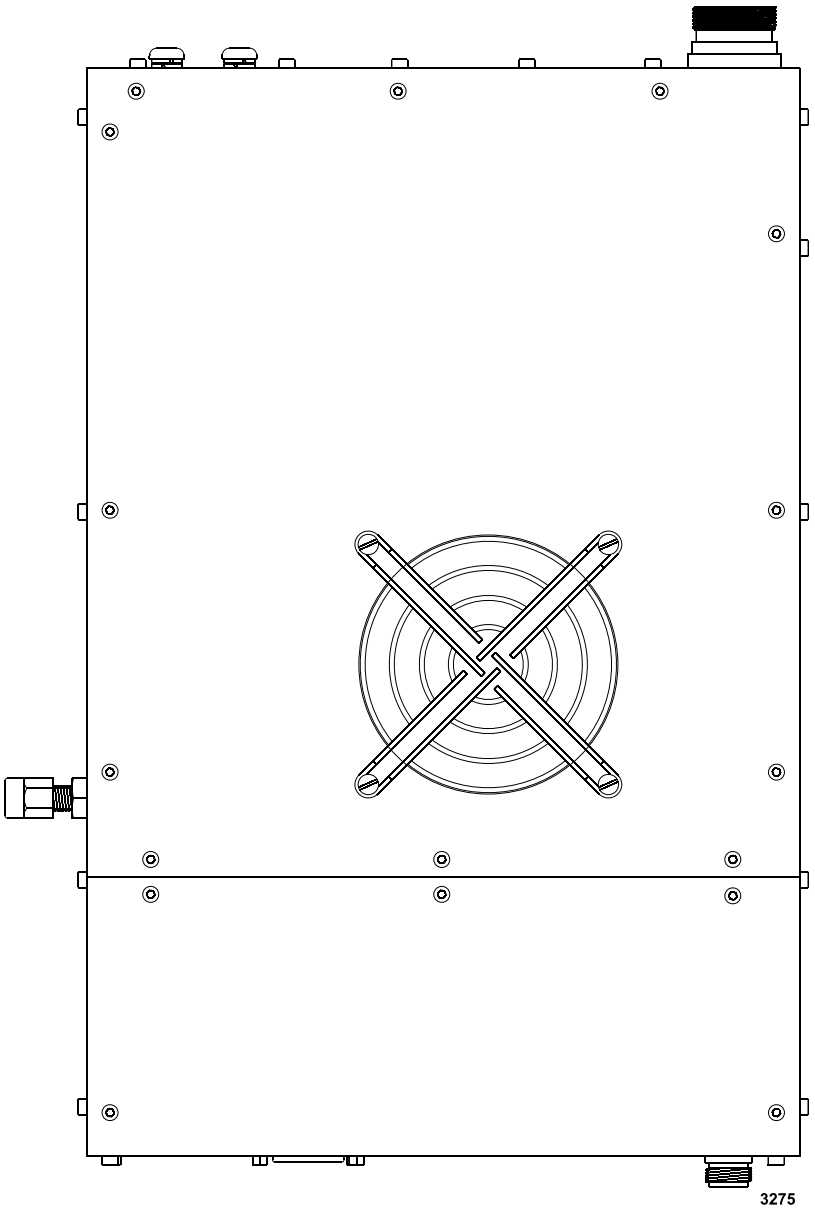


Figure 3-5. *VM 1000/1500 platform top panel*

Spacing Requirements

The following sections describe the space needed to provide room for connections and to meet cooling requirements.

FRONT PANEL CONNECTIONS

For front panel **RF Input** and other connections:

- 200 mm (7.9″) required for the **RF Input** connector when using a straight connector
- 100 mm (3.9″) required for the **RF Input** connector when using an angled connector

PLASMA/LOAD CONNECTION

- For units with the **PLASMA/LOAD** connection on the bottom panel:
  - 200 mm (7.9″) required for 7/16 connector when using a straight connector
  - 70 mm (2.8″) required for 7/16 connector when using an angled connector
- For units with the **PLASMA/LOAD** connection on the rear panel:
  - 200 mm (7.9″) required for 7/16 connector when using a straight connector
  - 80 mm (3.1″) required for 7/16 connector when using an angled connector (to also accommodate proper airflow)

No spacing recommendations are available from AE for other **PLASMA/LOAD** connections.

COOLING

For proper airflow, allow 80 mm (3.1″) above the top and rear of the unit.

For connection to water, 100 mm (3.9″) is required on the left side of the unit. If your unit is water-cooled you will see a **W** or **AW** after the model number on the product label.

Physical Specifications Table

Table 3-1 describes the physical specifications of the VarioMatch match network.

Table 3-1. *Physical specifications*

Description	Specification
Mounting	Directly onto the load or onto a mounting plate. See "Installing the VarioMatch Match Network" on page 5-4.
Size	375 mm x 245 mm x 150 mm (14.75" x 5.9" x 9.65") *Note:* Additional space required for air flow and connections. See "Spacing Requirements" on page 3-5. (See also Figure 3-1 through Figure 3-4.)
Weight	6.5 kg (14.3 lb)
Clearance	See "Spacing Requirements" on page 3-5. (See also Figure 3-1 through Figure 3-4.)
Connector/cable specifications	
Match **INTERFACE** connector	15-pin subminiature-D female. For pinout and functional description see Table 4-1 on page 4-2.
RF-GENERATOR input connector	50 Ω N-type

Table 3-1. *Physical specifications (Continued)*

Description	Specification
PLASMA/LOAD connector	Varies by VarioMatch product PN PNs 69002206, 69002207, 69002208: 6 mm brass tube fittings PNs 69000004, 69000018, 69000022, 69000024, 69000032, 69000033, 69000037, 69000041, 69000046, 69000062, 69000070, 69000080, 69000114, 69000116, 69000226, 69000227, 69000228, 69000229, 69000230, 69001214: 7/16 DIN socket PN 69000001: M6 bolt PNs 69000007, 69000023, 69000025, 69000034, 69000036, 69000115, 69000214, 69001207: MC B6N (female 6 mm) PN 69000082: Customer-supplied The connection is located on the rear, side, or bottom panel of the unit.
AC power input (**AC-MAINS**) connector	IEC 320 connector
Coolant connectors	Brass water fittings for water tubing 6 mm OD / 4 mm ID (0.24" OD / 0.16" ID)
Internal coil specifications	

Table 3-1. *Physical specifications (Continued)*

Description	Specification
Tune coil	The tune coil varies by part number on the number of turns, the number of possible taps, and the default tap setting from the factory. PN 69000001: 2.5 turns, fixed coil PN 69000036, 69000116: 14 turns, taps at 4, 6, 8, 10, 12, 14 turns, default tap setting on 1 PN 69000033, 69000037, 69000228: 14 turns, taps at 4, 6, 8, 10, 12, 14 turns, default tap setting on 2 PN 69000032, 69000080: 14 turns, taps at 4, 6, 8, 10, 12, 14 turns, default tap setting on 3 PNs 69000004, 69000018, 69000022, 69000023, 69000024, 69000025, 69000034, 69000046, 69000114, 69000115, 69000230, 69000227, 69000229, 69001207, 69001214: 14 turns, taps at 4, 6, 8, 10, 12, 14 turns, default tap setting on 4 PN 69000007, 69000041: 25 turns, taps at 10, 13, 16, 19, 22, and 25 turns, default tap setting on 4 PN 69000062, 69000226: 6 turns, taps at every turn, default tap setting on 6 PN 69000070: 6 turns, taps at every turn, default tap setting on 2 PN 69000214: 26.5 turns, taps at 1 through 10, default tap setting on 3 PN 69000082: 5 turns, fixed PN 69002206, 69002207, 69002208: no tune coil on these ICP units

Table 3-1. *Physical specifications (Continued)*

Description	Specification
Load coil	The load coil varies by VarioMatch product part number on the number of turns, the number of possible taps, and the default tap setting from the factory (A, B, or C). PN 69000001, 69000062, 69000226, 69002206, 69002207, 69002208: No load coil PN 69000004, 69000018, 69000022, 69000023, 69000024, 69000025, 69000046, 69000114, 69000115, 69000214, 69000230, 69000227, 69000229, 69000032, 69000034, 69001207, 69001214: 2 turns, 3 taps, default: B PN 6900003, 69000036, 69000037, 69000080, 69000082, 69000116, 69000228: 2 turns, 3 taps, default: C PN 69000007, 69000041: 4 turns. 5 taps. default: B
Topology	Varies by VarioMatch product PN PN 69002206, 69002207, 69002208: L match or Gamma (Default: Gamma) PN 69000001: Gamma All other PNs: L match

ELECTRICAL SPECIFICATIONS

This section includes electrical specifications for VM 300, VM 700, VM 1000, and VM 1500 products.

VM 300 Series

Table 3-2 describes the VM 300 series electrical specifications.

Table 3-2. *Electrical specifications for VM 300 series*

Description	Specification
Frequency	13.56 MHz
AC line voltage	100 VAC to 240 VAC, single ϕ
AC line frequency	50 Hz to 60 Hz
AC line current (maximum)	1.0 A to 0.7 A
Maximum transfer power	300 W
Maximum reactive power	88,000 W
Maximum RF load current	22 A
Maximum RF load voltage	4000 V_{peak}
Input impedance to generator	50 Ω
Maximum load DC self bias voltage	0 VDC to 10 VDC
Runtime from start point to end point	3 seconds
Tuning range	To reach appropriate resistance and reactance values, you may need to change load and/or tune coil settings. See "Set Up the Match for Your Load" on page 5-16. For details on tuning ranges possible for your unit, see Chapter 7, "VarioMatch Match Network Tuning Ranges".

VM 700 Series

Table 3-3 describes the VM 700 series electrical specifications.

Table 3-3. *Electrical specifications for VM 700 series*

Description	Specification
Frequency	13.56 MHz
AC line voltage	100 VAC to 240 VAC, single ϕ
AC line frequency	50 Hz to 60 Hz
AC line current (maximum)	1.0 A to 0.7 A
Maximum transfer power	700 W
Maximum reactive power	60,000 W

Table 3-3. *Electrical specifications for VM 700 series (Continued)*

Description	Specification
Maximum RF load current	15 A
Maximum RF load voltage	4000 V_{peak}
Input impedance to generator	50 Ω
Maximum load DC self bias voltage	0 VDC to 4000 VDC
DC selfbias monitor voltage	0 V to 10 V
Runtime from start point to end point	3 seconds
Tuning range	To reach appropriate resistance and reactance values, you may need to change load and series coil settings. See "Set Up the Match for Your Load" on page 5-16. For details on tuning ranges possible for your unit, see Chapter 7, "VarioMatch Match Network Tuning Ranges".

VM1000 Series

Table 3-2 describes the VM 1000 series electrical specifications.

Table 3-4. *Electrical specifications for VM 1000 series*

Description	Specification
Frequency	13.56 MHz
AC line voltage	100 VAC to 240 VAC, single ϕ
AC line frequency	50 Hz to 60 Hz
AC line current (maximum)	1.0 A to 0.7 A
Maximum transfer power	1000 W
Maximum reactive power	Varies by VarioMatch product part number: PN 69000023, 69000115: 100,000 W All other PNs: 88,000 W
Maximum RF load current	Varies by part number: PN 69000023, 69000115: 25 A All other PNs: 22 A
Maximum RF load voltage	4000 V_{peak}
Input impedance to generator	50 Ω

Table 3-4. *Electrical specifications for VM 1000 series (Continued)*

Description	Specification
Maximum load DC self bias voltage	0 VDC to 4000 VDC
DC selfbias monitor voltage	0 V to 10 V
Runtime from start point to end point	3 seconds
Tuning range	To reach appropriate resistance and reactance values, you may need to change load and/or tune coil settings. See "Set Up the Match for Your Load" on page 5-16. For details on tuning ranges possible for your unit, see Chapter 7, "VarioMatch Match Network Tuning Ranges".

VM 1500 Series

Table 3-5 describes the VM 1500 series electrical specifications.

Table 3-5. *Electrical specifications for VM 1500 series*

Description	Specification
Frequency	Varies by VarioMatch product part number. PN 69000001, 69000024, 69000025, 69000229, 69001207, 69001214, 69002207: 13.56 MHz PN 69000007, 69000041: 2.00 MHz or 4.00 MHz, set at the factory PN 69000062, 69000226: 27.12 MHz PN 69000070, 69002208: 40.68 MHz
AC line voltage	100 VAC to 240 VAC, single ϕ
AC line frequency	50 Hz to 60 Hz
AC line current (maximum)	1.0 A to 0.7 A
Maximum transfer power	1500 W

Table 3-5. *Electrical specifications for VM 1500 series (Continued)*

Description	Specification
Maximum reactive power	Varies by VarioMatch product part number: PN 69000070, 69000226: 80,000 W PN 69000062: 100,000 W PN 69000001, 69000024, 69000025, 69000229, 69001207, 69001214, 69002207, 69002208: 140,000 W PN 69000007, 69000041: 220,000 W
Maximum RF load current	Varies by VarioMatch product part number: PN 69000070, 69000226: 20 A PN 69000062: 25 A PN 69000001, 69000024, 69000025, 69000229, 69001207, 69001214, 69002207, 69002208: 35 A PN 69000007, 69000041: 55 A
Maximum RF load voltage	4000 V_{peak}
Input impedance to generator	50 Ω
Maximum load DC self bias voltage	0 VDC to 4000 VDC
DC selfbias monitor voltage	0 V to 10 V
Runtime from start point to end point	3 seconds
Tuning range	To reach appropriate resistance and reactance values, you may need to change load and series coil settings. See "Set Up the Match for Your Load" on page 5-16. For details on tuning ranges possible for your unit, see Chapter 7, "VarioMatch Match Network Tuning Ranges".

COOLING SPECIFICATIONS

Table 3-6 lists the cooling specifications for the match network. Table 3-7 describes the environmental and climatic specifications.

CAUTION:
Do not use de-ionized water for cooling purposes. De-ionized water causes both corrosion and erosion of cooling manifolds.

Table 3-6. *Cooling specifications*

Description	Specification
Cooling medium	Air-cooled (for units that show only "A" after the model name or Air- and Water-cooled (for units that show "W" or "AW" after the model name)
Minimum water flow	1 lpm (0.26 gpm)
Water pressure	0.5 bar (7.25 psi) differential as required to achieve minimum flow rate. Maximum water pressure 4 bar (58 psi), maximum inlet, not recommended for operation.
Cooling water temperature	20ºC to 35ºC. Cooling water temperature must always be higher than ambient temperature to avoid condensation.

Table 3-6. *Cooling specifications (Continued)*

Description	Specification
Contaminates	AE recommends the following specifications for the water used to cool the Navigator match network: • pH between 7 and 9 • total chlorine <20 ppm • total nitrate <10 ppm • total sulfate <100 ppm • total dissolved solids <250 ppm • total hardness expressed as calcium carbonate equivalent maximum 250 ppm • <250 ppm • specific resistivity of 2500 Ω/cm or higher at 25ºC • total dissolved solids (TDS) as estimated by the following: TDS ≤ 640,000/specific resistivity (in Ω/cm) *Note:* Do not use deionized water for cooling purposes in order to prevent corrosion and erosion of cooling manifolds
Minimum air flow	120 m^3/h

ENVIRONMENTAL SPECIFICATIONS

Table 3-7 and Table 3-8 describe the environmental specifications of the VarioMatch match network.

Table 3-7. *Climatic specifications (per EN50178)*

	Temperature	Relative Humidity	Air Pressure
Operating	+5ºC to +40ºC +41ºF to 104ºF	5% to 85% Note 1 +1 g/m^3 to +25 g/m^3	78 kPa to 106 kPa 788 mbar to 1060 mbar Equivalent altitude: 2000 m to -500 m (6562 ft to -1640 ft)
Storage	-25ºC to +55ºC -13ºF to +131ºF	5% to 95% +1 g/m^3 to +29 g/m^3	78 kPa to 106 kPa 788 mbar to 1060 mbar Equivalent altitude: 2000 m to -500 m (6562 ft to -1640 ft)
Transportation	-25ºC to +70ºC -13ºF to +158ºF	95% Note 2 +60 g/m^3 Note 3	65.6 kPa to 106 kPa 656 mbar to 1060 mbar Equivalent altitude: 3500 m to -500 m (11480 ft to -1640 ft)

Note 1 Noncondensing, no formation of ice

Note 2 Maximum relative humidity when the unit temperature slowly increases, or when the unit temperature directly increases from -25ºC to +30ºC

Note 3 Maximum absolute humidity when the unit temperature directly decreases from +70ºC to +15ºC

Table 3-8. *Environmental specifications*

Description	Specification
Overvoltage	Category II
Pollution degree	2

Chapter 4

Communication Interfaces and Controls

This chapter describes the VarioMatch match network's communication interface.

15-PIN VARIOMATCH MATCH INTERFACE

The 15-pin match **INTERFACE** on the VarioMatch match network provides analog and digital signals for controlling and monitoring the unit. This interface allows manual tune, preset, and monitoring functionality for a VarioMatch match network by an AE generator, such as a CESAR. It can also be used by an external controller.

Table 4-1 on page 4-2 describes each pin used in the match **INTERFACE**.

Alternatively, you can control the VarioMatch match network using five switches (see "Match INTERFACE Using Switches" on page 4-7).

INTERFACE Connector

The match **INTERFACE** connector is a 15-pin, shielded, female, subminiature-D connector (see Figure 4-1).

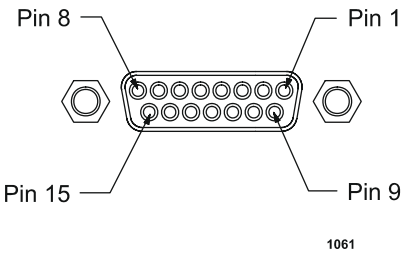


Figure 4-1. *VarioMatch match INTERFACE connector*

Match Interface Cabling Requirements

Connect the VarioMatch match network's 15-pin **INTERFACE** port to the generator with a shielded, 15-wire I/O cable. Minimize signal losses by keeping the cable as short as possible. The maximum recommended cable length between the VarioMatch match network and the controller is 10 meters (33 feet), although this may vary by installation. Minimize interference from adjacent electrical equipment by terminating the EMI shield in the cable to the metal shells of the cable's connectors. Additionally, you must tie the chassis of the VarioMatch match network to a local earth ground through an adequately sized copper grounding strap.

Note: Grounding the **INTERFACE** port at the VarioMatch match network reduces noise interference. To avoid ground loop problems, you should typically ground only one end of the **INTERFACE** port cable.

Pin Descriptions

Unless otherwise specified, all analog signals are 0 V to 10 V. Digital signals are referenced to ground. All inputs need to be switched to ground to activate, all outputs are open-collector.

Table 4-1. *VarioMatch match INTERFACE connector pin description*

Pin	Return Pin	Name	Signal Type	Description
1	GND	*GROUND*	Gnd	Connect to the shield of the cable (for example RC cable).
2	1 or 9	*DECREASE* C_{Load}	Input	Connect this +15 V input to ground to turn motor load counterclockwise and thus decrease C_{Load}. Interrupt the connection to ground when the desired position for C_{Load} is reached.
3	1 or 9	*INCREASE* C_{Load}	Input	Connect this +15 V input to ground to turn motor load clockwise and thus increase C_{Load}. Interrupt the connection to ground when the desired position for C_{Load} is reached.
4	1 or 9	*DECREASE* C_{Tune}	Input	Connect this +15 V input to ground to turn motor load counterclockwise and thus decrease C_{Tune}. Interrupt the connection to ground when the desired position for C_{Tune} is reached.
5	1 or 9	*INCREASE* C_{Tune}	Input	Connect this +15 V input to ground to turn motor load clockwise and thus increase C_{Tune}. Interrupt the connection to ground when the desired position for C_{Tune} is reached.

Table 4-1. *VarioMatch match INTERFACE connector pin description*

Pin	Return Pin	Name	Signal Type	Description
6	GND	*GROUND*	Gnd	Reference ground for DC Bias and capacitor position signals.
7	N/A			Reserved
8	1 or 9	*MANUAL MODE*	Input	Connect this +15 V input to ground to set the VarioMatch match network into manual mode.
9	GND	*GROUND*	Gnd	Ground connect to the cable shield.
10	1 or 9	*+5V SUPPLY*	Output	+5 Volts DC from internal DC supply. For external use. Maximum current draw 100 mA.
11	1 or 9	*+15V SUPPLY*	Output	+15 V DC from internal DC supply. For external use. Maximum current draw 100 mA.
12	6	*DC-SELFBIAS MONITOR*	Output	DC self bias test voltage. Provides a test voltage to monitor the DC self bias of the plasma electrode in the vacuum chamber. The output voltage is scaled down 400:1 (400 V of DC bias results in 1 V output). The instrument used to measure the bias voltage should have an input impedance of at least 10 kΩ.
13	6	C_{Tune} *POSITION MONITOR*	Output	Series (tune) capacitor position signal. The voltage at this output is directly proportional to the position of the capacitor C_{Tune}. The minimum voltage is approximately 0.3 V representing the minimum capacity of C_{Tune}. The maximum voltage is approximately 9.7 V representing the maximum capacity of C_{Tune}.

Table 4-1. *VarioMatch match INTERFACE connector pin description*

Pin	Return Pin	Name	Signal Type	Description
14	6	C_{Load} *POSITION MONITOR*	Output	Shunt (load) capacitor position signal. The voltage at this output is directly proportional to the position of the capacitor C_{Load}. The minimum voltage is approximately 0.3 V representing the minimum capacity of C_{Load}. The maximum voltage is approximately 9.7 V representing the maximum capacity of C_{Load}.
15	1 or 9	*MATCHING ACTIVITY STATUS*	Output	This open collector output is pulled low when the VarioMatch match network is active (the motors are running) and floats when the matching is done (the motors are not running). 30 V maximum, 20 mA maximum.

Wiring Diagrams

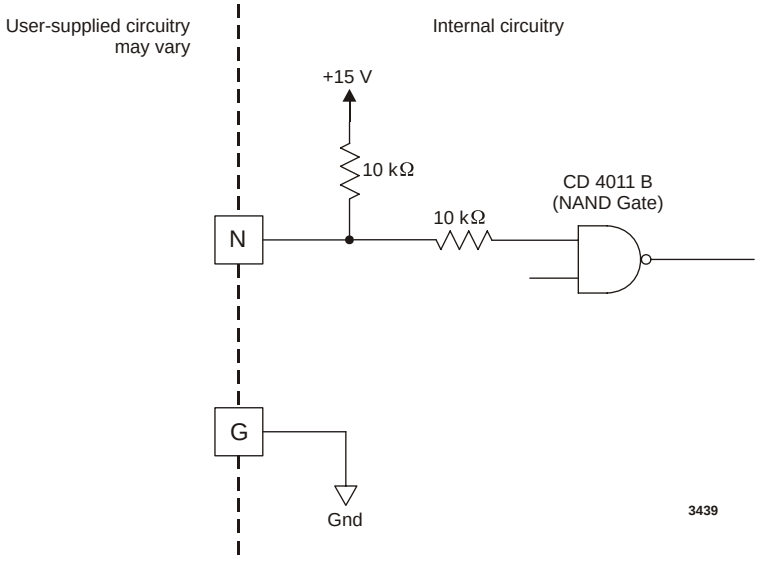


Figure 4-2. *Pins 2, 3, 4, 5, 8*

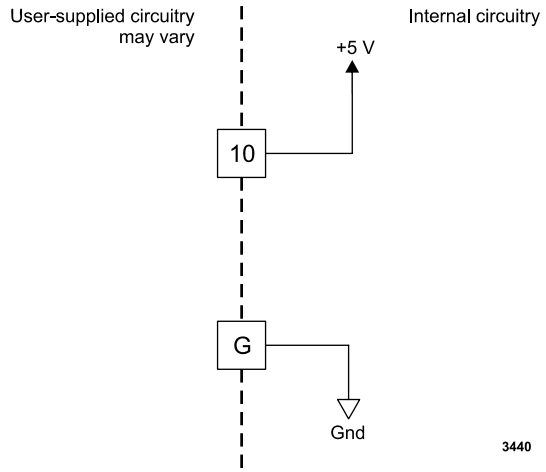


Figure 4-3. *Pin 10*

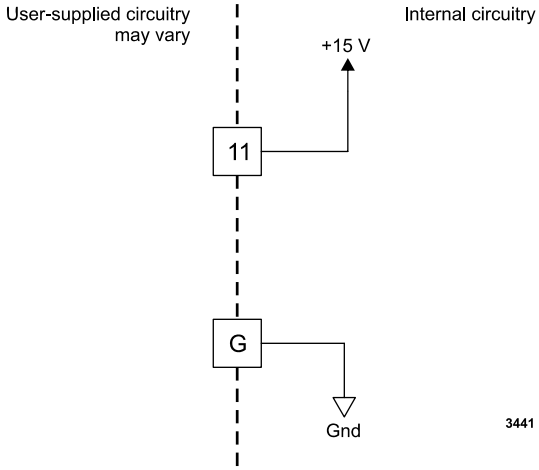


Figure 4-4. *Pin 11*

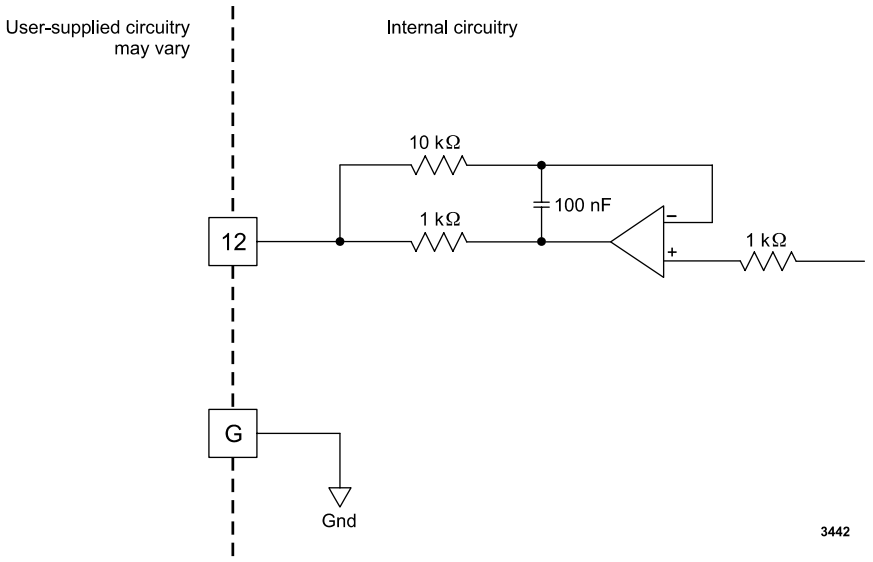


Figure 4-5. *Pin 12*

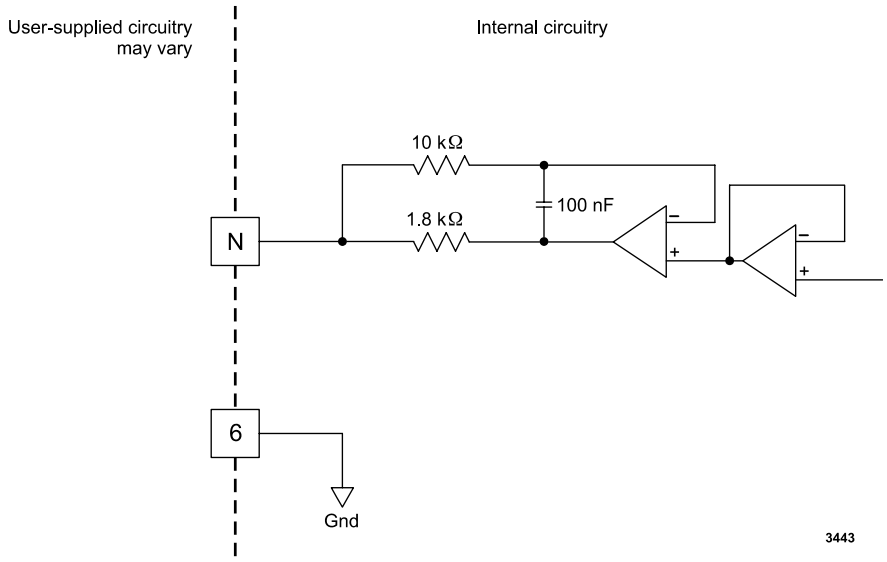


Figure 4-6. *Pins 13, 14*

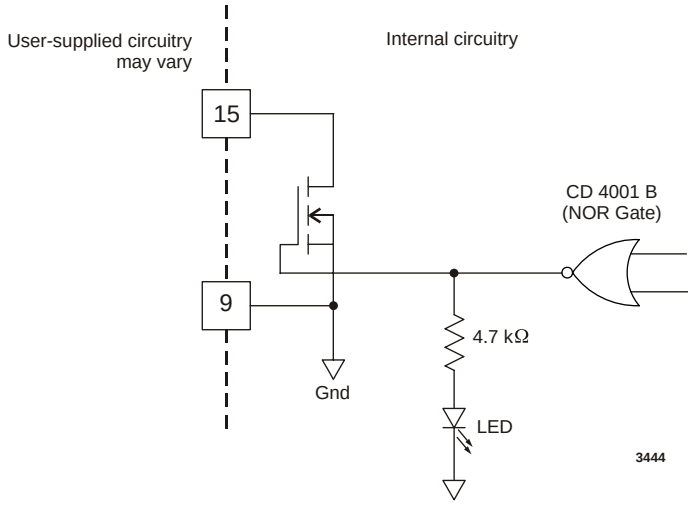


Figure 4-7. *Pin 15*

Match INTERFACE Using Switches

To construct a simple manual control, wire four normally open momentary switches for the motor drive and one on/off switch for auto/manual mode selection as described below.

Table 4-2. *Match INTERFACE switch descriptions*

Momentary switch	Motor drive	Results		Connect to INTERFACE Pin #
Common connection of all 5 switches (Ground)				1
Switch 1	motor 1	run clockwise	decrease C_{Tune}	2
Switch 2	motor 1	run counter clockwise	increase C_{Tune}	3
Switch 3	motor 2	run clockwise	decrease C_{Load}	4
Switch 4	motor 2	run counter clockwise	increase C_{Load}	5
Switch 5 (on/ off)	Manual/ Auto	Selects Manual or Auto mode		8

Connect the switch box to the match **INTERFACE** using a shielded cable. The shield should be connected to ground at pin 1 of the D-connector. To avoid a ground loop, which could result in erratic operation of the remote control, do not connect the cable shield to any other ground in the system.

Chapter 5

Installation, Setup, and Operation

PREPARING TO INSTALL THE VARIOMATCH MATCH NETWORK

The following sections provide information that you need to understand before installing the VarioMatch match network.

Spacing Requirements

See "Physical Specifications" on page 3-1 for the unit dimensions and clearance.

Installation Requirements

Install this unit according to the following requirements.

WARNING:
Maintenance personnel must receive proper training before installing, troubleshooting, or maintaining high-energy electrical equipment. Potentially lethal voltages could cause death, serious personal injury, or damage to the equipment. Ensure that all appropriate safety precautions are taken.

DANGER:
RISK OF DEATH OR BODILY INJURY. Disconnect and lockout/tagout all sources of input power before working on this unit or anything connected to it.

COOLING REQUIREMENTS

Ensure that exhausted air does not circulate back into the unit and become input air. Also, ensure that all cooling requirements are within specification. See “Cooling Specifications” on page 3-14.

Tools Required for Installation

AE supplies the following equipment:

- Two AC **MAINS** cables. Use the cable appropriate to your location.
- If the P**LASMA/LOAD** connector on your VarioMatch match network is MC6 or 6 mm brass tube fittings, AE supplies the matching plug. See the “Physical Specifications” on page 3-1 to see which **PLASMA/LOAD** connector your unit uses.

For successful installation, you will need to supply the following additional equipment:

- Four M6 mounting screws (preferably brass) and an appropriate screwdriver.
- If the **PLASMA/LOAD** connector on your VarioMatch match network is a strap connection, you need to supply the strap connector and the ground strap. See the “Physical Specifications” on page 3-1 to see which **PLASMA/LOAD** connector your unit uses.
- For water-cooled units: Plastic hose 6 mm OD / 4 mm ID (0.24" OD / 0.16" ID) (see “Connecting the Cooling Water” on page 5-7).
- Cables (see also “Connector/Cable specifications” on page 3-3):
  - Shielded 50 Ω coaxial cable for RF input from the generator
  - RF cabling to connect the unit to a generator. See “Cable Requirements” on page 5-3.
  - Communication interface cable if you will use remote control of the unit.
- If you purchased an ICP unit, you must supply the tune coil. See the “Physical Specifications” on page 3-1 to see if your unit is ICP.

Unpacking

Unpack and inspect the unit carefully, looking for obvious physical damage. If no damage is apparent, proceed with the installation. If you do see signs of shipping damage, contact Advanced Energy® and the carrier immediately (see “Contacting AE Global Services” on page 6-4). Save the shipping container for submitting necessary claims to the carrier.

Cable Requirements

GENERAL CABLING CONSIDERATIONS FOR PLASMA/LOAD

The main objective of an RF delivery system is to provide as much of the generator's output power to the load as possible. However, losses occur in the coaxial cable, the match network, and in the lead between the match network and load. These losses should be kept as low as possible.

Guidelines to Minimize Losses

Use the following guidelines to minimize losses:

- Keep RF cabling between matching network and load as short as possible.
- Ensure proper shielding of all RF leads.
- Ensure a proper RF return path (ground). Remember that RF can only run on the surface, but not through material.
- All RF conductive parts should consist of silver plated copper, electrolytic copper, aluminium, or stainless steel.
- Do not use regular steel because it is a bad RF conductor. It will cause high losses and eventually burn away.

Guidelines for PLASMA/LOAD Cables and Connectors

The proper connection of the VarioMatch match network to the load influences operation of the whole RF system. The following is important information for connecting to **PLASMA/LOAD**.

There will be a high RF current flowing between the VarioMatch match network and the load. The RF output (**PLASMA/LOAD**) is much higher than RF input (**RF-GENERATOR**). High currents are common because the real part of a load impedance is typically between 1 Ω and 10 Ω. This results in a relatively high current even at low RF power levels.

Due to skin effects, the RF current will flow only on the surface of the conductor, reaching a depth of only 10 micrometers to 20 micrometers, depending on the conductor material and the frequency. To reduce the conductive losses as well unwanted voltages drops across the lead, always try to optimize the surface area of a lead.

The large RF current flowing through the lead to the load will cause losses in power as well as RF radiation. For optimum results, minimize the lead length and maximize the lead surface area. If you don't use a coaxial cable as the **PLASMA/LOAD** connection (coaxial cable should not be used at power levels exceeding approximately 1.5 kW), you must ensure adequate RF shielding of the connection to prevent RF radiation which can cause malfunctions in nearby instrumentation and electronic equipment.

If your unit uses a coaxial connector, then wire the coaxial connector to the load using the shortest possible length of cable. For power levels greater than 1 kW cable length should not exceed one meter. Use a coaxial cable with high voltage capability and good thermal immunity. AE recommends RG 393/U, a coaxial cable with Teflon insulation. Compared to conventional coaxial cable capable of operating at 80°C maximum, this cable can run at up to 200°C without any damage. This consideration is important, as the heat generated by the losses of the connection plus the heat transferred from the load is considerable.

If your VarioMatch match network uses a female 6 mm multi-contact high-current connector or an M6 bolt, connect the **PLASMA/LOAD** connector to the load with wiring of the lowest possible impedance. A flat copper strip 30 to 50 mm or more wide is much better suited for this connection than a thick wire.

See the "Physical Specifications" on page 3-1 to see which connector your unit uses.

SHIELDING THE RF CONNECTIONS

Shield all RF connections to prevent RF radiation and to minimize safety hazards. Shielding is also important to communication, as excessive noise can corrupt the data packet and cause errors. If you are using a copper strap, arrange a good, well-grounded shield around the copper strap (as you would with a coaxial cable) to prevent RF radiation.

INSTALLING THE VARIOMATCH MATCH NETWORK

⚠ WARNING:
Maintenance personnel must receive proper training before installing, troubleshooting, or maintaining high-energy electrical equipment. Potentially lethal voltages could cause death, serious personal injury, or damage to the equipment. Ensure that all appropriate safety precautions are taken.

The following sections explain how to install the unit.

2. “Connecting the Match INTERFACE (Optional)” on page 5-7
3. “Connecting the Cooling Water” on page 5-7
4. “Connecting RF Input From a Generator” on page 5-8
5. “Connecting to the Load” on page 5-9
6. “Connecting AC Input (Mains) Power” on page 5-11

Mounting the Unit

GENERAL MOUNTING INSTRUCTIONS

CAUTION:
Do not mount on hot tool; excessive temperatures can cause components to overheat and fail.

When mounting the VarioMatch match network, keep in mind the following:

- Mount the VarioMatch match network as close as possible to the load, leaving room to access all connectors and to open the top panel. See “Physical Specifications” on page 3-1 for dimensions and spacing requirements.
- Ensure the unit will remain within the specified operating temperatures. See “Cooling Specifications” on page 3-14.
- Ensure that exhausted air does not circulate back into the unit to become input air.
- Install the VarioMatch match network so that the cooling fan is facing up.
- Position the unit so that it is easy to unplug the AC input power cord, unless you install another suitable disconnecting device that complies with the accessibility and other applicable requirements of EN 61010-1.
- Ensure proper grounding (see “Grounding the Unit” on page 5-5).
- Mount the VarioMatch match network (see “Mounting the VarioMatch Match Network” on page 5-6).

GROUNDING THE UNIT

WARNING:
Do not attempt to turn on power until the VarioMatch match network is grounded.

A good ground connection is essential to achieve the best possible RF connection between the match network and the ground of the load. The VarioMatch match network chassis must be intimately grounded to the plasma chamber

The ground lead must provide a low impedance RF path. If a proper RF ground is not achieved, the RF current flowing through the ground leads will cause ground bouncing. The RF current flowing through a poor ground connection will result into a voltage across that ground lead. In this situation, the load and the match network will have a different voltage potential and the ground can no longer be regarded as a good and common ground, which can result in the following:

- RF radiation
- Malfunction of match controllers or other devices
- Electrical shock from the VarioMatch match network cabinet

To Properly Ground the VarioMatch Match Network:

Mount the unit as described in “Mounting the VarioMatch Match Network” on page 5-6. RF grounding is achieved via mounting the unit to the mounting plate.

Note: Use the **GROUND** connectors on the rear of the unit only if you cannot mount the VarioMatch match network as described.

MOUNTING THE VARIOMATCH MATCH NETWORK

Note: VM 69000082: see your company's internal documentation for mounting instructions.

Use these instructions for mounting the VarioMatch match network to a mounting plate attached to the load. The mounting plate acts as ground for the VarioMatch match network.

There is no need to open the VarioMatch match network cover. You can secure the unit to the mounting plate using the four M6 mounting threads on the bottom panel.

For the location of the screw holes, see “Unit Dimensions” on page 3-1.

When selecting the mounting hardware, choose screws that will not extend into the unit cabinet more than 10 mm. Brass fasteners are recommended.

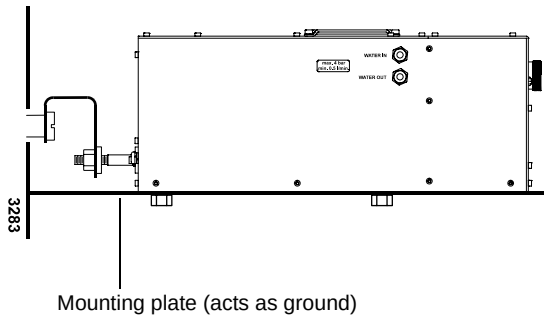


Figure 5-1. *Installing the VarioMatch match network to a mounting plate*

To Mount the VarioMatch Match Network:

1. Ensure AC **MAINS**, **PLASMA/LOAD**, and **RF-GENERATOR** are all disconnected.
2. If the **PLASMA/LOAD** connector is on the bottom of the unit, ensure you have an opening in the mounting plate that lines up with the connector.
3. Attach the VarioMatch match network cabinet to the mounting plate with four M6 screws.

Connecting the Match INTERFACE (Optional)

The 15-pin female subminiature-D connector on the front panel lets you connect the VarioMatch match network to an external remote controller (like the AE RMC-1 or a homemade controller) or to an AE RF generator.

To Connect the Match INTERFACE:

Connect the cable between the controlling device and the **INTERFACE** connection on the VarioMatch match network. For specific information on the interface connection, including pin descriptions and communication protocols, see Chapter 4, “Communication Interfaces and Controls”.

Connecting the Cooling Water

CAUTION:
Do not use de-ionized water for cooling purposes. De-ionized water causes both corrosion and erosion of cooling manifolds.

> **CAUTION:**
> **When fastening the water hose, be sure the bullkhead does not rotate; this could cause internal damage to the unit.**

If your unit is not water-cooled, skip this section.

The **Water In** and **Water Out** connectors are brass hose connectors on the side panel of the VarioMatch match network. The VarioMatch match network includes the water fitting (see Figure 5-2) for plastic hoses with 6 mm OD / 4 mm ID (0.24" OD / 0.16" ID). The VarioMatch match network water cooling system does not include water solenoid, water flow meter, or humidity sensor. You must take external measures to protect the unit and the environment.

To Connect Cooling Water:

1. Install the user-supplied water lines to **WATER IN** and **WATER OUT**. See the SERTO® documentation for instructions on properly connecting the water lines to the water fitting.
2. Ensure you meet all cooling requirements (see "Cooling Requirements" on page 5-2).
3. Leak-check the water connections.

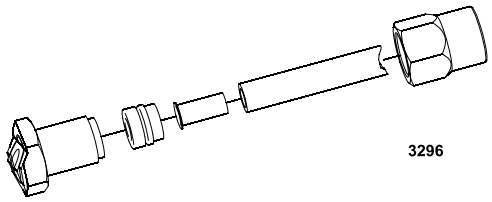


Figure 5-2. *Water fitting for plastic hose with 6 mm OD / 4 mm ID (0.24" OD / 0.16" ID)*

Connecting RF Input From a Generator

Connect the user-supplied coaxial cable from the generator's RF output to the **RF-GENERATOR** connector on the match network.

The **RF-GENERATOR** connector is a 50 Ω N-type connector. Figure 5-3 shows the **RF-GENERATOR** connector, and Table 5-1 describes the input connector pins.

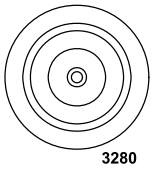


Figure 5-3. *N-type connector*

Table 5-1. *RF input connector pin descriptions*

Pin	Description
Center	RF input
Outer	Ground

Connecting to the Load

Note: VM 69000082: The RF output connector is customer supplied. See your company's internal documentation for information.

The VarioMatch match network uses one of the following RF Output (**PLASMA/LOAD**) connectors, located on the rear, side, or bottom panel of your unit (See the "Physical Specifications" on page 3-1 to see which connector your unit uses.):

- 7/16 DIN socket (Figure 5-4 on page 5-10)
- MC6 (Figure 5-5 and Figure 5-6 on page 5-10)
- 6 mm brass tube fitting (Figure 5-7 on page 5-11)

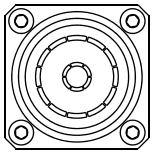


Figure 5-4. *7/16 DIN female connector*

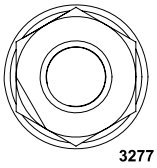


Figure 5-5. *MC6 connector*

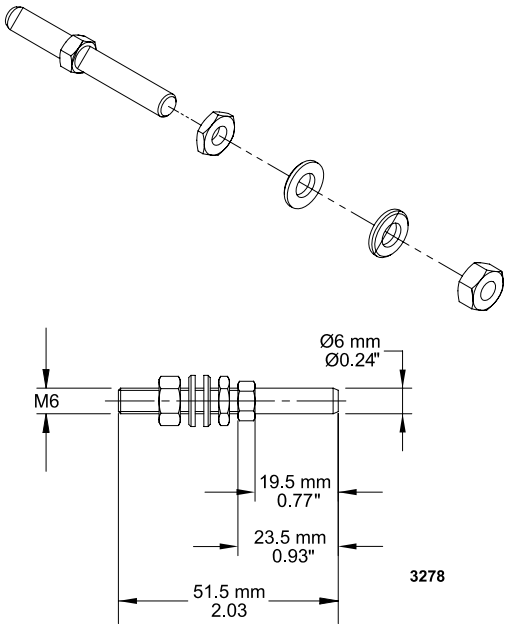


Figure 5-6. *MC6 plug*

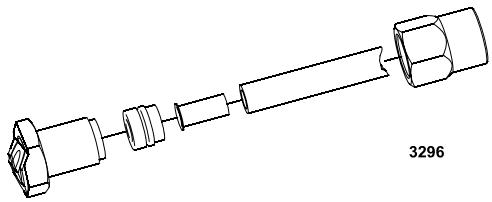


Figure 5-7. *6 mm brass tube fitting*

CONNECTING THE VARIOMATCH MATCH NETWORK TO THE LOAD

To Connect the VarioMatch Match Network to the Load:

1. Review the cabling requirements in "Cable Requirements" on page 5-3.
2. Locate the **PLASMA/LOAD** connector or opening on the bottom or side of your unit.
   - For units with 7/16 DIN socket: Connect one end of a user-supplied coaxial cable to the **PLASMA/LOAD** output connector on the match network. Attach the other end of the coaxial cable to the load.
   - For units with MC6 connector: Attach the AE-supplied MC6 plug to one end of a user-supplied cable or copper strap. Attach the plug to the MC6 **PLASMA/LOAD** output connector. Attach the other end of the cable or copper strap to the load.
   - For units with 6 mm brass fittings: AE supplies the brass ferrule and compression nut for this fitting. Attach the SERTO® compression nut and ferrule directly to the user-supplied coil. See the SERTO® documentation for instructions on properly connecting the plug. Attach the plug to the 6 mm brass **PLASMA/LOAD** output connector.

Connecting AC Input (Mains) Power

⚠ DANGER:

RISK OF DEATH OR BODILY INJURY. Disconnect and lockout/tagout all sources of input power before working on this unit or anything connected to it.

The AC input (**Mains**) connector is an IEC 320 connector. Figure 5-8 shows the input power connector, and Table 5-2 describes each pin.

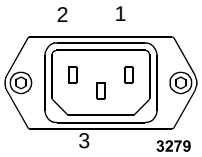


Figure 5-8. *Input (Mains) connector*

Table 5-2. *Input connector pin description*

Pin	Description
1	Phase (or neutral if pin 2 is phase)
2	Neutral (or phase if pin 1 is neutral)
3	Ground

To Connect the AC Input Power:

Connect the VarioMatch match network to the power mains by connecting the AC **MAINS** cord with your input power source (see Chapter 3, "Specifications" for the input voltage for your unit).

Note: The VarioMatch match network does not contain an on/off power switch. To turn off the unit you must completely disconnect the **Mains**.

FIRST-TIME OPERATION

WARNING:
Maintenance personnel must receive proper training before installing, troubleshooting, or maintaining high-energy electrical equipment. Potentially lethal voltages could cause death, serious personal injury, or damage to the equipment. Ensure that all appropriate safety precautions are taken.

DANGER:

RISK OF DEATH OR BODILY INJURY. Disconnect and lockout/tagout all sources of input power before working on this unit or anything connected to it.

WARNING:

Leaving on the RF power after turning off the input power to the match network may damage the unit.

AE recommends that you operate the unit in automatic mode for first-time operation.

To Operate the VarioMatch match network:

1. Turn on the system by connecting AC **MAINS**.
2. Turn on the RF generator and adjust it to 100 W.

   A substantial amount of RF power is necessary for proper operation of the automatic detection circuitry and the control circuitry within the VarioMatch match network.

   Allow 5 to 10 seconds for the unit to tune automatically.

   If you are testing the unit with a dummy load, use the minimum power to start (the minimum amount of power to ensure operation is 25 W.)

3. Check to see that you have a correct and appropriate response from your load.

   For example, if you are using a plasma chamber, look for the following:

   a. Is the plasma lit? If not, you may have a faulty connector or too little input power. Check your match process and check that the full system is properly designed and installed.

   b. Is the plasma stable (that is, is there a constant glow)? If not, switch to manual tune mode and experiment to see if you can get it stable. Once it is stable in manual mode, look at the positions of the capacitors. Minimally, the capacitors should be in the tuning range of 20 to 80%; ideally between 30 to 80%. If the capacitors are outside this range, change the coil tappings (see “Set Up the Match for Your Load” on page 5-16).

   c. Did the capacitors begin to move? If not, check if AC **MAINS** is properly connected, then switch to manual tune mode. If the capacitors move in manual tune mode but not in automatic tune mode, verify that you have RF coming into the match network from the generator. If not, the matching motors won’t move in automatic tune mode. If the capacitors still do not move, contact AE Global

Services (see Chapter 6, “Troubleshooting and Global Services”).

d. Did reflected power decrease to within specifications? If not, ensure the capacitors are within the tuning range of 30 to 80%.

e. Did the motors stop moving? If the motors do not stop moving, ensure the capacitors are within the tuning range of 30 to 80%.

4. Vary the chamber conditions according to your process requirements, and verify that the VarioMatch match network can cover the required load impedance range.

NORMAL OPERATION

The VarioMatch Match Network operates in the following modes:

- “Automatic Tune Mode” on page 5-14
- “Manual Tune Mode” on page 5-15

When connected to the AC power **MAINS**, the VarioMatch match network will immediately turn on in the automatic tune mode. To manually tune the capacitors, use a match controller or an AE Cesar RF generator (see “Interaction With a Cesar Generator” on page 5-16).

To allow easy incorporation of the VarioMatch match network into most any load system, the unit does not use an on/off switch. To turn on the unit, connect the VarioMatch match network to the AC **MAINS** connector. Use the AC **MAINS** cable appropriate for your installation (100 V to 240 V at 50 Hz to 60 Hz).

Also read the information in “Importance of Igniting Plasma” on page 5-16.

Automatic Tune Mode

AE recommends using automatic tune mode for normal operation. In automatic tune mode, the VarioMatch match network controls the impedance functions internally.

Automatic tune mode requires no user interface. Whenever the VarioMatch match network detects RF power, the unit automatically moves the capacitors to optimum positions and minimizes the reflected power.

A minimum RF input power is necessary to allow the electronic circuit to work properly and accurately and to automatically tune the network for minimum reflected power. This minimum input power is approximately 1% of the maximum transfer power (see Chapter 3, “Specifications”).

The magnitude (amplitude) detector checks the RF voltage and RF current present on the 50 Ω line between RF generator and VarioMatch match network, and then compares this with 50 Ω. The magnitude detector drives the load variable capacitor.

The second sensor is the phase detector, which measures the phase change compared to a perfect 50 Ω resistive load. This sensor drives the tune variable capacitor which is in series with the coil.

Both magnitude and phase information are fed to the motor drive electronics which immediately drive the electric motors in the correct direction.

To Operate the VarioMatch Match Network in Automatic Tune Mode:

- With the VarioMatch match network connected to a generator, connect the VarioMatch match network to AC power and it will turn on in automatic mode.

Note: To operate the VarioMatch match network in automatic tune mode when connected to a CESAR generator, refer to the CESAR user manual.

If the matching quality isn't acceptable and the reflected power cannot be reduced below approximately 1% of maximum transfer power, the automatic mode will be unable to match properly and the motors will never stop. This condition indicates that the VarioMatch match network isn't set up correctly for the load (see "Set Up the Match for Your Load" on page 5-16).

Manual Tune Mode

In addition to the automatic mode, all VarioMatch match network models can be controlled manually by means of an external controller. This controller can be the AE RMC-1 Match Network Controller, an AE Cesar RF Generator, or an arrangement of five switches.

Manual control is useful when the load isn't known and you must find the most suitable match. Manual tune mode lets you determine whether matching is possible as configured and if the match is achieved near the limits of one or both of the variable capacitors.

In manual tune mode, the automatic tune feature is disabled and the capacitor positions are controlled through the **INTERFACE** port on the VarioMatch match network. When the interface signal *MANUAL MODE* is pulled high, the capacitor positions follow the signals present on the match **INTERFACE**.

To Operate the VarioMatch Match Network in Manual Tune Mode:

- If the VarioMatch match network is connected to a CESAR generator, see "Interaction With a Cesar Generator" and Chapter 4, "Communication Interfaces and Controls".
- If the VarioMatch match network is connected to a set of five switches, see Chapter 4, "Communication Interfaces and Controls".

Interaction With a Cesar Generator

You can control the VarioMatch match network in either manual mode or automatic mode using a Cesar generator. When the VarioMatch match network is connected to a Cesar generator via the **MATCHING** interface, you can control the VarioMatch match network using either of the following two methods:

- Front Panel Display

  The front panel display on the CESAR generator will show the position of the capacitors, the mode (automatic or manual), the measured DC bias, and whether the match network is active or not. It also allows you to change the mode (automatic or manual) via buttons and to move the capacitors manually. The information of the match network is shown on the Cesar front panel as soon as the Cesar generator detects a connection to the match **INTERFACE**.

- Host Port

  You can use the Cesar generator **Host Port** to control the VarioMatch match network.

See the Cesar generator user manual for additional information.

Importance of Igniting Plasma

A matching optimization can be done only when the load is consuming energy, meaning that there exists a resistive part to which all the energy is transferred. Purely reactive components do not dissipate any energy.

When the load is plasma, this means you need to ignite the plasma. After the plasma ignites, it is then possible to optimize the components in the match network for the best tuning.

If, while experimenting with the match, the plasma does not ignite, the match components cannot be optimized because there is no load in which to dissipate the RF energy.

SET UP THE MATCH FOR YOUR LOAD

See Chapter 7, “VarioMatch Match Network Tuning Ranges” to check the tune range for your VarioMatch match network.

WARNING:
Maintenance personnel must receive proper training before installing, troubleshooting, or maintaining high-energy electrical equipment. Potentially lethal voltages could cause death, serious personal injury, or damage to the equipment. Ensure that all appropriate safety precautions are taken.

DANGER:
RISK OF DEATH OR BODILY INJURY. Disconnect and lockout/tagout all sources of input power before working on this unit or anything connected to it.

WARNING:
Leaving on the RF power after turning off the input power to the match network may damage the unit.

The ability of the VarioMatch match network to properly match your load will be determined by two major match components:

- The variable capacitors

  The variable capacitors are determined by the VarioMatch match network model you purchased. The capacitors use motors to match the load.

- The coils (and the number of turns on the coils)

  The number of turns on the coil is determined by the part number of the VarioMatch match network model you purchased (see "Physical Specifications Table" on page 3-7). The following sections describe the two coils and describe how to select the taps for the coils:

  - "Selecting the Correct Tap Setting for the Tune Coil" on page 5-18
  - "Selecting the Correct Tap Setting for the Load Coil" on page 5-22

If you purchased an ICP unit:

- The ICP units have no main (tune) coil. Some units have a shunt (load) coil. See "Physical Specifications Table" on page 3-7 for a listing of tune and load coil specifications by part number.

- You can configure some ICP units to use either the Gamma or the L match topology. See “Changing the Configuration Between the L match and the Gamma Topology” on page 5-27.

If you purchased a unit with 2 MHz frequency, you can change additional fixed capacitors. See “Changing the Fixed Capacitor Setting (Model 0415 2 MHz Units Only)” on page 5-36.

Selecting the Correct Tap Setting for the Tune Coil

The VarioMatch match network is equipped with a tune coil. This design enables the taps to be effective for large RF currents. The transformation step is determined mostly by the tune coil, represented by the tune capacitor in series with the coil. To compensate and correct the phase for optimum matching quality, a load capacitor and coil are also used. Both tuning elements interact somewhat, and are used together to obtain the best possible match.

Depending on your unit, you may be able to set taps to match your load (see “Setting Tune Coil Taps” on page 5-18). See “Physical Specifications Table” on page 3-7 for your unit’s internal coil specifications.

SETTING TUNE COIL TAPS

The number of turns and available taps enables the VarioMatch match network to be flexible enough to match nearly all load systems. The number of turns and available taps varies based on the model you purchased (see “Physical Specifications” on page 3-1).

The following guidelines will help to determine the optimum component values for a particular load system:

- The match network should be configured to allow matching with the tune capacitor set between 20 and 80% of its capacitance range to avoid extreme RF stress. Always try to achieve a tuning position with both capacitors in the range of 20 to 80%.
- Increase the number of active coils if the tune capacitor is at the upper end of its tuning range (greater than 80%).
- Decrease the number of active coils if the tune capacitor is at the lower end of its tuning range (less than 20%).
- Large and highly capacitive loads require, for example, 4 to 6 turns on a coil with 14 turns.
- Medium capacity loads require, for example 6 to 10 turns on a coil with 14 turns.
- Small area loads (for example, etching diodes), for example 10 to 14 turns on a coil with 14 turns.

For specific recommendations, contact Global Services for a technical bulletin for your model.

To Change the Tap Settings on the Tune Coil:

1. Turn off RF from the generator.
2. Disconnect AC **MAINS**.
3. Disconnect RF in (from the **RF-GENERATOR**).
4. Disconnect RF out (to **PLASMA/LOAD**).
5. Remove the top cover, being careful to not damage the plug leading to the fan:
   a. Remove the large top cover (with the fan) from the VarioMatch match network by unscrewing the twelve screws on the cover. Leave the small top and side covers in place.
   b. Disconnect the plug leading from top lid to the fan.
6. Using a 7 mm wrench, unscrew the tap from its current position.

   Tabs are silver soldered to the coil. The metal interconnect ribbon is attached to the tab of the selected turn using a threaded bar and two bolts.
7. Move the tap setting to the desired turn on the coil (for examples, see Figure 5-9 through Figure 5-11). It is possible that you will also need to move the other end of the ribbon to a new position so the ribbon will reach the chosen tap.

8. Using the wrench, screw the tap to the selected turn on the coil.

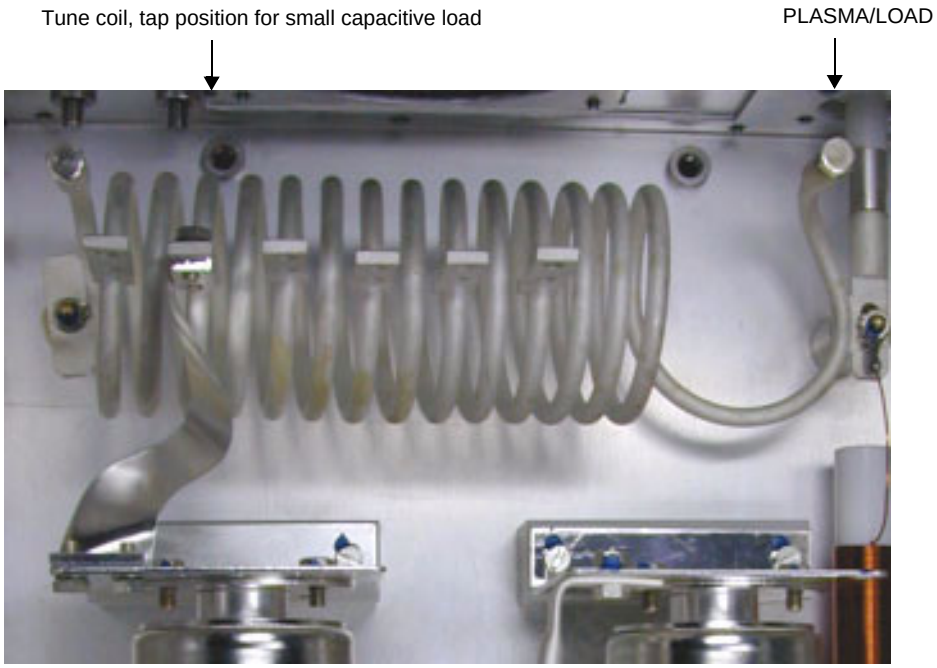


Figure 5-9. *Tapping of the tune coil for small capacitive load*

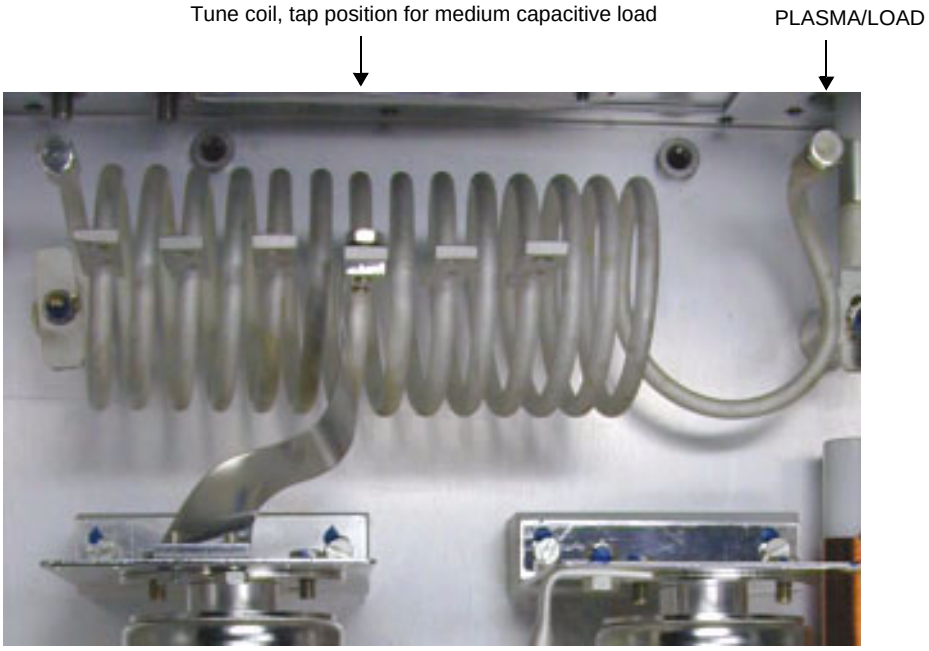


Figure 5-10. *Tapping of the tune coil for medium capacitive load*

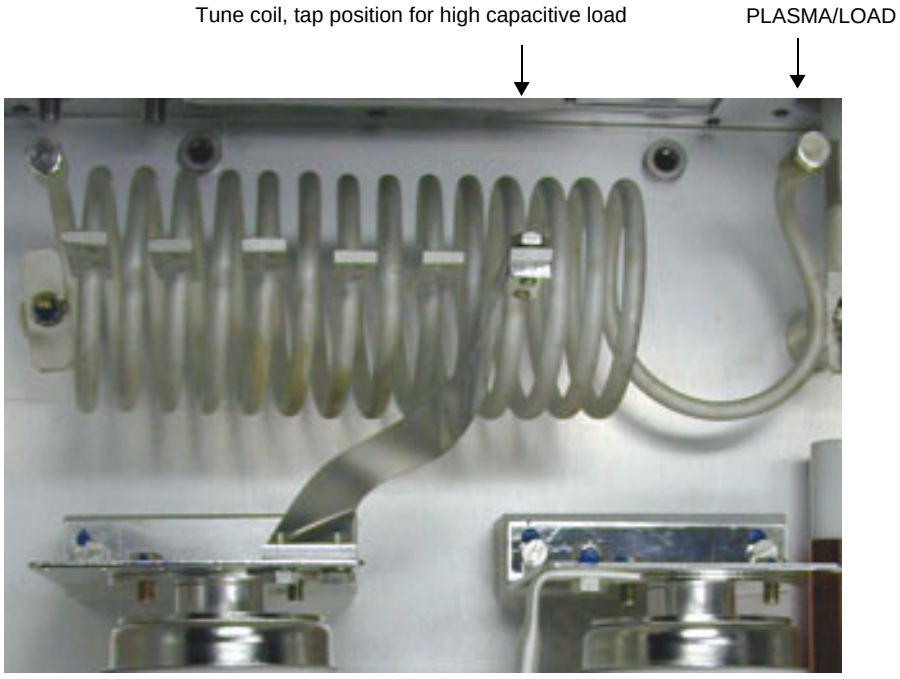


Figure 5-11. *Tapping of the tune coil for high capacitive load*

9. Reattach the top cover:
   a. Plug in the fan
   b. Attach the top cover using the twelve screws you removed in step 2.
10. Reconnect **PLASMA/LOAD**, **RF-GENERATOR**, and AC **MAINS** as described in "Installing the VarioMatch Match Network" on page 5-4.

Selecting the Correct Tap Setting for the Load Coil

See "Physical Specifications Table" on page 3-7 for your unit's internal coil specifications.

The other device in the match network that affects the range of the match capability is the load capacitor. Depending upon the load resistance (the real part of the load impedance) this load capacitor needs to be more or less capacitive. A small tapped coil at the input of the VarioMatch match network enables the effective value of the load capacitor to be increased to several times its actual value.

By changing the tap position on this coil, you can adjust the match range for the size of the load. The more coils that are active between the tap and the load capacitor, the higher the resulting capacitance. The ideal position of the tap on the load coil depends on the real part of the load impedance. For example, lower load impedance requires more capacitance of load capacitor, which requires more active coils.

The number of turns on the load coil depends on your unit. For example, if you unit contains a load coil with 3 tapped positions:

- Use the position closest to the load capacitor for small loads.
- Use the center position for medium size loads.
- Use the position furthest from the load capacitor for large loads.

For specific recommendations, contact Global Services.

To Change the Tap Settings on the Load Coil:

1. Turn off RF from the generator.
2. Disconnect AC **MAINS**.
3. Disconnect RF in (from the **RF-GENERATOR**).
4. Disconnect RF out (**PLASMA/LOAD**).
5. Remove the top cover, being careful to not damage the plug leading to the fan:
   a. Remove the large top cover (with the fan) from the VarioMatch match network by unscrewing the twelve screws on the cover. Leave the small top and side covers in place.
   b. Disconnect the plug leading from top lid to the fan.
6. Using a flathead screwdriver, unscrew the bolt from the current tap setting.
7. Move the lugged tap wire to the desired coil and screw the bolt into the tab (for examples, see Figure 5-12, Figure 5-13, Figure 5-14).

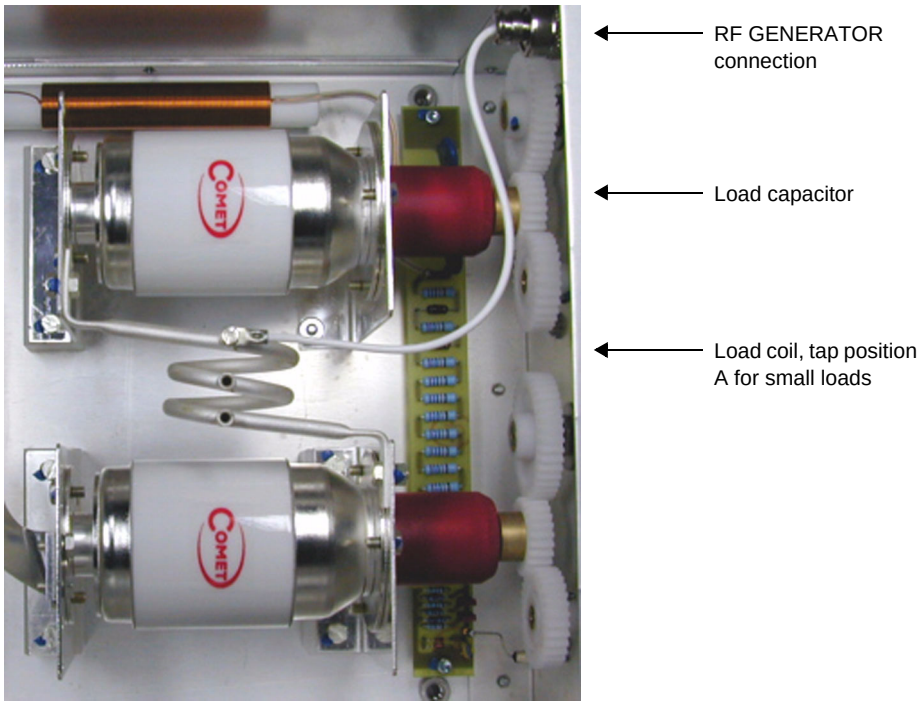


Figure 5-12. *Tap position for small loads*

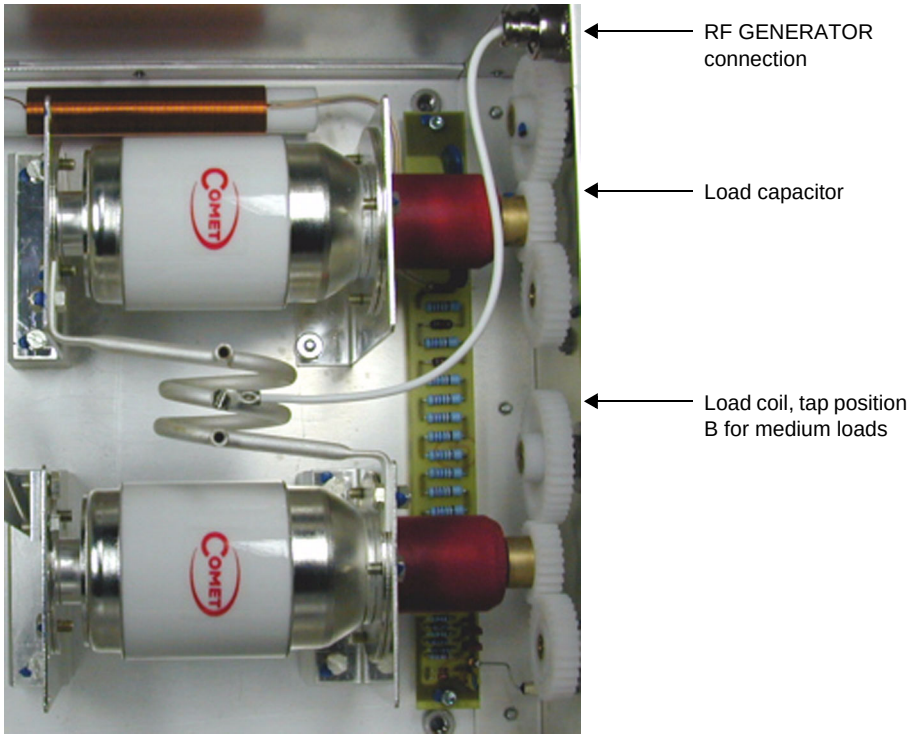


Figure 5-13. *Tap position for medium loads*

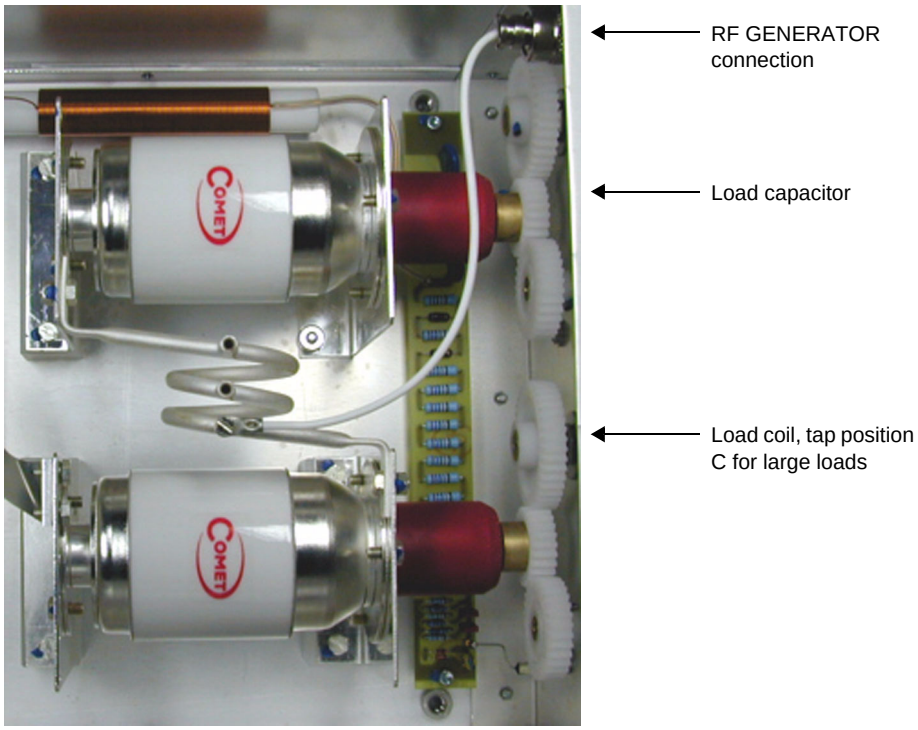


Figure 5-14. *Tap position for large loads*

8. Reattach the top cover:
   a. Plug in the fan
   b. Attach the top cover using the twelve screws you removed in step 2.
9. Reconnect **PLASMA/LOAD**, **RF-GENERATOR**, and AC **MAINS** as described in "Installing the VarioMatch Match Network" on page 5-4.

Changing the Configuration Between the L match and the Gamma Topology

WARNING:
Maintenance personnel must receive proper training before installing, troubleshooting, or maintaining high-energy electrical equipment. Potentially lethal voltages could cause death, serious personal injury, or damage to the equipment. Ensure that all appropriate safety precautions are taken.

DANGER:
RISK OF DEATH OR BODILY INJURY. Disconnect and lockout/tagout all sources of input power before working on this unit or anything connected to it.

WARNING:
Leaving on the RF power after turning off the input power to the match network may damage the unit.

Some ICP units can be operated using either the L match or the Gamma topology, which allow two different load impedance ranges. By changing the capacitor's interconnection, you can change the topology of the VarioMatch match network. See Chapter 3, "Specifications"for a list of part numbers that support this. See "Topologies" on page 2-4 for information about the L Match and Gamma topologies.

If your IPC VarioMatch match network supports changing between L Match and Gamma topologies:

- The default topology, as shipped from the factory, is Gamma (Configuration A).
- Use the instructions in this section to change from Gamma to L match topology.
- The load impedance ranges for each configuration are shown in the Smith® charts in the Technical Bulletin for your unit. Contact Global Services to obtain the correct Technical Bulletin.

To change topology, perform the tasks documented in the following sections:

- "Tools Required to Change the Interconnection" on page 5-28
- "Disconnecting Power and RF, and Removing the Cover" on page 5-28

- “Changing the Interconnector” on page 5-29
- “Changing the Jumpers” on page 5-32
- “Reattaching the Top Cover and Reconnecting Power and RF” on page 5-35
- Also see “Interaction With a Cesar Generator” on page 5-16 for information on using a CESAR generator to control the VarioMatch match network

TOOLS REQUIRED TO CHANGE THE INTERCONNECTION

AE supplies the following equipment:

- Interconnector
- Bridge, to hold the water tubing in place once you remove the original interconnector

You will need to supply the following additional equipment:

- 7 mm wrench
- 12 mm wrench
- 14 mm wrench

DISCONNECTING POWER AND RF, AND REMOVING THE COVER

To Disconnect Power and RF and to Remove the Cover:

1. Turn off RF from the generator.
2. Disconnect AC **MAINS**.
3. Disconnect RF in (**RF-GENERATOR**).
4. Disconnect RF out (**PLASMA/LOAD**).
5. Remove the top cover, being careful to not damage the plug leading to the fan:
   a. Remove the large top cover (with the fan) from the VarioMatch match network by unscrewing the twelve screws on the cover. Leave the small top and side covers in place.
   b. Disconnect the plug leading from top lid to the fan.

CHANGING THE INTERCONNECTOR

To Change the Interconnector:

1. Locate the alternate interconnector and bridge. These two pieces were attached to the unit when shipped from the factory.

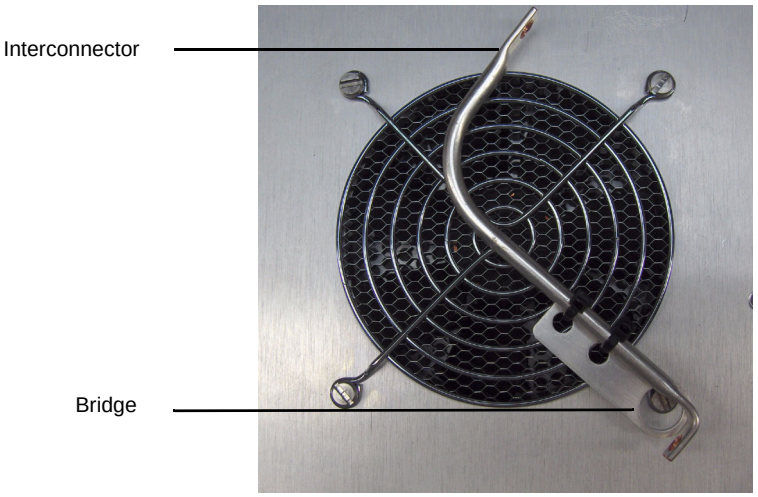


Figure 5-15. *Alternate interconnector and bridge*

2. Disconnect water and drain the unit. See "Disconnecting Water and Draining the VarioMatch Match Network" on page 5-38.
3. Using a 12 mm wrench, disconnect the compression nut on the copper tube, so that the tube is loose.
4. Using the 14 mm wrench, unscrew the nut on the copper tube side.
5. Pull the brass tube through the hole. The plastic tube will stay connected.

6. Using a 7 mm wrench, unscrew the interconnection from it's current position.

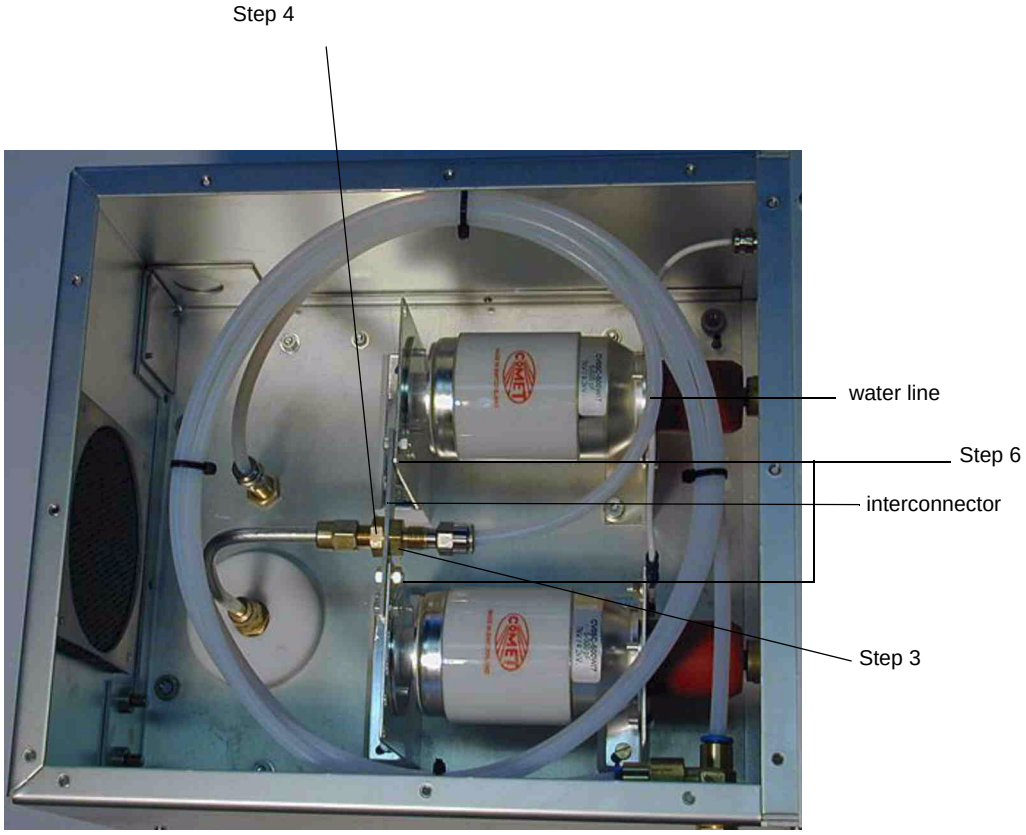


Figure 5-16. *Disconnect the original interconnection*

7. Attach the bridge by screwing it onto the bracket with two 7 mm bolts.
8. Feed the brass water tube through the hole in the bridge.
9. Replace the nut from the copper tube.
10. Replace the compression nut from the copper tube.
11. Attach the new interconnector. The new interconnector attaches:
    a. On the non-water-supported side
    b. On the same screw hole as the feed line from the phase magnitude detector.

    In both places, the interconnection is placed on the inner side of the screw hole. You need to first disconnect the screw holding the feed line, then reattach.

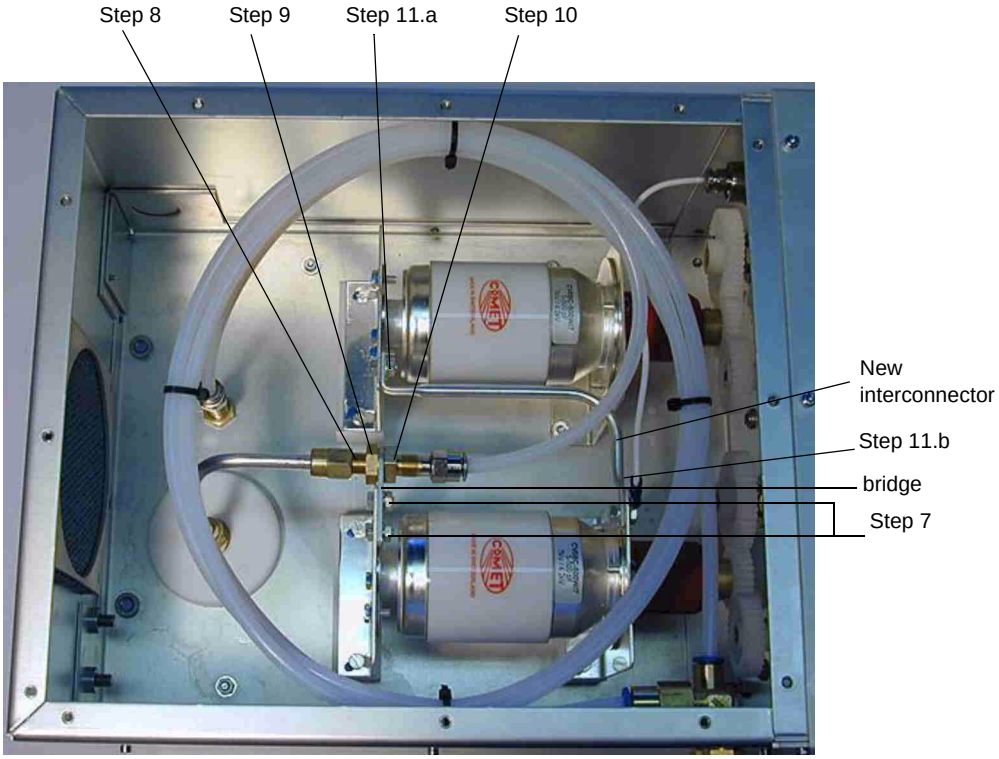


Figure 5-17. *Attach the new interconnector*

CHANGING THE JUMPERS

To Change the Jumpers:

1. Remove the front panel by unscrewing the eleven screws as shown, then remove the front panel.

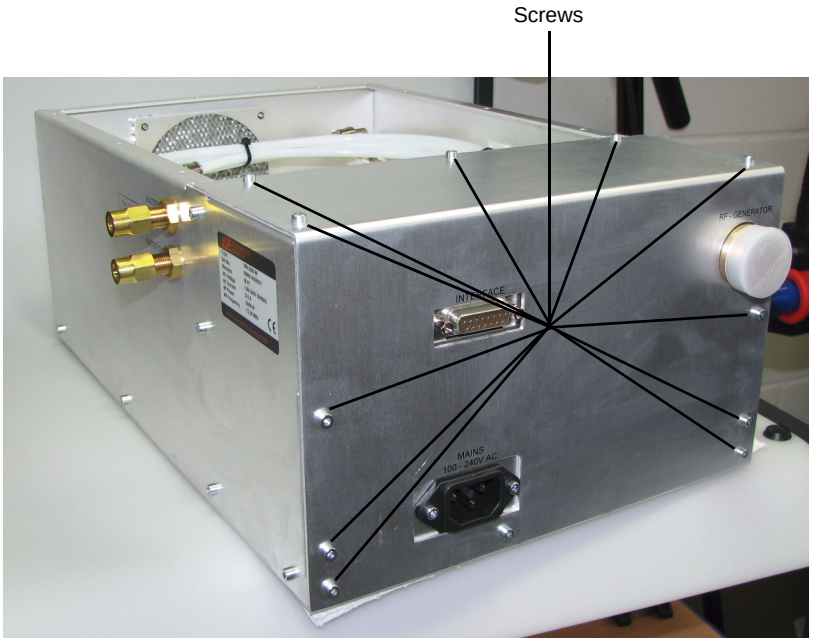


Figure 5-18. *Remove the front panel*

2. Carefully remove the three solder joints on the left box as shown, and remove the top of the box.

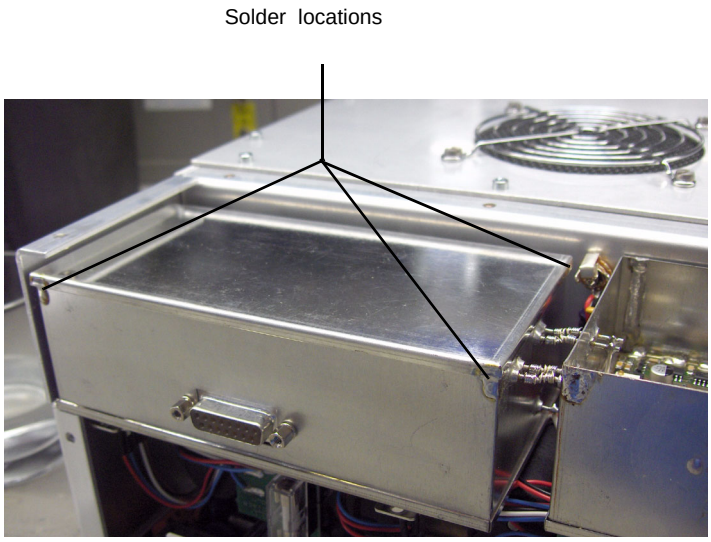


Figure 5-19. *Remove solder joints*

3. Move the jumpers as needed for the desired configuration (see Figure 5-20 on page 5-34 and Figure 5-21 on page 5-35).

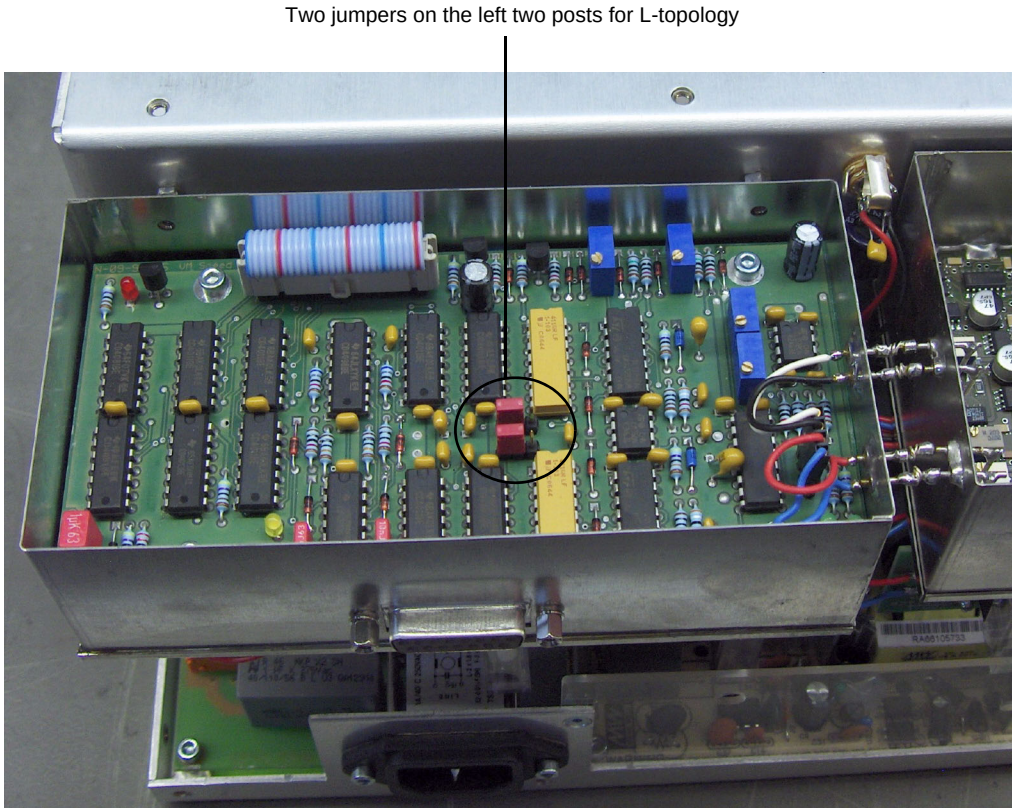


Figure 5-20. *Jumper setting for L match topology*

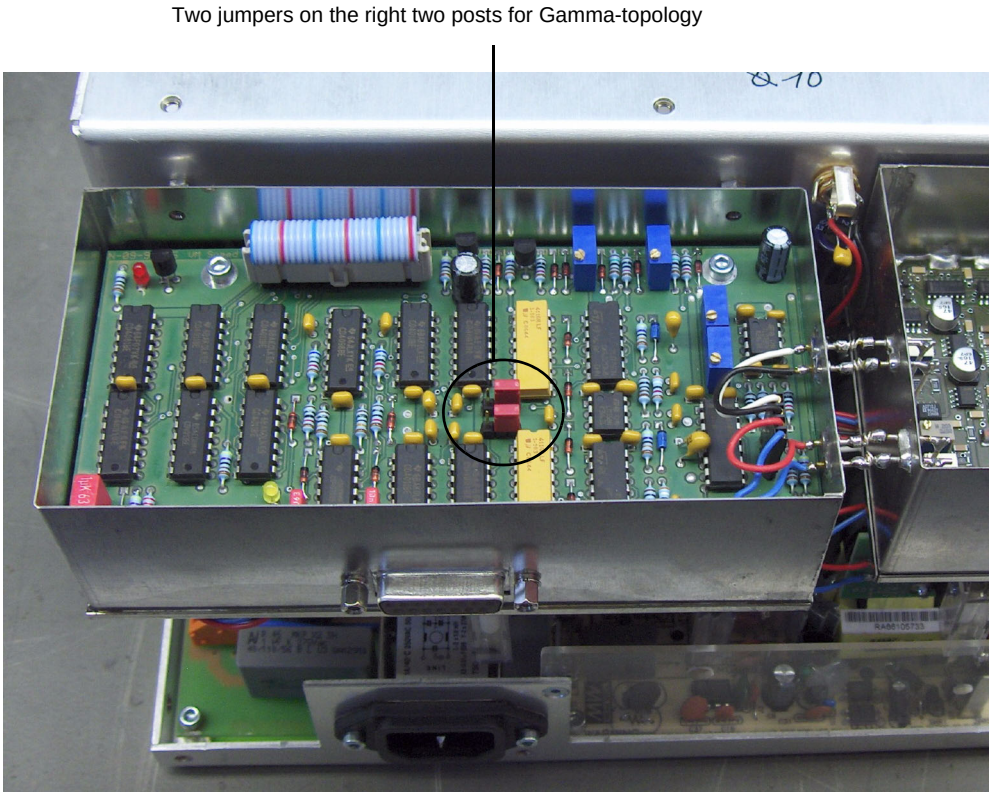


Figure 5-21. *Jumper setting for Gamma topology*

4. Replace the top cover of the metal box, carefully resoldering in place.
5. Replace the front panel by replacing the eleven screws.

REATTACHING THE TOP COVER AND RECONNECTING POWER AND RF

To Reattach the Top Cover and Reconnect Power and RF:

1. Reattach the top cover:
   a. Plug in the fan
   b. Attach the top cover using the twelve screws you removed earlier.
2. Reconnect **PLASMA/LOAD**, **RF-GENERATOR**, and AC **MAINS** as described in "Installing the VarioMatch Match Network" on page 5-4.

Changing the Fixed Capacitor Setting (Model 0415 2 MHz Units Only)

The VarioMatch match network Model 0415 2 MHz unit is equipped with a circuit board containing additional fixed capacitors You can switch these capacitors in parallel to the load capacitor to increase the capacitance.

To Change the Capacitor Settings:

1. Turn off RF from the generator.
2. Disconnect AC **MAINS**.
3. Disconnect RF in (from the **RF-GENERATOR**).
4. Disconnect RF out (**PLASMA/LOAD**).
5. Remove the top cover, being careful to not damage the plug leading to the fan:
   a. Remove the large top cover (with the fan) from the VarioMatch match network by unscrewing the twelve screws on the cover. Leave the small top and side covers in place.
   b. Disconnect the plug leading from top lid to the fan.
6. Using an appropriate wrench, open or close the jumper bridge to set the desired capacitance. This circuit board is located in the RF-section of the VarioMatch match network on the inner side of the cabinet close to C_{LOAD}. The following

table shows the additional capacitance as a consequence of the jumper settings. Figure 5-22 shows the location of the circuit board and jumpers.

Table 5-3. *Capacitance due to jumper settings on circuit board*

Bridge			Capacitance
J1	**J2**	**J3**	
–	–	–	0 pF
–	X	–	680 pF
–	–	X	1360 pF
–	X	X	2040 pF
X	–	X	2720 pF
X	X	X	3400 pF

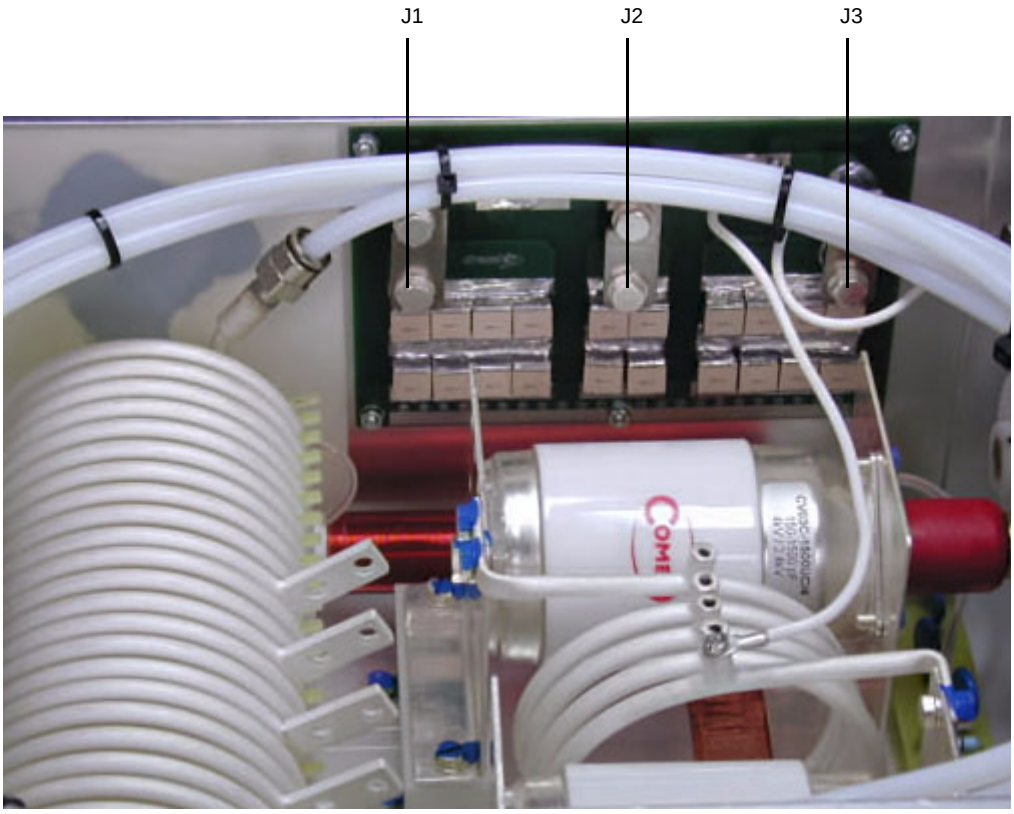


Figure 5-22. *Location of capacitor bank with three jumpers*

7. Reattach the top cover:
   a. Plug in the fan

b. Attach the top cover using the twelve screws you removed in step 2.

8. Reconnect **PLASMA/LOAD**, **RF-GENERATOR**, and AC **MAINS** as described in "Installing the VarioMatch Match Network" on page 5-4

DISCONNECTING WATER AND DRAINING THE VARIOMATCH MATCH NETWORK

Use this procedure when you need to purge the VarioMatch match network of cooling water for maintenance, moving, or storing. When moving or storing the unit, use special care to ensure that the cooling system is properly drained. If water freezes in the cooling system during storage, it could damage the unit.

⚠ CAUTION:
Be sure to purge all water from the generator before shipping. Failure to do so can result in damage to the unit during shipping.

Note: You must evacuate the water from both the rack and from individual CESAR generators in the rack.

The following steps are listed in the order they are to be performed when preparing the unit for moving or storage.

Note: These recommended steps are not meant to supersede your organization's safety regulations. Observe proper electrical safety precautions and observe your local safety regulations.

To Prepare the Unit for Moving or Storage:

1. Turn the power supply off.

   Lockout/tagout all sources of input power to the VarioMatch match network.

⚠ DANGER:
RISK OF DEATH OR BODILY INJURY. Disconnect and lockout/tagout all sources of input power before working on this unit or anything connected to it.

2. Disconnect the input power cable.

For information to assist you in disconnecting the input power cable, see “Connecting AC Input (Mains) Power” on page 5-11.

3. Disconnect the **RF** input connector.

   For information to assist you in this procedure, see “Connecting RF Input From a Generator” on page 5-8.

4. Disconnect the **PLASMA/LOAD** connector.

   For information to assist you in this procedure, see “Connecting to the Load” on page 5-9.

5. Disconnect the cooling hoses.

   For information to assist you in this procedure see “Connecting the Cooling Water” on page 5-7.

6. Drain the water.

   Blow the lines out with compressed air. Clean dry air, CDA, is preferred.

Once you complete the above process, the VarioMatch match network is ready for moving, storing, or other tasks requiring that the unit is purged of water.

Chapter 6

Troubleshooting and Global Services

This chapter contains basic troubleshooting information, as well as procedures for returning a unit for repair.

TROUBLESHOOTING OVERVIEW

Before calling AE Global Services, consult the following sections and perform recommended checks and troubleshooting procedures. If you are still unable to resolve faults or warnings and resume normal operation after following these checks and procedures, contact AE Global Services.

- "Troubleshooting Checklists" on page 6-2: Use these checklists to begin troubleshooting your unit at the system level.
- "Troubleshooting Unit Output" on page 6-3: Use this advanced troubleshooting section to evaluate unit output.
- "Contacting AE Global Services" on page 6-4: Use this section to look up phone numbers and addresses for AE support centers around the world. You can also find warranty and return information in this section.

TROUBLESHOOTING CHECKLISTS

Use troubleshooting checklists to begin troubleshooting your unit.

⚠ WARNING:
RISK OF DEATH OR BODILY INJURY. Disconnect all sources of input power before working on this unit or anything connected to it.

⚠ WARNING:
Operating and maintenance personnel must have the correct training before setting up, maintaining, or troubleshooting high-energy electrical equipment. Potentially lethal voltages may cause serious personal injury or damage to equipment. Ensure that proper safety precautions are taken.

Checks With the Power Off

With Power Off, Complete the Following Checks:

1. Ensure the power to the unit is off.
2. Check for visible damage to the unit, cables, and connectors.
3. Ensure all unit connectors are installed correctly and are fastened tightly.
4. Ensure ground connections are adequate and secure.

Checks With the AC Power On

After you have performed checks with the unit power off, follow this checklist.

With Power On, Complete the Following Checks:

1. Follow the procedures for first-time operation. See “First-Time Operation” on page 5-12.
2. Ensure that the proper power is being supplied to the unit’s input power connection. See “Electrical Specifications” on page 3-10 for requirements.

TROUBLESHOOTING UNIT OUTPUT

Use extreme caution as this section involves troubleshooting the output of the unit.

WARNING:
RISK OF DEATH OR BODILY INJURY. Disconnect all sources of input power before working on this unit or anything connected to it.

WARNING:
Operating and maintenance personnel must have the correct training before setting up, maintaining, or troubleshooting high-energy electrical equipment. Potentially lethal voltages may cause serious personal injury or damage to equipment. Ensure that proper safety precautions are taken.

External Load Checks - Open/Short RF Output Path

There are three basic components that could impede the RF path: the VarioMatch match network output connector, the output cable or lead, or the chamber. Follow the steps below.

1. Disconnect AC **MAINS** from both the generator and the VarioMatch match network to ensure that there is no RF power at the output of the unit.
2. For the unit output connector:
   a. Remove the output cable and visually inspect the output connector for signs of arcing or heat stress.
   b. Verify an open is measured between the center conductor and outer shield.
   c. Make sure the output connector is mounted firmly to the VarioMatch match network chassis.
3. For the output cable:
   a. Visually make sure there is a good connection between the output cable and end connectors on both sides of the output cable.
   b. Swap cables if possible and retry operating the VarioMatch match network.
4. For the tuner and the chamber:
   - Swap the VarioMatch match network with another known good unit.

Also consider these questions:

1. Are you currently setting up a new chamber system?
2. Has any work been done recently on the chamber?
3. Have there been any changes in your process recently?

If you answered yes to any one of the previous questions, the unit is probably working properly and it may be reacting to an external load condition. You may want to consult your process engineer or system manufacturer to troubleshoot chamber related issues.

CONTACTING AE GLOBAL SERVICES

Please contact AE Global Services if you have questions or problems that cannot be resolved by working through the provided troubleshooting procedures.

When you call Global Services, make sure to have the unit serial number and part number. These numbers are available on unit labels.

Advanced Energy World Headquarters, 24 x 7 Technical Support

Table 6-1. *AE Global Services contact information*

Office	Contact
AE, World Headquarters 1625 Sharp Point Drive Fort Collins, CO 80525 USA	Phone (24 hrs/day, 7 days/week): 800.446.9167 or + 1.970.221.0108 Fax (M–F, 7:00 am – 5:30 pm MST): + 1.970.407.5981 Email: technical.support@aei.com We will respond to email by the next business day. For Aera flow product support, call 800.MFC.AERA (800.632.2372) For Sekidenko thermal product support, contact thermalapplications@aei.com
If you would prefer to contact a local or regional sales or service office, visit the Advanced Energy web site for current contact information: • http://www.advanced-energy.com and click on **Sales & Support**	

RETURNING UNITS FOR REPAIR

Before returning any product for repair and/or adjustment, first follow all troubleshooting procedures. If, after following these procedures, you still have a problem, or if the procedure instructs you to, contact AE Global Services and discuss the problem with a representative. Be prepared to give them the model number and serial number of the unit as well as the reason for the proposed return. This consultation call will allow Global Services to determine if the unit must actually be returned for the problem to be corrected. Such technical consultation is always available at no charge.

Chapter 7

VarioMatch Match Network Tuning Ranges

This chapter shows the VarioMatch match network's tuning ranges, using Smith charts. The figure captions include the number of turns and tap settings for the Smith chart shown in the illustration. To find the number of turns and tap settings of the load and tune coils of your unit, see "Physical Specifications Table" on page 3-7.

14-TURN TUNE (SERIES) COIL

Schematic

The tune (series) coil has taps at 4, 6, 8, 10, 12, and 14 turns. These are labeled 1 through 6 in the schematic. The load (shunt) coil has 3 turns, labeled A, B, and C. These labels are used in the Smith charts.

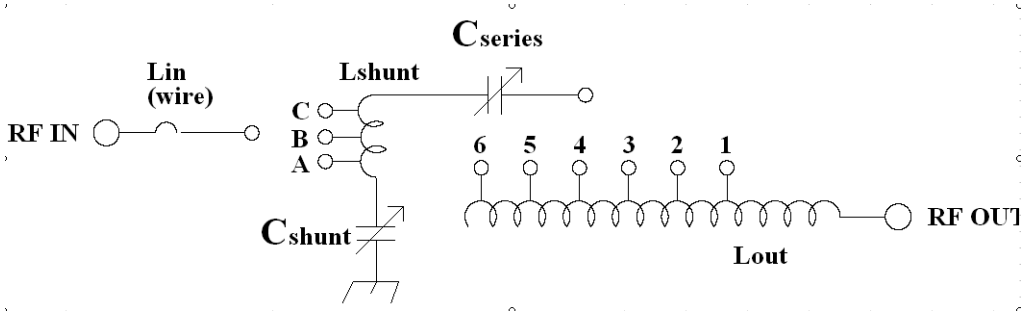


Figure 7-1. *Models 300, 1000, and 1500 coil and inductor schematic; 14 turn tune coil*

Smith Charts

Table 7-1. *Location of Smith chart illustrations for 14-turn tune coil*

Tune Coil Tap Setting	Load Coil Tap Setting		
	A	B	C
1	Figure 7-2	Figure 7-8	Figure 7-14
2	Figure 7-3	Figure 7-9	Figure 7-15
3	Figure 7-4	Figure 7-10	Figure 7-16
4	Figure 7-5	Figure 7-11	Figure 7-17
5	Figure 7-6	Figure 7-12	Figure 7-18
6	Figure 7-7	Figure 7-13	Figure 7-19

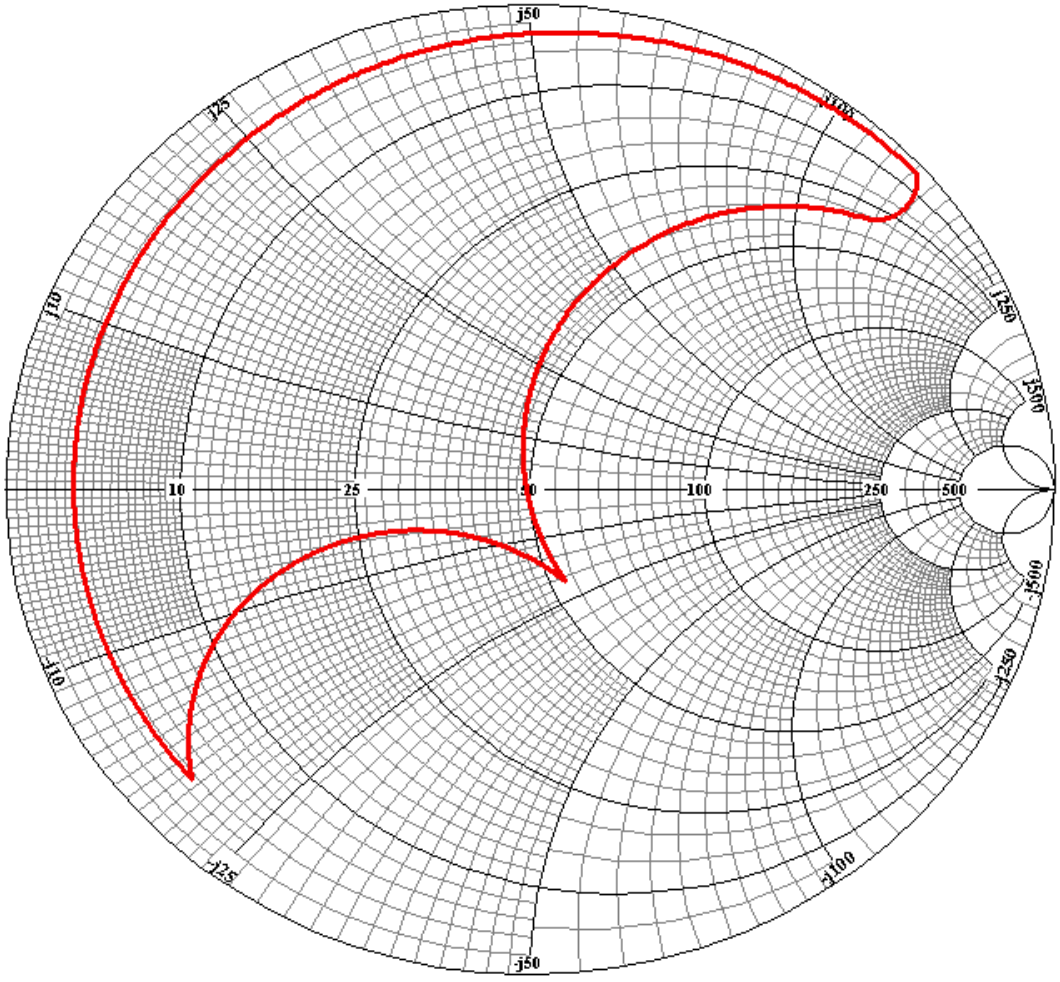


Figure 7-2. *Tune coil, 14 turns: tap 1; Load coil, 3 turns: tap A*

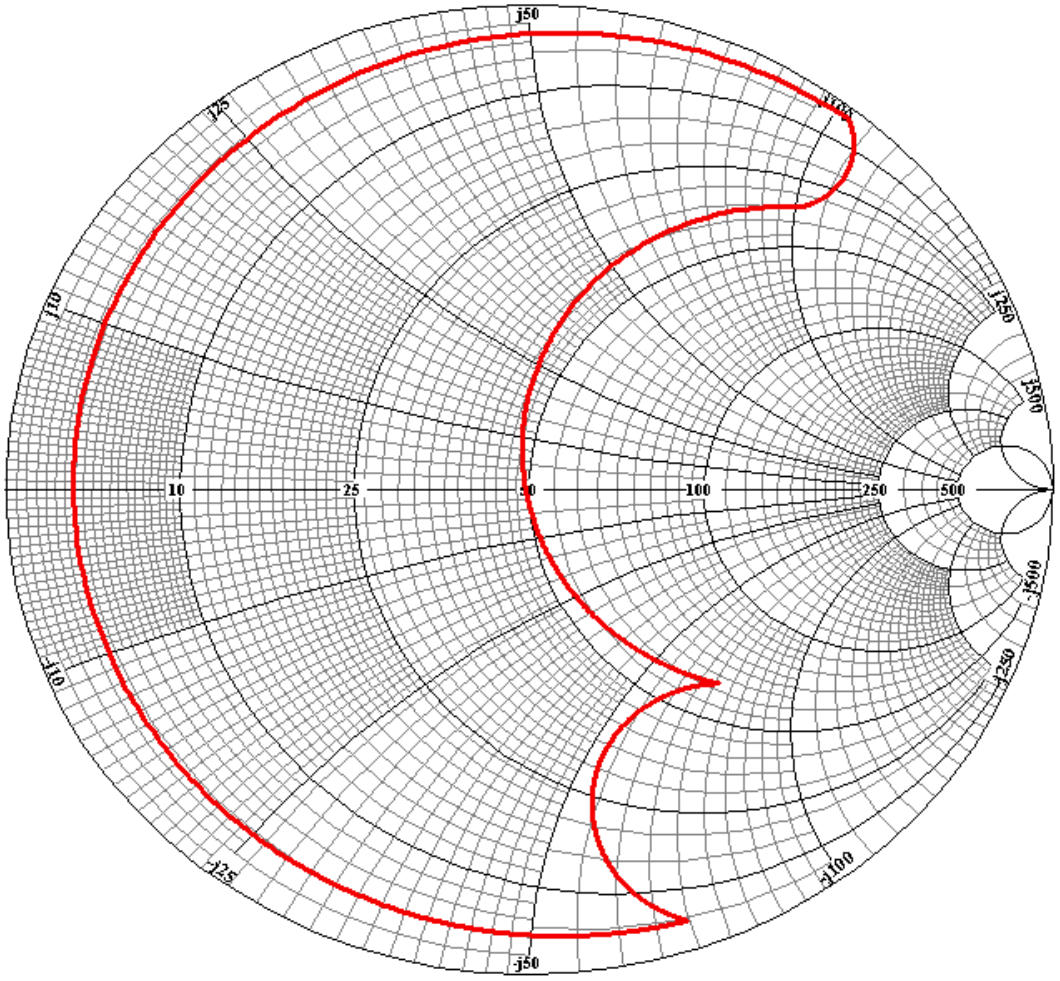


Figure 7-3. *Tune coil, 14 turns: tap 2; Load coil, 3 turns: tap A*

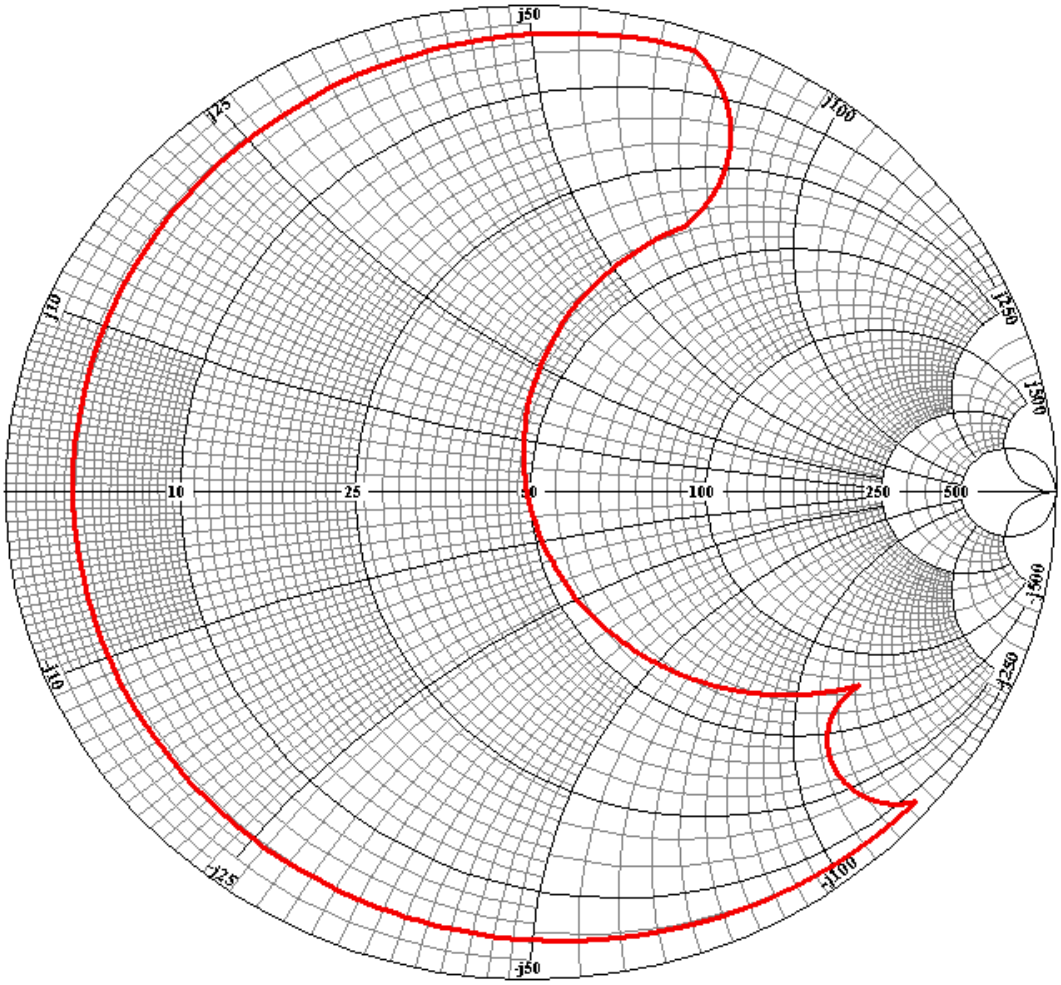


Figure 7-4. *Tune coil, 14 turns: tap 3; Load coil, 3 turns: tap A*

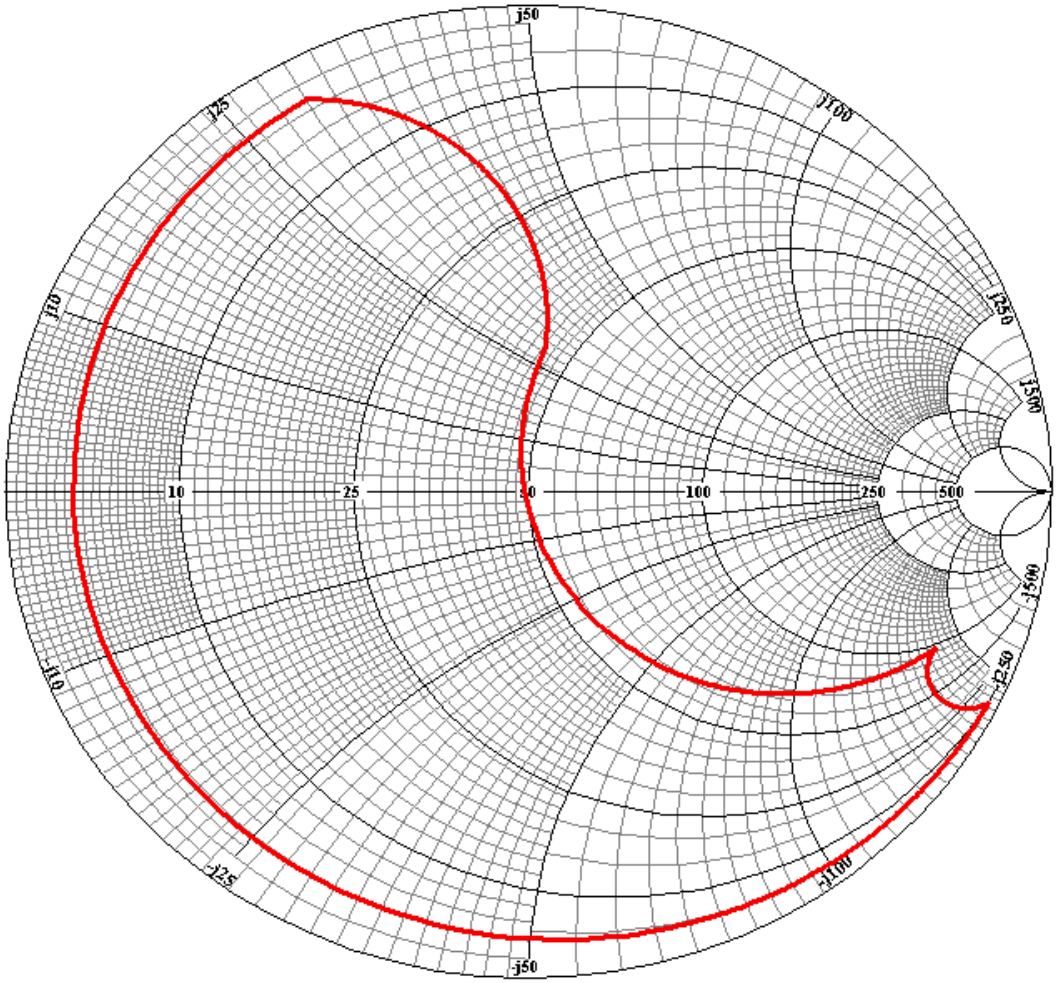


Figure 7-5. *Tune coil, 14 turns: tap 4; Load coil, 3 turns: tap A*

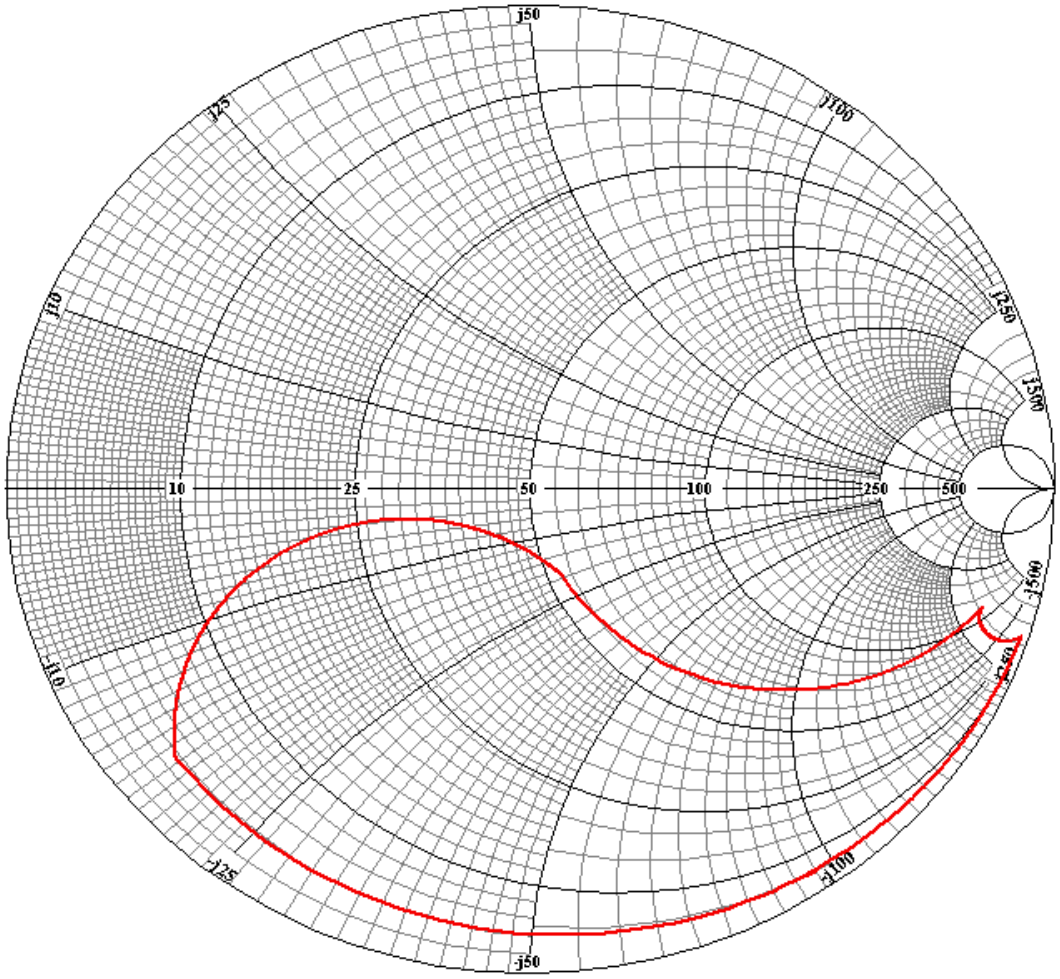


Figure 7-6. *Tune coil, 14 turns: tap 5; Load coil, 3 turns: tap A*

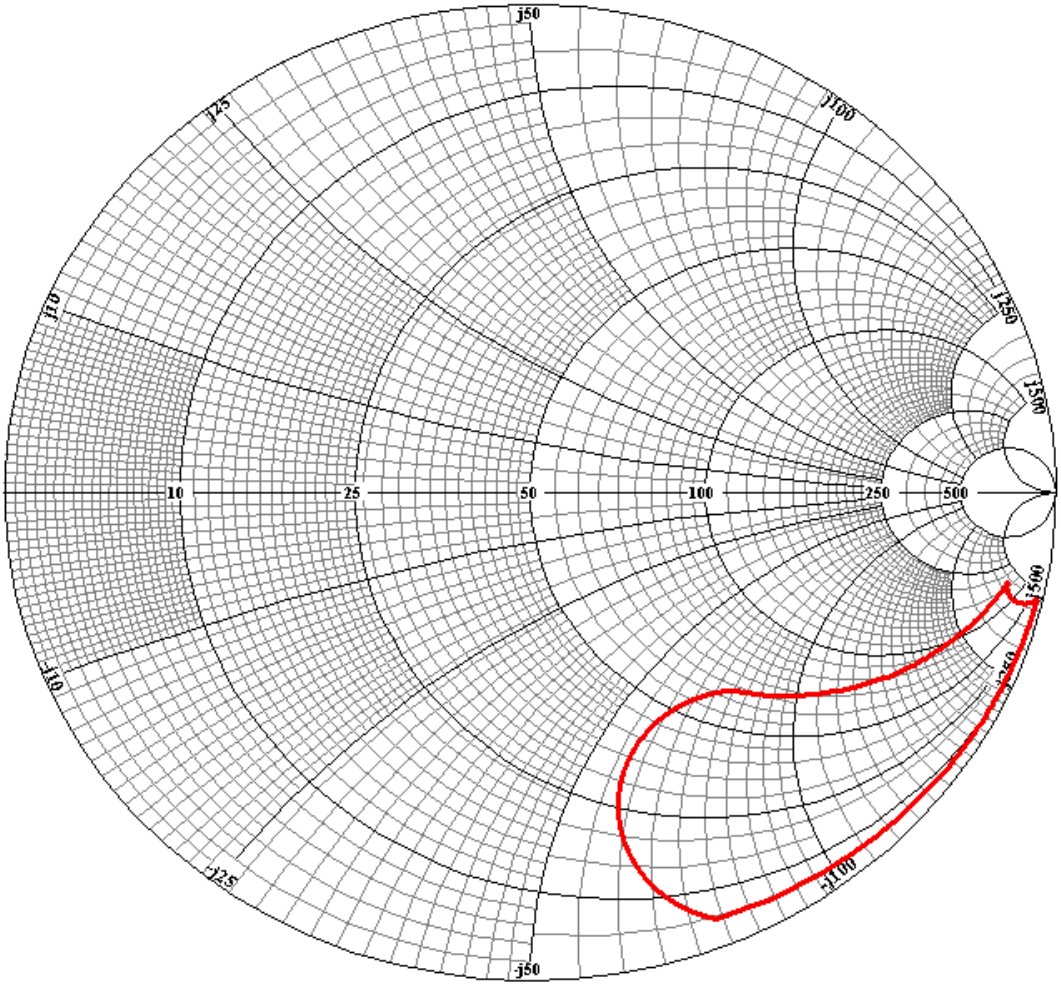


Figure 7-7. *Tune coil, 14 turns: tap 6; Load coil, 3 turns: tap A*

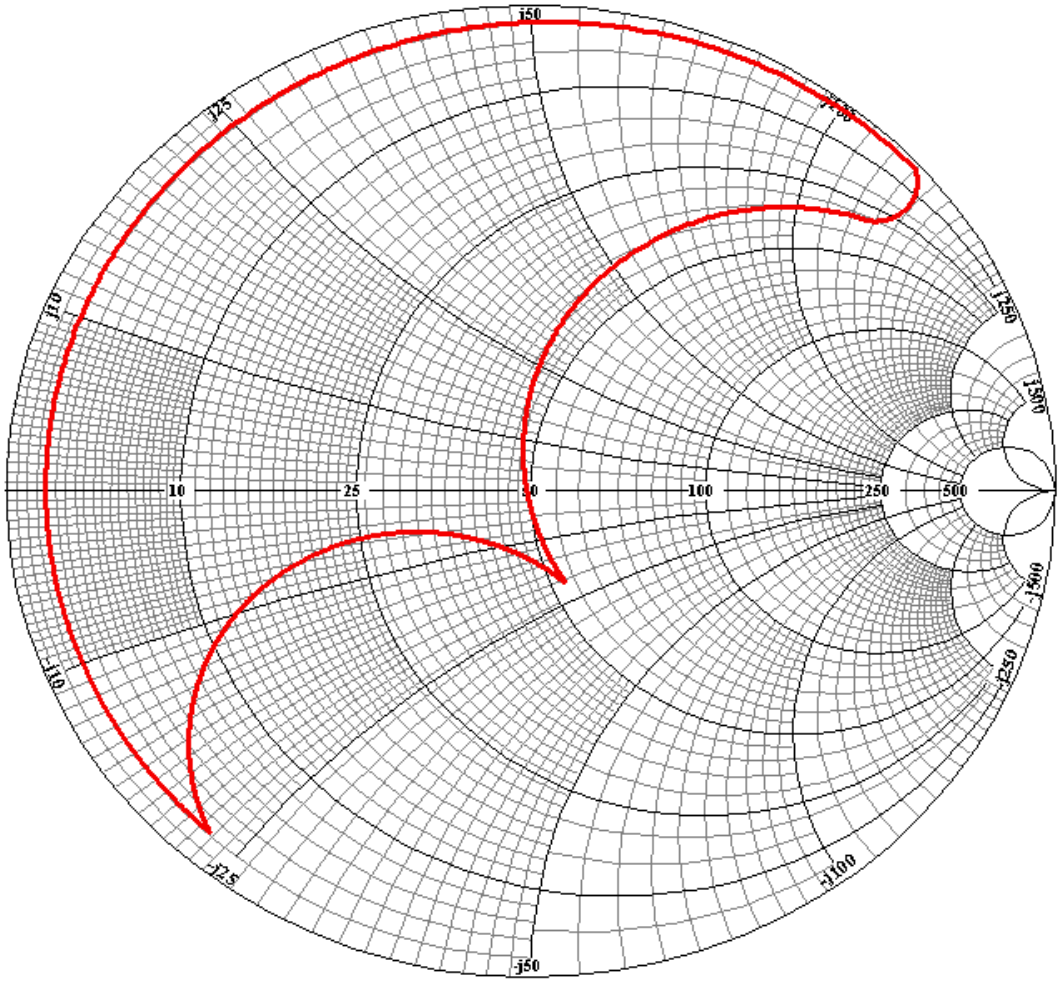


Figure 7-8. *Tune coil, 14 turns: tap 1; Load coil, 3 turns: tap B*

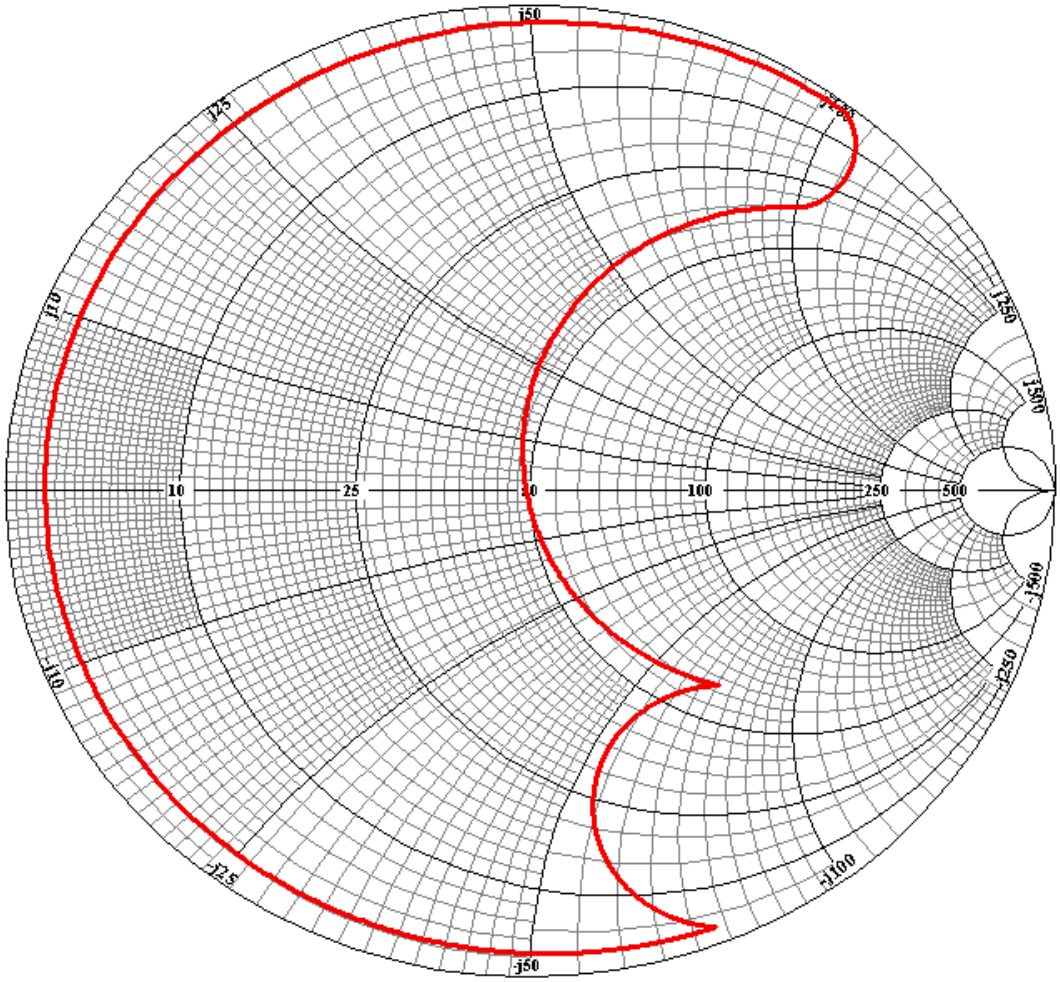


Figure 7-9. *Tune coil, 14 turns: tap 2; Load coil, 3 turns: tap B*

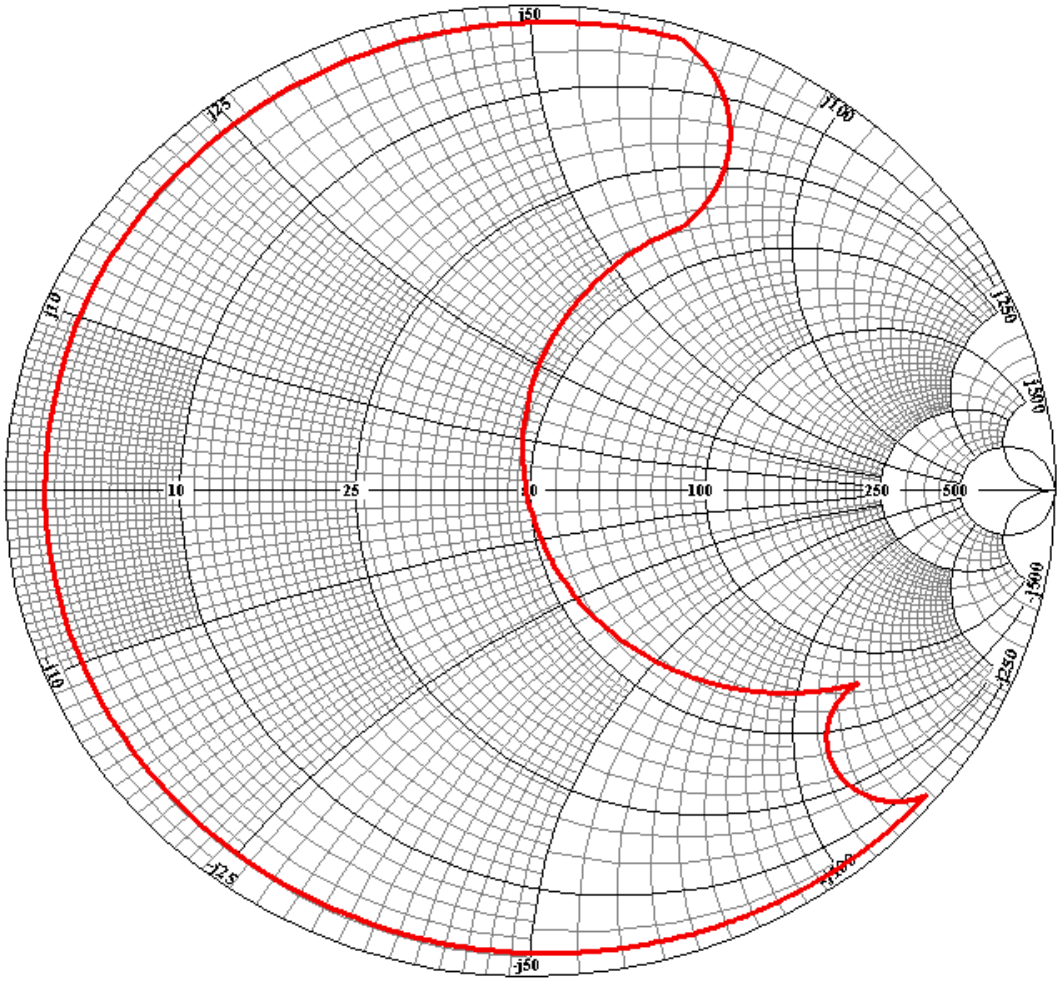


Figure 7-10. *Tune coil, 14 turns: tap 3; Load coil, 3 turns: tap B*

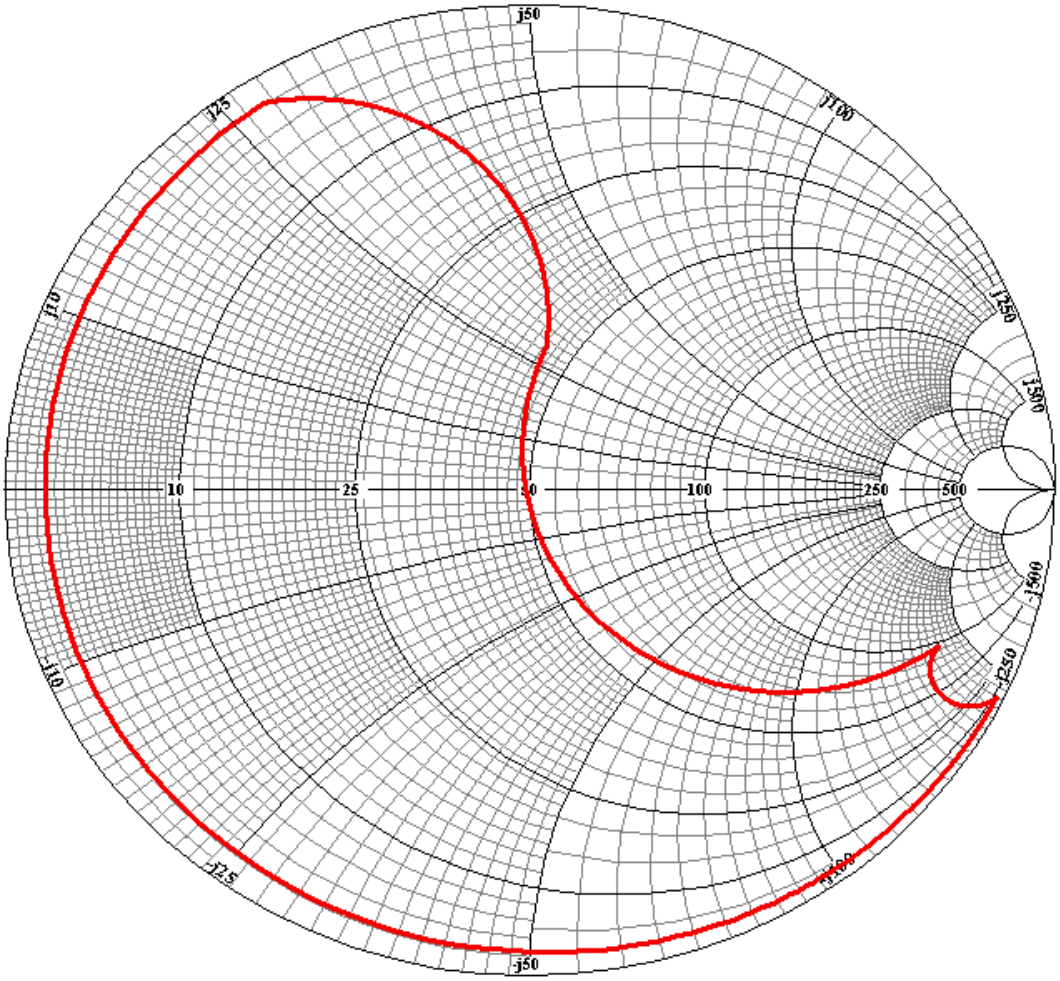


Figure 7-11. *Tune coil, 14 turns: tap 4; Load coil, 3 turns: tap B*

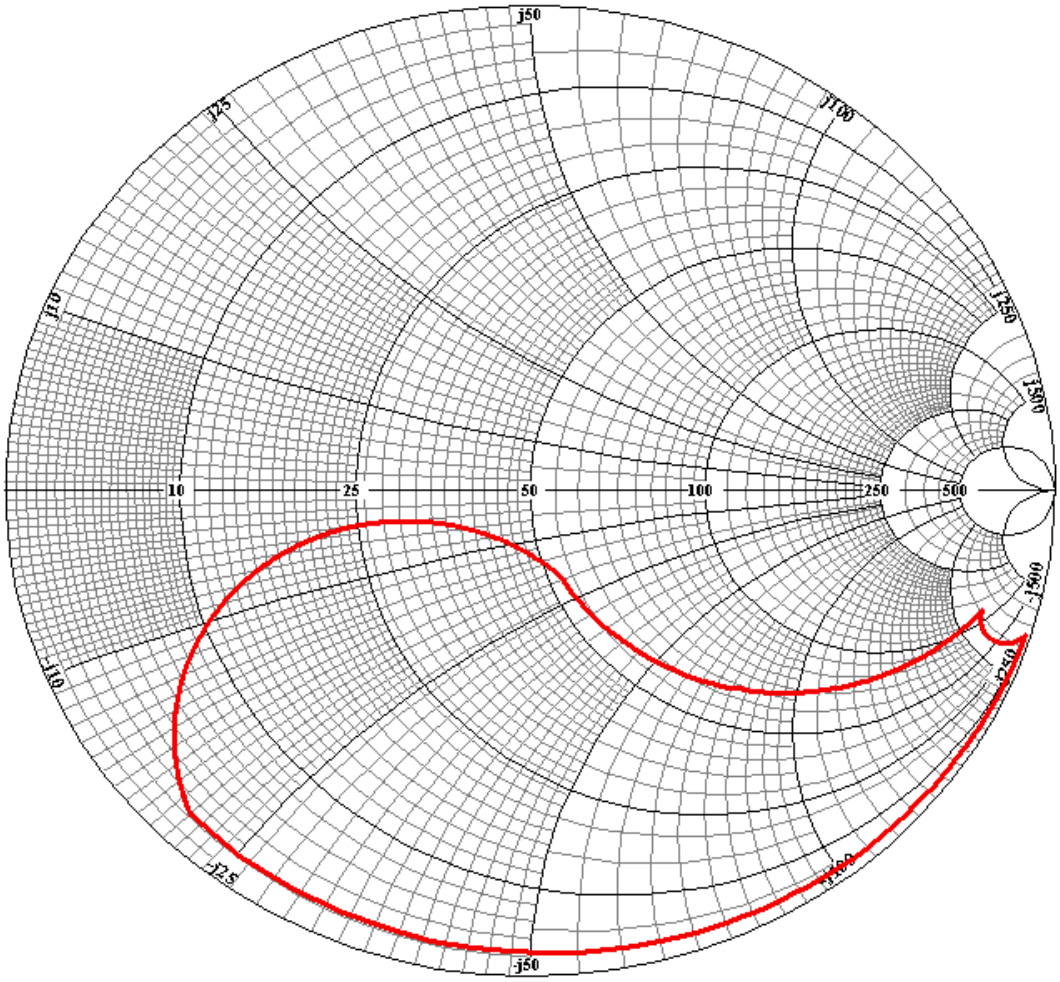


Figure 7-12. *Tune coil, 14 turns: tap 5; Load coil, 3 turns: tap B*

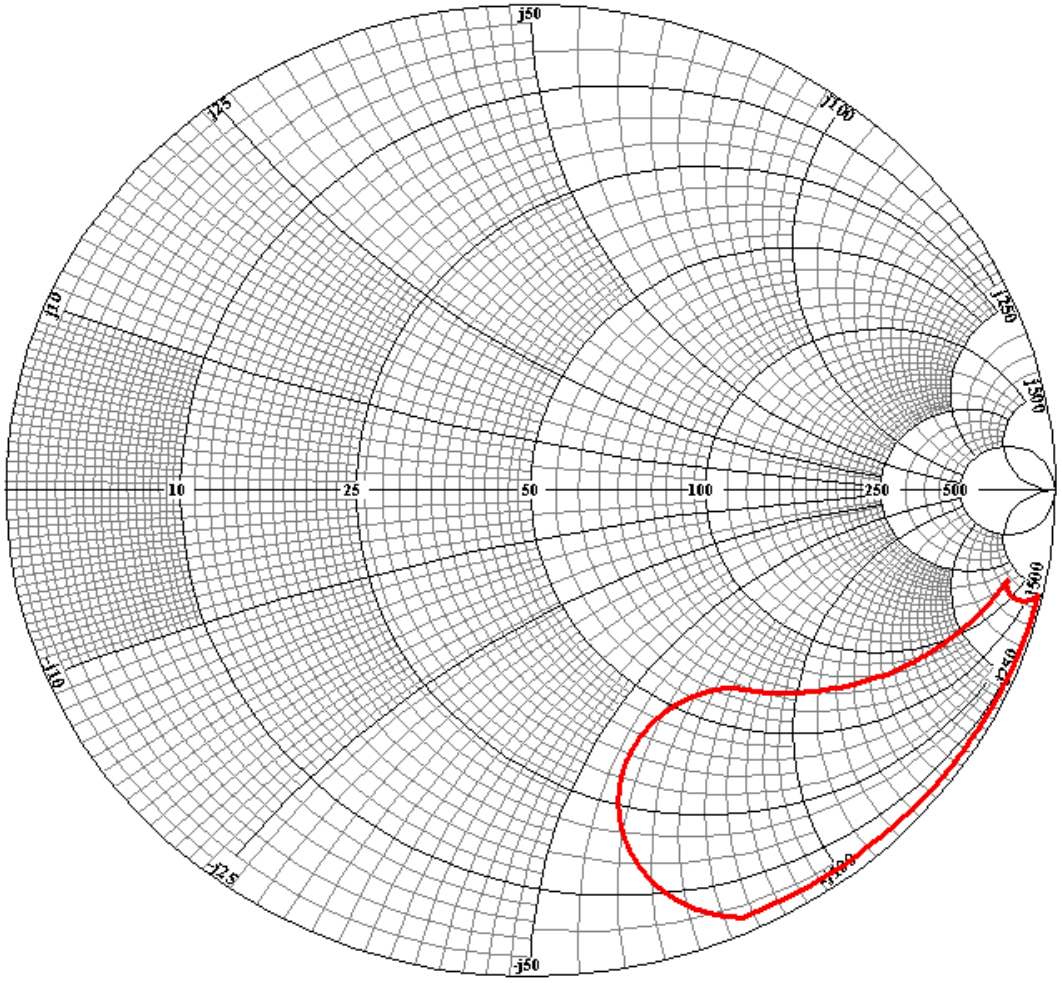


Figure 7-13. *Tune coil, 14 turns: tap 6; Load coil, 3 turns: tap B*

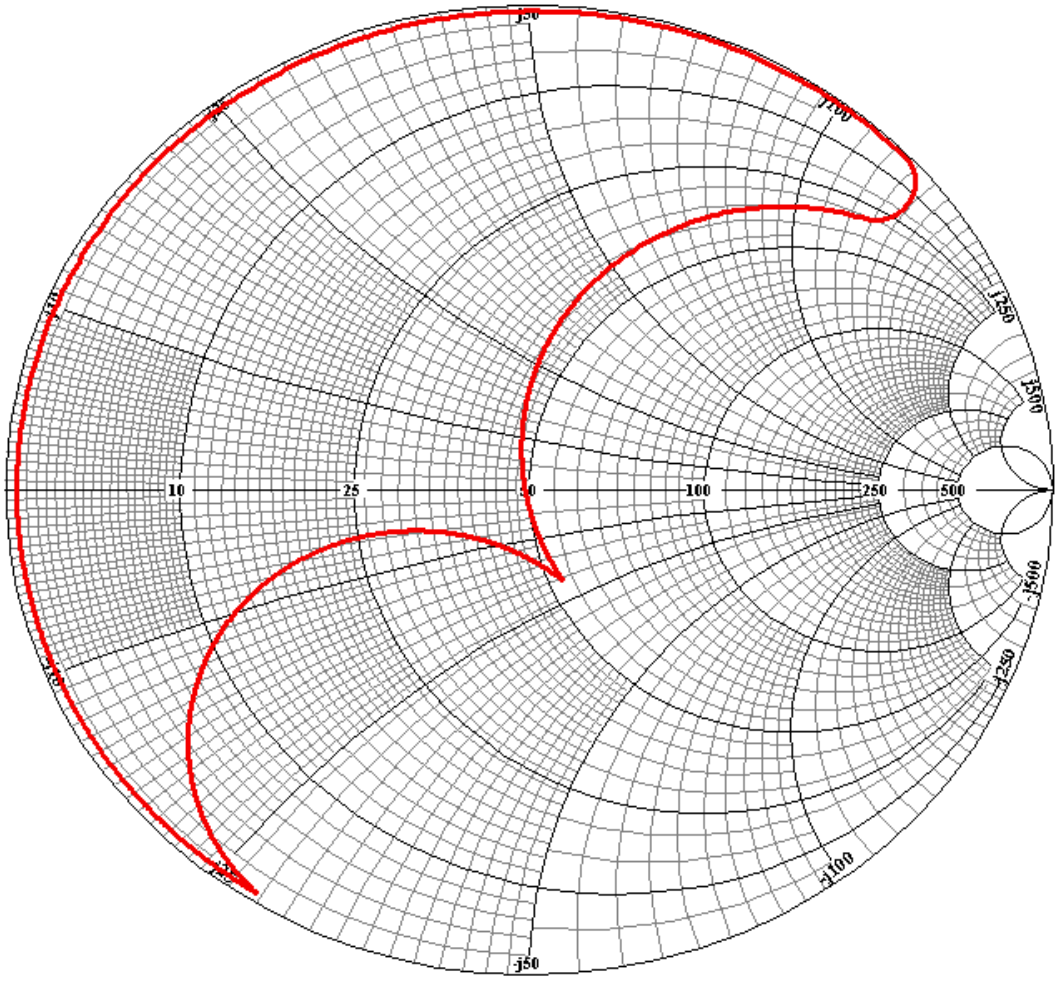


Figure 7-14. *Tune coil, 14 turns: tap 1; Load coil, 3 turns: tap C*

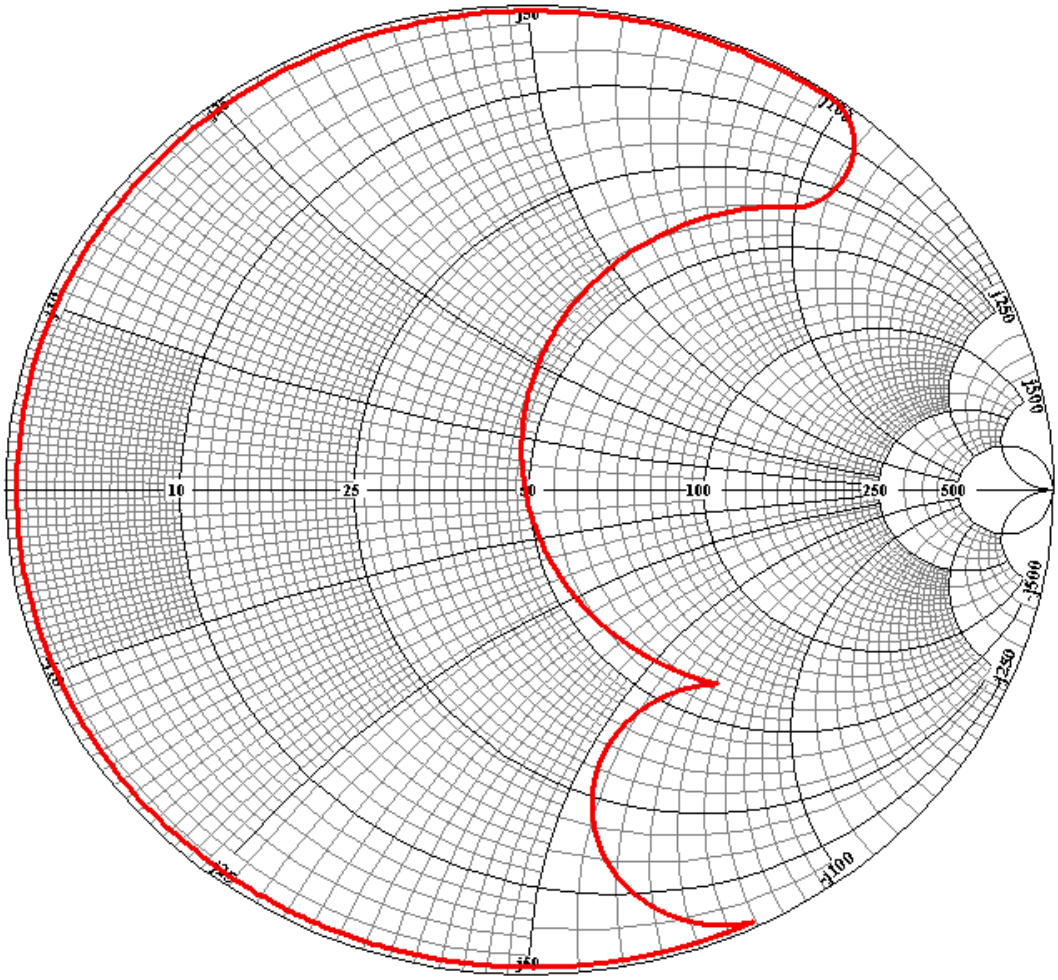


Figure 7-15. *Tune coil, 14 turns: tap 2; Load coil, 3 turns: tap C*

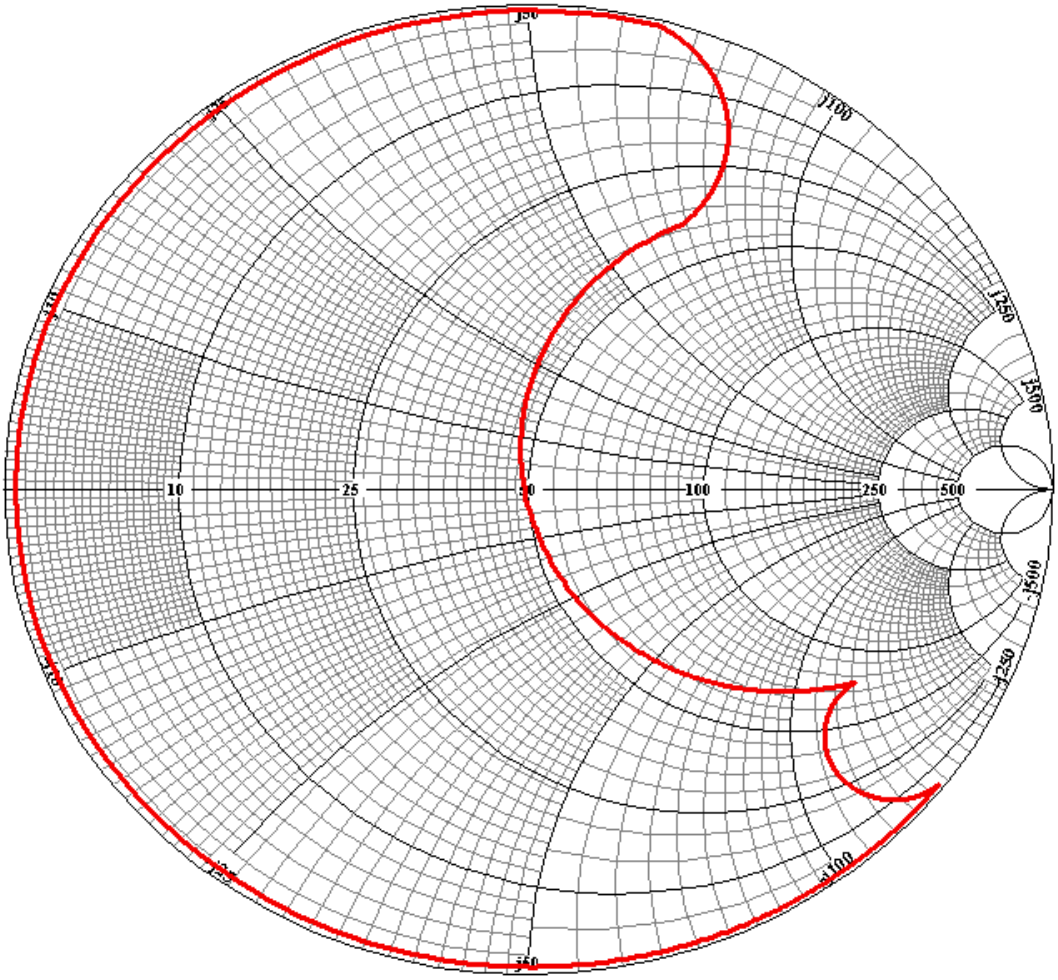


Figure 7-16. *Tune coil, 14 turns: tap 3; Load coil, 3 turns: tap C*

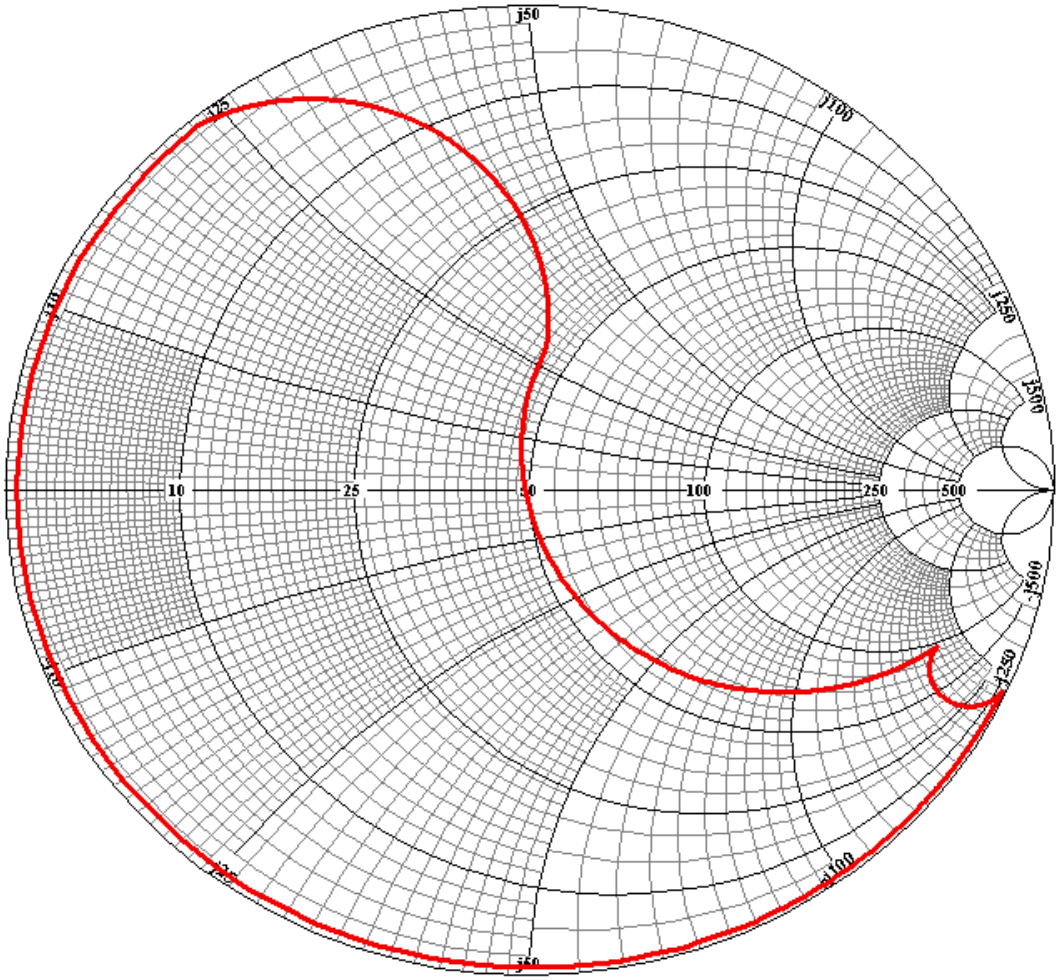


Figure 7-17. *Tune coil, 14 turns: tap 4; Load coil, 3 turns: tap C*

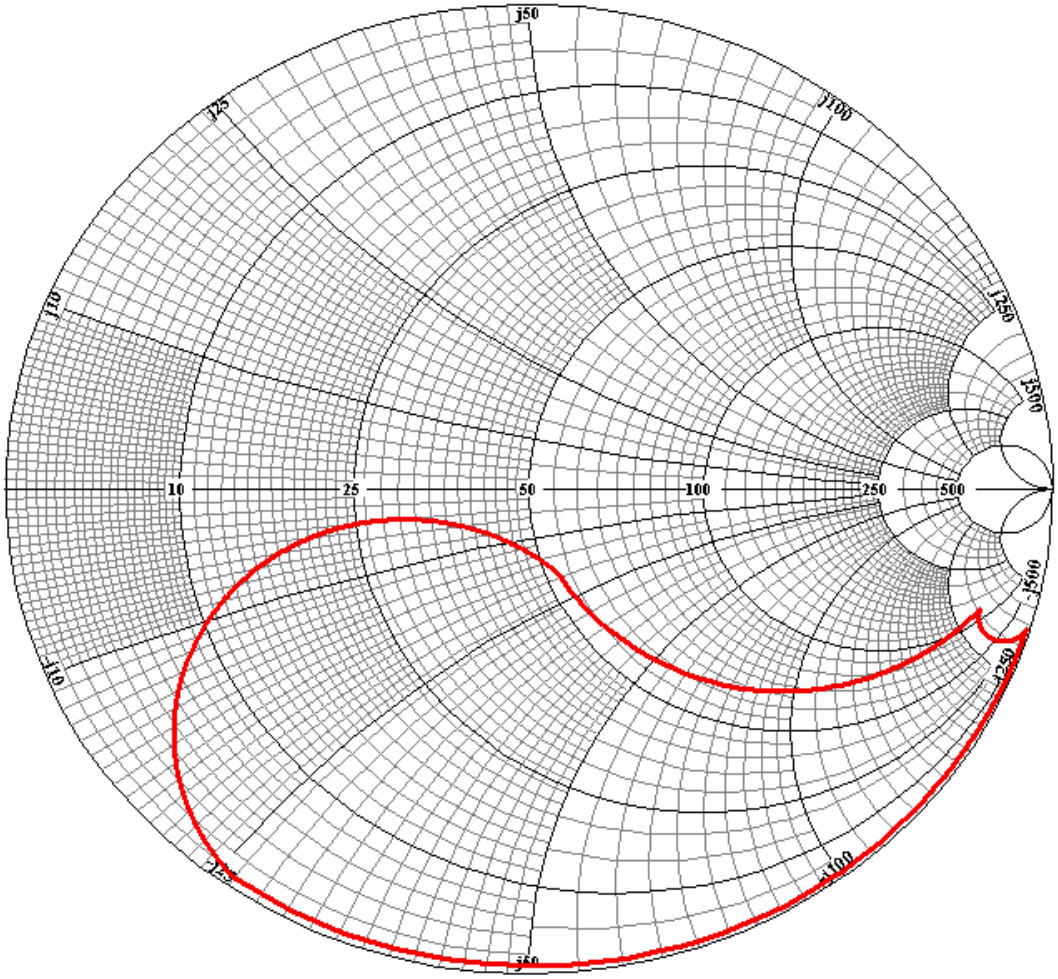


Figure 7-18. *Tune coil, 14 turns: tap 5; Load coil, 3 turns: tap C*

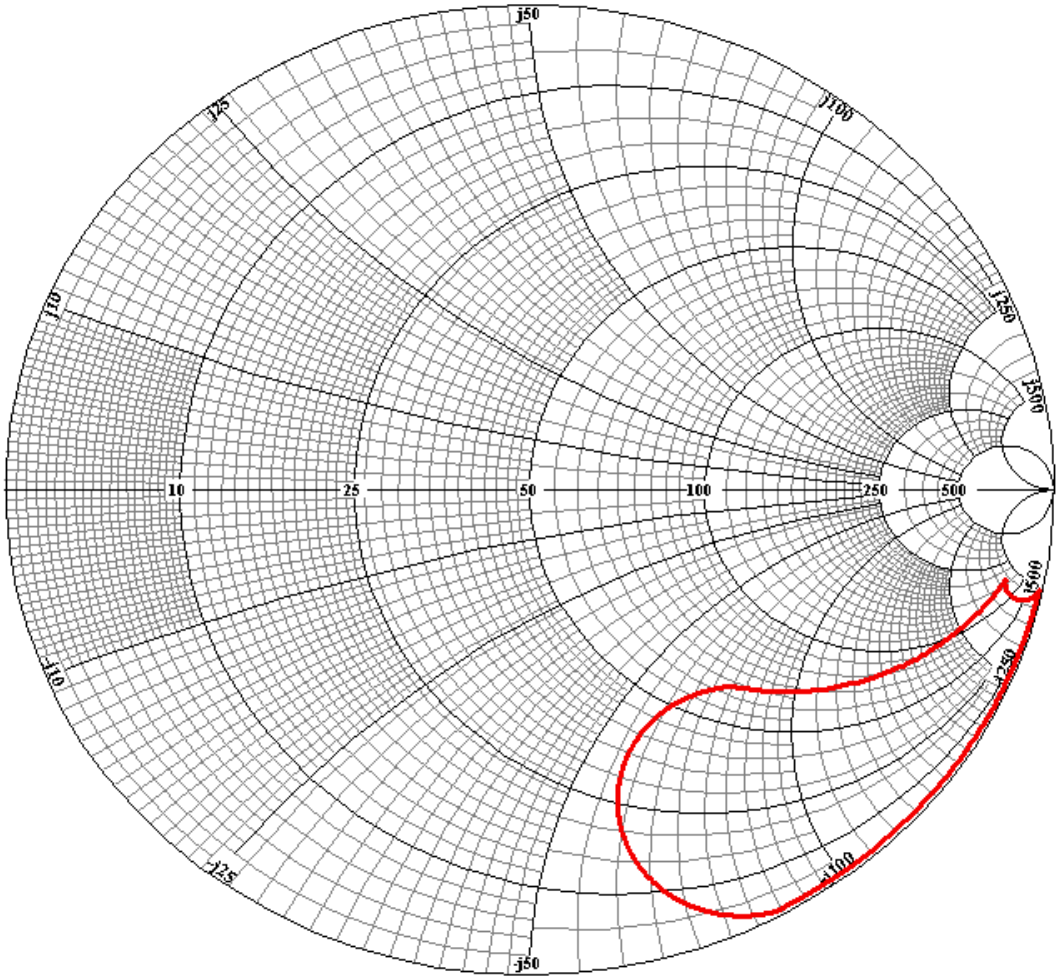


Figure 7-19. *Tune coil, 14 turns: tap 6; Load coil, 3 turns: tap C*

6-TURN TUNE (SERIES) COIL

Schematic

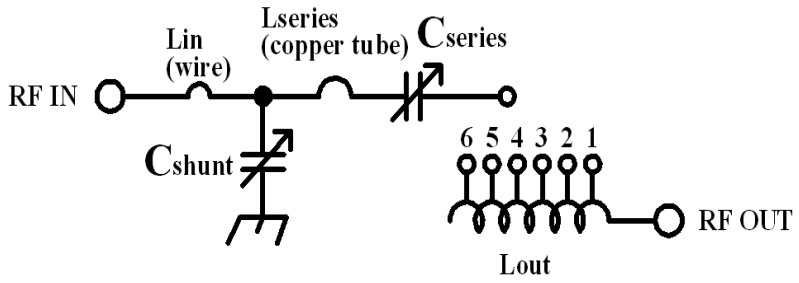


Figure 7-20. *Models 1000 and 1500 coil and inductor schematic, 6 turn coil*

Smith Charts

Table 7-2. *Location of Smith chart illustrations for 6-turn tune coil*

Tune Coil Tap Setting	VarioMatch Frequency	
	27 MHz	40 MHz
1	Figure 7-21	Figure 7-27
2	Figure 7-22	Figure 7-28
3	Figure 7-23	Figure 7-29
4	Figure 7-24	Figure 7-30
5	Figure 7-25	Figure 7-31
6	Figure 7-26	Figure 7-32

27 MHZ UNITS

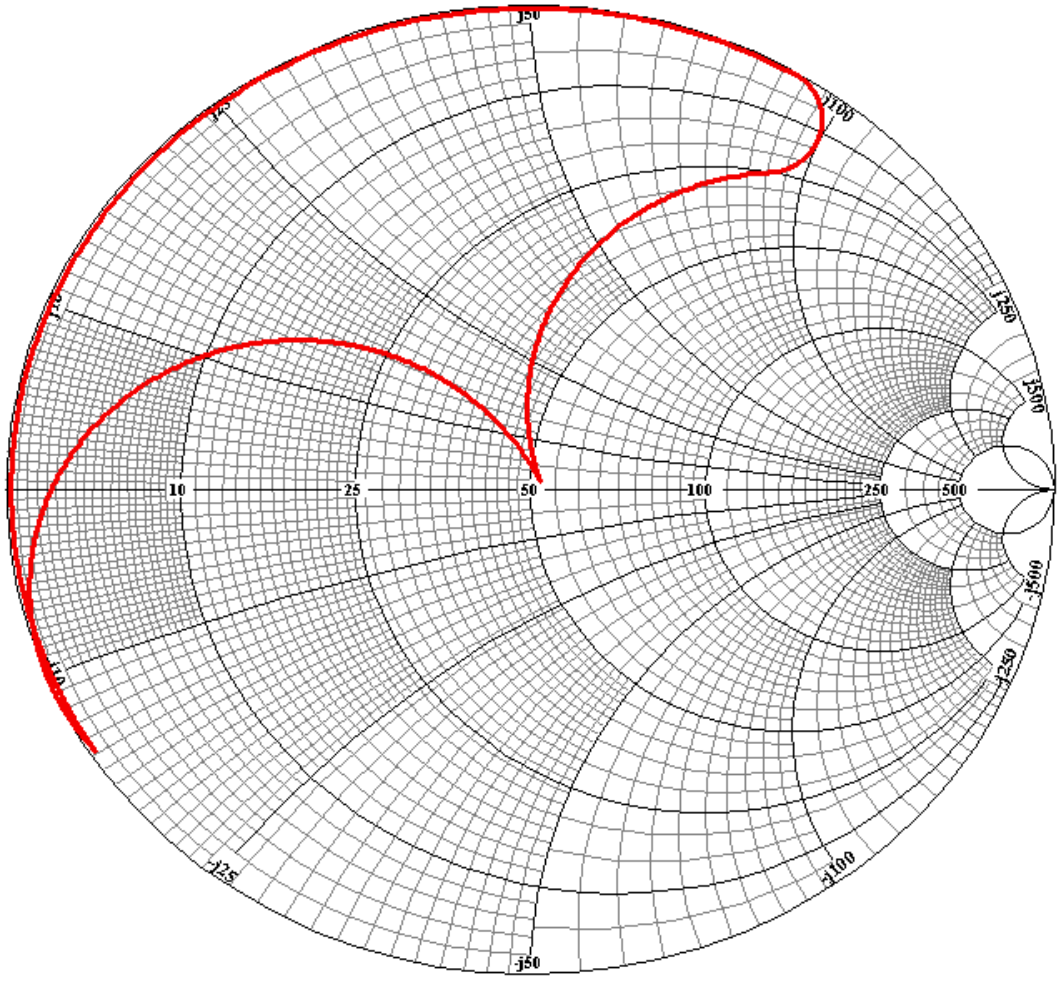


Figure 7-21. *27 MHz; Tune coil, 6 turns: tap 1;*

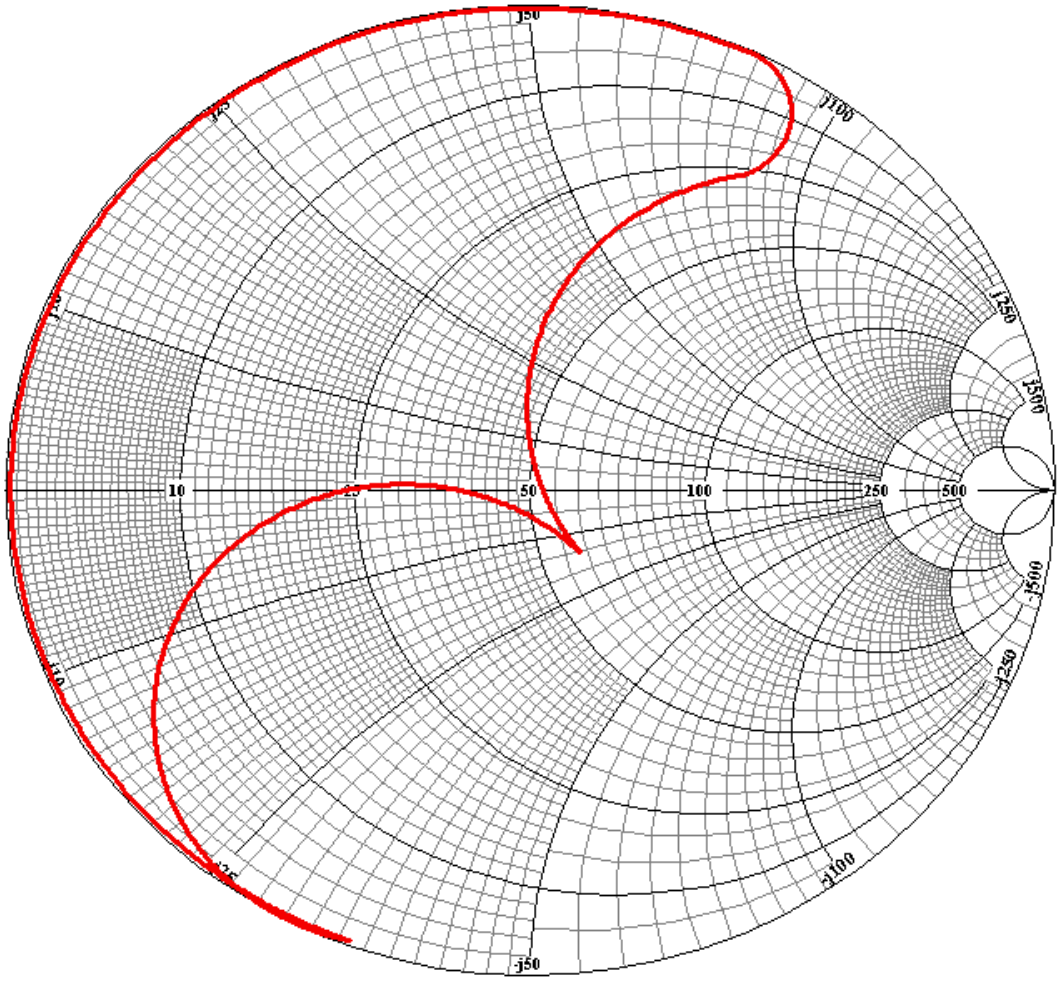


Figure 7-22. *27 MHz; Tune coil, 6 turns: tap 2*

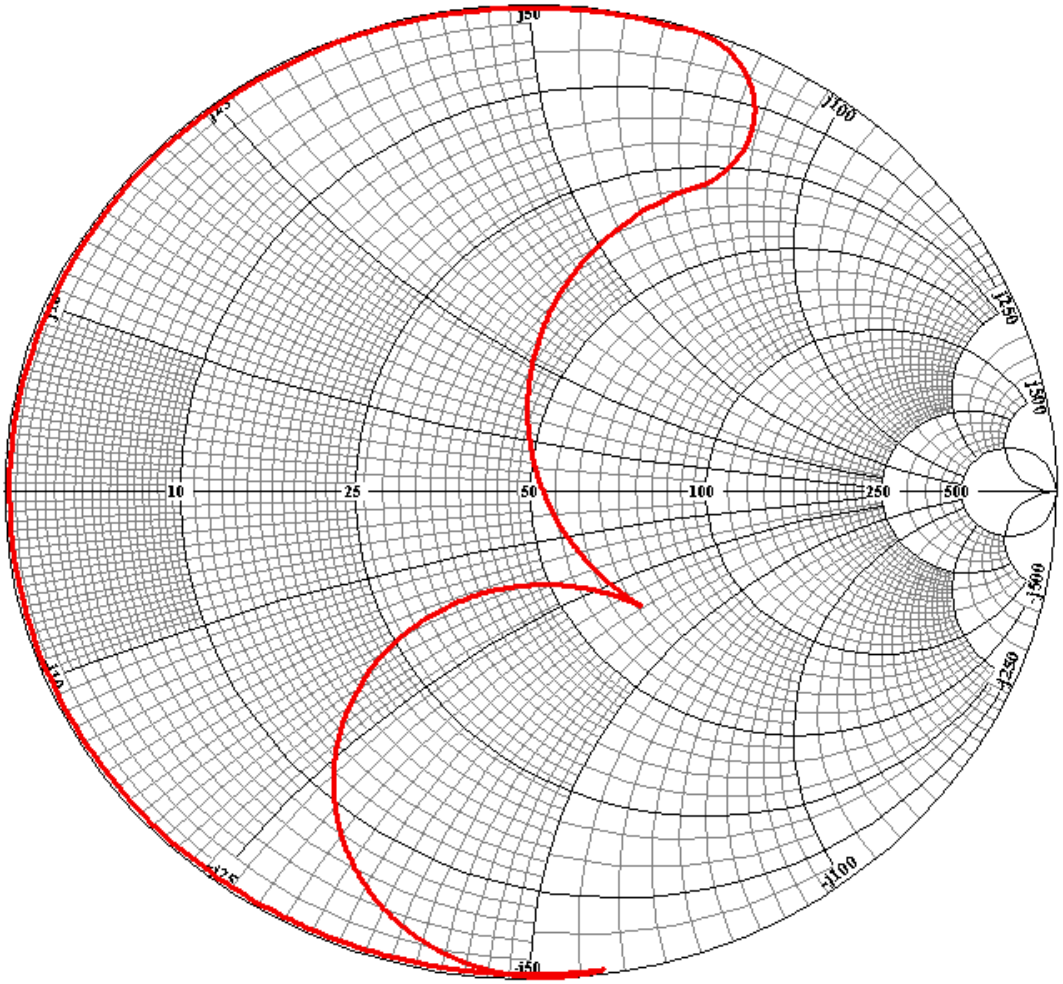


Figure 7-23. *27 MHz; Tune coil, 6 turns: tap 3*

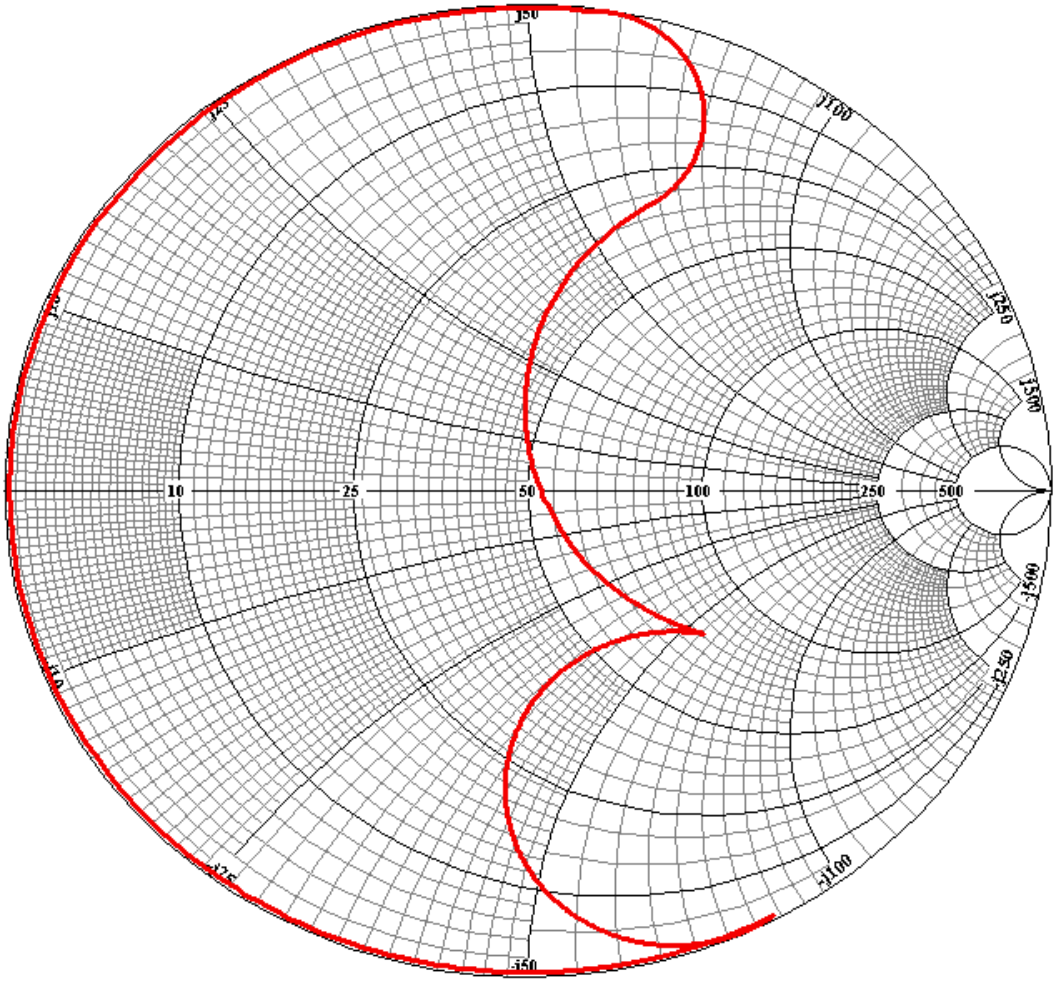


Figure 7-24. *27 MHz; Tune coil, 6 turns: tap 4*

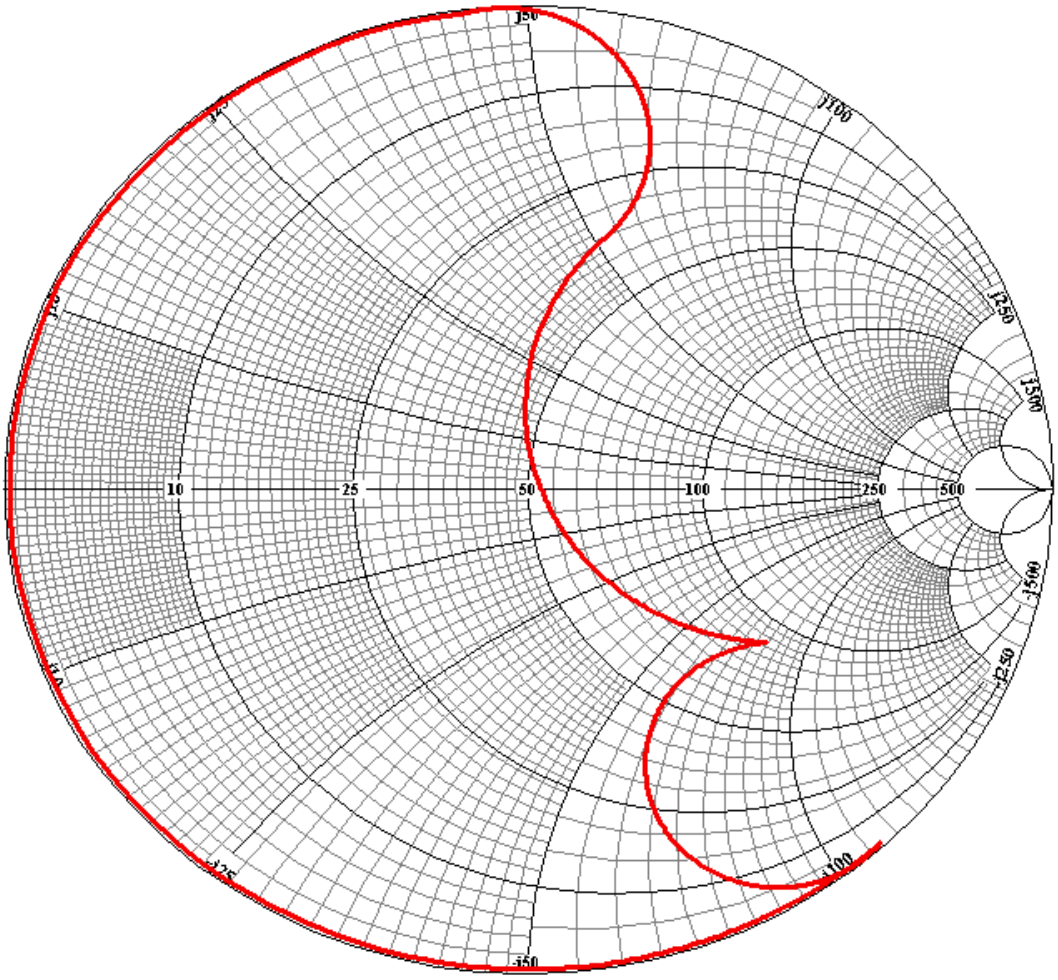


Figure 7-25. *27 MHz; Tune coil, 6 turns: tap 5*

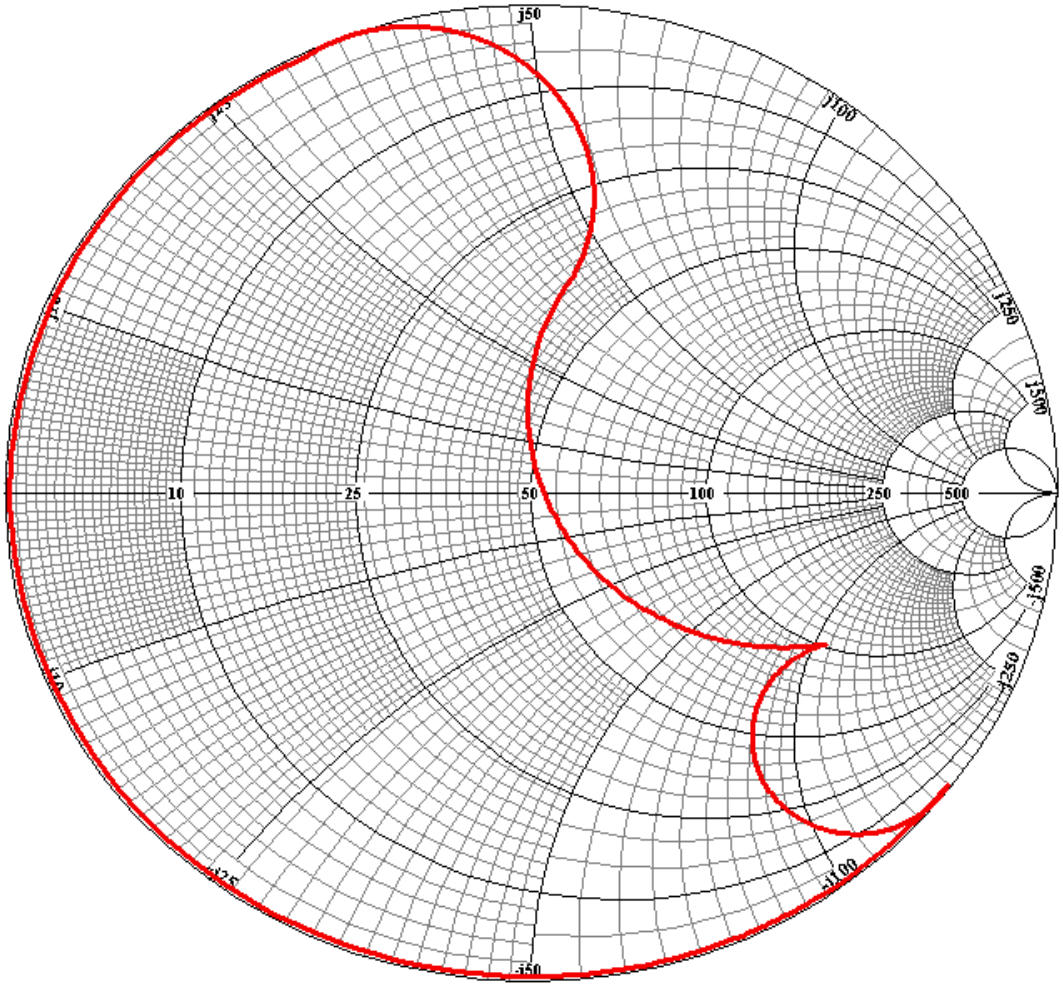


Figure 7-26. *27 MHz; Tune coil, 6 turns: tap 6*

40 MHZ UNITS

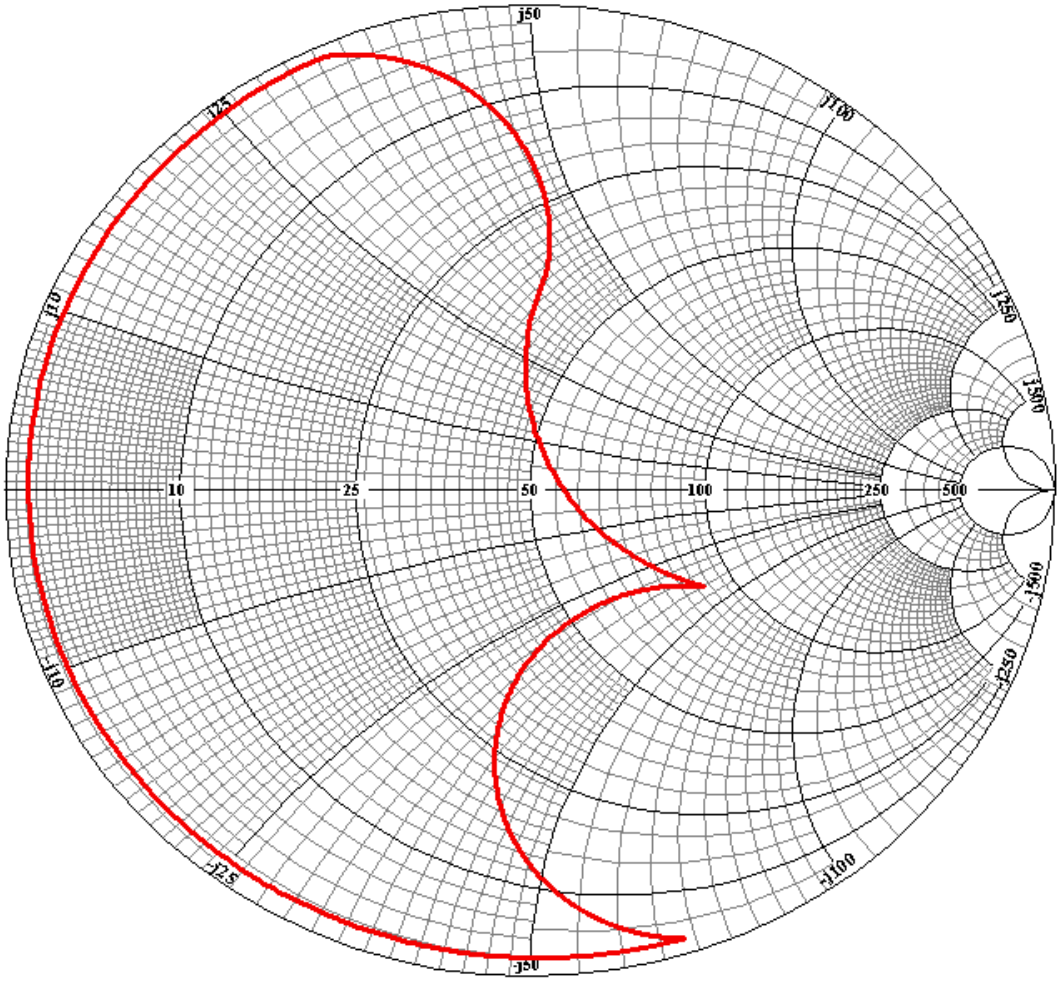


Figure 7-27. *40 MHz; Tune coil, 6 turns: tap 1*

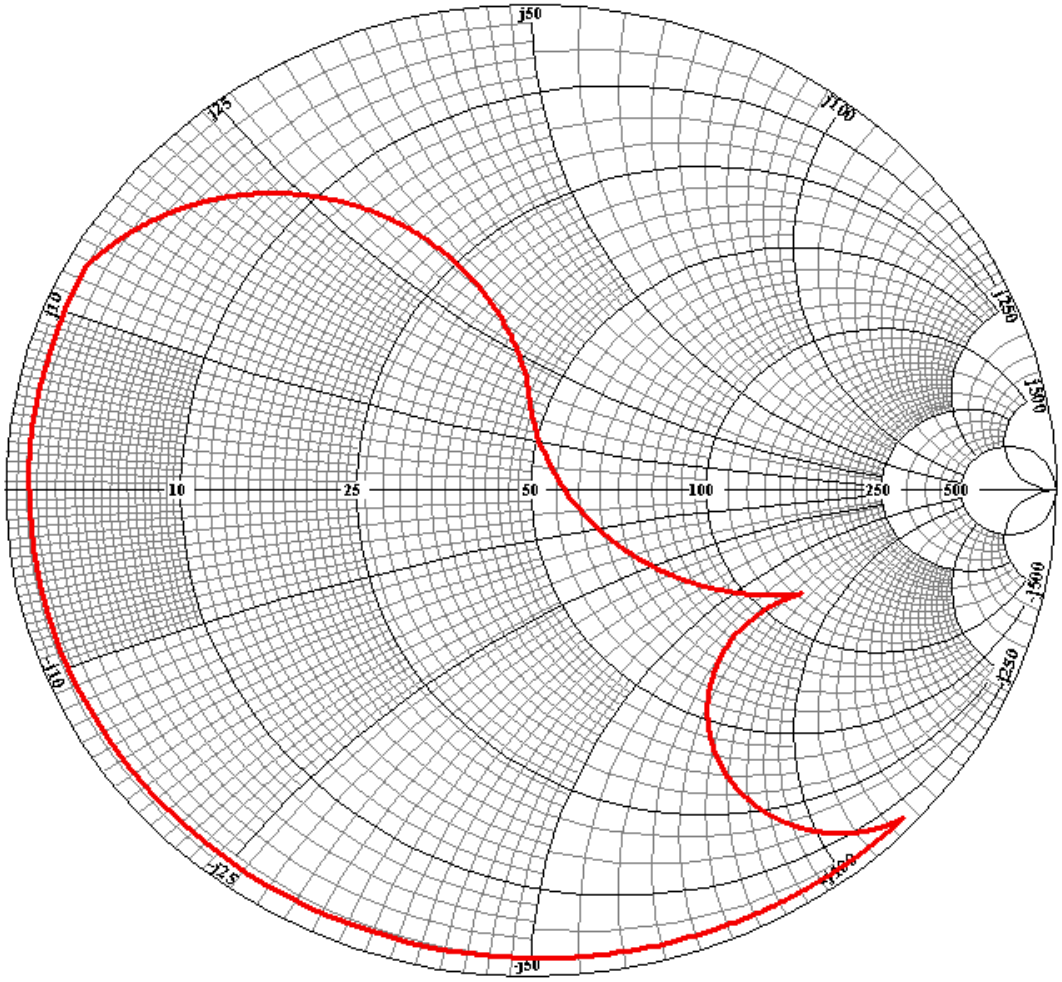


Figure 7-28. *40 MHz; Tune coil, 6 turns: tap 2*

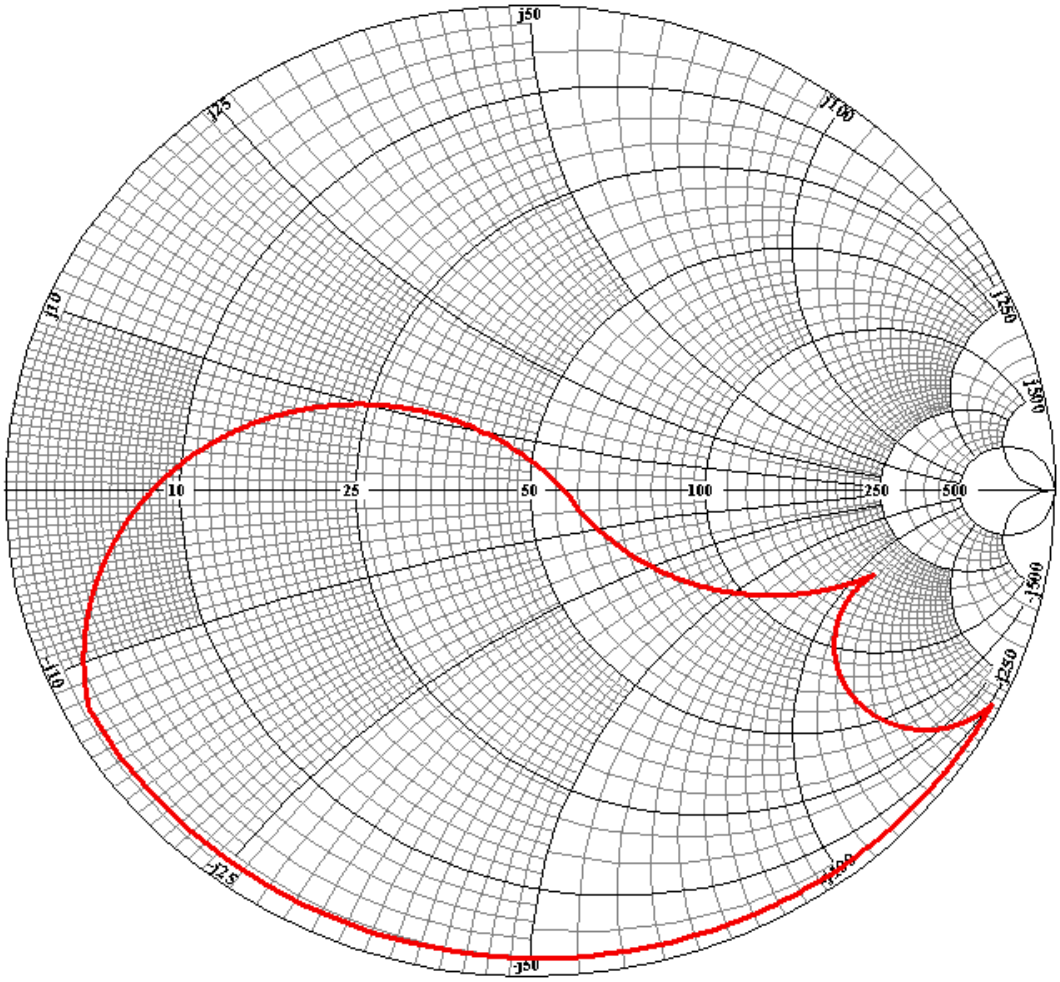


Figure 7-29. *40 MHz; Tune coil, 6 turns: tap 3*

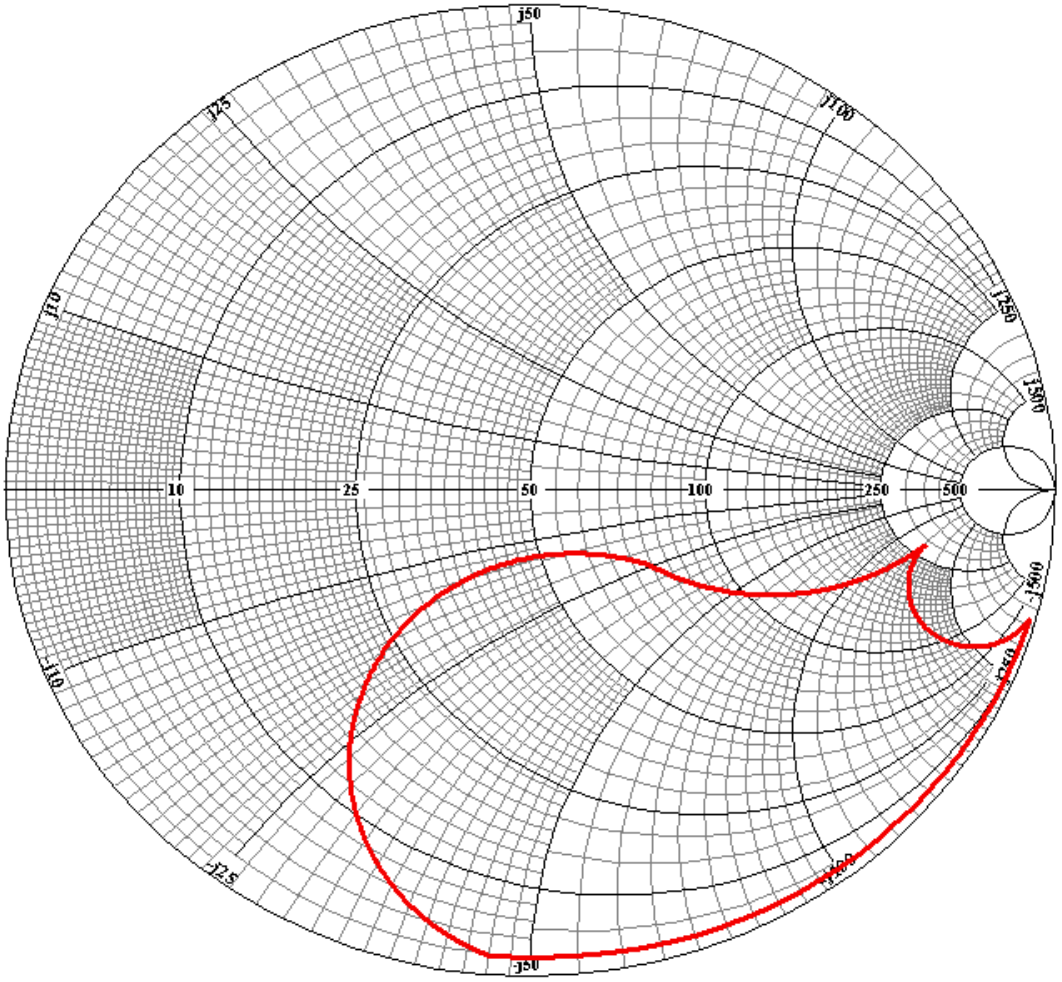


Figure 7-30. *40 MHz; Tune coil, 6 turns: tap 4*

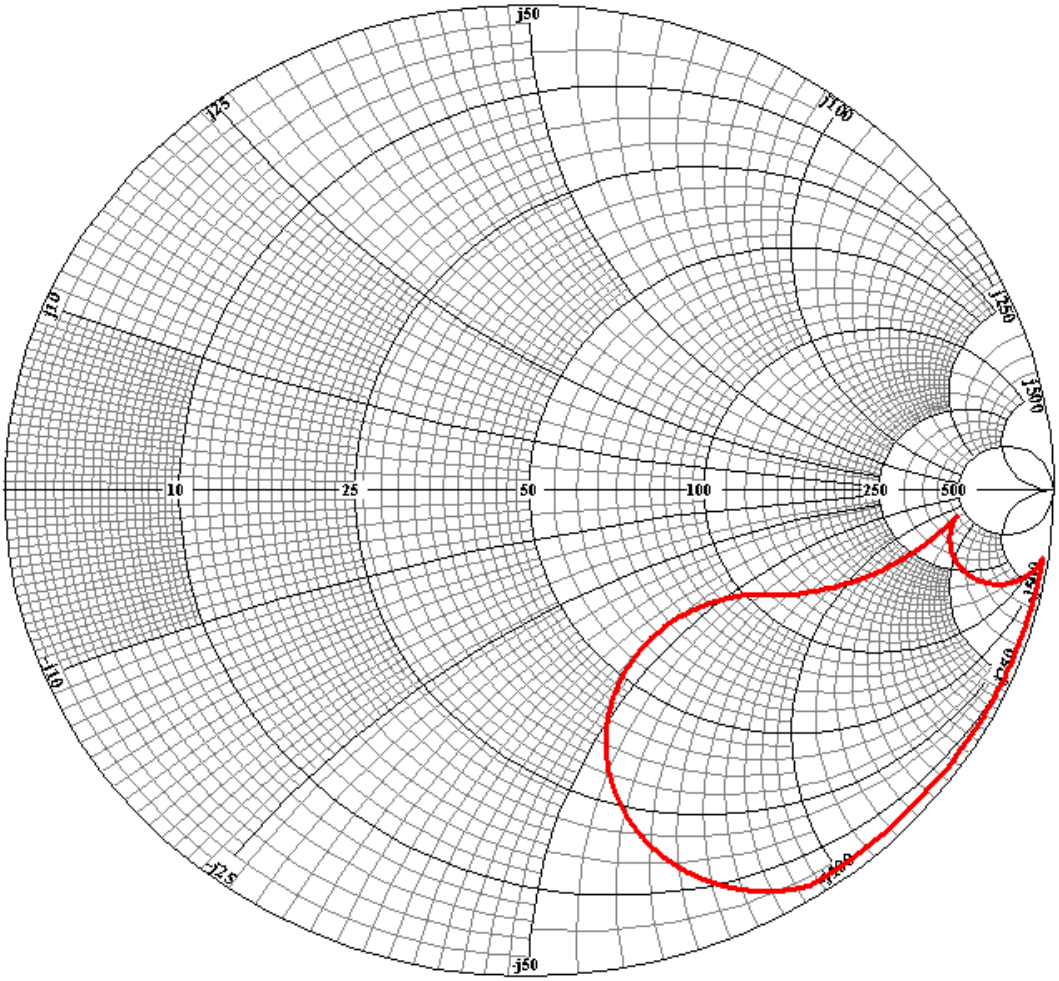


Figure 7-31. *40 MHz; Tune coil, 6 turns: tap 5*

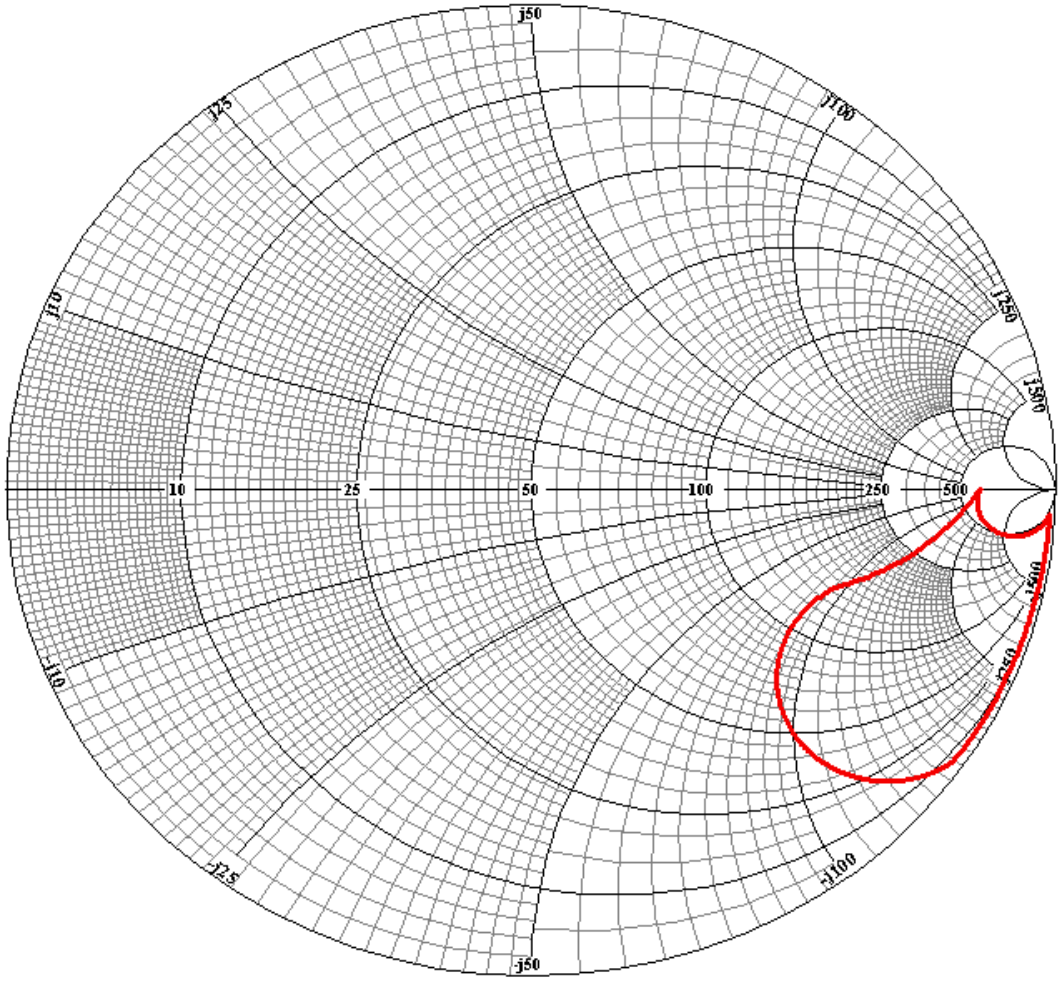


Figure 7-32. *40 MHz; Tune coil, 6 turns: tap 6;*

VM 0415

Schematic

The tune (series) coil has taps at taps at 10, 13, 16, 19, 22, and 25 turns. These are labeled 1 through 6 in the schematic. The load (shunt) coil has 4 turns with 5 taps, labeled A, B, C, D, and E. These labels are used in the Smith charts.

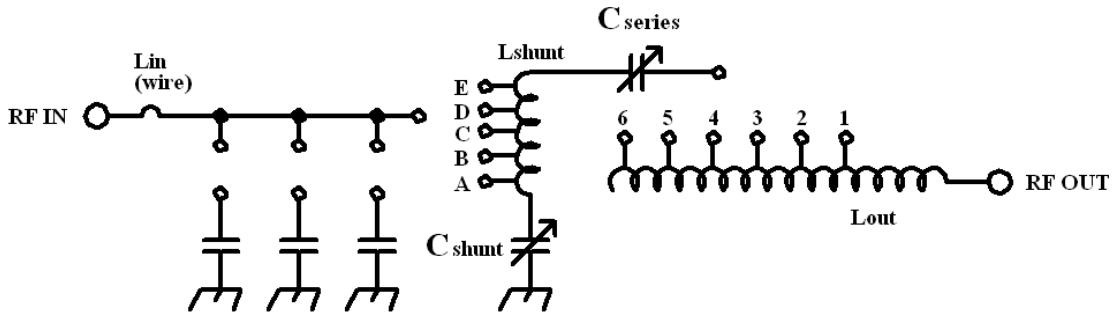


Figure 7-33. *VM 0415 coil and inductor schematic*

Smith Charts

2 MHZ UNITS

The Smith charts for the 2 MHz VM 4015 show the tuning range with tune coil tap set at 6, load coil tap set at E. The tune range varies by capacitance setting.

Table 7-3. *Location of Smith chart illustrations for 2 MHz VM 0415*

Capacitance Setting	Smith Chart
0 pF	Figure 7-34
680 pF	Figure 7-35
1360 pF	Figure 7-36
2040 pF	Figure 7-37
2720 pF	Figure 7-38
3400 pF	Figure 7-39

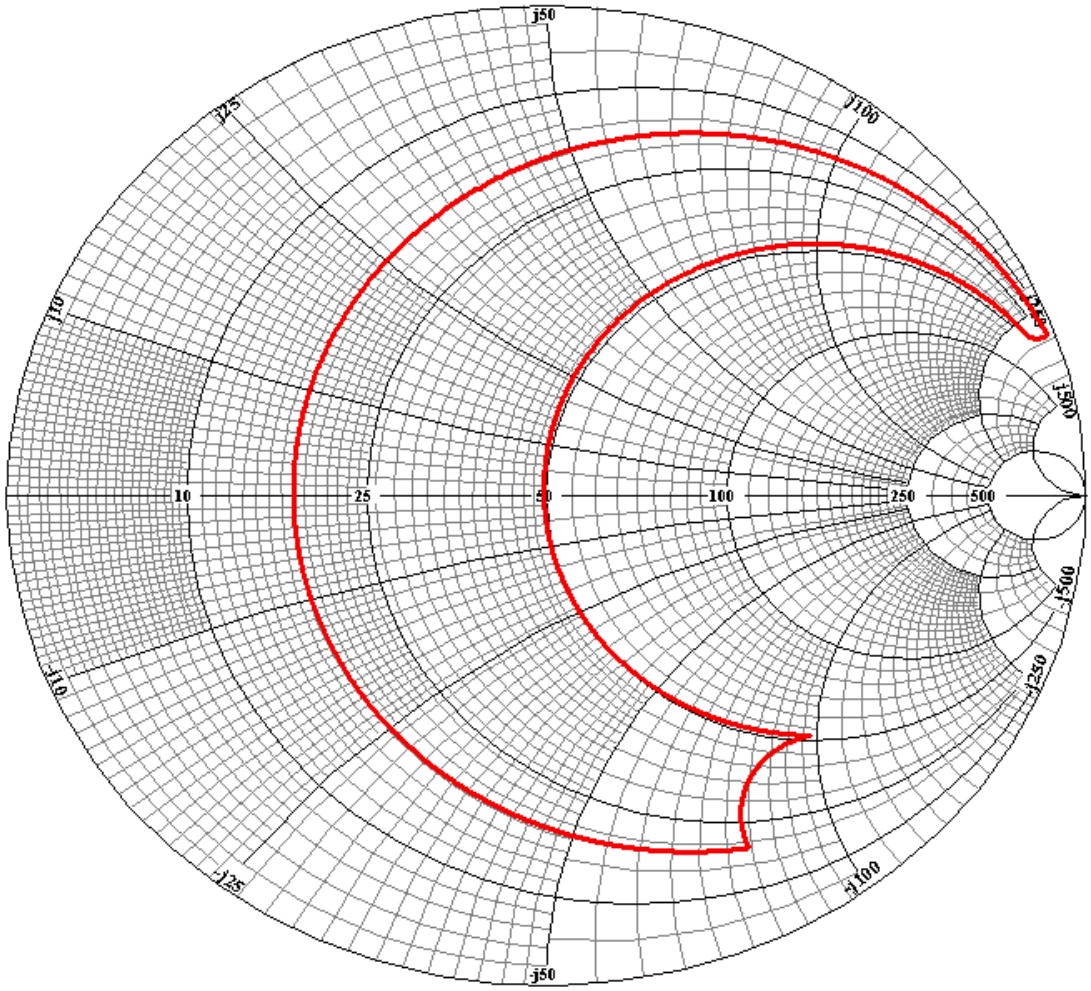


Figure 7-34. *2 MHz; Tune coil, 6; Load coil, E; 0 pF*

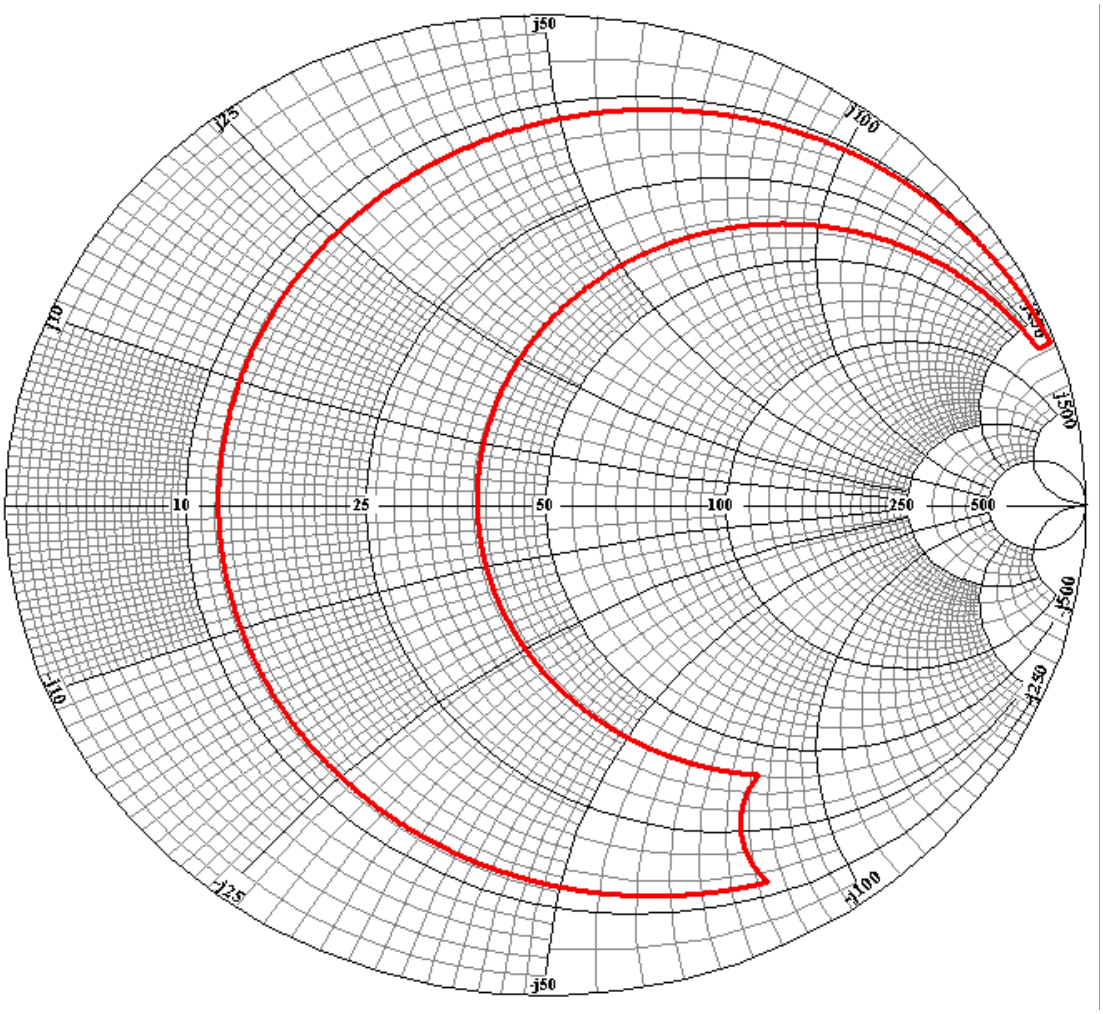


Figure 7-35. *2 MHz; Tune coil, 6; Load coil, E; 680 pF*

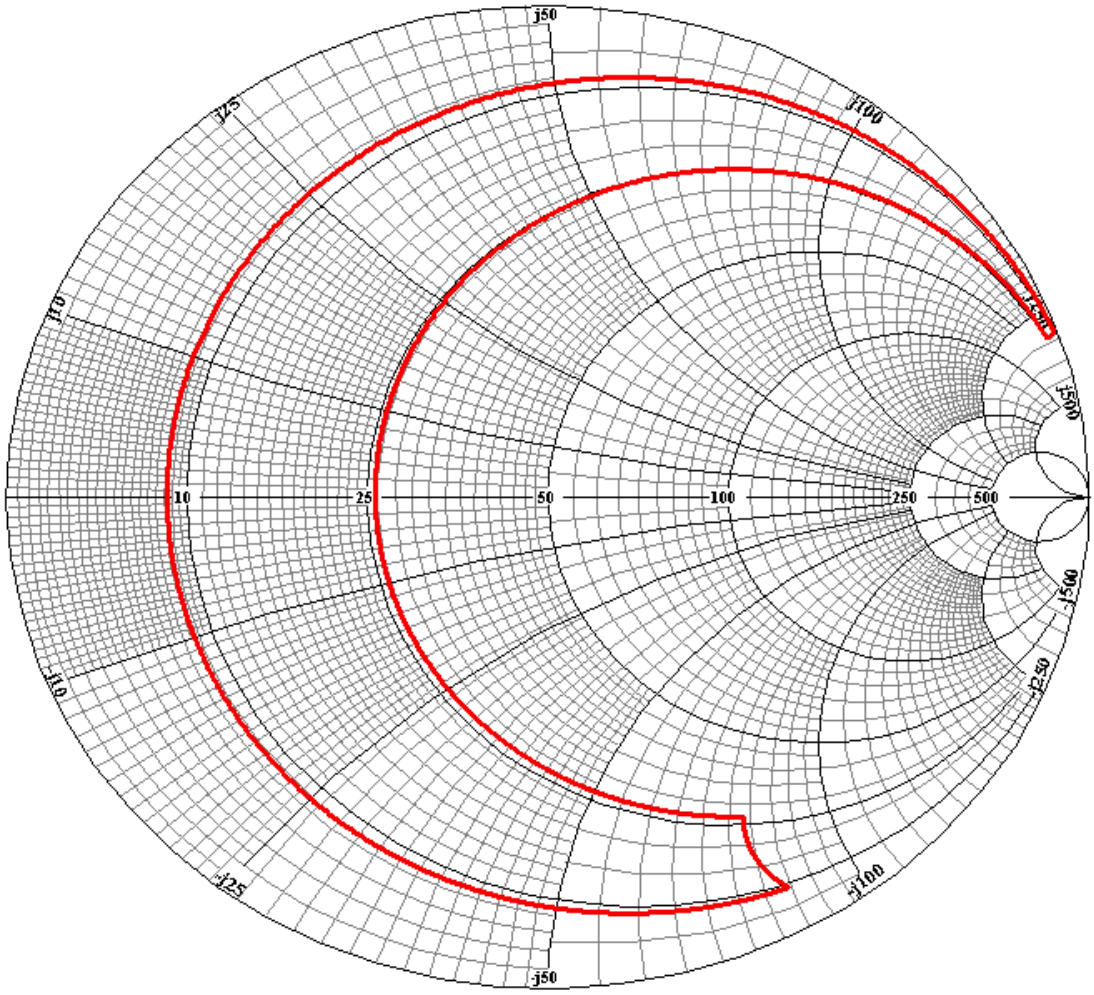


Figure 7-36. *2 MHz; Tune coil, 6; Load coil, E; 1360 pF*

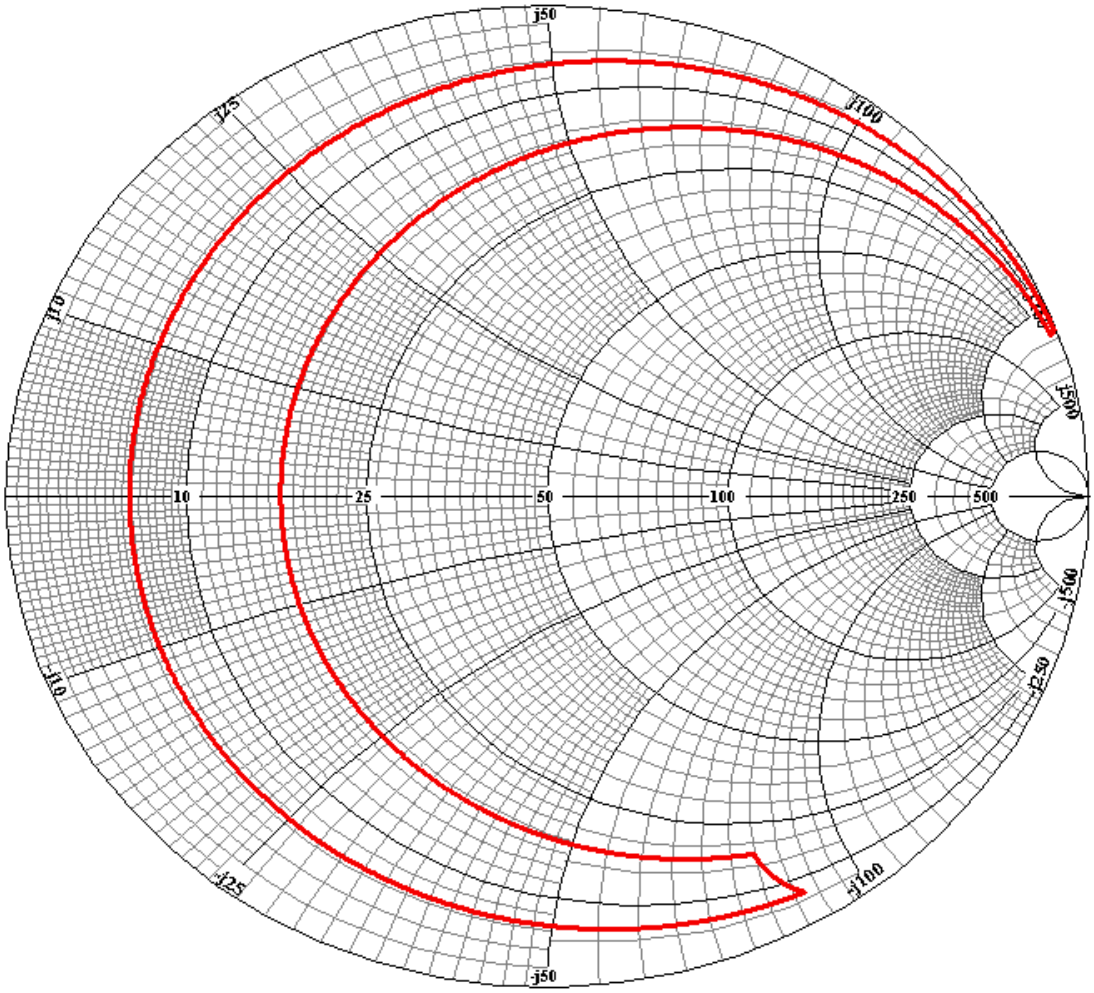


Figure 7-37. *2 MHz; Tune coil, 6; Load coil, E; 2040 pF*

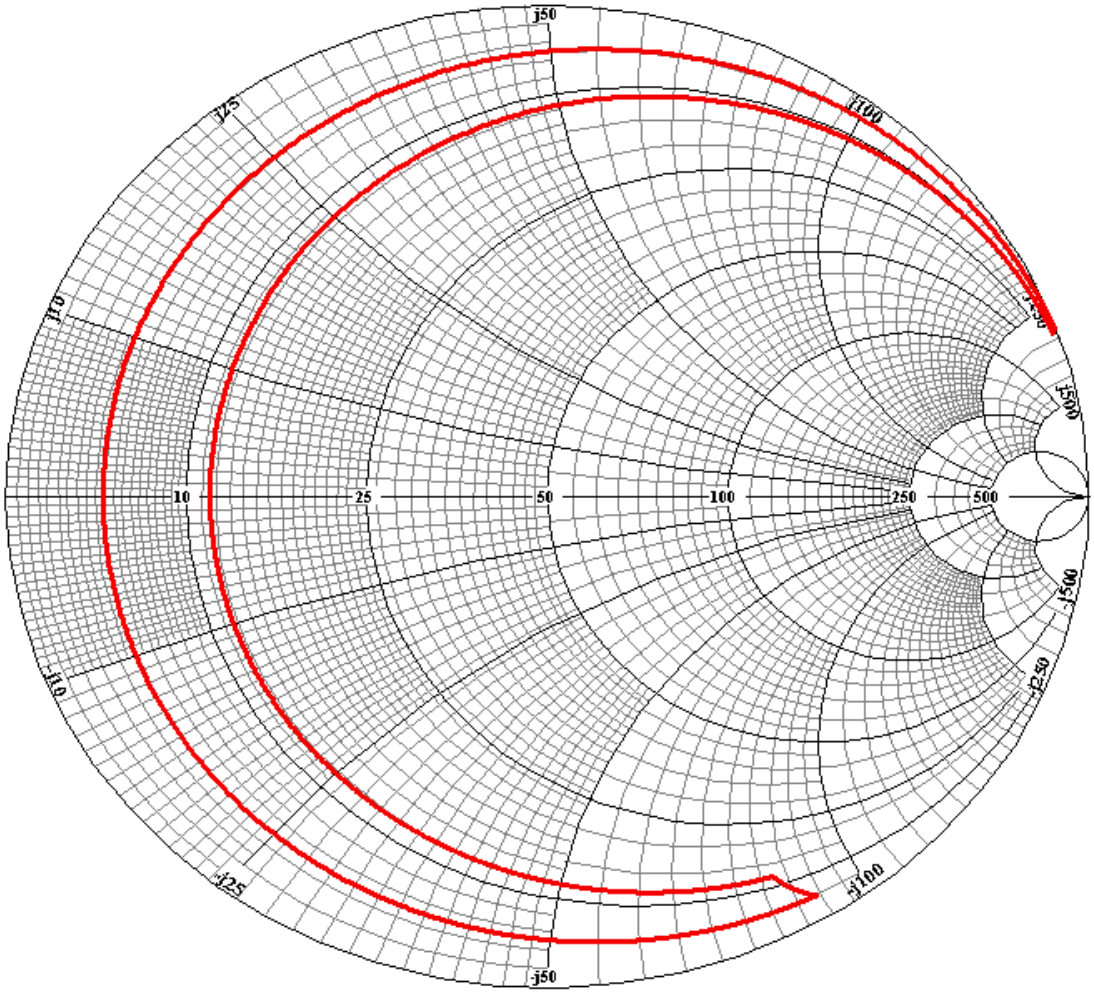


Figure 7-38. *2 MHz; Tune coil, 6; Load coil, E; 2720 pF*

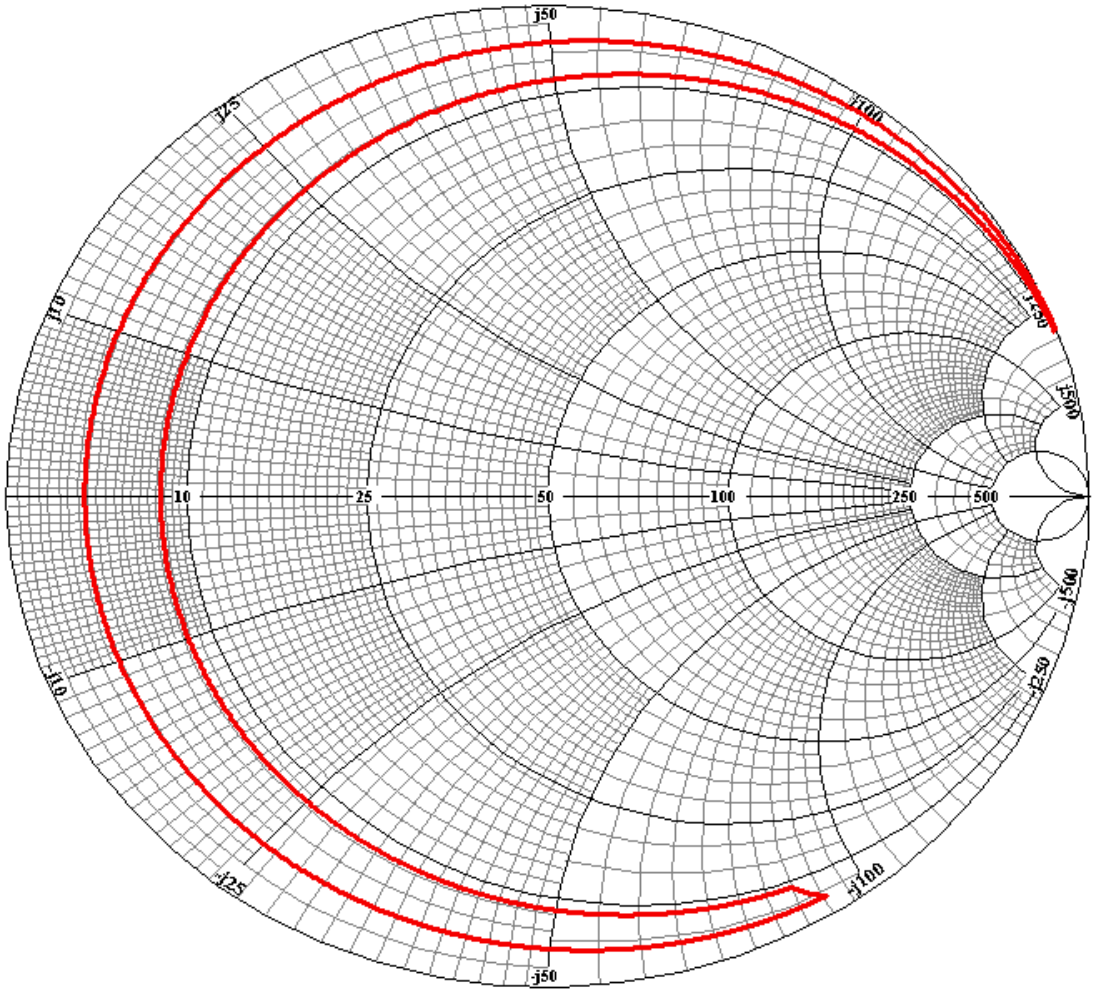


Figure 7-39. *2 MHz; Tune coil, 6; Load coil, E; 3400 pF*

4 MHZ UNITS

The Smith charts for the 4 MHz VM 4015 show the tuning range at each tune and load coil tap setting. AE does not recommend varying the additional capacitance setting.

Table 7-4. *Location of Smith for 4 MHz VM 0415*

Tune Coil Tap Setting	Load Coil Tap Setting				
	A	B	C	D	E
1	Figure 7-40	Figure 7-46	Figure 7-52	Figure 7-58	Figure 7-64
2	Figure 7-41	Figure 7-47	Figure 7-53	Figure 7-59	Figure 7-65

Table 7-4. *Location of Smith for 4 MHz VM 0415*

Tune Coil Tap Setting	Load Coil Tap Setting				
	A	B	C	D	E
3	Figure 7-42	Figure 7-48	Figure 7-54	Figure 7-60	Figure 7-66
4	Figure 7-43	Figure 7-49	Figure 7-55	Figure 7-61	Figure 7-67
5	Figure 7-44	Figure 7-50	Figure 7-56	Figure 7-62	Figure 7-68
6	Figure 7-45	Figure 7-51	Figure 7-57	Figure 7-63	Figure 7-69

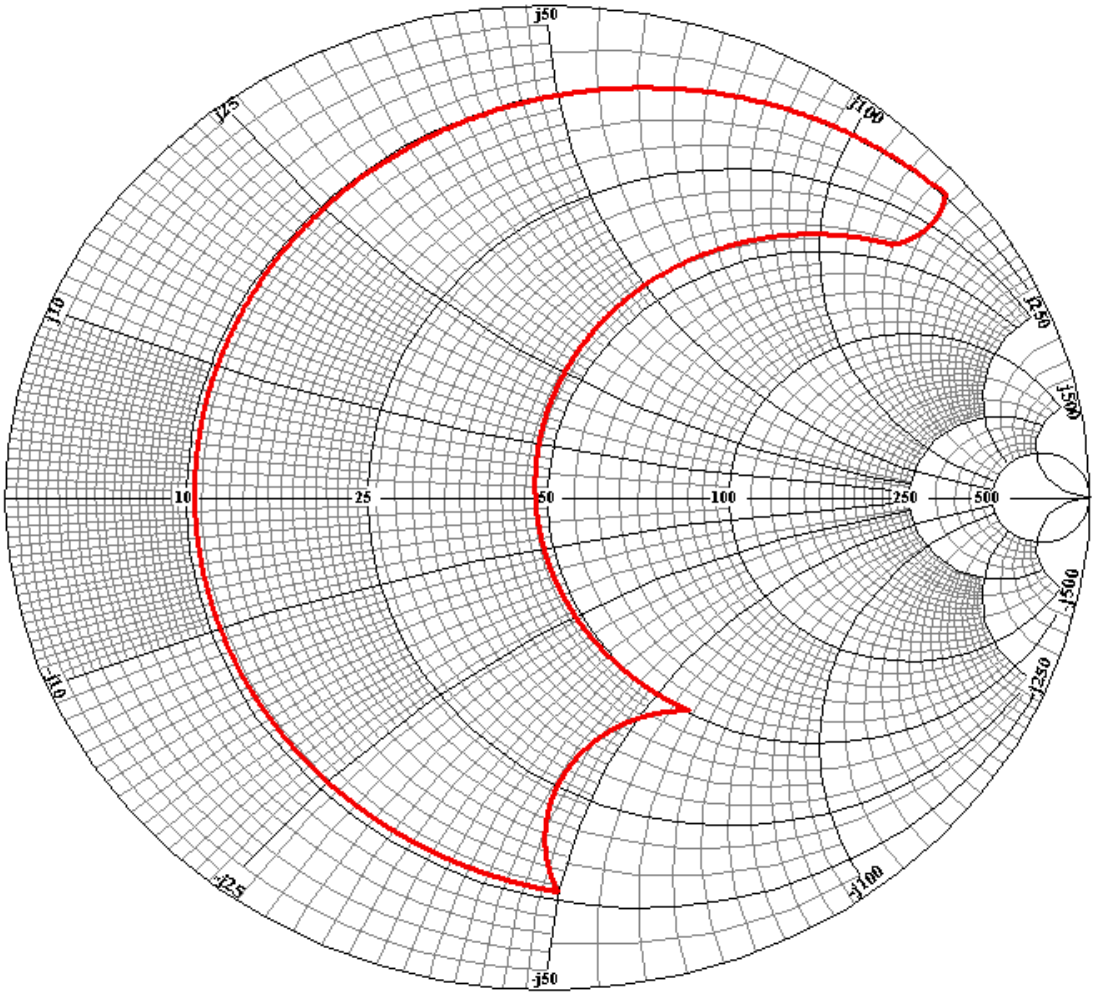


Figure 7-40. *4 MHz; Tune coil, 25 turns: tap 1; Load coil, 4 turns: tap A*

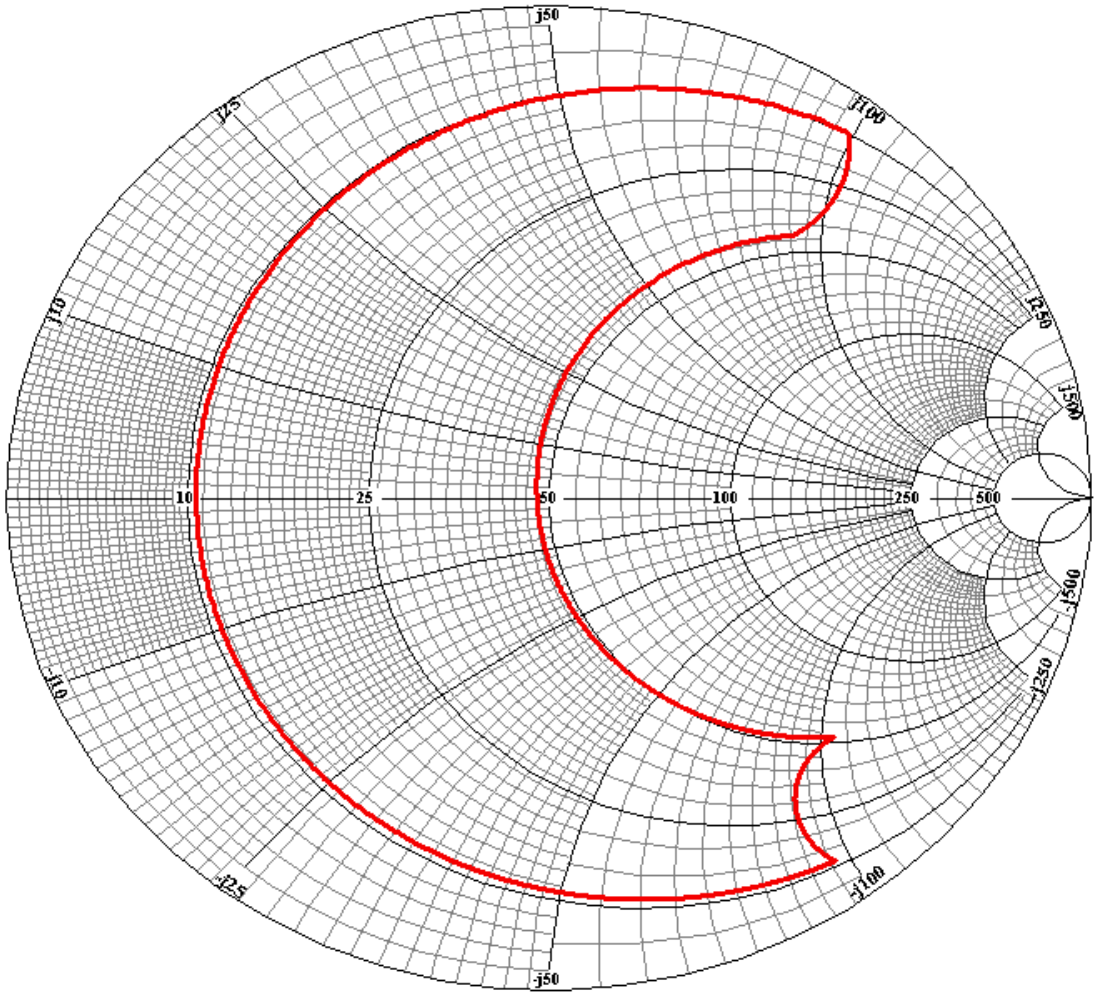


Figure 7-41. *4 MHz; Tune coil, 25 turns: tap 2; Load coil, 4 turns: tap A*

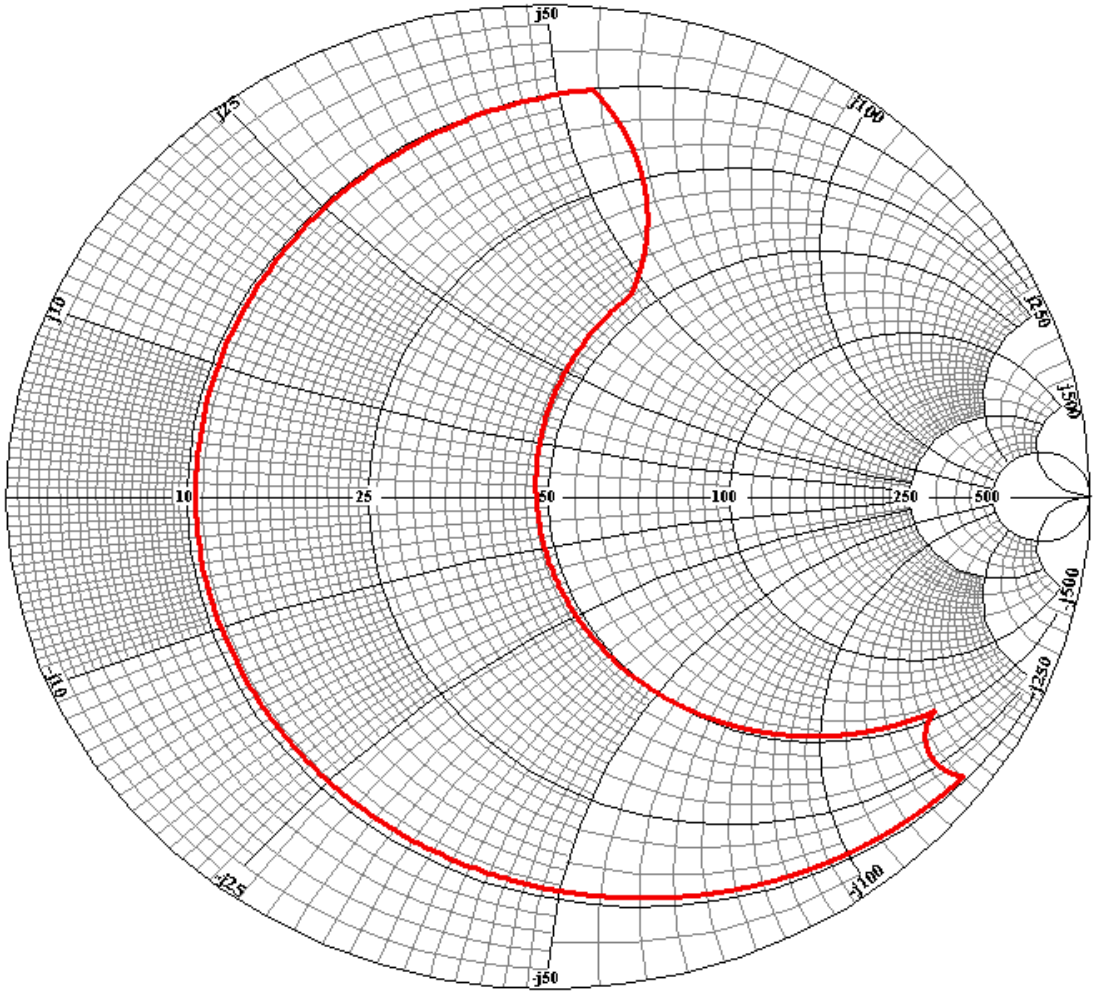


Figure 7-42. *4 MHz; Tune coil, 25 turns: tap 3; Load coil, 4 turns: tap A*

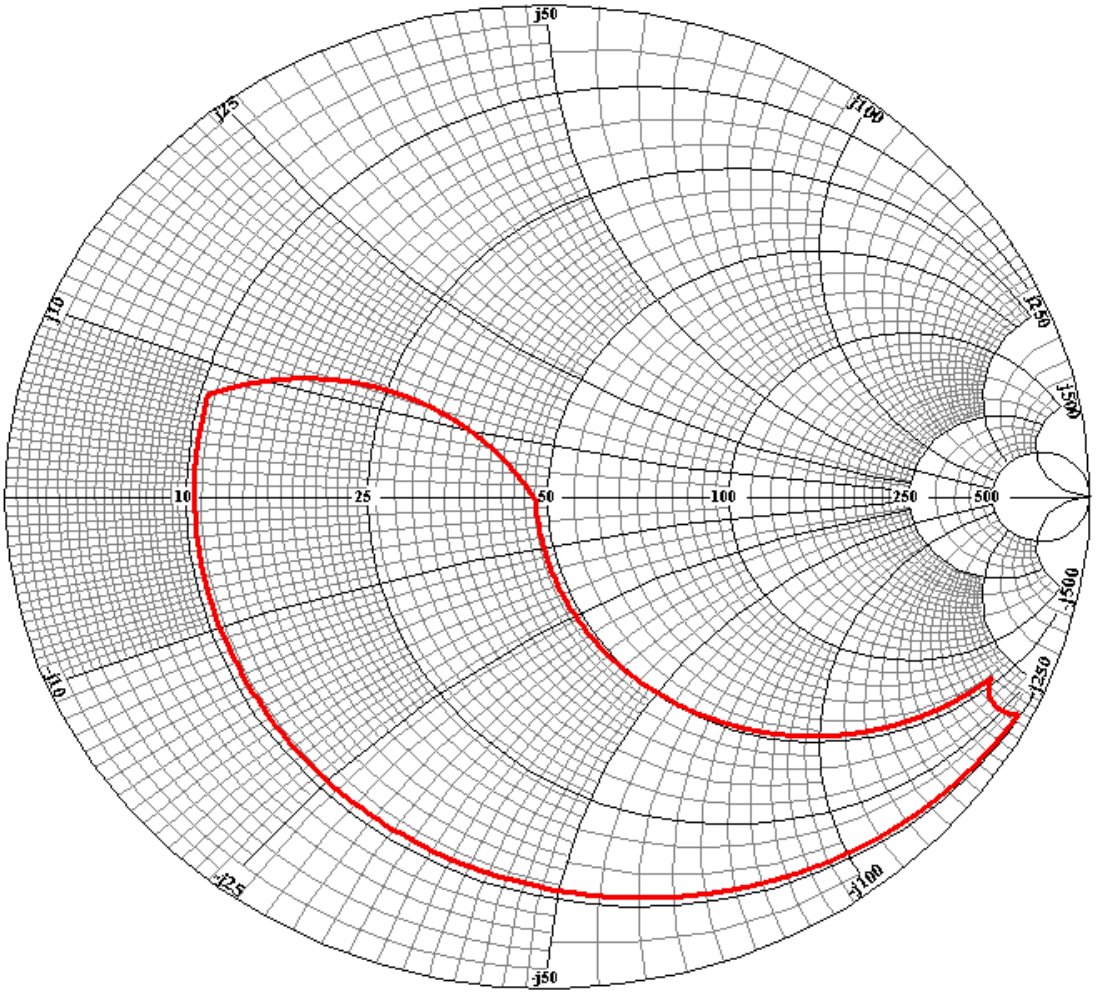


Figure 7-43. *4 MHz; Tune coil, 25 turns: tap 4; Load coil, 4 turns: tap A*

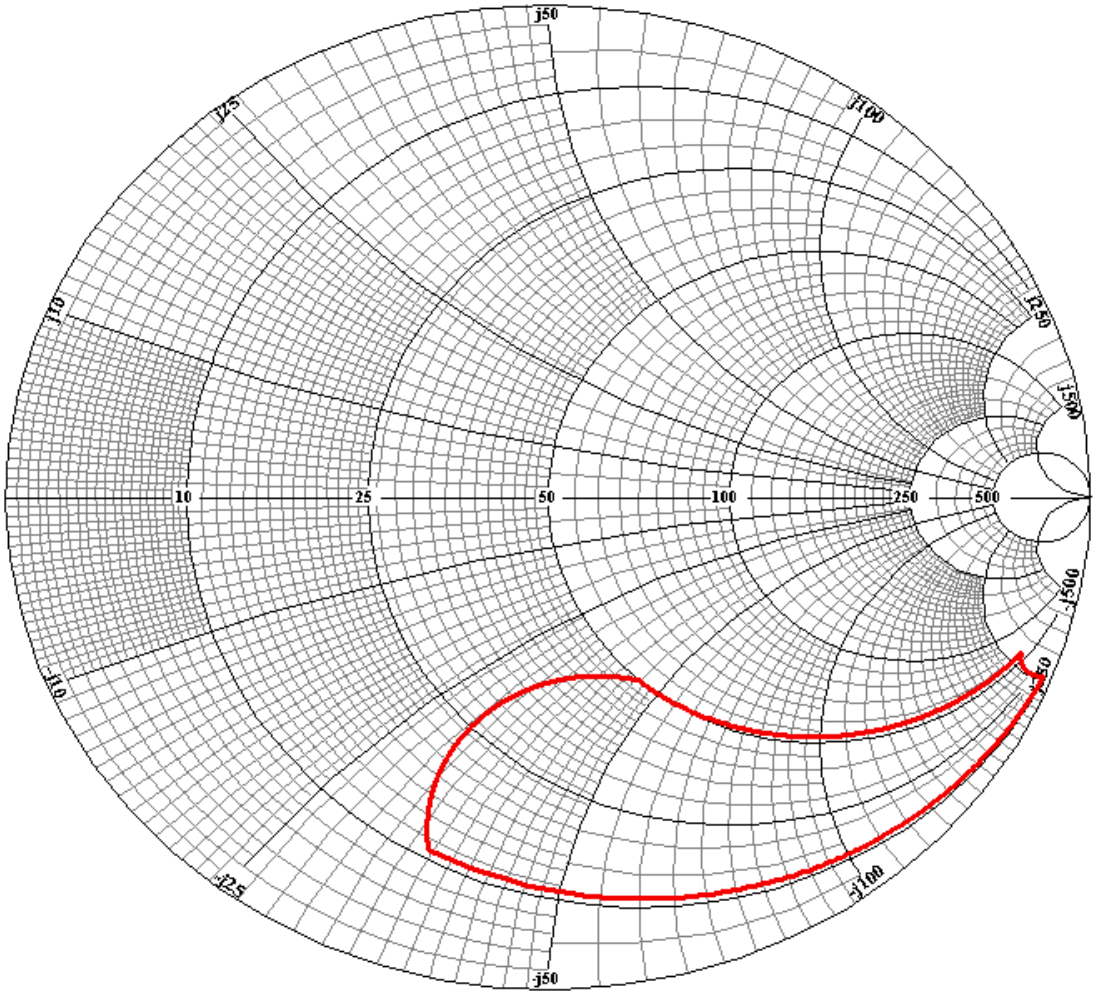


Figure 7-44. *4 MHz; Tune coil, 25 turns: tap 5; Load coil, 4 turns: tap A*

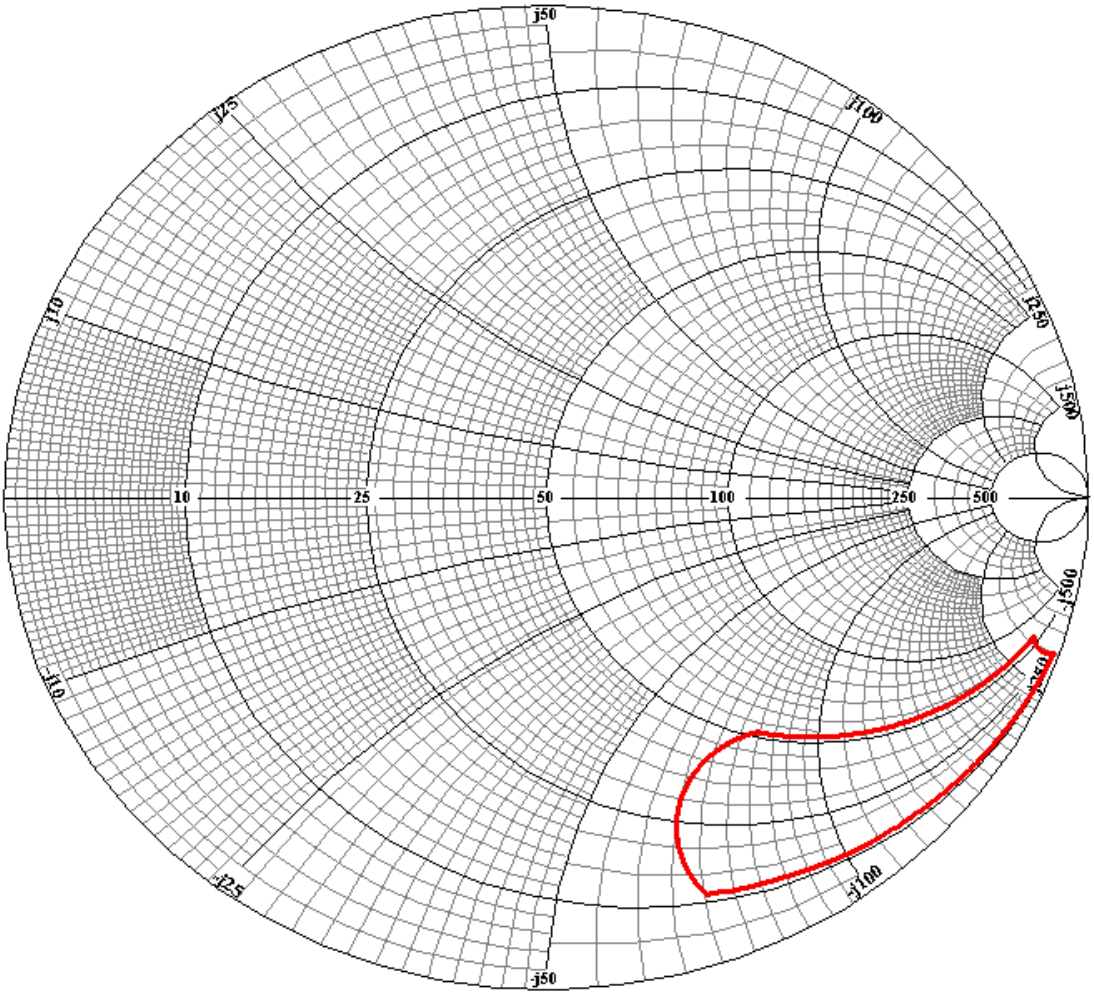


Figure 7-45. *4 MHz; Tune coil, 25 turns: tap 6; Load coil, 4 turns: tap A*

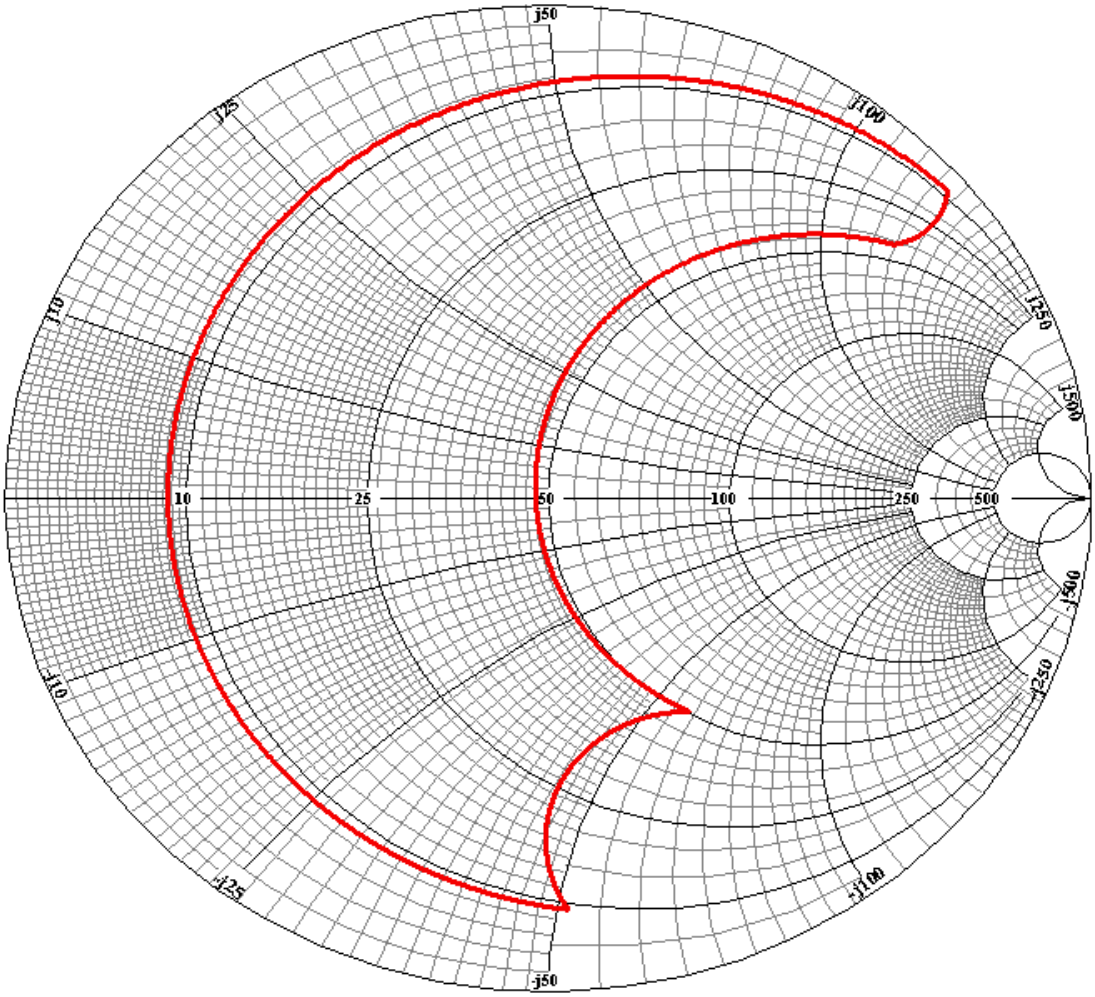


Figure 7-46. *4 MHz; Tune coil, 25 turns: tap 1; Load coil, 4 turns: tap B*

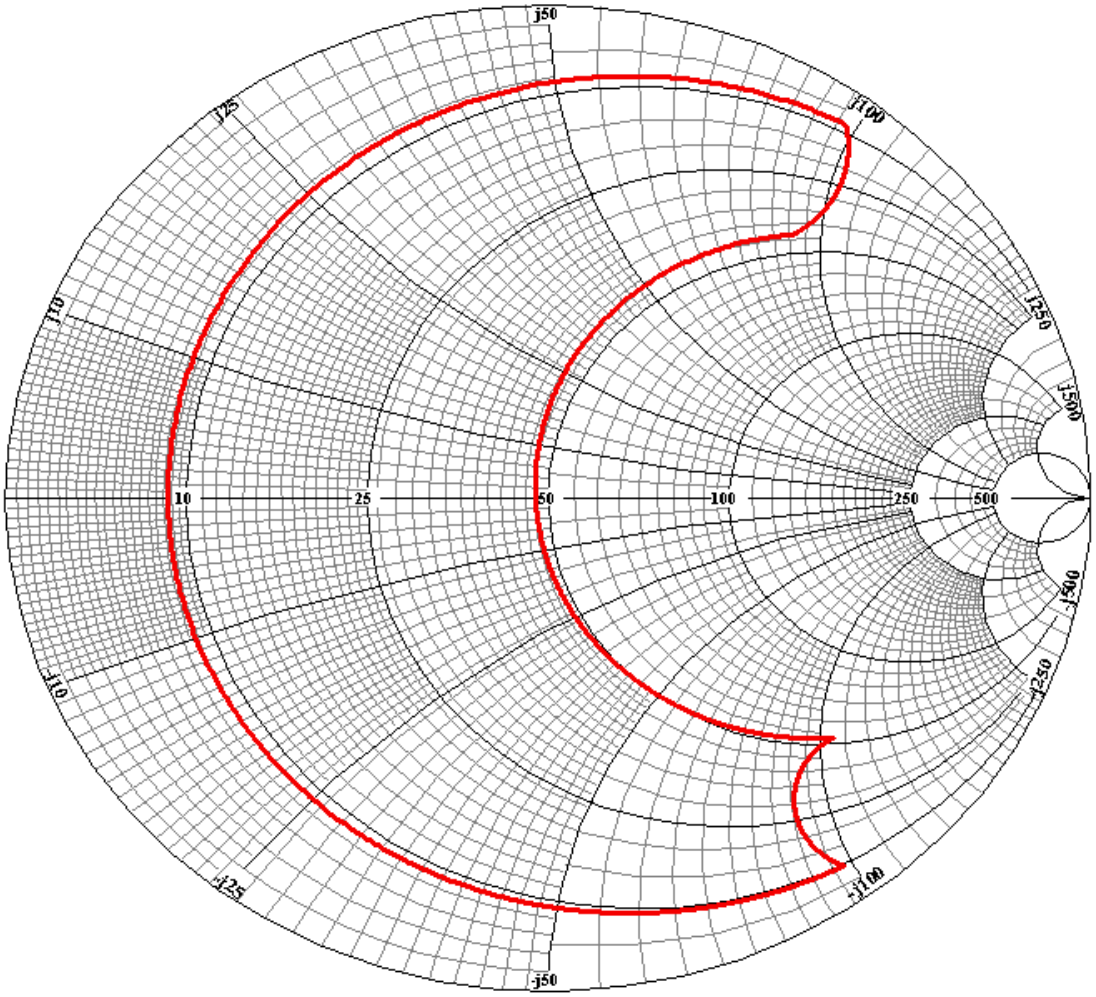


Figure 7-47. *4 MHz; Tune coil, 25 turns: tap 2; Load coil, 4 turns: tap B*

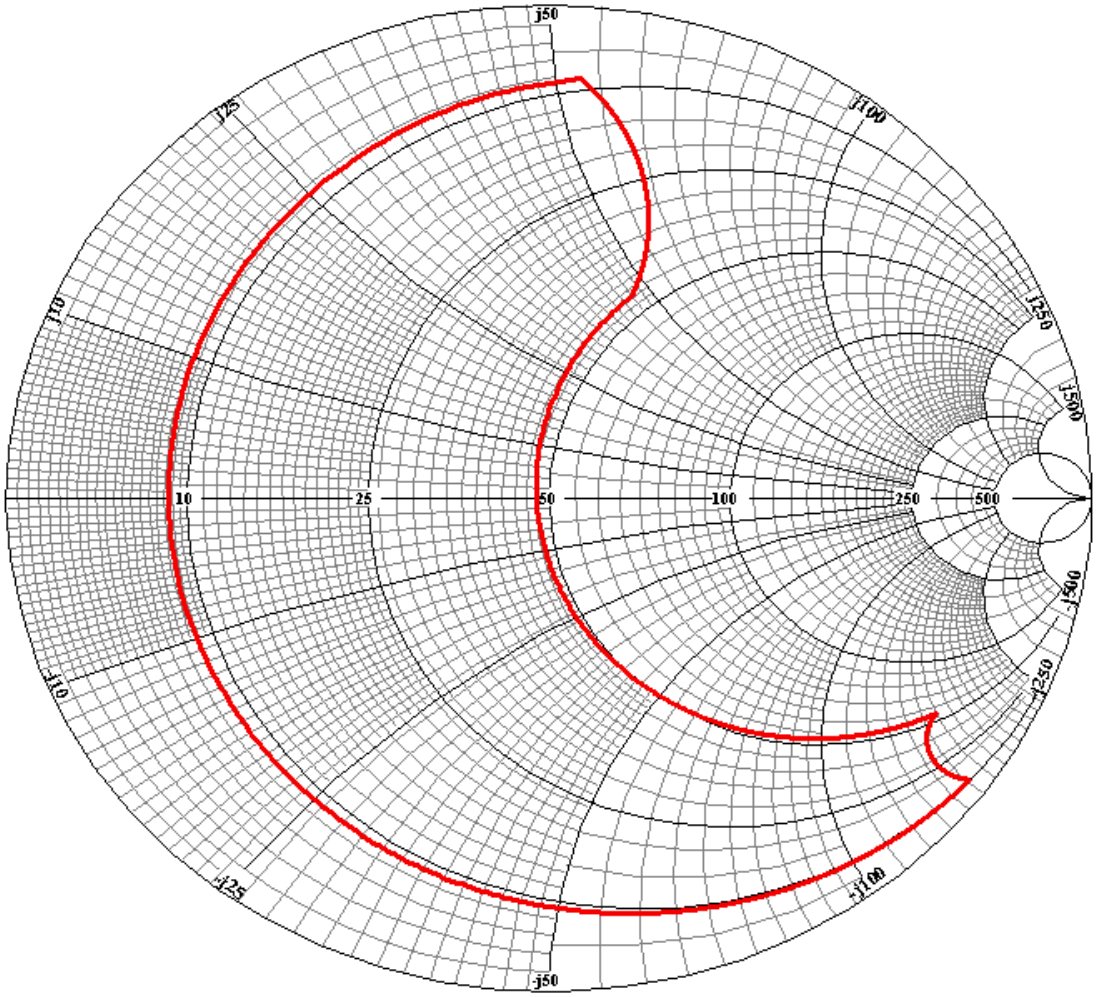


Figure 7-48. *4 MHz; Tune coil, 25 turns: tap 3; Load coil, 4 turns: tap B*

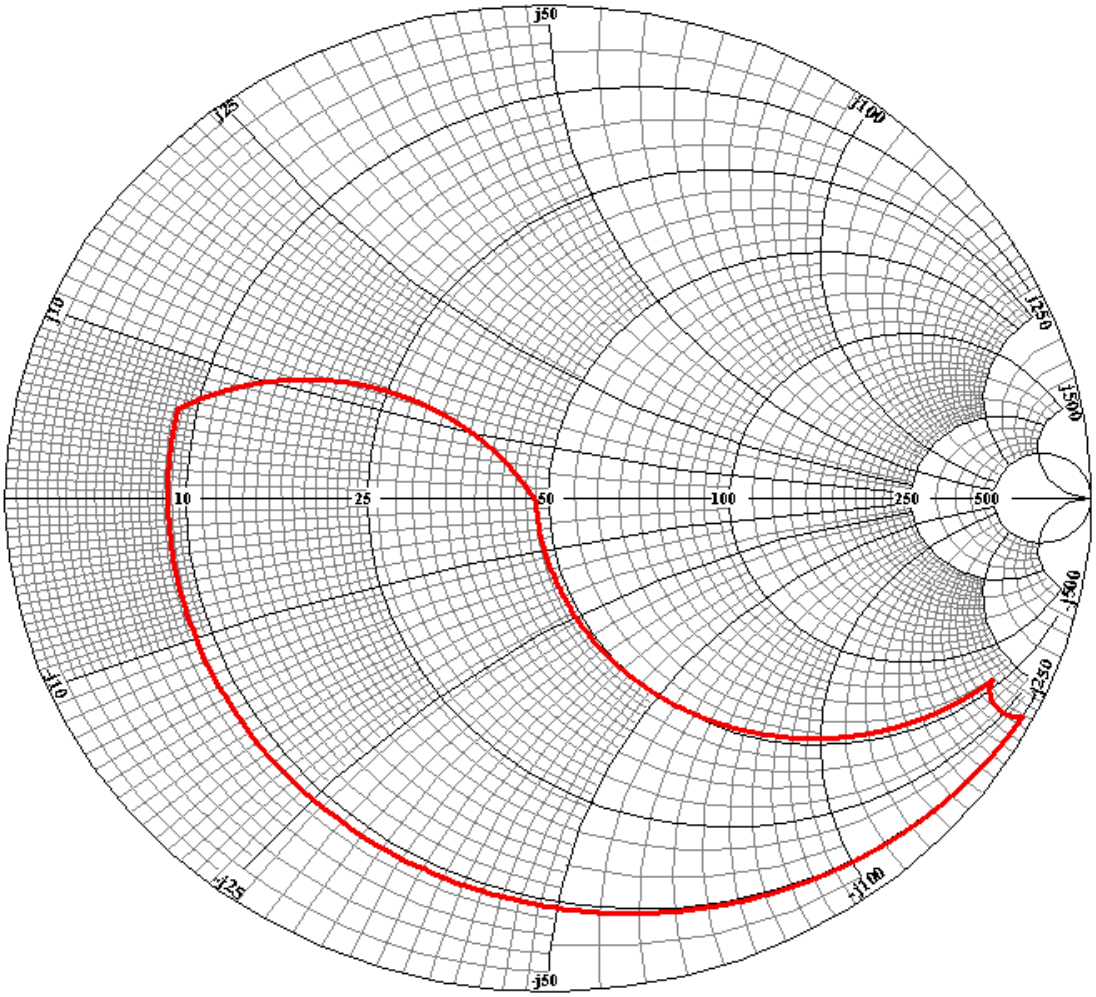


Figure 7-49. *4 MHz; Tune coil, 25 turns: tap 4; Load coil, 4 turns: tap B*

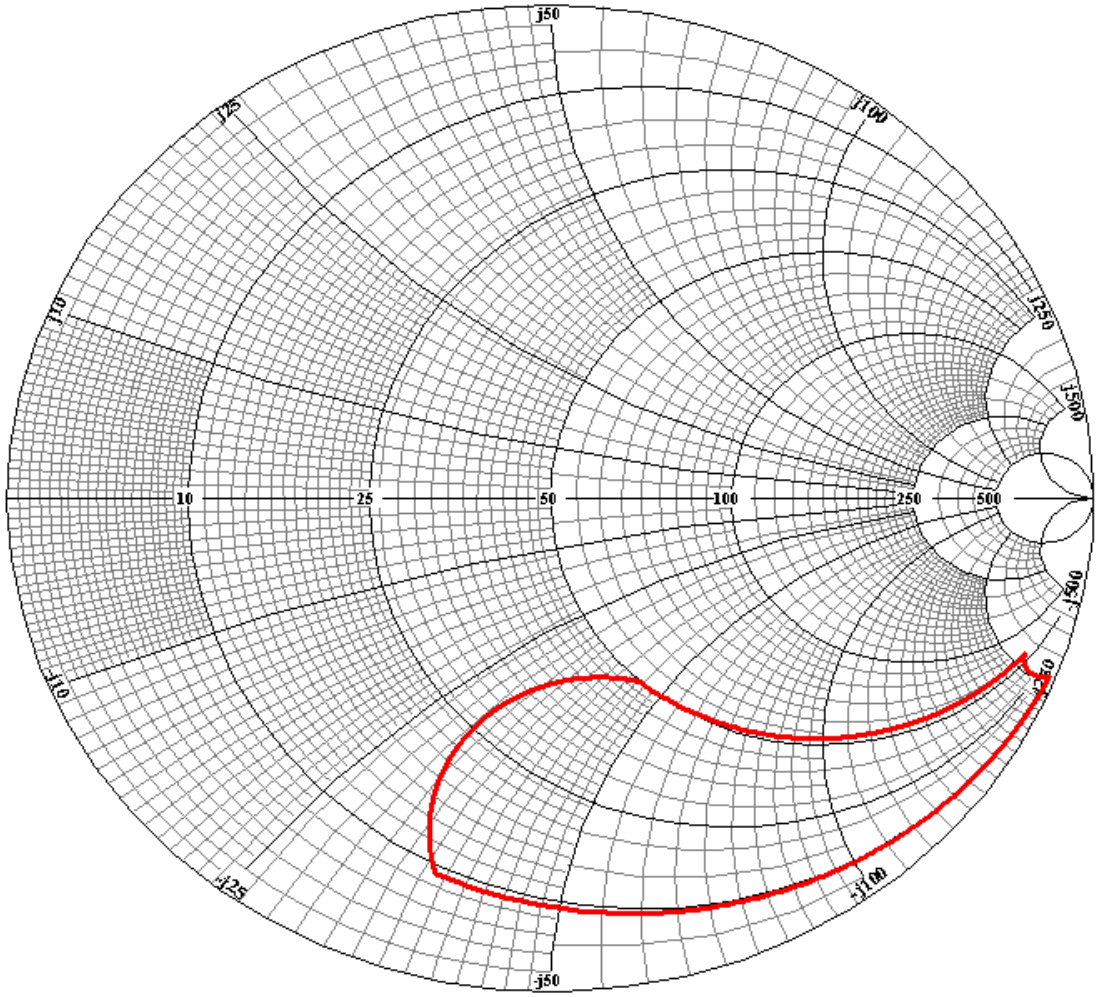


Figure 7-50. *4 MHz; Tune coil, 25 turns: tap 5; Load coil, 4 turns: tap B*

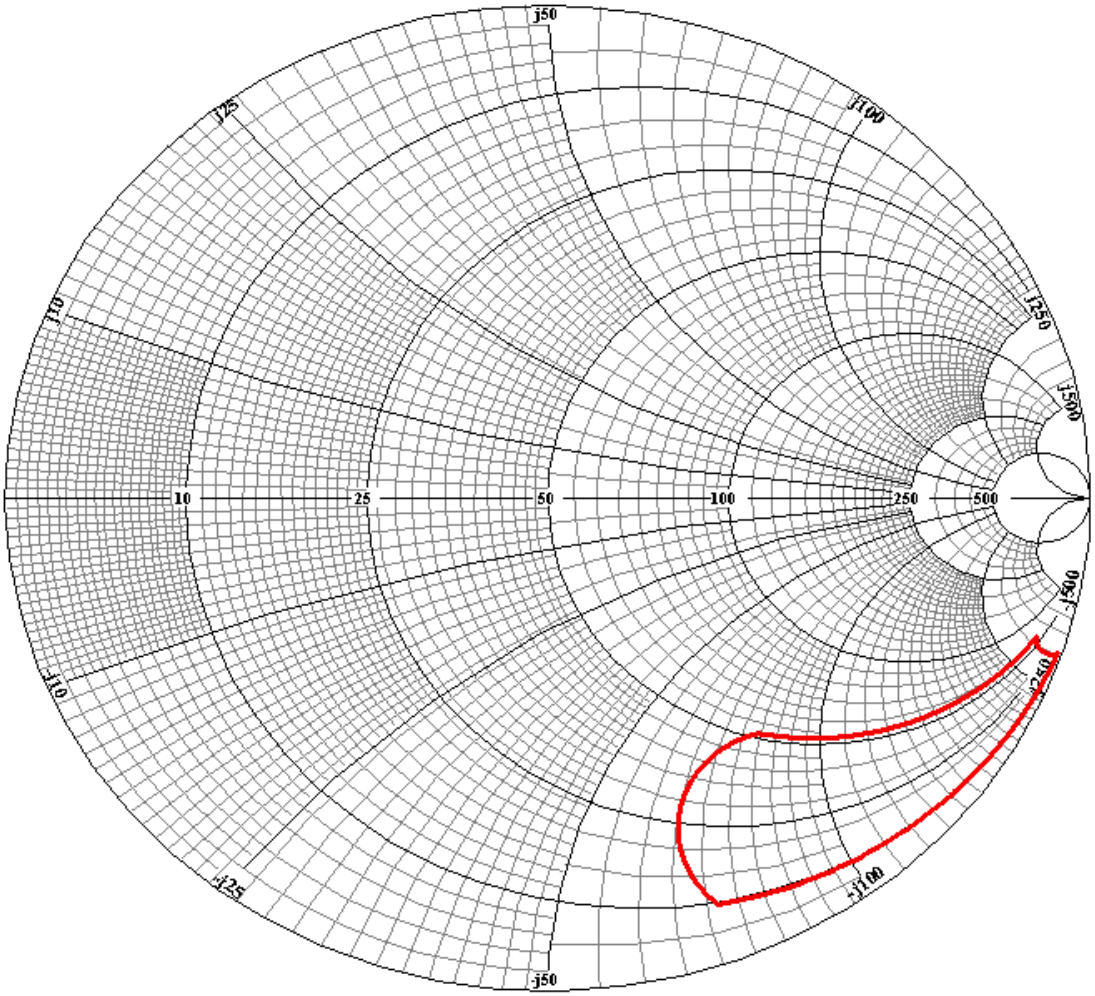


Figure 7-51. *4 MHz; Tune coil, 25 turns: tap 6; Load coil, 4 turns: tap B*

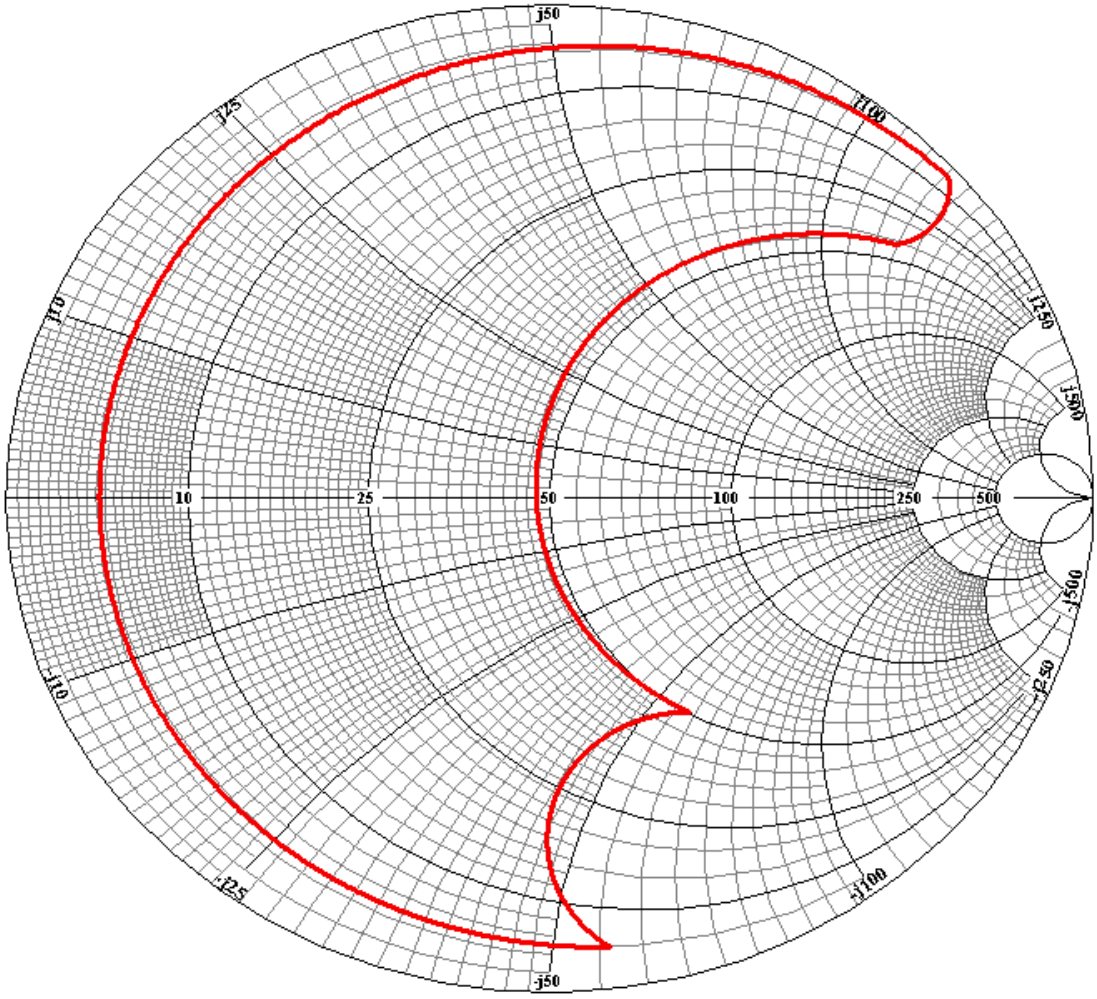


Figure 7-52. *4 MHz; Tune coil, 25 turns: tap 1; Load coil, 4 turns: tap C*

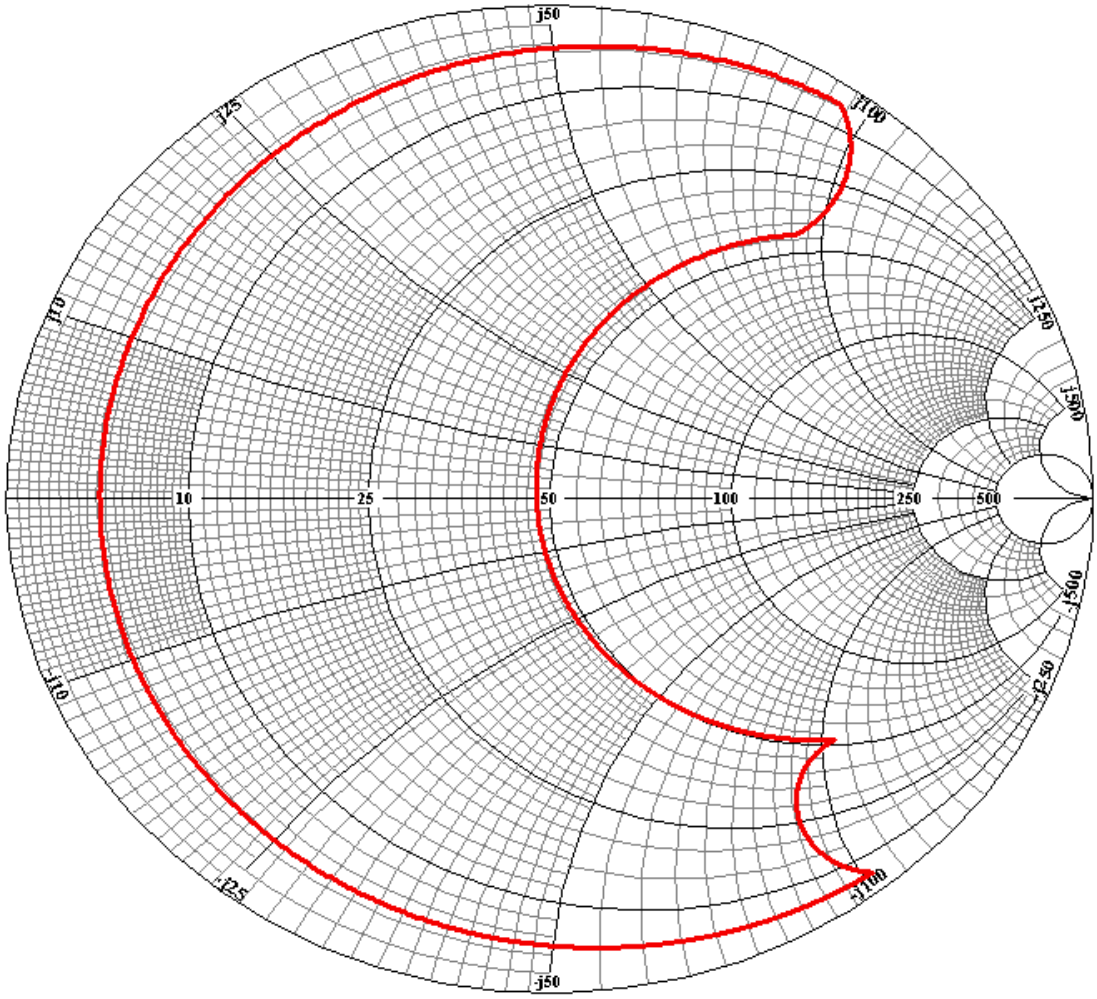


Figure 7-53. *4 MHz; Tune coil, 25 turns: tap 2; Load coil, 4 turns: tap C*

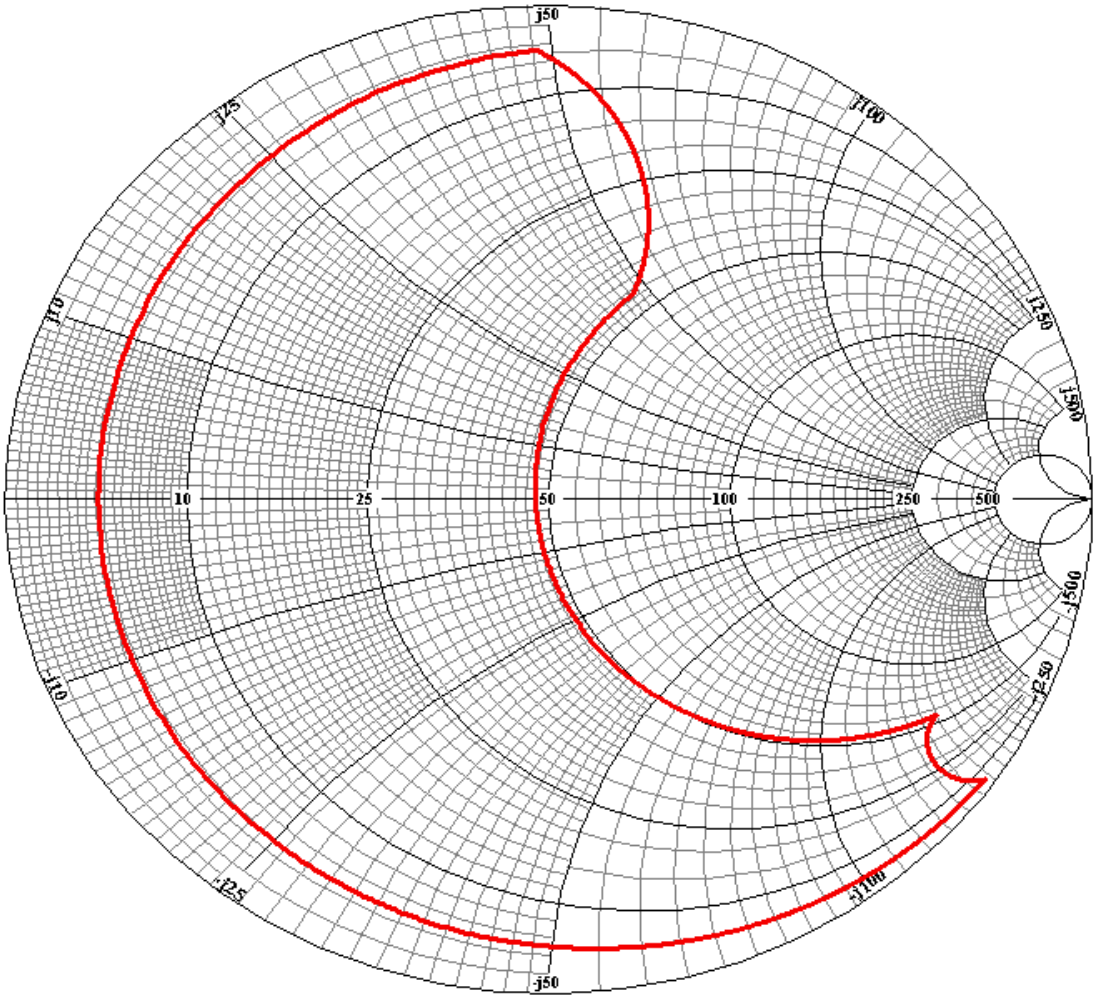


Figure 7-54. *4 MHz; Tune coil, 25 turns: tap 3; Load coil, 4 turns: tap C*

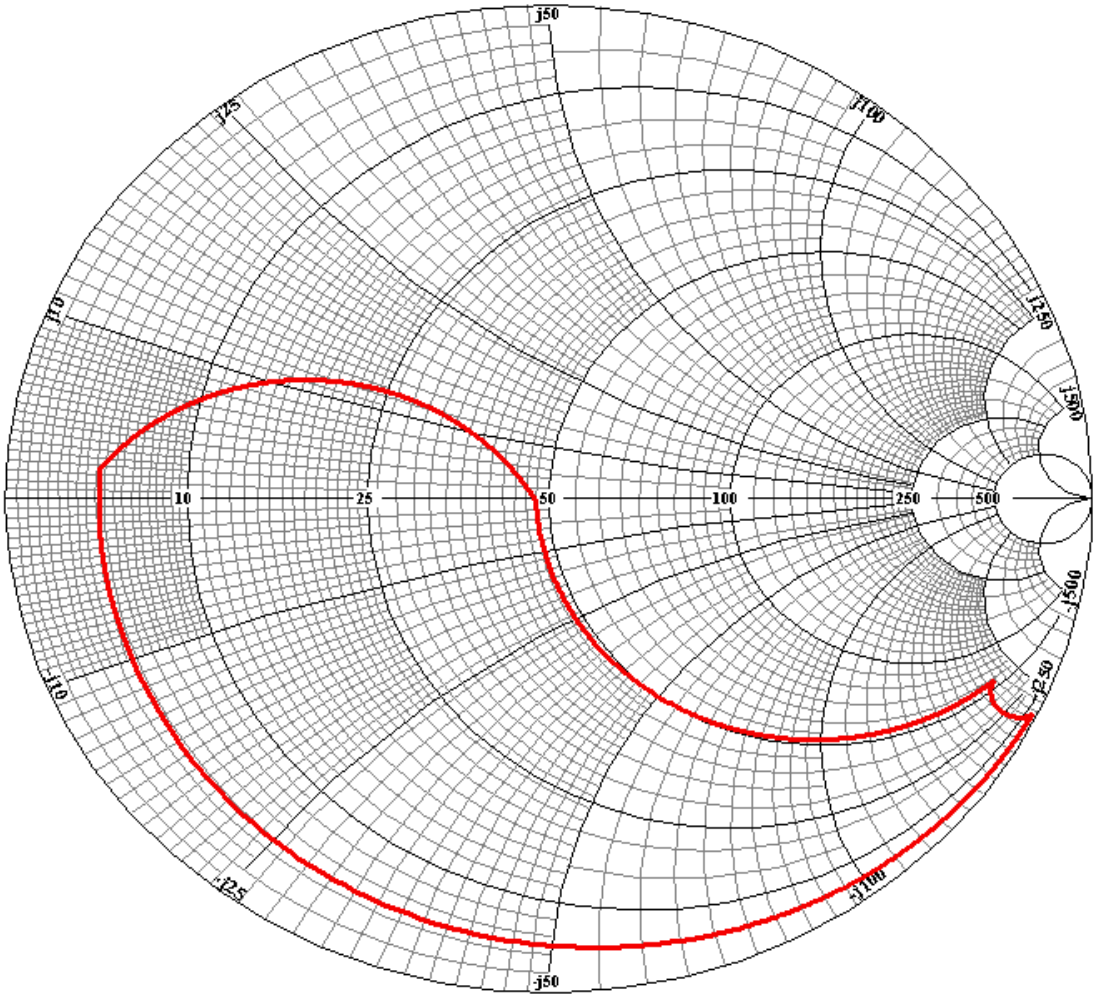


Figure 7-55. *4 MHz; Tune coil, 25 turns: tap 4; Load coil, 4 turns: tap C*

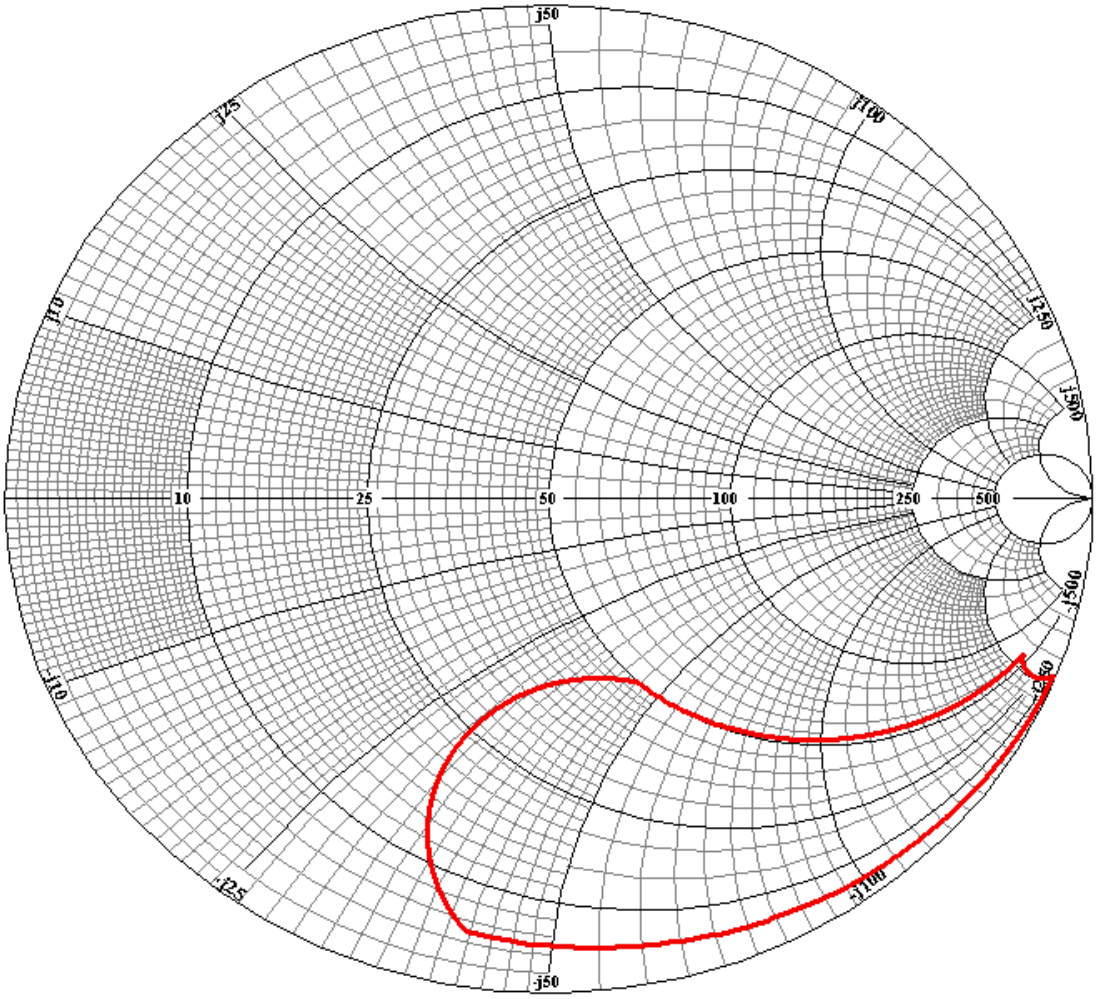


Figure 7-56. *4 MHz; Tune coil, 25 turns: tap 5; Load coil, 4 turns: tap C*

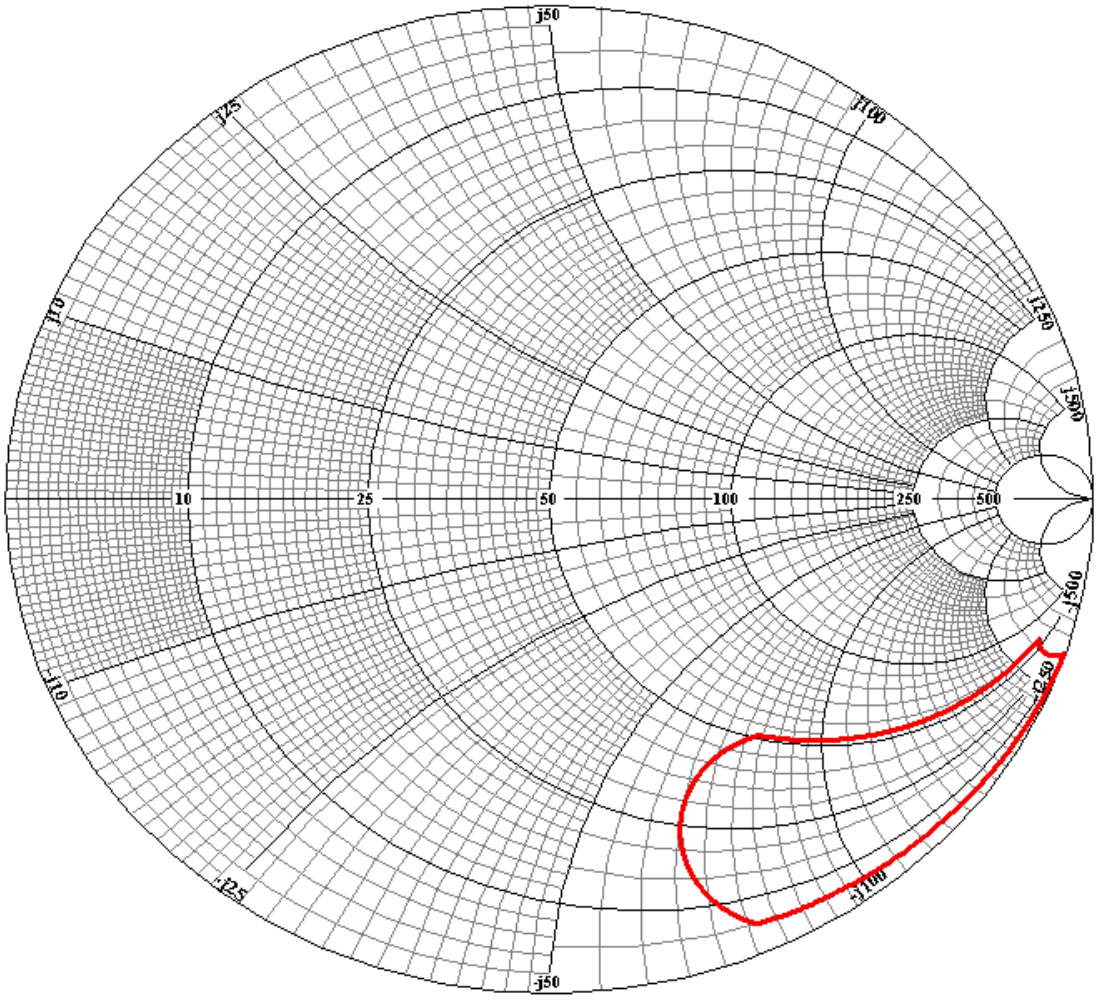


Figure 7-57. *4 MHz; Tune coil, 25 turns: tap 6; Load coil, 4 turns: tap C*

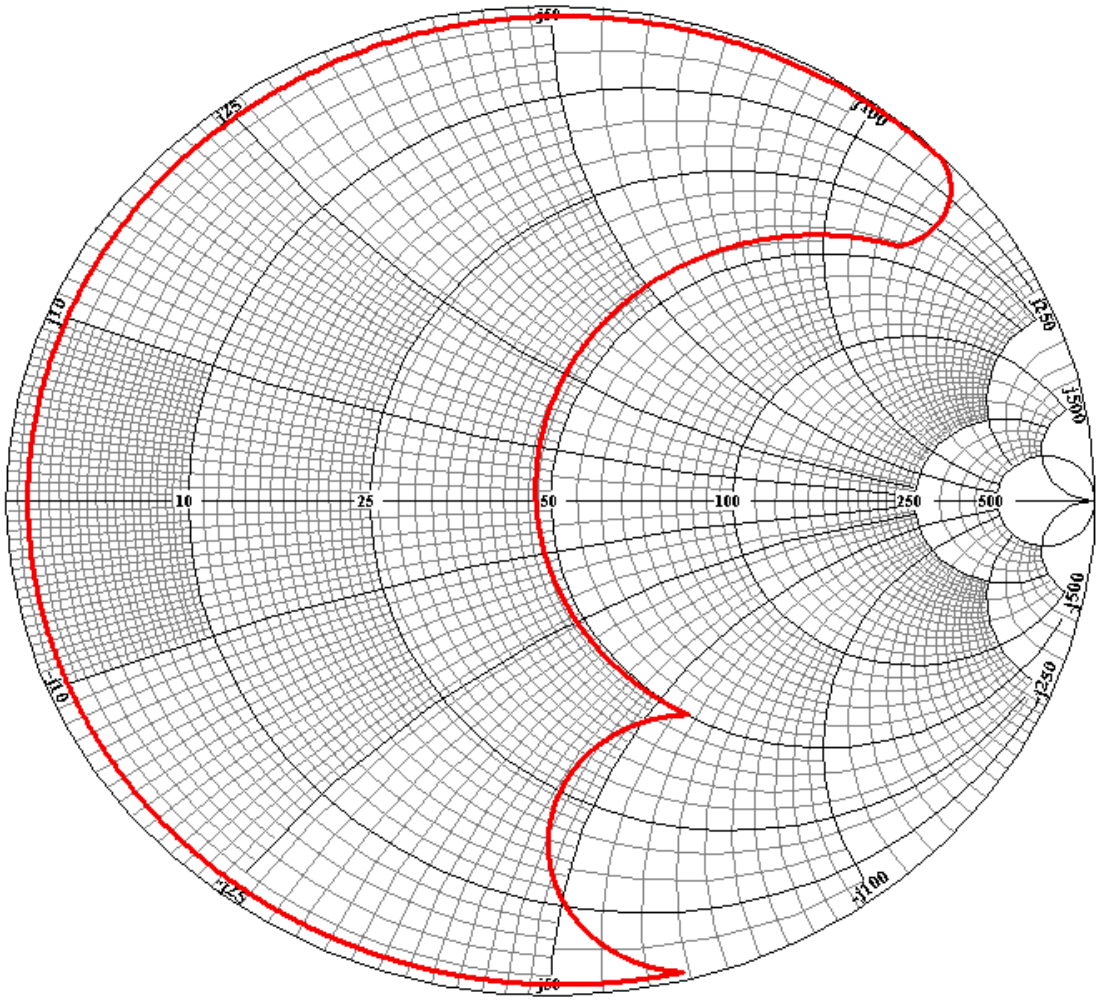


Figure 7-58. *4 MHz; Tune coil, 25 turns: tap 1; Load coil, 4 turns: tap D*

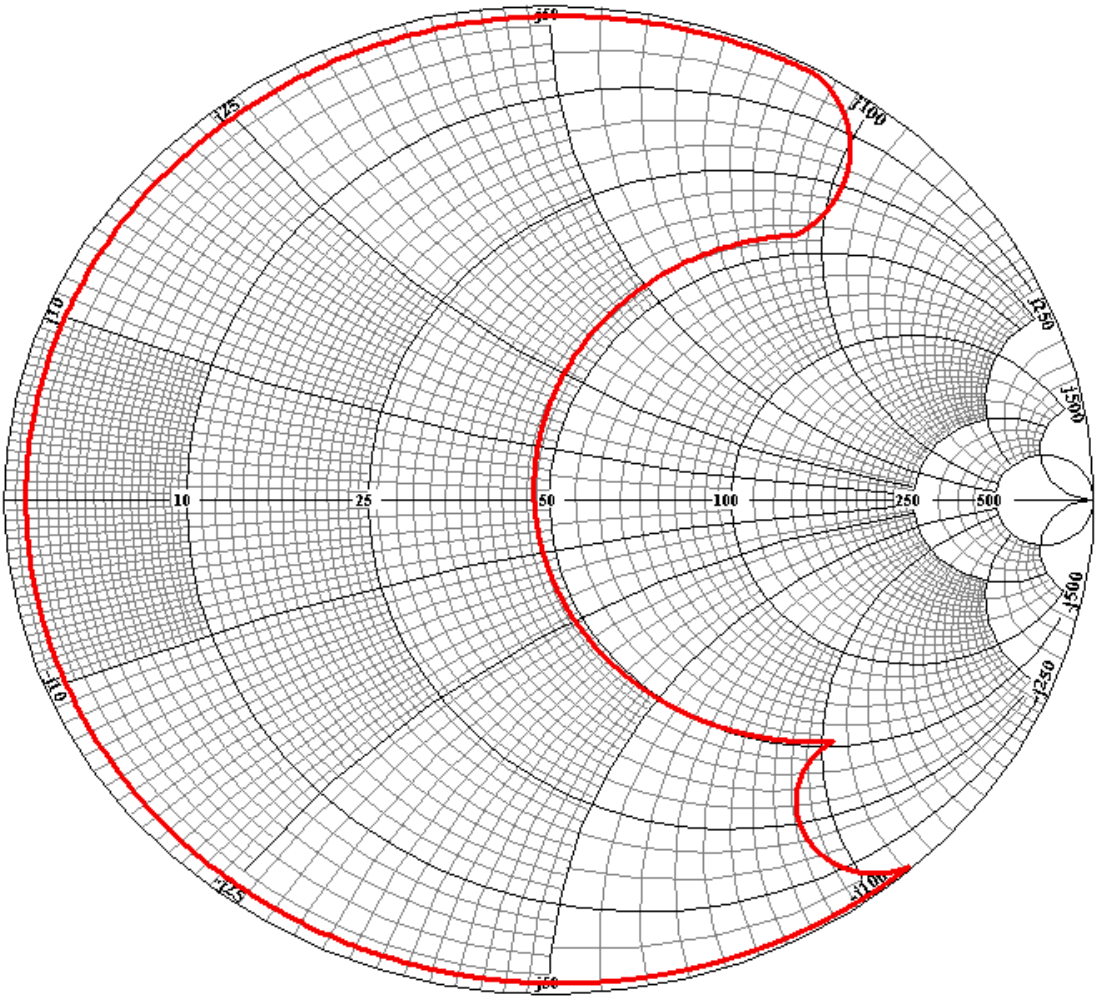


Figure 7-59. *4 MHz; Tune coil, 25 turns: tap 2; Load coil, 4 turns: tap D*

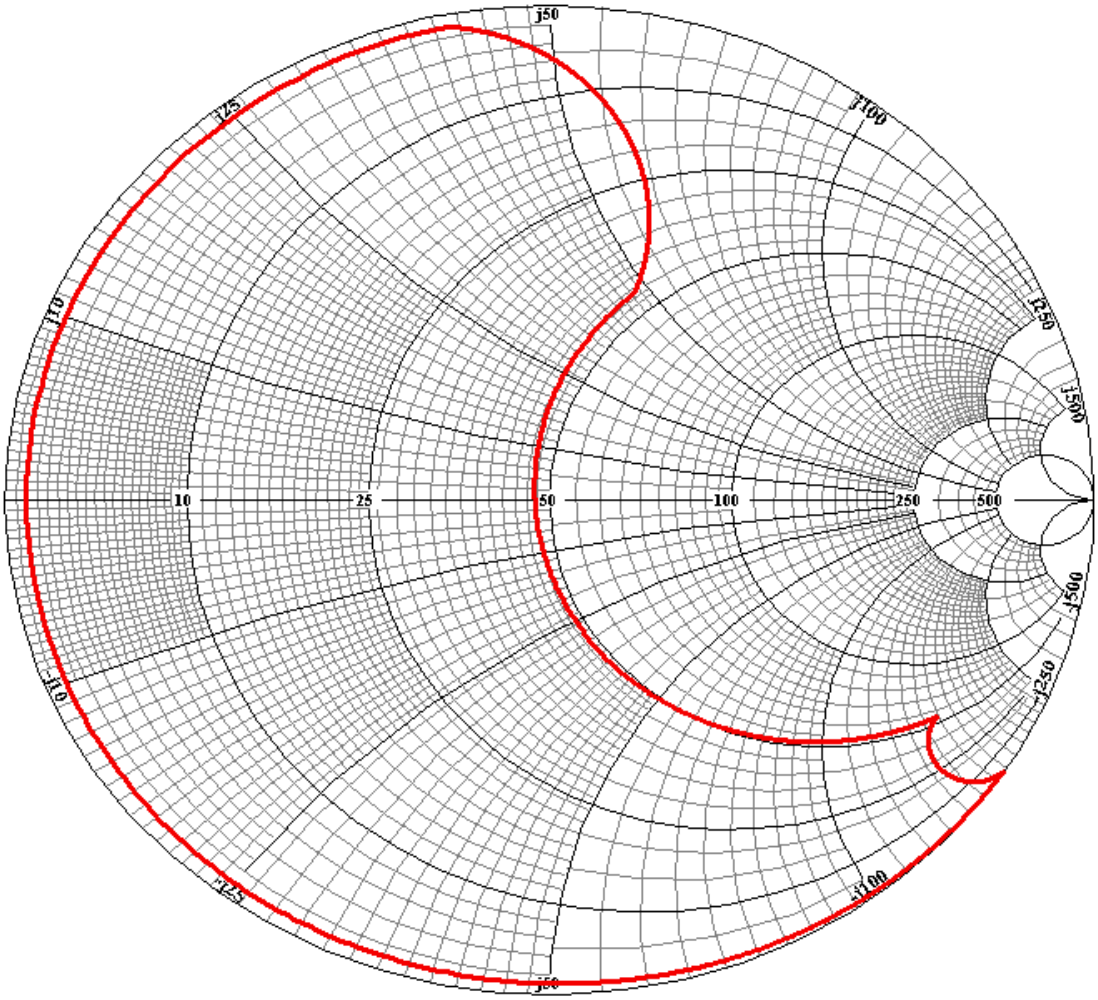


Figure 7-60. *4 MHz; Tune coil, 25 turns: tap 3; Load coil, 4 turns: tap D*

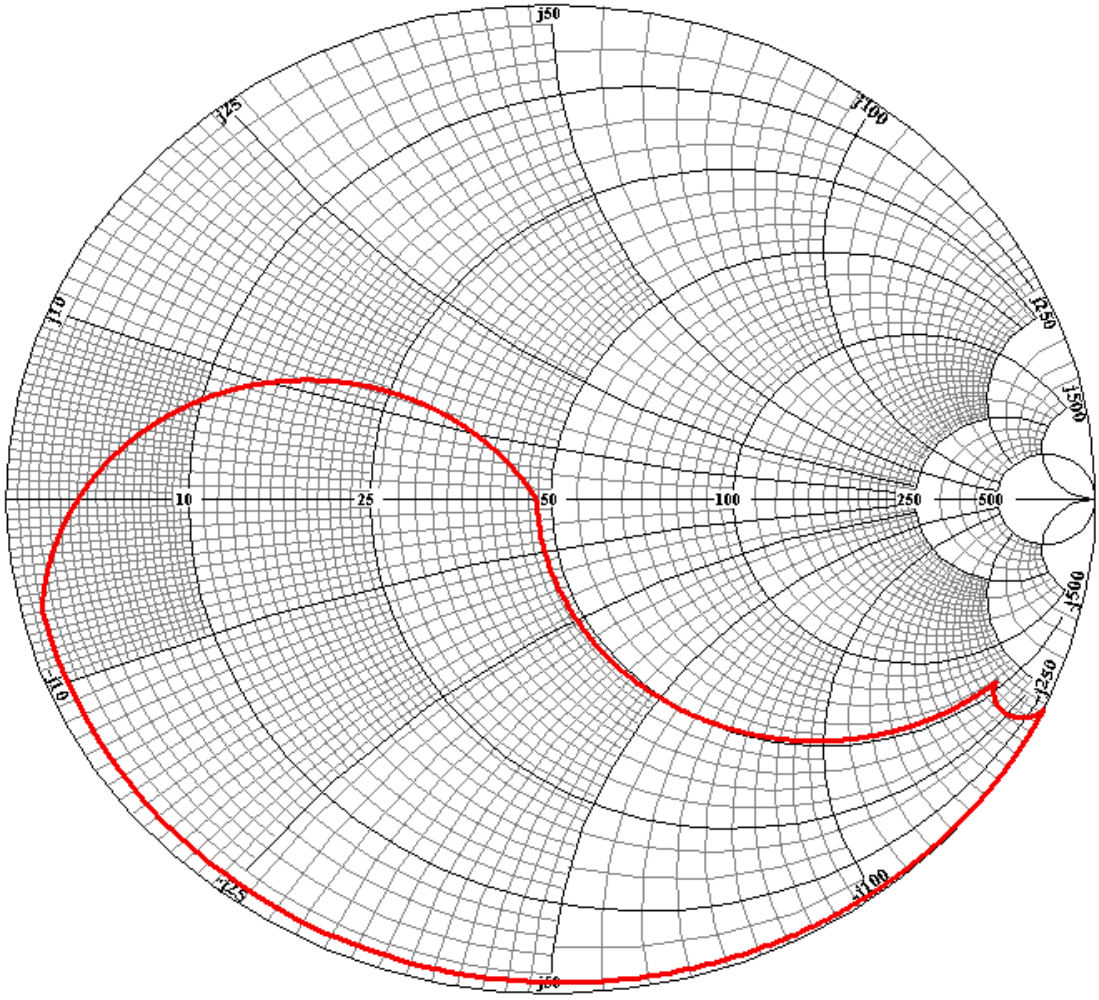


Figure 7-61. *4 MHz; Tune coil, 25 turns: tap 4; Load coil, 4 turns: tap D*

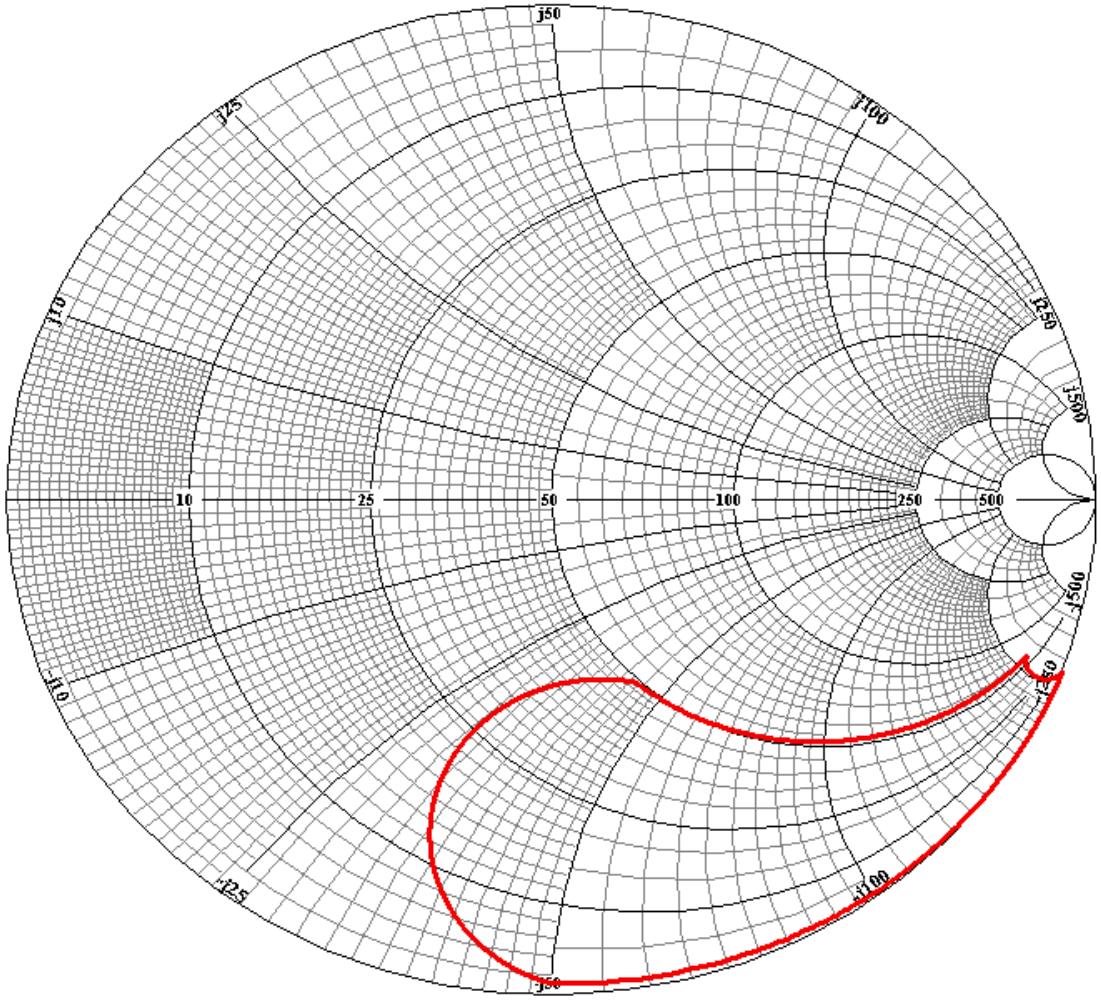


Figure 7-62. *4 MHz; Tune coil, 25 turns: tap 5; Load coil, 4 turns: tap D*

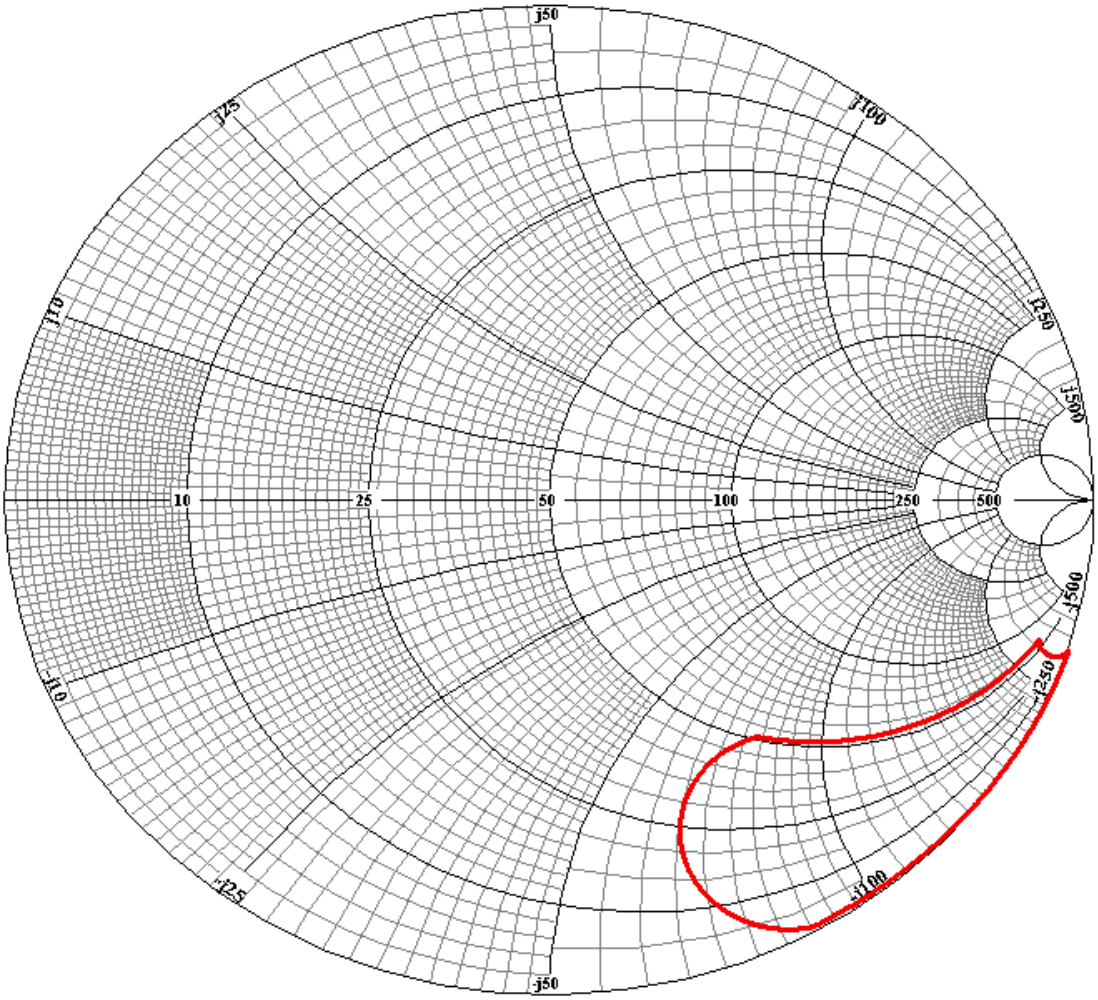


Figure 7-63. *4 MHz; Tune coil, 25 turns: tap 6; Load coil, 4 turns: tap D*

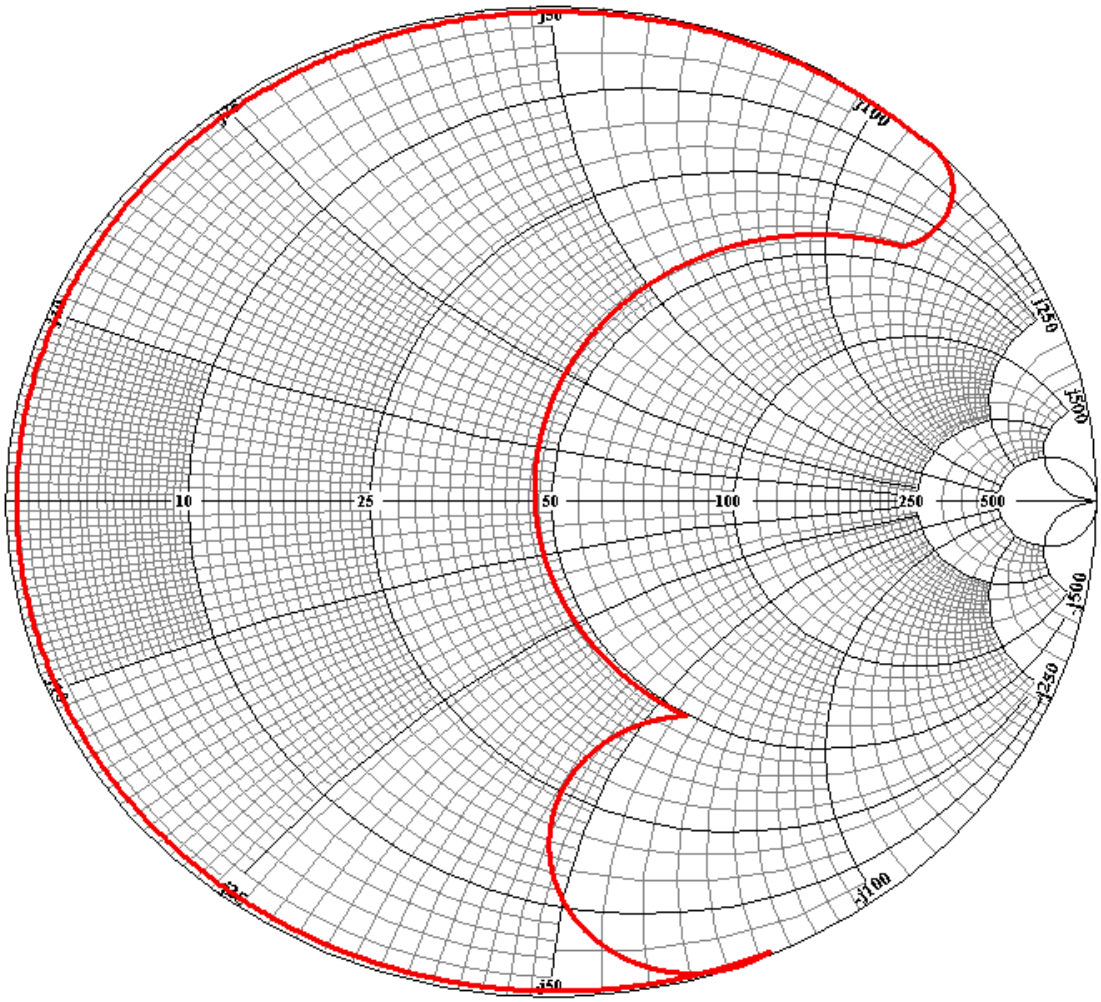


Figure 7-64. *4 MHz; Tune coil, 25 turns: tap 1; Load coil, 4 turns: tap E*

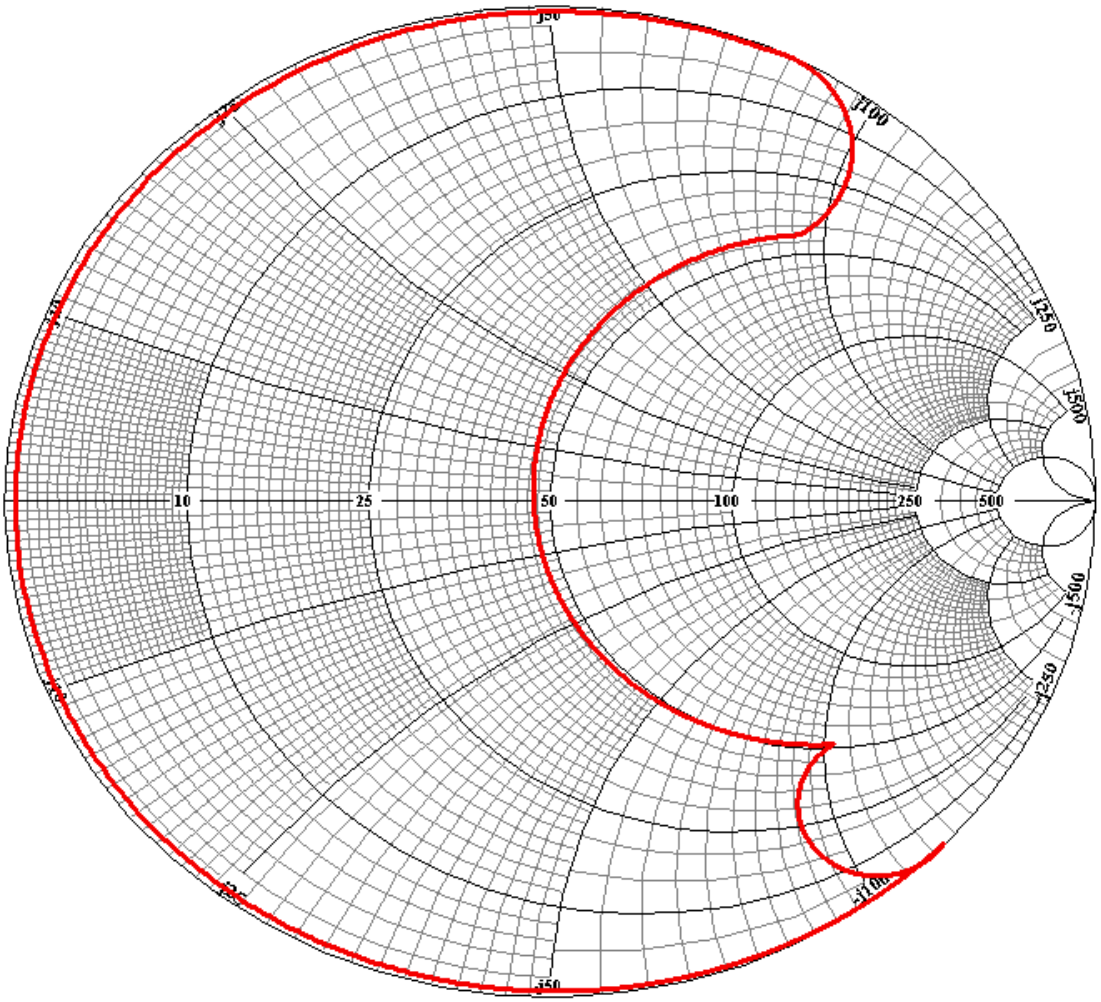


Figure 7-65. *4 MHz; Tune coil, 25 turns: tap 2; Load coil, 4 turns: tap E*

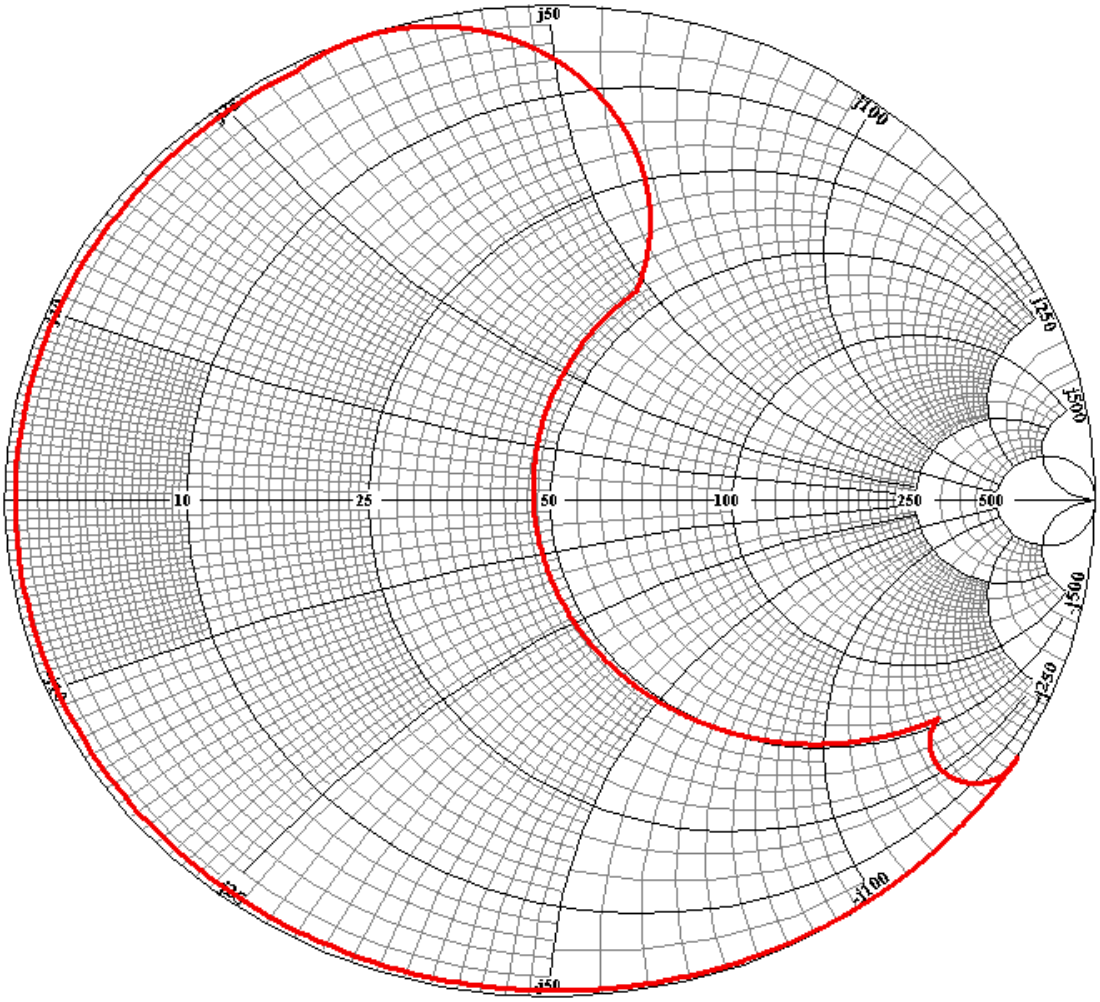


Figure 7-66. *4 MHz; Tune coil, 25 turns: tap 3; Load coil, 4 turns: tap E*

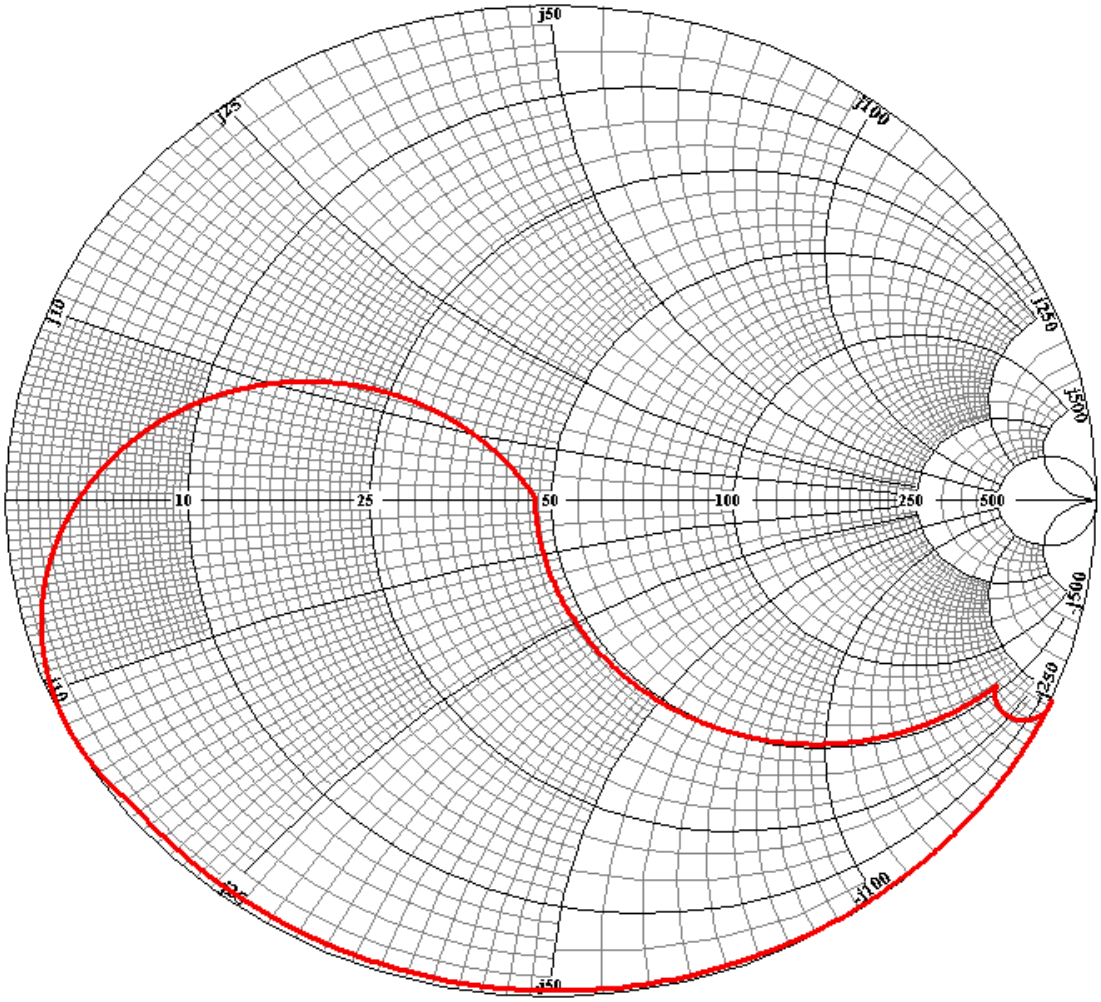


Figure 7-67. *4 MHz; Tune coil, 25 turns: tap 4; Load coil, 4 turns: tap E*

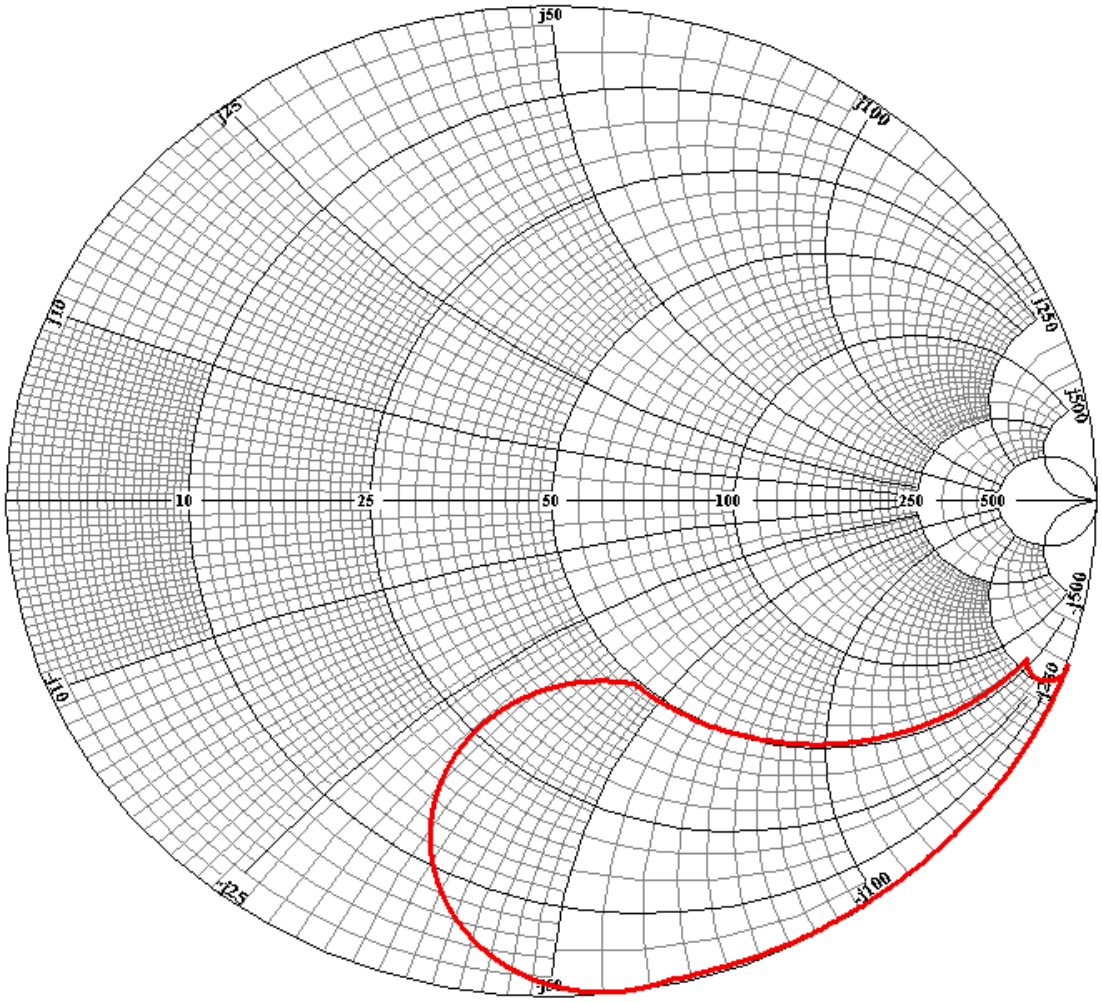


Figure 7-68. *4 MHz; Tune coil, 25 turns: tap 5; Load coil, 4 turns: tap E*

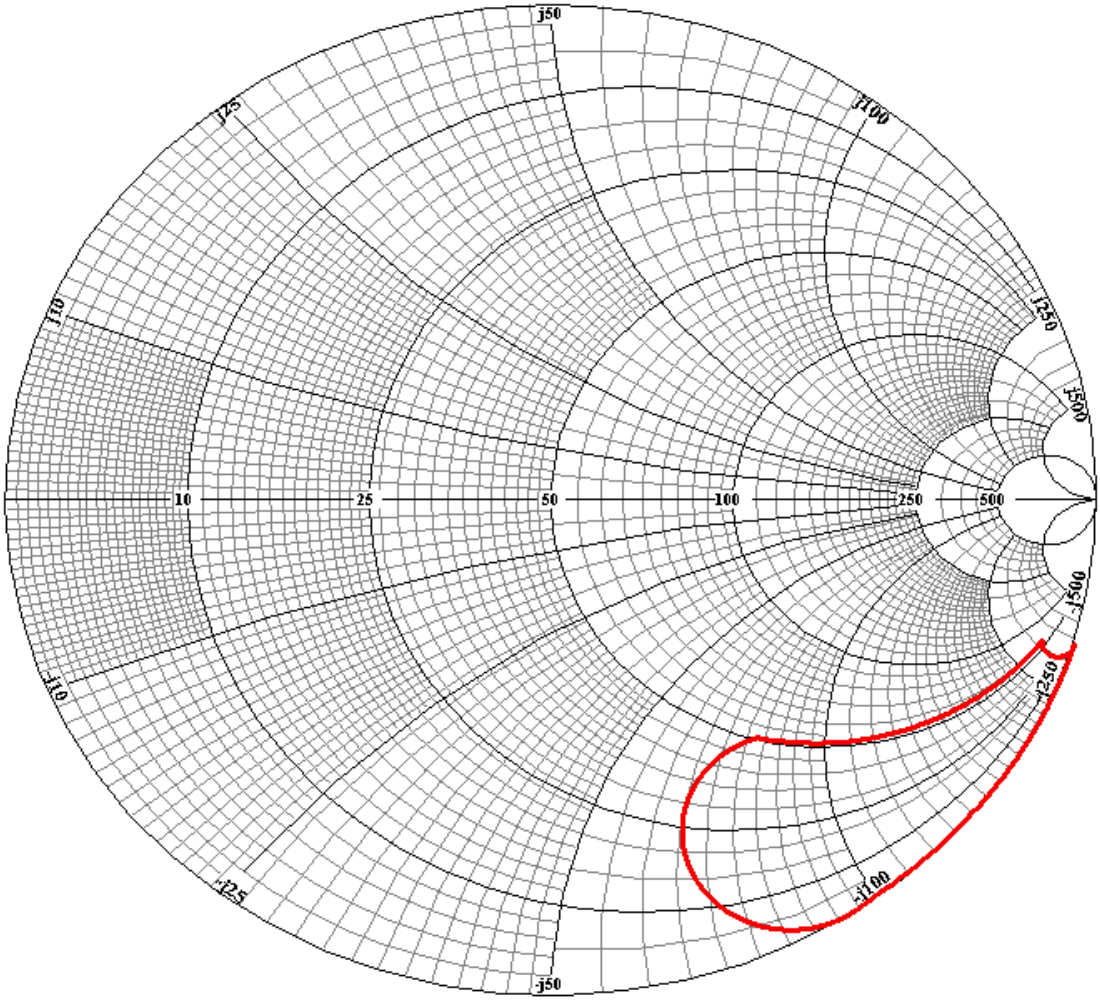


Figure 7-69. *4 MHz; Tune coil, 25 turns: tap 6; Load coil, 4 turns: tap E*

ICP

Schematics

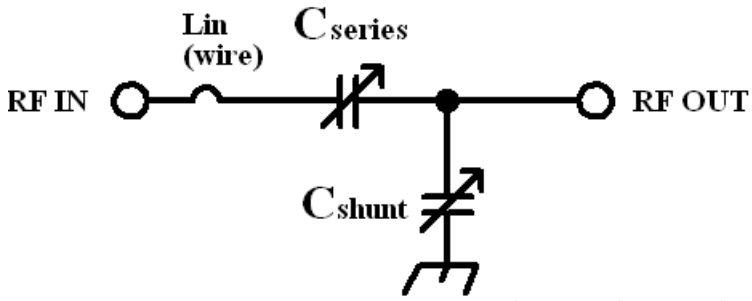


Figure 7-70. *ICP coil and inductor schematic, Gamma*

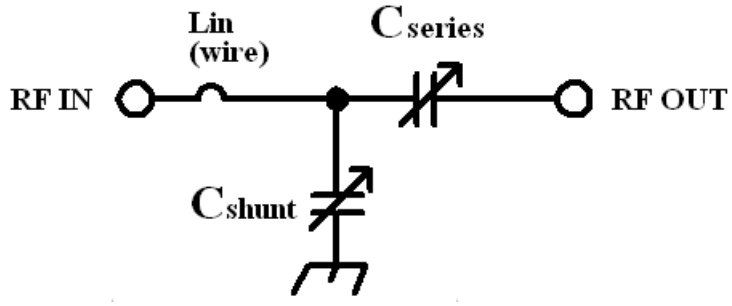


Figure 7-71. *ICP coil and inductor schematic, L match*

Smith Charts

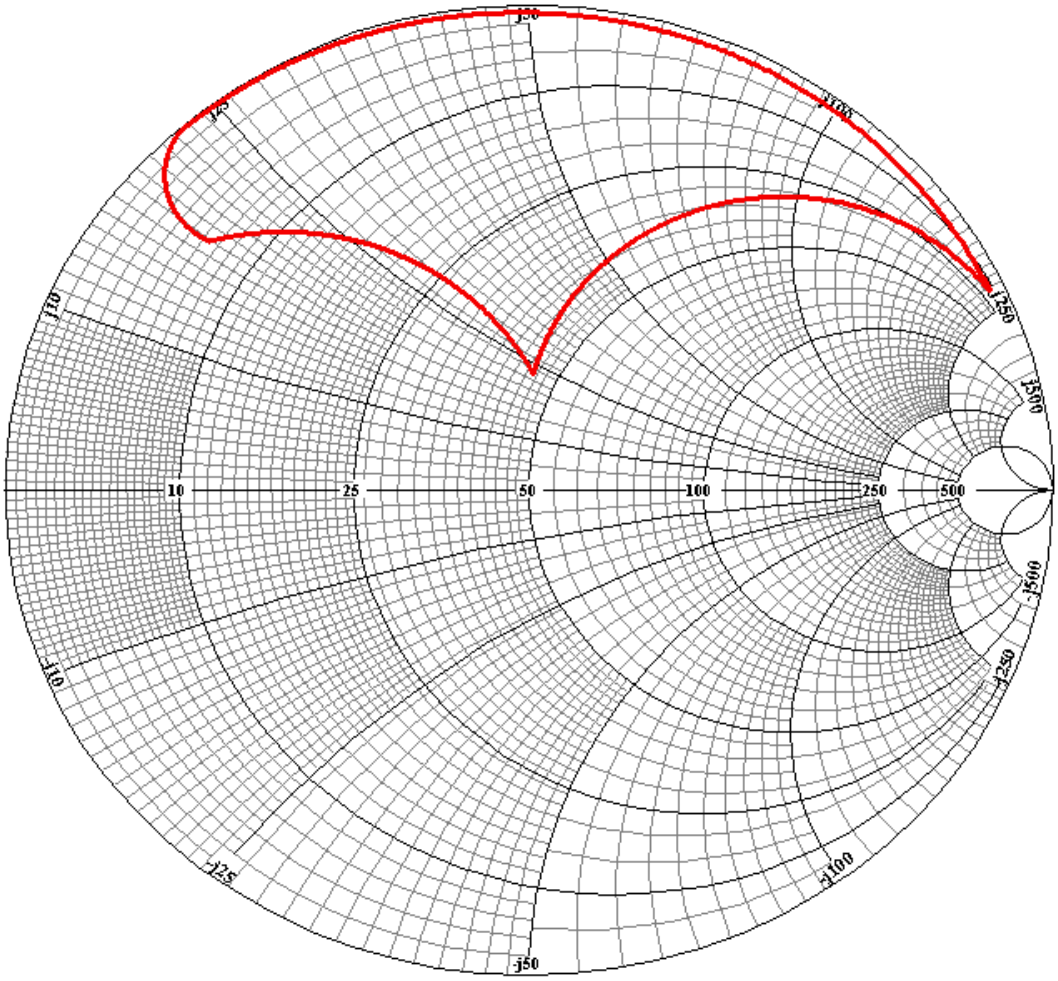


Figure 7-72. *VM 1500, Gamma*

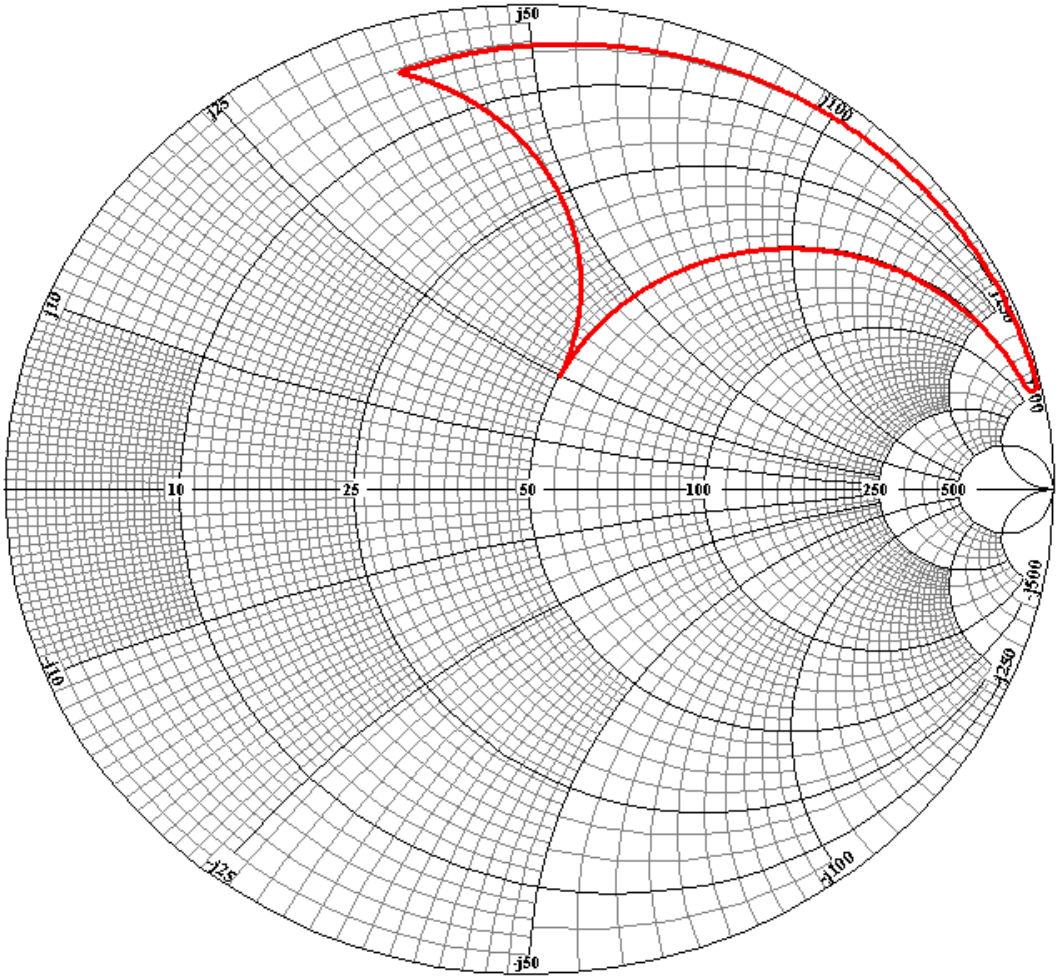


Figure 7-73. *VM 1500, L match*

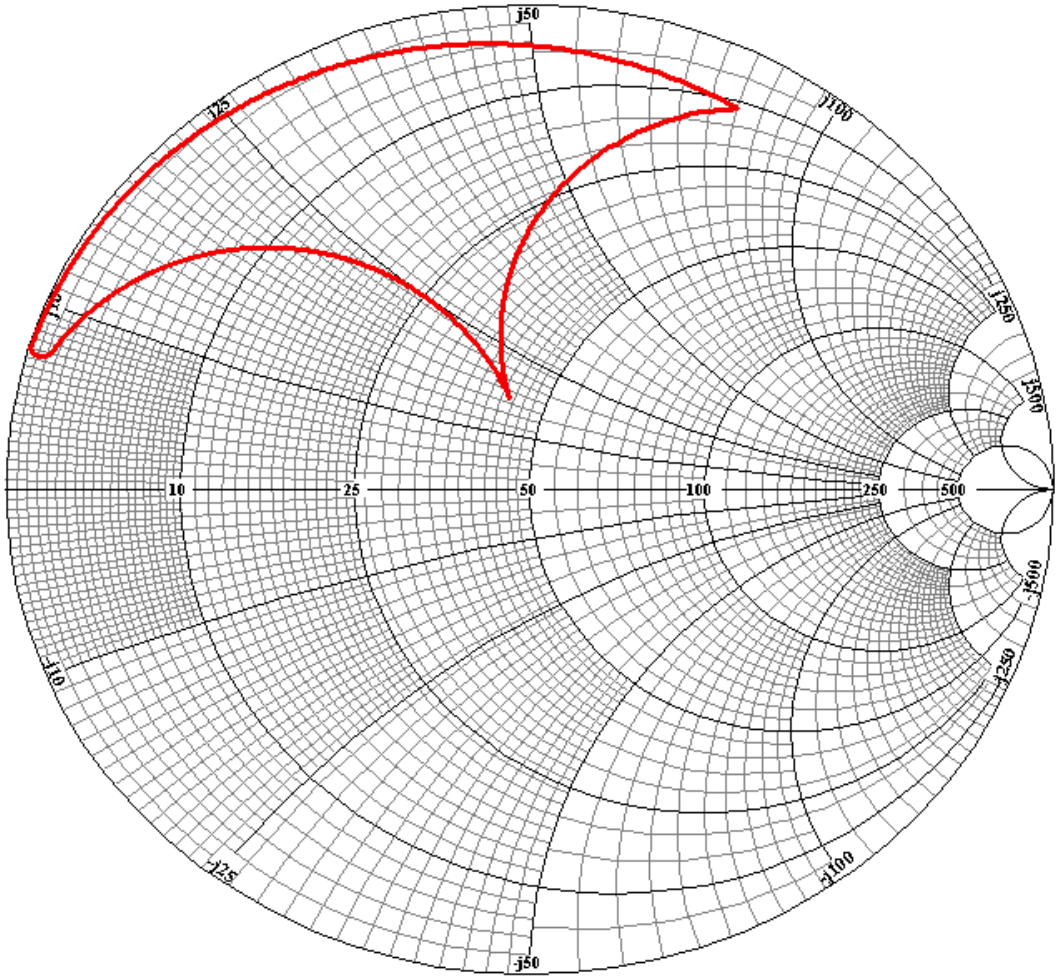


Figure 7-74. *VM 4015, Gamma*

DELTA MATCH

Schematic

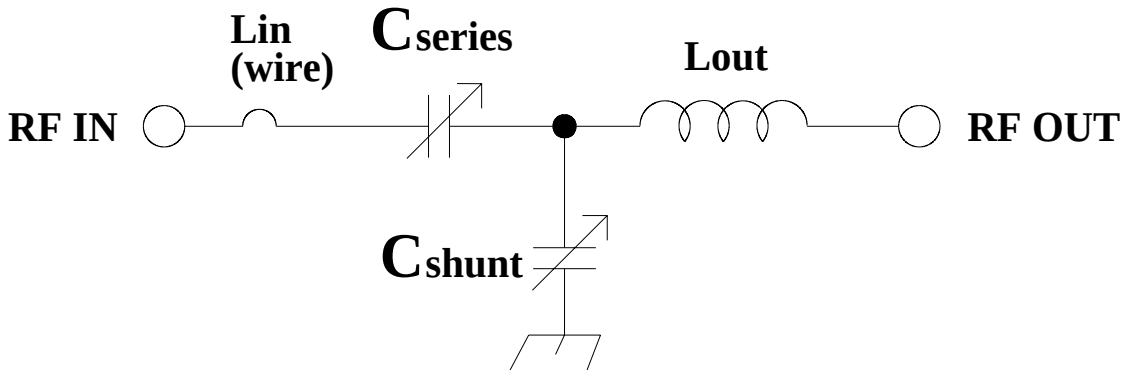


Figure 7-75. *Delta match coil and inductor schematic*

Smith Chart

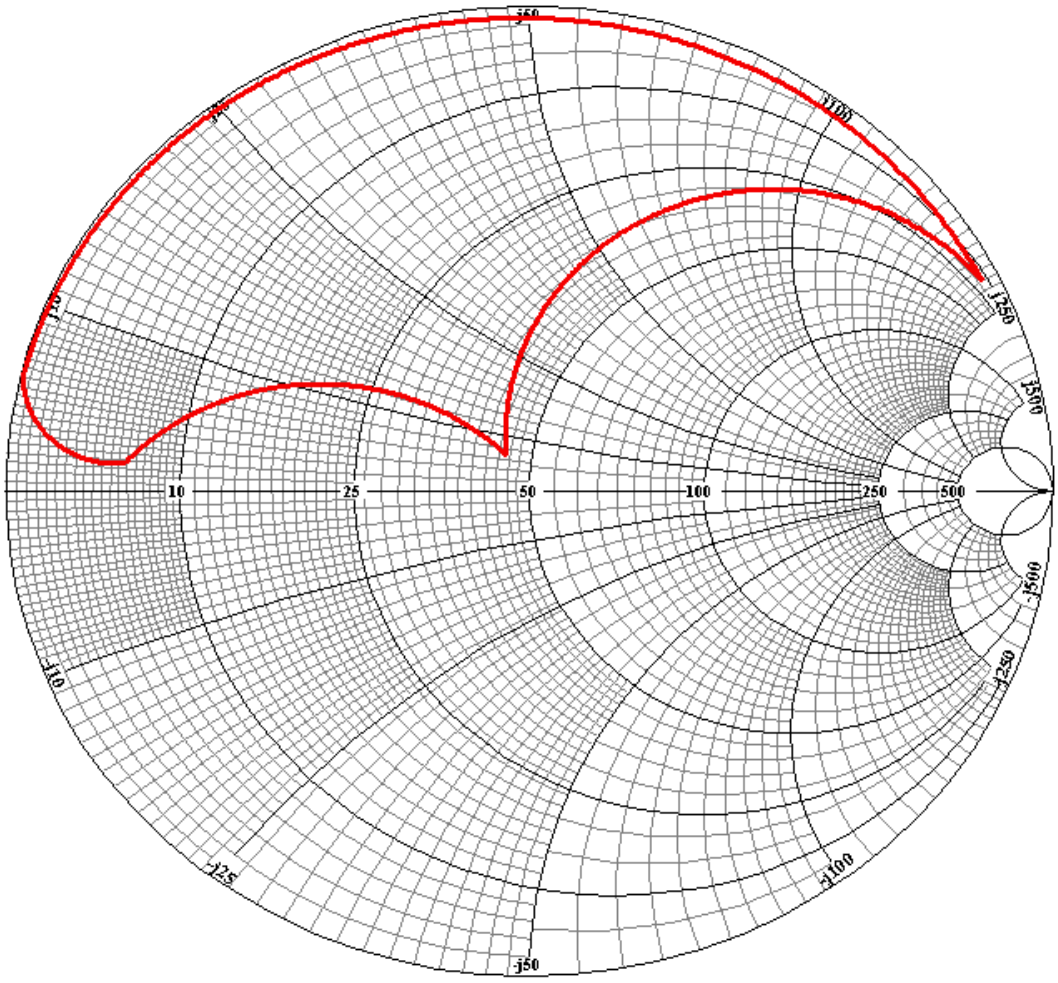


Figure 7-76. *Tune coil, 2.5 turns*

VM PN 69000082

Schematic and Smith charts are not available.

VM 700

Schematic

These units have one 10-turn tapped tune (series) coil and one 26.5-turn fixed coil. The tapped coil has taps on every turn, labeled 1 through 10 in the schematic. The load (shunt) coil has 3 turns, with taps labeled A, B, and C.

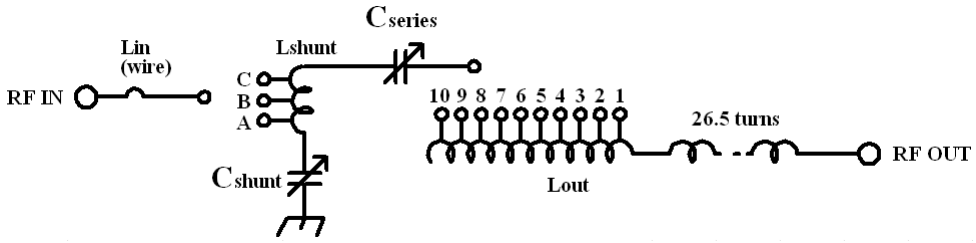


Figure 7-77. *VM 700 coil and inductor schematic*

Smith Chart

The Smith charts in this manual show the tuning only at tap A on the load coil. Although the tuning differs for tap B and C, the range would not be apparent given the resolution of the Smith charts in this manual.

Table 7-5. *Location of Smith chart illustrations for VM 700*

Tune Coil Tap Setting	Load Coil Tap Setting
	A
1	Figure 7-78
2	Figure 7-79
3	Figure 7-80
4	Figure 7-81
5	Figure 7-82
6	Figure 7-83

Table 7-5. *Location of Smith chart illustrations for VM 700*

Tune Coil Tap Setting	Load Coil Tap Setting
	A
7	Figure 7-84
8	Figure 7-85
9	Figure 7-86
10	Figure 7-87

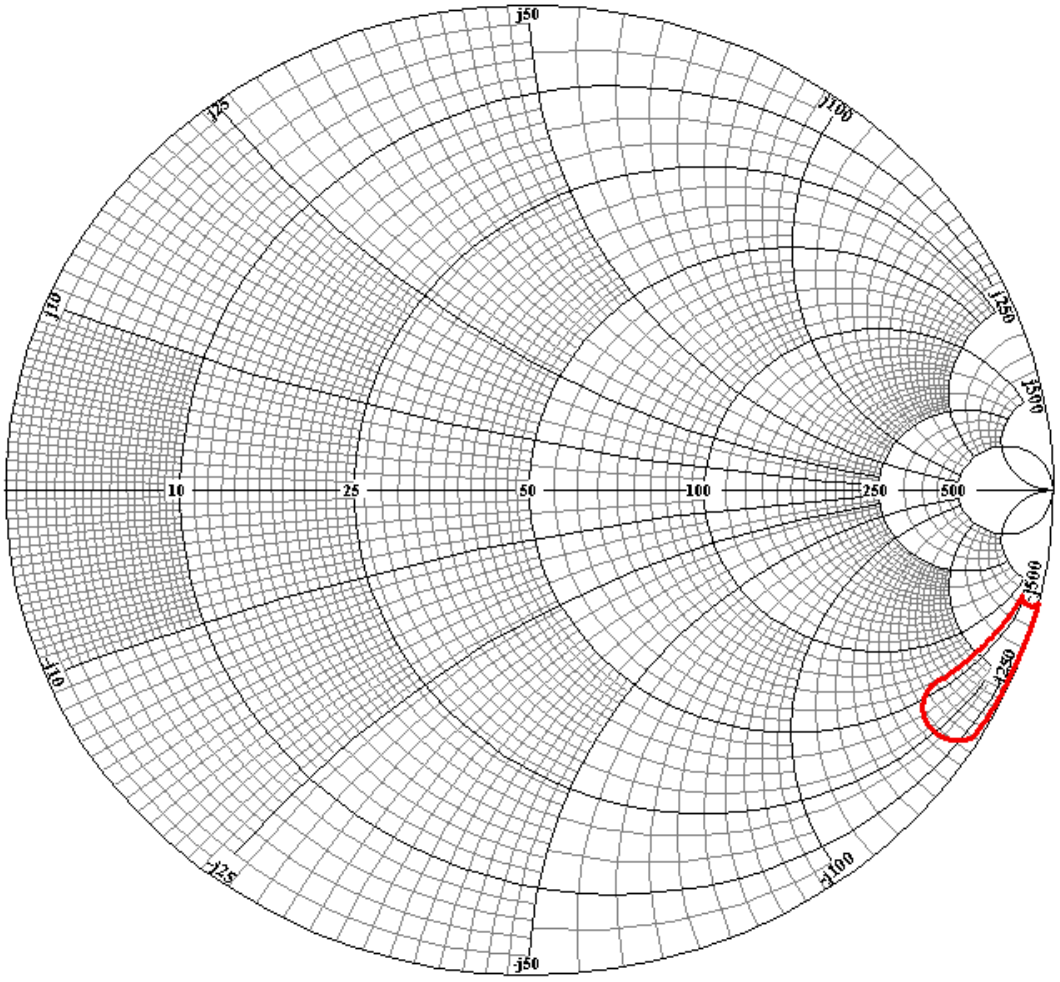


Figure 7-78. *Tune coil, 10 turns: tap 1; Load coil, 3 turns: tap A*

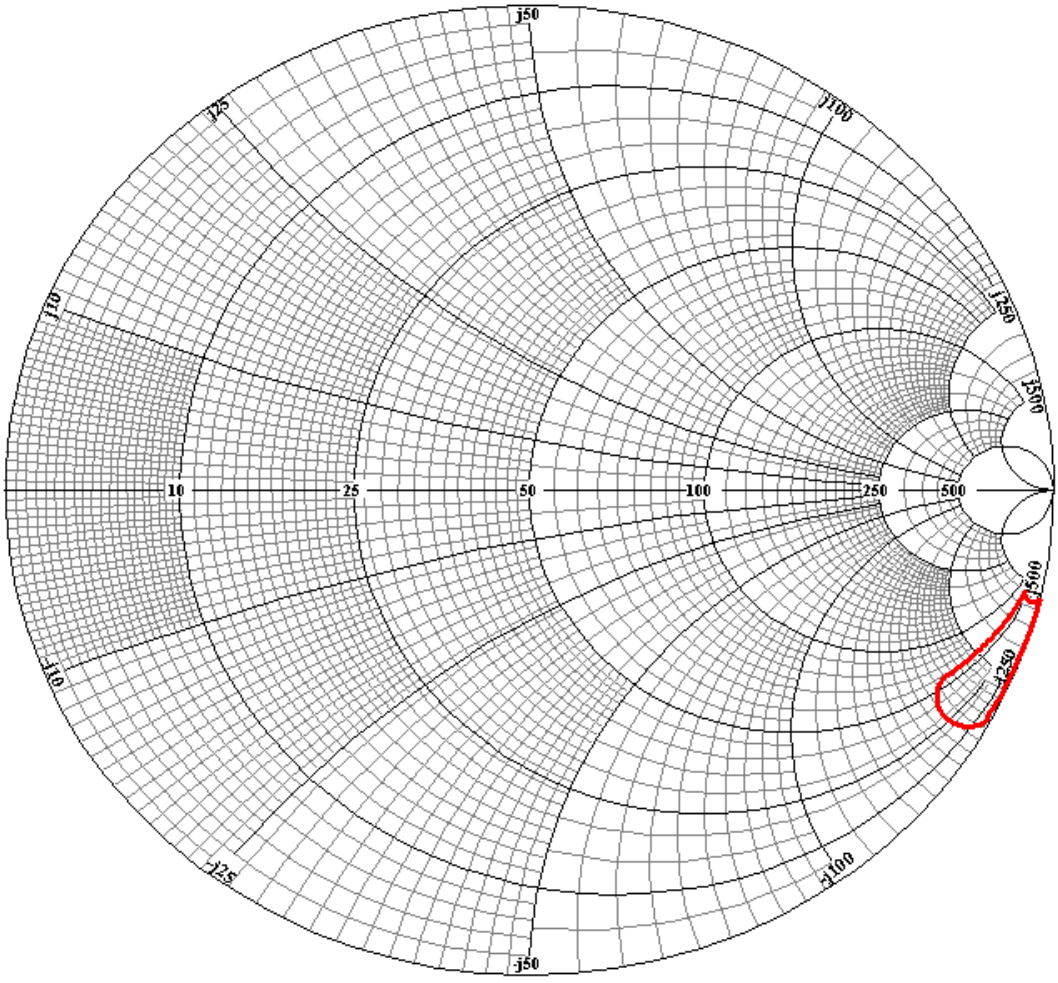


Figure 7-79. *Tune coil, 10 turns: tap 2; Load coil, 3 turns: tap A*

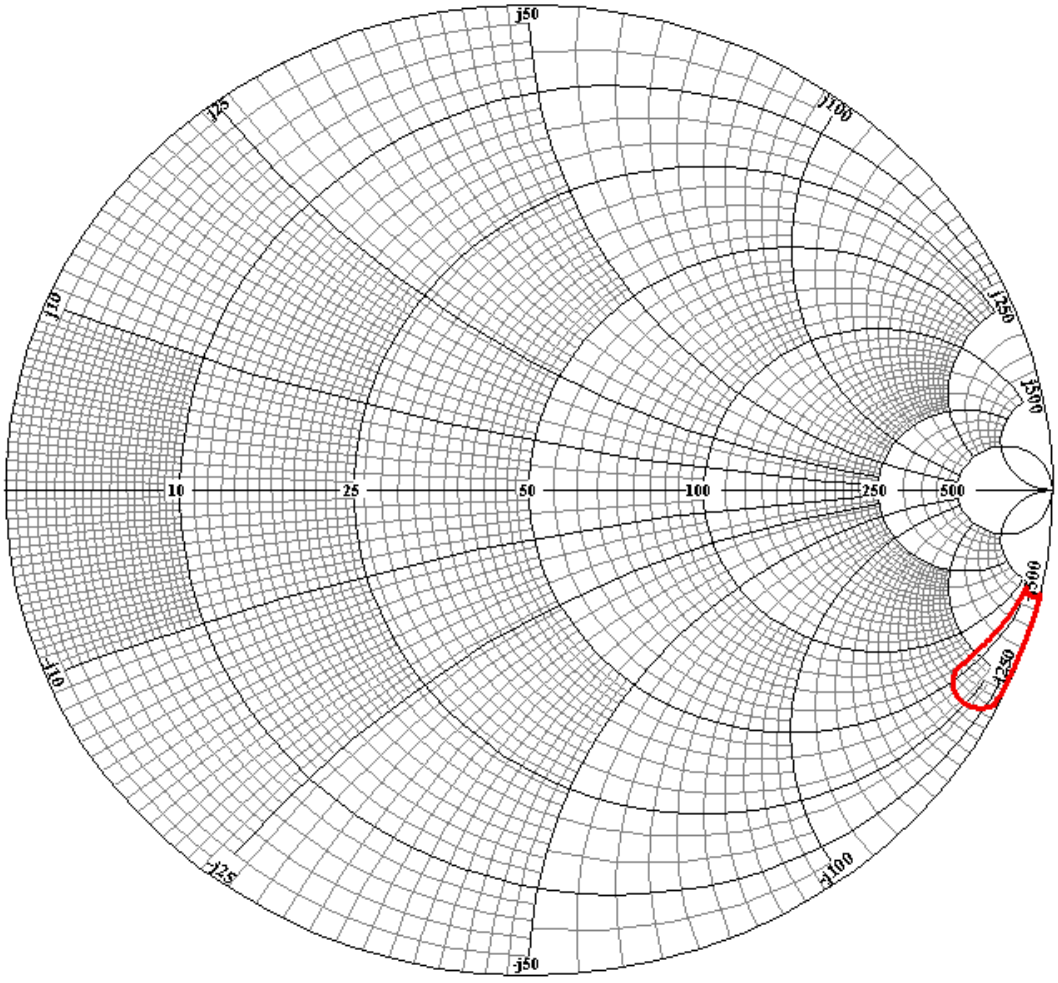


Figure 7-80. *Tune coil, 10 turns: tap 3; Load coil, 3 turns: tap A*

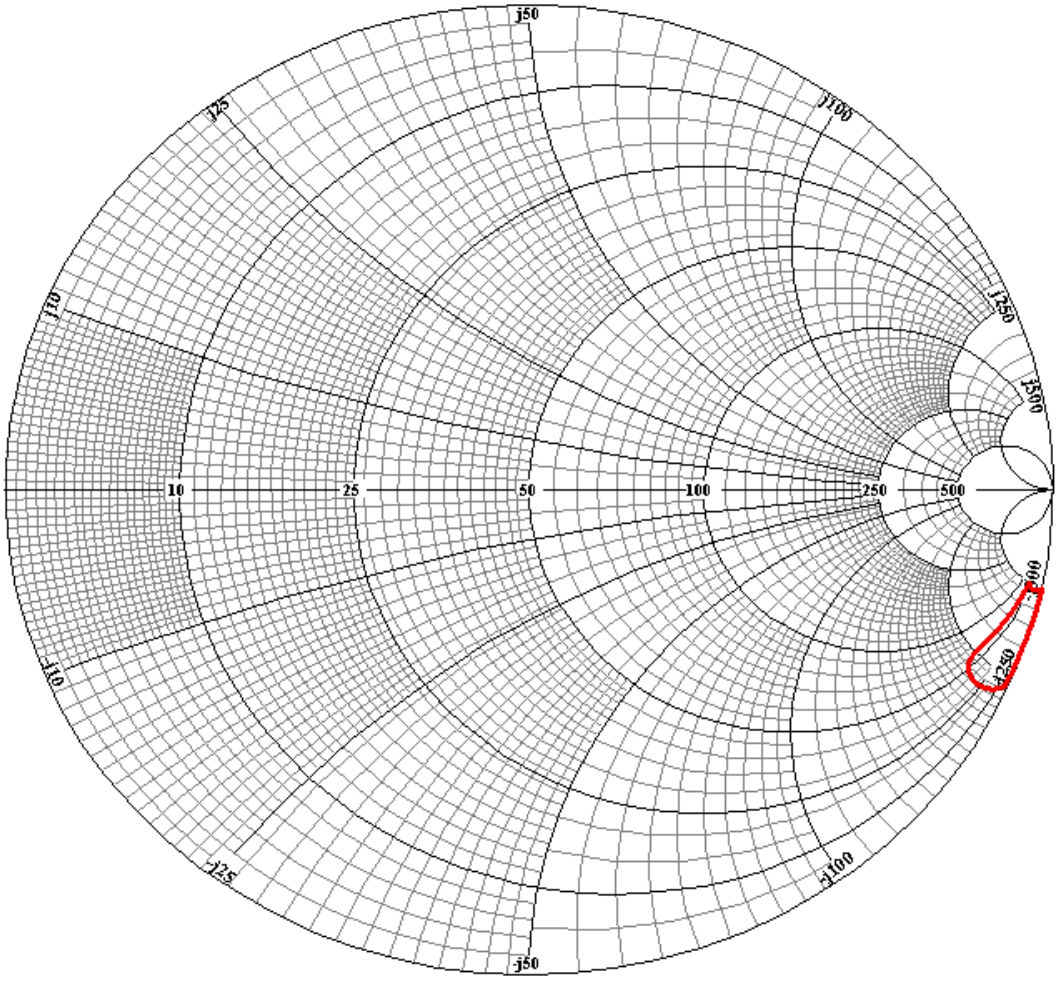


Figure 7-81. *Tune coil, 10 turns: tap 4; Load coil, 3 turns: tap A*

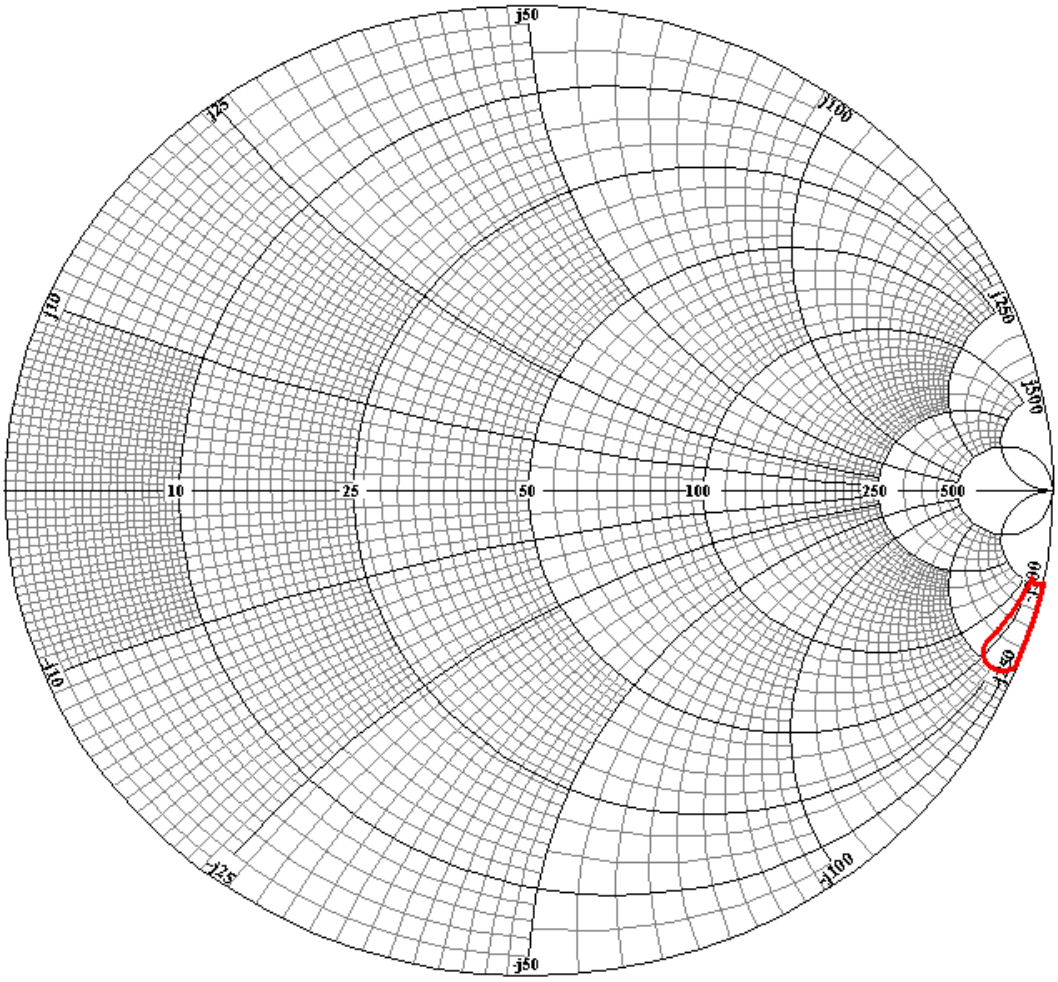


Figure 7-82. *Tune coil, 10 turns: tap 5; Load coil, 3 turns: tap A*

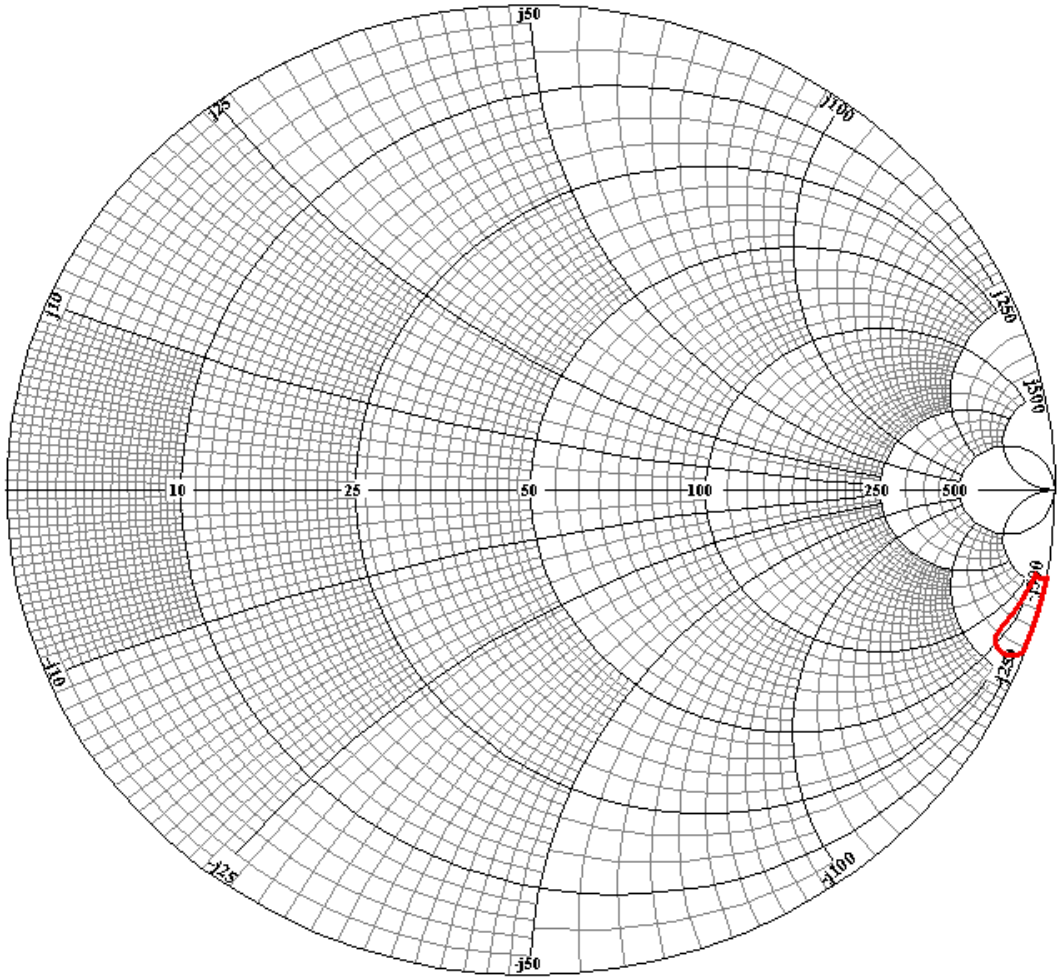


Figure 7-83. *Tune coil, 10 turns: tap 6; Load coil, 3 turns: tap A*

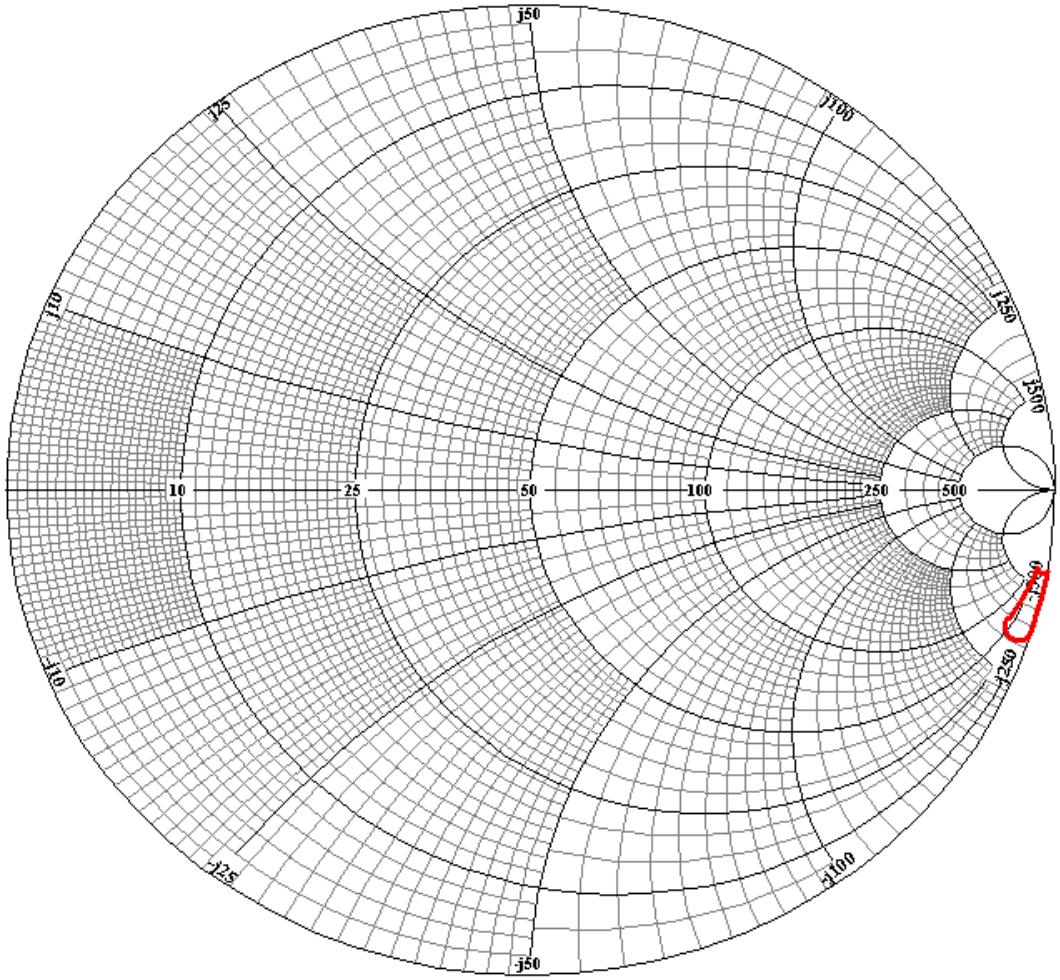


Figure 7-84. *Tune coil, 10 turns: tap 7; Load coil, 3 turns: tap A*

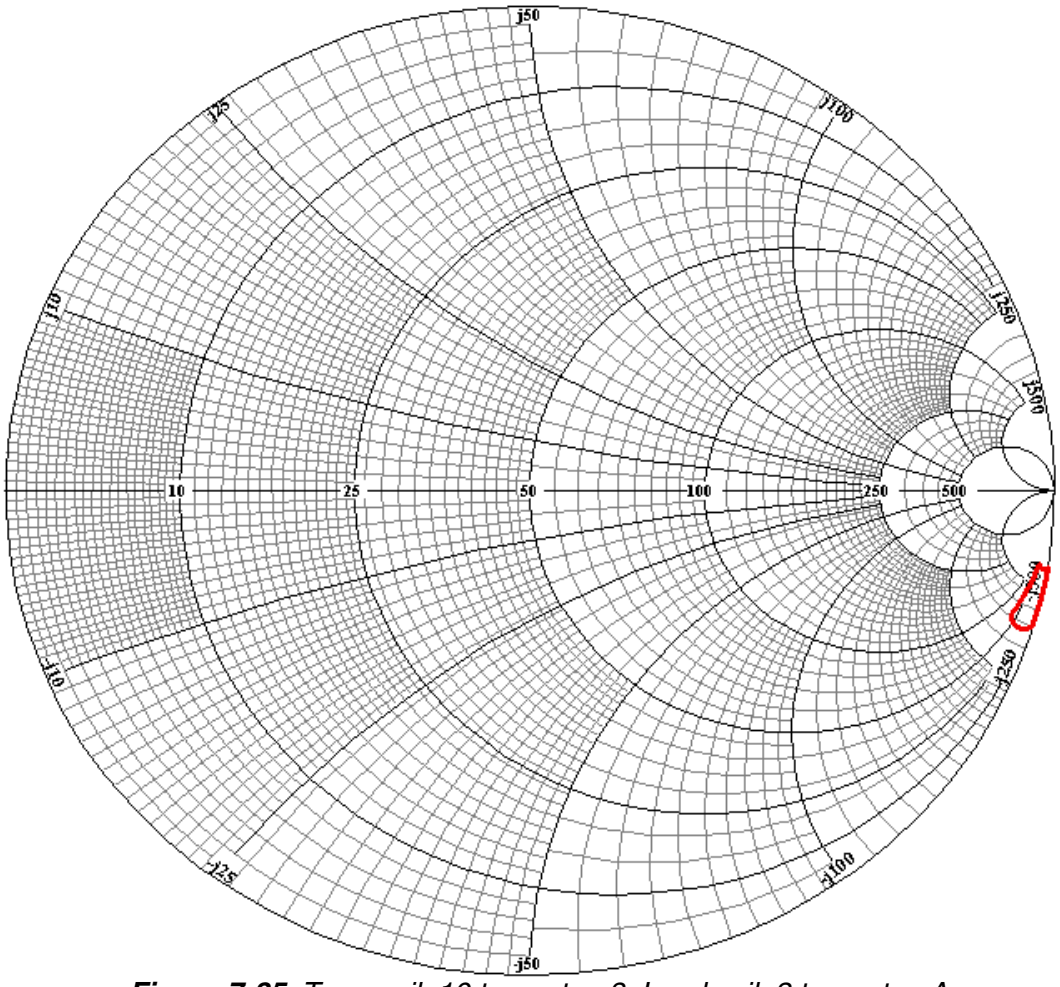


Figure 7-85. *Tune coil, 10 turns: tap 8; Load coil, 3 turns: tap A*

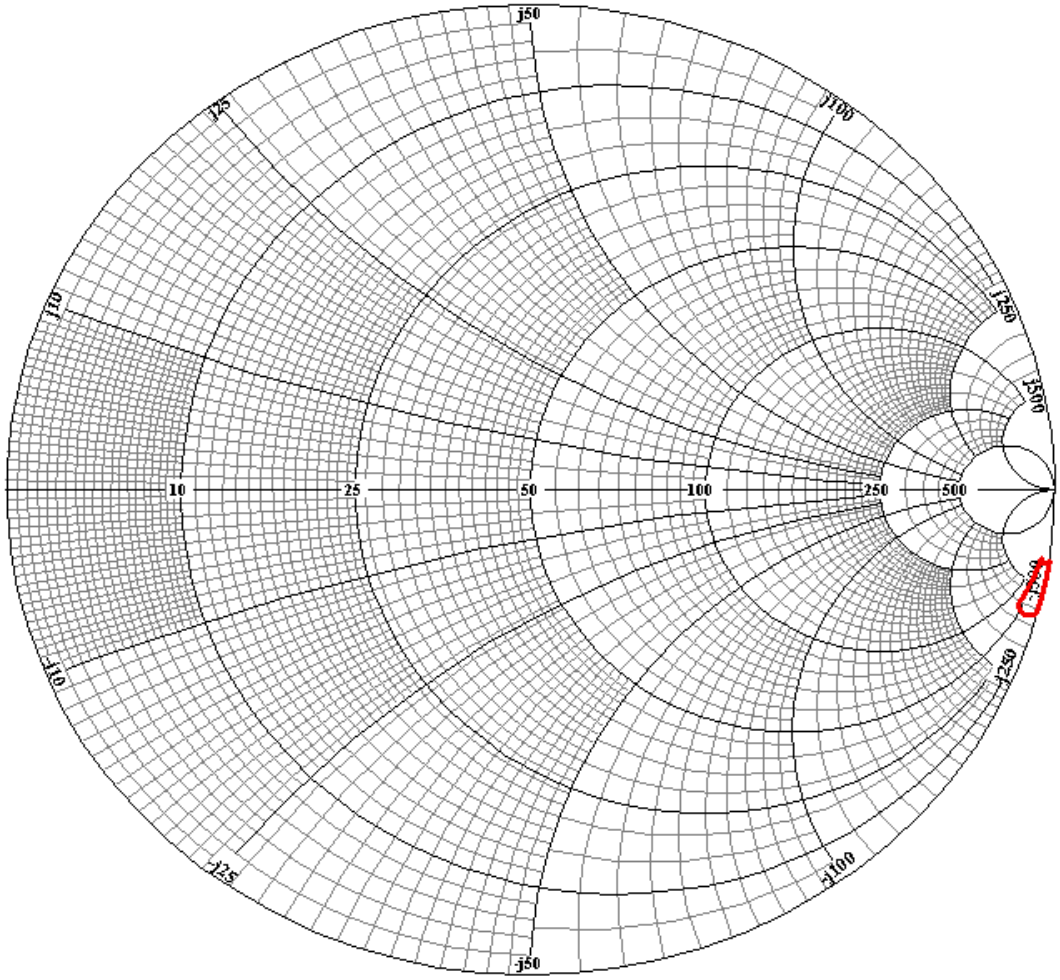


Figure 7-86. *Tune coil, 10 turns: tap 9; Load coil, 3 turns: tap A*

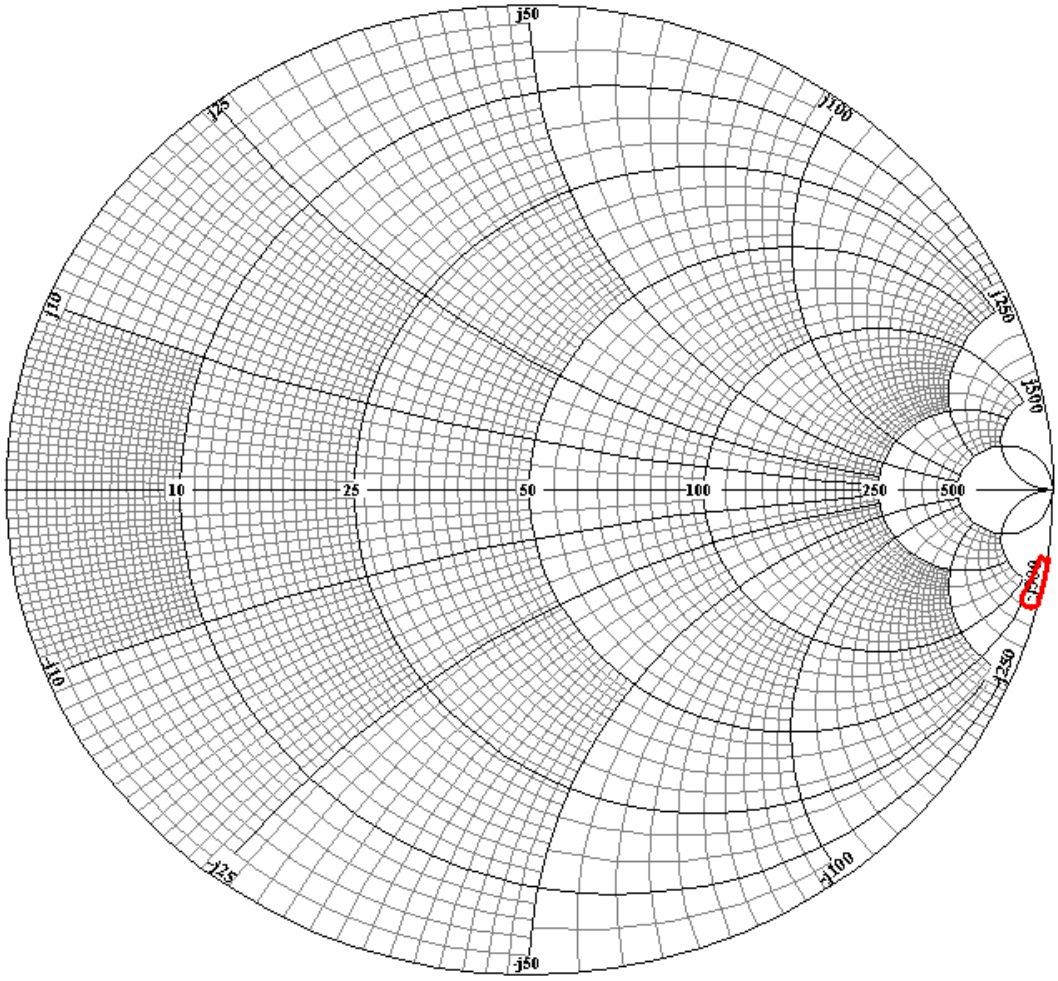


Figure 7-87. *Tune coil, 10 turns: tap 10; Load coil, 3 turns: tap A*

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