

VOLTAGE TUNABLE MAGNETRON APPLICATION NOTES



M i c t r o n *inc.*

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VOLTAGE TUNABLE MAGNETRON

The Voltage Tunable Magnetron is a versatile and, to some people, a new microwave tube. It is being used in a wide variety of applications as a local oscillator, signal source, driver and power output tube. Some of the particular applications include —

Radar Receivers

Telemetry

Communications

Beacons

Parametric Amplifier Pumps

Drivers in Countermeasures Systems

Fuses and Altimeters

Test Equipment

Countermeasures

A discussion follows on many of the characteristics that are of importance in the application of a VTM. It is worth noting that characteristics that are important in one type of application may be of little concern in a different type of utilization. This latter point may be used to advantage during the manufacture of the particular VTM to optimize on the parameters of concern. Results on specific tubes for many of the parameters are given to provide useful numbers for those considering the application of a VTM.

LINEARITY

The VTM has a voltage-frequency characteristic that is essentially linear with the curve passing nearly through the origin. This means, for example, that a 2:1 change in anode voltage will cause a 2:1 change in frequency.

There are two aspects of linearity (or deviation from linearity) that are most generally considered. First is the deviation from the voltage-frequency curve. One may expect a deviation of approximately 1% for wide band VTM's covering 2:1 or 3:1 bands; deviations of .1% have been repeatedly obtained for 1.1:1 tubes. A voltage-frequency curve is given for the 2L1-2 in Figure 1.

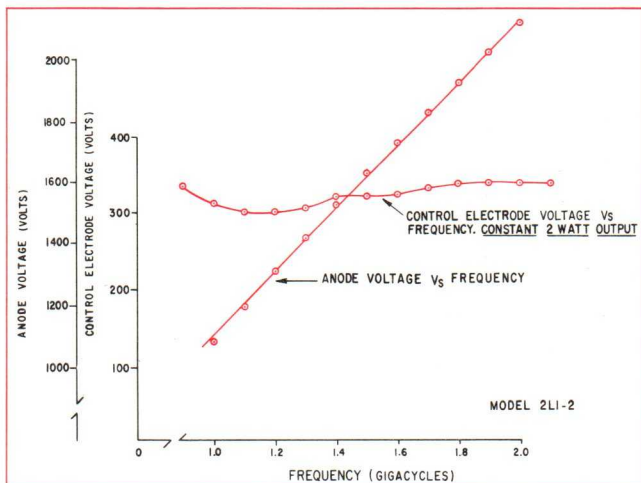


FIGURE 1

The second consideration of linearity is concerned with the slope of the voltage-frequency curve as a function of frequency. This is sometimes referred to as the modulation sensitivity. Variations of less than 10% have been consistently measured for 1.1:1 tubes.

Several things can play a role in the linearity. The first is the way that the tube is made. The linearity will be good if the power-frequency spectrum is flat. External loads also play an important role in the linearity. To optimize in this direction, circulators, isolators, and attenuators have been used to isolate the tube from load mismatches and preserve the linearity.

TUNING RATE OR MODULATION SENSITIVITY

The tuning rate will be a function of the frequency range of interest and the anode voltage. A quick way to determine the tuning rate for a particular VTM is to divide the frequency by the voltage. It may be noted that every tube in the Mictron series that covers at 2:1 frequency band operates over the same voltage range. One may expect therefore that the tube operating from 500 to 1000 Mc will have $\frac{1}{2}$ the tuning rate as the one covering the 1000 to 2000 Mc range while the tube covering 2000 to 4000 Mc will have twice the tuning rate as the tube covering 1000 to 2000 Mc.

Some latitude may be designed into the VTM's. For example, a narrow band VTM centered at 1500 Mc can be designed to operate at 600 volts or it can be designed to operate at 1800 volts — the tuning rate would differ by 3:1 in these two cases. It is recognized that there may be advantages on both sides for different applications so it may be helpful to explore this for optimizing the tuning rate for the specific application.

The deviation in tuning rate has been treated under *Linearity*.

FREQUENCY MODULATION AT HIGH RATES

Voltage Tunable Magnetrons can be frequency modulated at very high rates. In one practical application, a VTM was swept across a 300 Mc band (in low S band) at a 50 Mc rate. (The modulation frequency was 50 Mc.) Modulation at high rates in a VTM is a practical concern for the modulator rather than a limitation of the tube. The capacity of all leads to ground in a standard Mictron VTM is approximately 35 μf and this must be considered in the modulator design.

NOISE

It is important to note at the outset of a noise discussion that a VTM must be factory aligned for the low noise performance that is desired. It is misleading to measure a standard VTM that has not been aligned for low noise and conclude anything about the low noise capability of VTM's.

There are three general types of noise that are of most interest, namely, (1) "IF noise", (2) spurious signal response, and (3) "FM noise" or width of signal.

(1) "IF noise" may be described as the unwanted noise power of a local oscillator that competes with the desired RF signal in the IF amplifier. For example, if one uses a 30 Mc IF that is 1 Mc wide, the "IF noise" of the tube is the noise that is in the 1 Mc bands both 30 Mc above and below the carrier.

Mictron tubes have been measured for a number of different types of IF noise and the results are presented to provide an indication of performance that can be obtained. A narrow band tube operating in S band had

IF noise 105 db down from the carrier. The IF band was 30 Mc and 1 Mc wide. Narrow L band VTM's were measured for the RMS noise in the band 200 Kc to 4 Mc around the carrier and found to be 100 db below the carrier.

Wide band tubes have been measured where the IF frequency was 60 Mc and 4 Mc wide and the noise was 85 db below the carrier. Other tubes have been performing well where the IF band is a function of the carrier frequency and not a fixed band.

It appears that it might be advisable to design the IF as high as possible since the VTM IF noise performance appears better as one goes farther from the carrier.

It is also important to consider aligning the tube during manufacture while observing the dynamic performance on the exact equipment (IF's and mixers) that are to be used in the system.

(2) The spurious signal noise is made up of any signals other than the carrier in some arbitrarily specified band around the carrier. This has proved to be an extremely difficult parameter to measure for a tube that is electronically tunable over a wide band of frequencies. Some measurements have been made at fixed frequency points. This tends to give an indication of the tube but it must be remembered that there are an infinite number of carrier frequencies to check. The theoretical considerations give every encouragement for very low spurious signal response and give more meaning to the single frequency measurement. Single frequency measurements have been made for wide band tubes and it was found that the greatest spurious appeared at the 2nd harmonic and this was 50 db down from the carrier. Narrow band tubes should be better and measurements bear this out being in the order of 60 to 70 db below the carrier.

(3) F.M. noise or width of carrier is most often of practical concern for the power supply. The VTM has a reasonably high tuning rate and ripple on the anode supply results in a modulated carrier. Experiments have been run where the power supply ripple was reduced so that 5 Kc at S band was observed but this still did not represent the limit of the VTM, but corresponded to the residual ripple of the power supply.

FREQUENCY COVERAGE

As a quite general observation it may be noted that electronic tuning range and power output of a VTM are inversely related. One may design into the VTM package the capability of higher power with a corresponding reduction of frequency coverage. For example, the Micron 10L1.5-2 delivers 10 watts over the 1500 to 2000 Mc frequency range, the 2L1-2 delivers 2 watts over the 1000 to 2000 Mc range and the .5LS1-3 delivers $\frac{1}{2}$ watt over the 1000 to 3000 Mc range.

While the Micron series of 2:1 frequency coverage starts with 250 Mc and extends to 4000 Mc in specific packages, 2:1 frequency coverage may be obtained anywhere within the 100 to 5000 Mc range. 3:1 coverage can be obtained over most of the above ranges also.

Another general observation to be noted is that power variation over the specified frequency range is greater for the wider frequency coverage tubes. All standard Micron 2:1 coverage tubes are less than 3 db in power variation while narrow band tubes covering 10 to 15% bands will vary less than 1 db in power. 3:1 coverage tubes will vary less than 4 db over the band. Flatter power response may be delivered upon request.

For example, 2 db in power variation can be obtained for most 2:1 coverage tubes and 3:1 tubes can be made to have less than 3 db variation in power upon special request.

THE VTM AS A STABLE FREQUENCY SOURCE

Frequency Locking by Feedback Systems or Injected Signal.

There are a number of applications where a stable frequency source is desired such as beacons or parametric amplifier pumps and other applications where the tunable feature is preserved but capability for locking provided at many frequencies. The VTM can be quite useful as a locked oscillator since it provides considerable tunable output power.

A number of schemes have been utilized for locking VTM's but there are two basic methods namely (1) sensing the frequency deviation and feeding back a correction voltage or (2) locking the tube by means of an injected signal.

The experience with Micron VTM's in frequency locked systems has been good since the range of lock has proved to be quite large. The high tuning rate of the VTM makes this a sensitive system. In many systems where feedback has been used, a reference cavity (in some cases tunable) provides the comparison means for obtaining the correction voltage. For injection locking, the injected signal may be fed back into any standard tube by means of a circulator.

Data taken on the 2L1-2 operating at $2\frac{1}{2}$ watts for an injected signal of 10 milliwatts, 5 milliwatts and 1 milliwatt, the locking range was $2\frac{3}{4}$ volts, 2 volts and .9 volt, respectively.

In an application, approximately 18 volts of locking range (12 Mc locking at 1000 Mc center frequency) was obtained for an injected signal 10 db down from the VTM. This is consistent for the data above.

Two final observations concerning locking; first, the locking range for a high power narrow band VTM appears to be greater than a wide band VTM when a signal the same number of db down from the VTM is injected. The second observation is that the injection process appears to sharpen the output signal. This is also consistent with findings on other tubes.

AMPLITUDE VARIATION AND PULSE OPERATION

The power output of the VTM may be controlled by varying the potential on the control electrode. This is similar in many ways to the operation of the grid in a low frequency triode. Amplitude variation in the wide band VTM's can be obtained over a range that is in the order of 3 to 5 db and in the order of 10 db in narrow band tubes. All Micron 2:1 band tubes have a maximum of 3 db of power variation across the entire band. The relation of the power output as a function of the control electrode voltage is essentially linear. A curve for a wide band IP.5-1 and a narrow band are shown in Figure 2.

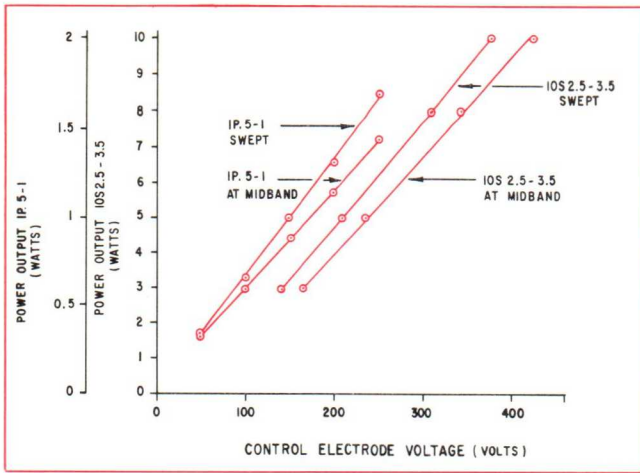


FIGURE 2

All of the Micron 10 watt series VTM's can be pulsed and many of the lower power tubes can also be pulsed. This is achieved by putting the pulsed supply between the control electrode and the emitter. Measurements have been made to determine the time delay between the pulse and tube operation. A wide band tube was operated with a pulse that had a rise time of .3 μ seconds and the tube followed. This rise time represented the limit of the supply as opposed to the limit of the tube. Further experiments with a 2L1-2 indicate that the time required to turn the unit on is of the order of .02 μ seconds.

PUSHING AND PULLING

Pushing. The change in frequency due to a change in anode current (hence power output) is called pushing. In a VTM the frequency is generally pushed to a lower value when the anode current is increased by means of the independent amplitude control, the control electrode. Results on a 2L1-2 for 3 points in the band namely 1000 Mc, 1500 Mc, and 2000 Mc for changes in anode current (and power) of 2 to 1 show that the frequency was pushed between 4 and 5 Mc.

A little thought on this matter in relation to the discussion on linearity leads one in the direction of optimizing the flatness of the power output as a function of frequency for realizing the best modulation sensitivity linearity.

Pulling. The change in frequency that is caused by varying a mismatched load through all phases is called pulling. The magnitude of the VSWR of the load and its distance from the tube are of importance to the performance of a VTM. In general, it is desirable to keep the mismatch as close to the tube as possible and hence minimize long line effects. In those applications where mismatch would cause degradation that is beyond a tolerable limit, the use of circulators, isolators or attenuators will prove to be a solution.

A mismatched load will cause the frequency to change, the power output to vary and the linearity to be degraded. These effects are not all strictly pulling but they are related to a mismatched load and improving the match will correct the condition.

The 2L1-2, operating between 1000 and 2000 Mc has been found to pull approximately 4 Mc when operated into a 1.5:1 mismatch that has been moved through all phases.

LEVELING

The VTM may be leveled in power output by applying a correction voltage back on the control electrode. The scheme to be employed need not differ from that which has been used on other electronically tunable tubes. A curve is given in Figure 1 for a Micron 2L1-2 where the power was kept at a constant 2 watts by adjusting the control electrode. It may be seen that the variation in control voltage ranged from 295 to 345 volts for the particular tube that was tested.

EXTERNAL INFLUENCES

MAGNETIC FIELD

The VTM package contains a permanent magnet; consequently the performance of the tube can be affected when placed near magnetic materials, or other magnetic fields. The frequency of the VTM is inversely proportional to the magnetic field in its magnet gap and external magnetic influences will cause the frequency of operation to change. Placing the tube near a piece of magnetic material will cause a shift in the frequency for a given voltage. This relationship will remain as long as the tube and magnetic material remain fixed. Placing the VTM near a time varying magnetic field (such as a transformer) will cause the tube to be frequency modulated.

It might also be helpful to know the stray field of the VTM's permanent magnet in order to determine its influence on other components. The standard 1½ pound unit has a stray field of 70 gauss 2 inches from the tube, 10 gauss 5 inches from the tube and a field that approximates the earth's magnetic field 14 inches from the tube.

The above values were obtained when moving away from the top or bottom of the tube. The fields are less when measured in any other direction from the tube.

There have been applications where shielding was felt desirable but in the overwhelming majority of cases, prudent packaging proved adequate for resolving the magnetic field influences.

ENVIRONMENTAL CAPABILITY

All Micron VTM's utilize an extremely rugged ceramic and metal tube construction. (Tubes have been heated to 500°C in air by directing a blow torch on the tube without damage.) This rugged tube envelope construction has been instrumental in the development of the VTM packages for extreme environmental conditions. Heat transfer, shock, vibration, humidity, acceleration, altitude, extreme temperature conditions, etc. as encountered in missile aircraft, sea and land applications have received design consideration in the Micron VTM packages.

M i c r o n inc.

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SOME UNIQUE MICTRON VTM's

Electronic Tuning Over the Entire 2-4 GC Band



Model 2S2-4

2 watts minimum from 2 to 4 GC.
 Power variation: $\pm 1\frac{1}{2}$ db
 Power requirement, size, and weight
 are consistent with other Mictron
 2 watt octave models.

3 To 1 Frequency Coverage



Model .5PL.4-1.2

$\frac{1}{2}$ watt minimum from .4 to 1.2 GC
 Power variation: $\pm 1\frac{1}{2}$ db

Model .5LS 1-3

$\frac{1}{2}$ watt minimum from 1 to 3 GC
 Power variation: $\pm 1\frac{1}{2}$ db

Subminiature VTM's

Weight: 11 ounces



Performance Data:

Typical subminiature units:

FREQUENCY BAND (mc)	1200-2400	1600-3200	1425-1575	1425-1575	1850-2150	2700-3300	2850-3150
POWER MINIMUM (watts)	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	3	3	2	5
CENTER VOLTAGE (volts)	1000	1000	500	1000	1000	1000	1000

A COMPLETE LIST OF VTM's AVAILABLE AT MICTRON

WIDE BAND SERIES

2:1

3:1

Model	.5P .25-5	1 P .5-1	2PL.75-1.5	2L1-2	2LS1.5-3	2S 2-4
Frequency Band (mc)	250-500	500-1000	750-1500	1000-2000	1500-3000	2000-4000
Power Minimum (watts)	.5	1	2	2	2	2
Price	\$750.00	\$750.00	\$750.00	\$750.00	\$750.00	\$1250.00

.25PL.4-1.2	.5LS1-3
400-1200	1000-3000
.25	.5
\$950.00	\$950.00

WEIGHT 1½ LBS. DELIVERY 2 WEEKS

10 WATT SERIES

Model	10P.75-1	10L1-1.5	10L1.5-2	10S2-3	10S2.5-3.5	10S3-4	10SC3.5-4.5
Frequency Band (mc)	750-1000	1000-1500	1500-2000	2000-3000	2500-3500	3000-4000	3500-4500
Power Minimum (watts)	10	10	10	10	10	10	10
Price	\$950.00	\$950.00	\$950.00	\$950.00	\$950.00	\$950.00	\$950.00

WEIGHT 1½ LBS. DELIVERY 2 WEEKS

Performance Data:

SUBMINIATURE SERIES

FREQUENCY BAND (mc)	1200-2400	1600-3200	1425-1575	1425-1575	1850-2150	2700-3300	2850-3150
POWER MINIMUM (watts)	½	½	½	3	3	2	5
CENTER VOLTAGE (volts)	1000	1000	500	1000	1000	1000	1000
Price	\$950.00	\$950.00	\$950.00	\$950.00	\$950.00	\$950.00	\$950.00

MICTRON REPRESENTATIVES

Home office
MICTRON, INC.
 265 Osborne Rd.
 Albany 11, N. Y.
 518-438-3531

Northwest

George Gostenhofer & Associates, Inc.
 3 Country Club Road
 Westchester, Conn. 203-BR 23091

George Gostenhofer & Asso., Inc.
 5 Bear Hill Road
 Northampton, Mass. 617 TW 4-9500

Middle Atlantic

C. E. Snow Co.
 3720 Farragrat St.
 Kensington, Maryland 301-949-1010

C. E. Snow Co.
 Friendship Int. Airport
 Suite 124C. Terminal Bldg.
 301-761-5757

C. E. Snow Co.
 613 Cheltenham Ave.
 Philadelphia, Pa. 215-CA 42626

C. E. Snow Co.
 5705 Grove Ave.
 Richmond, Va. 703-288-1855

Southeast

E. G. Holmes & Assoc.
 306½ South Bunby St.
 Orlando, Florida 305-CH-12128

E. G. Holmes & Assoc.
 4969 Roswell Rd., N.E.
 Atlanta, Ga. 404 BL 56660

E. G. Holmes & Assoc.
 408 W. Clinton Ave.
 Huntsville, Alabama 205-539-1114

West Coast

Cain & Company
 15840 Ventura Blvd.
 Los Angeles, California 213-783-4700

Cain & Company
 175 S. San Antonio Rd.
 Los Altos, California 408-948-6533



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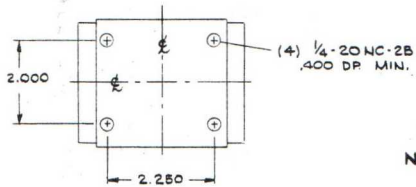
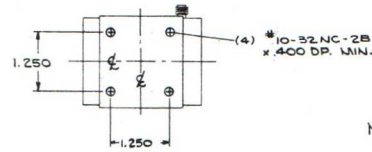
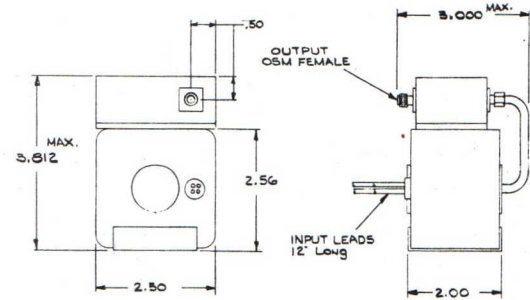
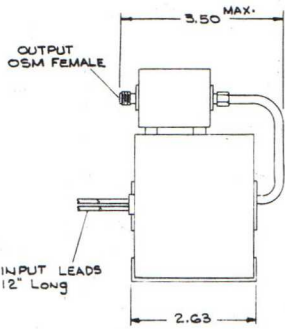
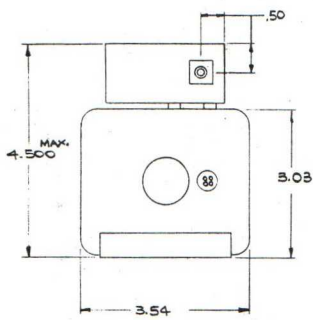
MICTRON

HIGH POWER VOLTAGE TUNABLE MAGNETRONS

DIVISION OF KMS INDUSTRIES, INC.
 P.O. BOX 10126
 SARASOTA, FLA. 33878
 PHONE 813-955-4259

MODEL	R F Characteristics			Electrical Parameters						Mechanical	
	Frequency Coverage GHZ	Power Out Watts (Min)	Power Variation db (Max)	Anode Voltage at center Frequency	Anode Voltage over band	Anode current Amps (Max)	Control Electrode Volts	Filament		Outline	Wt.
								Amps	Volts		
100L1.25-1.5	1.25-1.5	100	± 1	3000	2700-3500	.080	1000	5.4	2.4	A	4½
100S2.7-3.3	2.7 - 3.3	100	± 1	3000	2700-3500	.080	1000	5.4	2.4	B	2½
										C	3½
100C4.8-5.3	4.75-5.25	100	± 1	3000	2700-3500	.080	1000	5.4	2.4	D	4½
500S2.8-3.4	2.8-3.2	500	± 1	6800	6200-7400	.125	1500	5.4	1.8	E	6½

NOTE: Control Electrode Current 1 ma max.

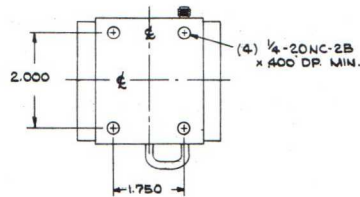
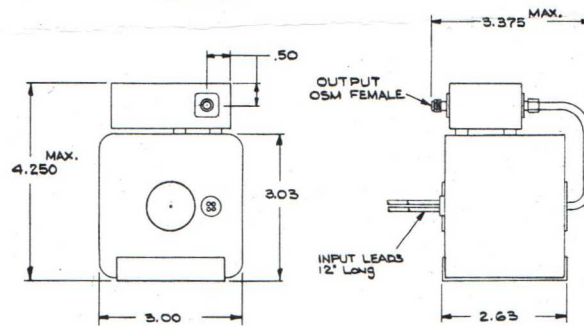


NOTE
1. TOLERANCES: .XX - .03
.XXX - .010

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.XXX - .010

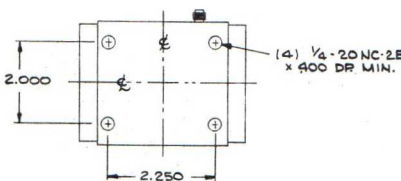
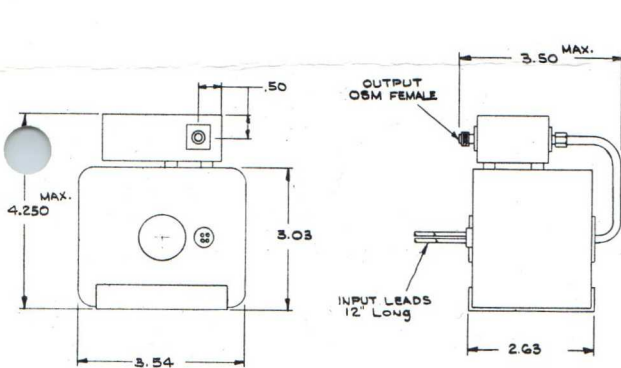
OUTLINE - B

OUTLINE - A

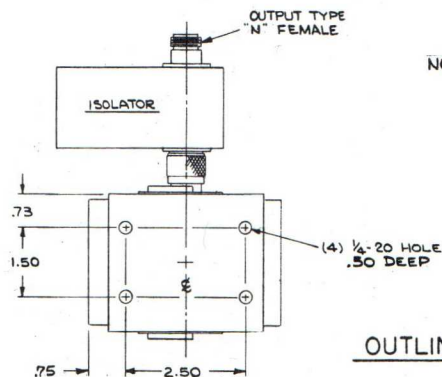
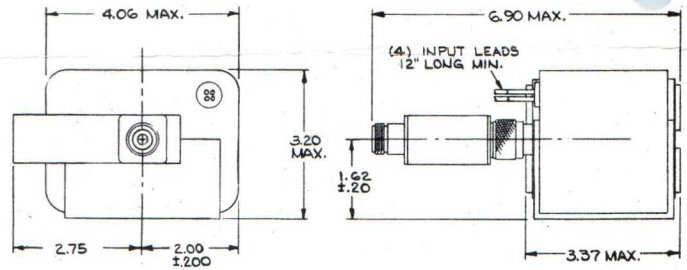


NOTE:
1. TOLERANCES: .XX - .030
.XXX - .010

OUTLINE - C



NOTE:
1. TOLERANCES: .XX - .03
.XXX - .010

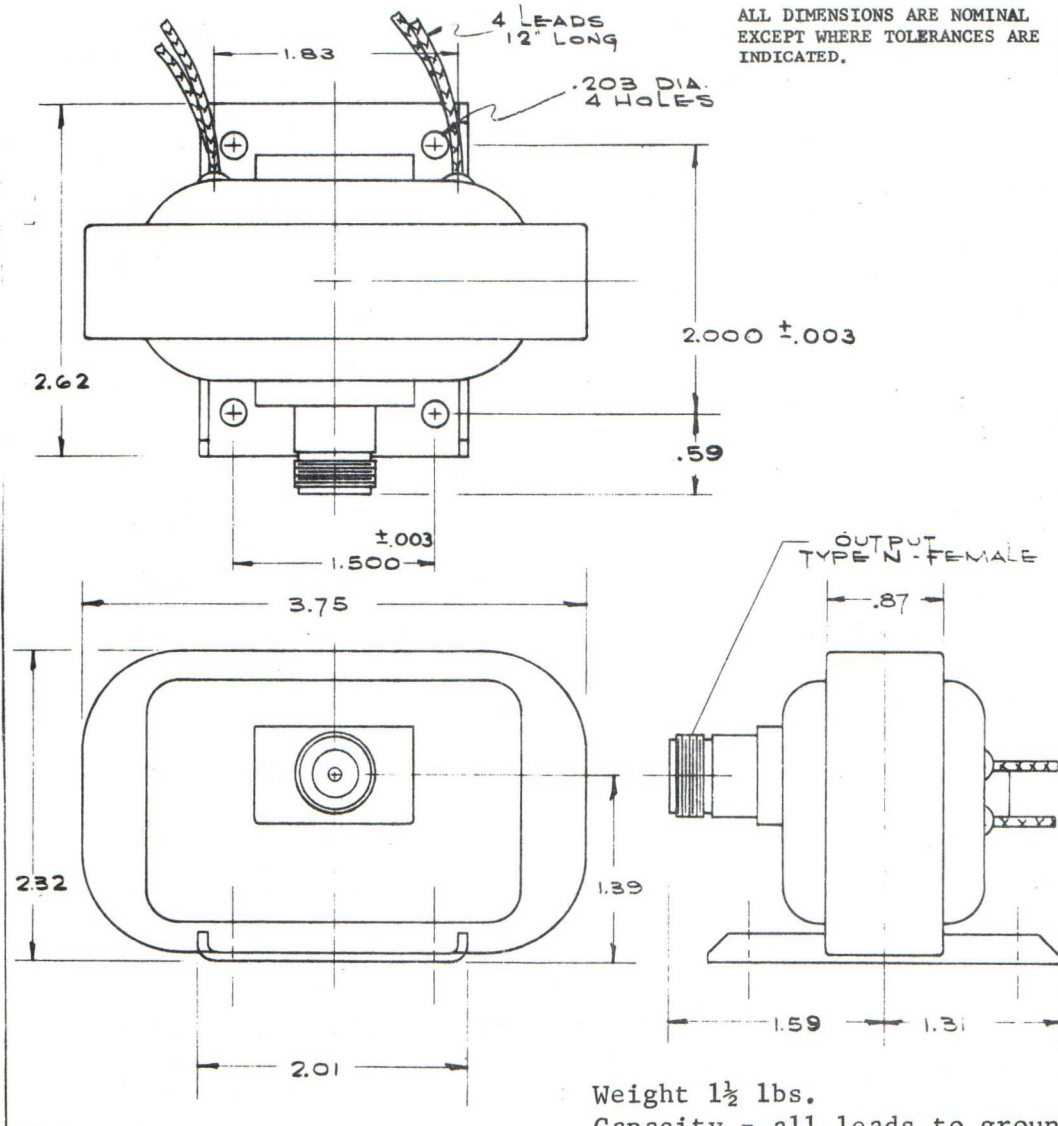


NOTE:
1. TOLERANCE - XX .03
XXX .010
UNLESS OTHERWISE SPECIFIED

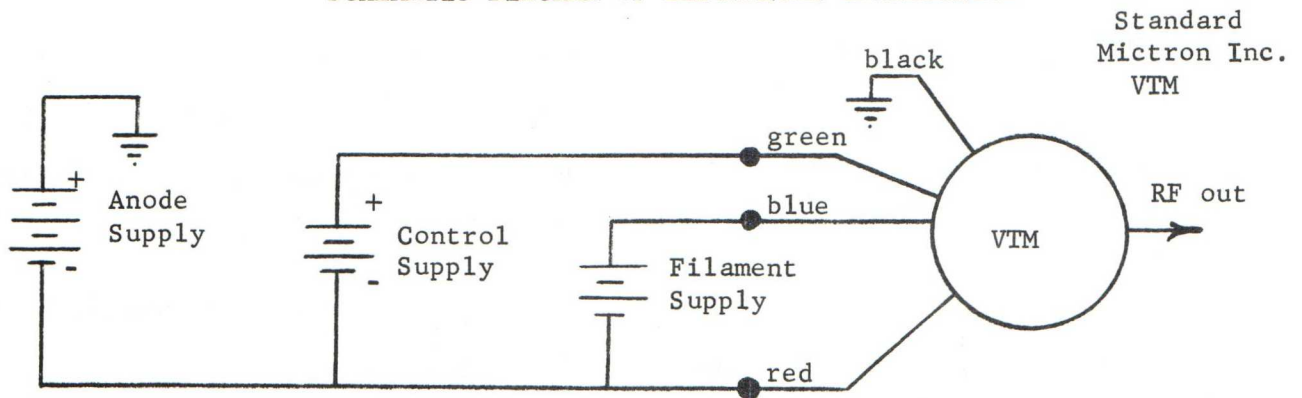
OUTLINE - D

OUTLINE - E

OUTLINE



SCHEMATIC DIAGRAM OF ELECTRICAL CONNECTIONS





VOLTAGE TUNABLE MAGNETRON
PRELIMINARY TECHNICAL INFORMATION

The following values are approximate values intended as a guide for ready comparison of various Voltage Tunable Magnetrons available. Actual values may vary slightly or can be changed to some extent to meet specific customer requirements.

Model	Freq. Range Mc	Power Output Watts	Anode Voltage @ Cent. Freq.	Anode Voltage Over Band	Max. Anode Current	Control Electrode Volts
.5P.25-.5	250- 500	½	1500	1000-2100	.015	300
1P.5-1	500-1000	1	1600	1050-2200	.015	300
2PL.75-1.5	750-1500	2	1600	1050-2200	.015	300
2L1-2	1000-2000	2	1600	1050-2200	.015	300
2LS1.5-3	1500-3000	2	1600	1050-2200	.015	300
2S2-4	2000-4000	2	1600	1050-2250	.015	300
.25P.35-1	350-1000	¼	1600	750-2500	.010	200
.25PL.4-1.2	400-1200	¼	1600	750-2500	.010	200
.5PL.5-1.5	500-1500	½	1600	750-2500	.010	200
.5PL.8-2.4	800-2400	½	1600	750-2500	.010	200
.5LS1-3	1000-3000	½	1600	750-2500	.010	200
.5LS1.2-3.6	1200-3600	½	1600	750-2500	.010	200
10P.75-1	750-1000	10	2000	1700-2300	.025	400
10L1-1.5	1000-1500	10	2000	1400-2600	.025	400
10L1.5-2	1500-2000	10	1800	1600-2200	.025	400
10S2-3	2000-3000	10	1900	1500-2300	.025	400
10S2.5-3.5	2500-3500	10	1800	1400-2200	.025	400
10S3-4	3000-4000	10	2000	1600-2400	.025	400
10SC3.5-4.5	3500-4500	10	2000	1700-2300	.025	400

Filament Current

3 amps for 10 watt models; 2 amps for all others

Filament Voltage

3 Volts

Control electrode current

Less than 1 Ma