Market Survey Report

Microwave Power module (MPM) is a device used to amplify radio frequency signal to a high power level.

MPM Parameters are as below:

1. **Frequency Range:** It is the radio frequency range from S band to W band.
2. **RF input Power:** The input RF signal given to high power amplifier in terms of dBm.
3. **RF output power:** It is the amplified version of RF input signal. It is measured in terms of dBm.
4. **Small signal Gain:** It is the gain obtained for an input signal which is so weak that it does not cause any gain saturation. It is measured in db.
5. **Duty cycle:** The percentage of time during which the power is present in one period.
6. **Efficiency:** The total efficiency is the peak RF output power divided by the total input power to the TWT or amplifier.
7. **Noise figure:** The noise figure is the ratio of the signal-to-noise level at the input of the TWT and the signal-to-noise level at the output of the TWT. It is measured in dB.
8. **Noise power density:** It is the noise power generated by a TWT within a given bandwidth measured in dBm per MHz.
9. **Phase noise:** It is the ratio of signal power to reflect power measured in a 1 Hz bandwidth at a given offset from the desired signal (carrier).
10. **Pulse width:** Time interval between leading edge and trailing edge of the pulse.
11. **Pulse delay:** it is time taken by the RF pulse to transmit through the TWT.
12. **Pulse repetition Frequency:** The PRF is the pulse train applied as a TTL level that is applied to the pulse input connector for modulating/switching the TWT on and off at the rate applied.
13. **Group Delay:** Group delay is a measure of the time delay of the signal envelope propagating through the device. It is measured in ns/MHz.
14. **AM/PM Ratio:** AM/PM is the amount of phase change in the output signal when the input amplitude is changed. It is measured in ^{0}/db.
15. **Intermodulation Distortion:** Distortion due to the sum and difference frequencies from a multi-carrier input signal.
16. **Spurious Noise:** Circuit noise or interference that is like a signal.
17. **VSWR:** VSWR is a measure of the reflections produced by impedance mismatches in an RF circuit.
18. **Primary Power**: It is input power given to Electronic power conditioner.
19. **Acoustic Noise:** Noise in the acoustic spectrum; usually measured in decibels.
20. **Operating Temperature**
21. **Storage Temperature**
22. **Humidity**
23. **Shock**
24. **Vibration**
25. **Altitude**
26. **Weight**

27. Size
28. Cooling

Based on military application we classify MPM into four types:

1. Radar MPM.
2. Electronic Warfare MPM.
3. Communication MPM.
4. Scientific and Industrial MPM.

Common parameters irrespective of application:

1. **RF output power:**
    - RF output power of TWT is determined by the efficiency with which energy in the electron beam is converted to microwave energy.
    - High amount of RF output power gives more transmission distance and hence increases the detection range of the target.
    - RF peak power measurements can be performed using a spectrum analyzer.
    - The output RF envelope is never perfectly rectangular, measurement errors may be introduced.
    - This measurement error may be significant in the case of short pulses where the rise and fall times may comprise a significant fraction of pulse width.
    - The measurement error may be minimized by using a corrected or effective duty cycle to calculate peak power.
2. **Small signal gain:**
    - When driven with small signals, the TWT exhibits a linear gain but as the RF drive signal increases, the TWT will be driven into saturation and any further increase in drive level lead to the reduction in the output power and beam defocusing occurs.
    - The use of the small signal gain gives the point where output power is 1db below the value of the extrapolated linear gain.
    - Measurement of small signal gain can be made using network analyzer.
3. **Duty cycle:**
    - Duty cycle (or duty factor) is a measure of the fraction of the time power is transmitting.
    - It is important because it relates to peak and average power in the determination of total energy output. This, in turn, ultimately affects the strength of the reflected signal as well as the required power supply capacity and cooling requirements of the transmitter.

4. **Noise figure:**
    - The noise figure of the TWT is defined as the ratio between the signal to noise level at the input of the TWT and the signal to noise level at the output of the TWT.
    - If the signal is amplified linearly, the noise associated with the signal due to electron velocity fluctuation increases linearly. Thus the noise figure increases as the gain of the TWT increases.
    - More noise figure reduces the sensitivity of the receiver.
    - Noise can be reduced by gating off the beam when signal transmission is not required either with grid or focus electrode.

5. **Noise power density:**
    - In beam on condition the output noise power density depends on the tube design considerations and the type of modulation electrode used.
    - In a gridded tube, the RF output noise power density is higher due to the disturbance to the electron beam caused by inserting the grid in its path.
    - In low output power application, it is possible to considerably reduce both the noise figure and noise power density in the beam on condition by using a high power solid state driver and very low gain TWT instead of a single high gain TWT.

6. **Efficiency:**
    - It is the ratio of the RF power output to the total prime power drawn by the tube.
    - Efficiency measurement requires the accurate RF power measurement and the accurate measurement of the prime power drain of the HVPS/modulator when feeding the tube.

Radar MPM and their specifications:

Radar systems use modulated waveforms and directive antennas to transmit electromagnetic energy into a specific volume in space to search for targets. Objects within a search volume will reflect portions of this energy, echoes, back to the radar. These echoes are then processed by the radar receiver to extract target information such as range, velocity, angular position and other target identifying characteristics.
Radars are classified by the types of waveforms they are:

1. Continuous wave radar.
2. Pulsed radar.

Continuous wave radar:

Continuous wave RADAR sends out a signal of a known frequency. Echoes from targets shift away from the transmitted signal's frequency (Doppler Effect). A disadvantage of continuous wave systems is they can only detect moving targets because targets at rest do not cause a Doppler shift.

This type of RADAR can be bulky because it requires 2 antennas, but it is more difficult to jam than a pulsed system. Because continuous wave RADAR does not pulse, a basic system can be simpler in design than pulsed systems, use a lower peak power, and have no absolute minimum or maximum ranges for most detection only uses.

Pulsed Radar:

A pulsed RADAR system sends out a pulse containing a signal of a known frequency. The time that it takes for the echo to return is used to compute the distance from the RADAR site to the target. A pulsed RADAR system can detect moving and stationary objects. Pulsed RADAR systems can be constructed with a single antenna where the antenna is switched between transmits and receives signal paths.

Pulse width:

- Pulse width is defined as the duration of the pulse transmitted.
- The pulse width (τ) of the transmitted signal is to ensure that the radar emits sufficient energy to allow that the reflected pulse is detectable by its receiver.
- The amount of energy that can be delivered to a distant target is the product of the output power of the transmitter, and the duration of the transmission. Therefore pulse width constrains the maximum detection range of a target.

Pulse Repetition frequency:

- High pulse repetition frequencies allow the system to detect targets at shorter ranges since the system is less likely to be in transmitting mode when the pulse returns from its shorter trip. These same higher rates also increase the detection probability by allowing the system to do more averaging.

Phase Noise:

- Phase noise is a ratio of signal power to reflect signal power measured in a 1 Hz bandwidth at a given offset from the desired signal (carrier).
- Target is detected only if the Radar phase noise at the reflected frequency is less than the power of reflected signal.
- More Phase noise makes the probability of detection of target object by the radar system to minimal.
- Phase noise measurements can be made as absolute output noise level measurements.

We have done market survey based on these applications. Below table shows specification of MPM from different manufacturer.

Radar based MPM

			Performance Characteristics								Environment Characteristic		Mechanical Characteristic			
Sl No	Manufacturer	model	Frequency range in G Hz	RF input power in dbm	RF output power in W	Small signal Gain in dB	Pulsed width in sec	PRF in Hz	Duty cycle %	phase noise in dBc	operating temp	storage temp range	Size(LxHXW) in mm	Weight in kg	Advantages	Limitation
1	TMD	PTX7468	9 to 9.5	10 to ±1	8K	60	0.2 to 50u	40K	5	-80	55 to -45	NA	508x178x483	30	1. High output power and moderate pulse width gives more transmission power. 2.moderate PRF	1. Low operating temp 2.Large size and heavy weight.
2	TMD	PTX7626	16 to 17	5	2K	60	0.2 to 100u	20K	2	NA	85 to -40	90 to -40	300x160x50	5	1. High output power and moderate pulse width gives more transmission power. 2.Low size and light weight 3.High PRF	
3	TMD	PTX8610	16.25 to 16.75	10	2K	60	0.2 to 90u	3K	2	NA	71 to -54	95 to -54	304x180x75	5.5	1. High output power and moderate pulse width gives more transmission power. 2.Low size and light weight	1. Low PRF
4	TMD	PTX7437	9 to 9.5	5	8K	60	0.2 to 20u	20K	2	-60	50 to -55	NA	365x155x430	21	1. High output power and pulse width gives more transmission power. 2. Moderate PRF	1. High phase noise makes uneasy for radar system to detect target object. 2. Large size and heavy weight.
5	TMD	PTX8400	9.2 to 9.5	5	1K	55	0.2 to 100u	20K	5	NA	85 to -40	90 to -40	300x160x50	4.5	1. High output power and moderate pulse width gives more transmission power. 2.Low size and light weight 3.moderate PRF	
6	TMD	PTM6288	8 to 12	NA	8K	NA	0.2 to 50	10K	5	-65	71 to -40	95 to -54	338.48x186.7x72.5	16	1. High output power and moderate pulse width gives more transmission power. 2. moderate PRF	1. Low phase noise. 2. Large size and heavy weight.
7	TMD	PTM6263	8 to 12	NA	8K	NA	0.2 to 45	10k	2	NA	60 to -30	95 to -54	352.2x190x72.5	16.6	1. High output power and moderate pulse width gives more transmission power. 2. moderate PRF	1. Large size and heavy weight. 2. Low temperature range.
8	TMD	PTM7599	8 to 12	NA	8K	NA	0.2 to 100	150 K	5	-120	71 to -40	95 to -54	429x186.7x120	13+	1. High output power and high pulse width gives more transmission power. 2. High PRF. 3. Low phase noise makes easy detection of target by radar system.	1. Large size and heavy weight. 2. Low temperature range.

9	TMD	PTM7722	8 to 12	NA	4K	NA	0.2 to 150	150 K	10	-100	71 to -40	85 to -54	440x187x120	13.5+	1. High output power and high pulse width gives more transmission power. 2. High PRF. 3. Low phase noise makes easy detection of target by radar system.	1. Large size and heavy weight.
10	TMD	PTM6395	8 to 12	NA	8K	NA	0.2 to 20	40K	2	NA	60 to -30	95 to -55	240x120x56	10.75	1. High output power and moderate pulse width gives more transmission power. 2. High PRF	1. Low temp range.
11	TMD	PTX8200	4.5 to 18	0 to ±1	100	58	0.1 to ∞	100 K	100	-120	85 to -40	100 to -54	260x200x32	4	1. High output power and moderate pulse width gives more transmission power. 2. High PRF 3. Low Phase Noise makes easy detection of target by radar system 4. good temperature range	
12	TMD	PTX7464	9.5 to 10		8K	54	0.2 to 20u	50K	2	NA	60 to -55	95 to -55	344.2x175x66	7	1. High output power and moderate pulse width gives more transmission power. 2. High PRF	1. Low temp range.
12	L3 Communication	M1270	8 to 12	5	2K	55	0.1 to 80	50K	5	NA	85 to- 40	NA	276.84x154.64x50.88	4	1. High output power and pulse width gives more transmission power. 2. high PRF	
13	L3 communication	M1220	6 to 18	±1	60	50	200n	50K	NA	NA	85 to -54	NA	190.8x159x25.44	1.68	1. High PRF 2.Small size and light weight	1. Low output power. 2.Low pulse width
14	Thales	TH24021	8.9 to 10.5	0 to ±2	375 to 500	NA	0.3 to 100u	0.3 to 90K	10	-110	71 to -40	85 to -40	440x340x136	25	1. High pulse width and high output power gives more transmission power. 2.high PRF 3. Low phase noise makes easy detection of target by radar system.	1. Low Temperature range. 2. Large size and heavy weight.
15	Thales	TH24475	13.5 to 18	±3	110	NA	0.2 to 150u	100 K	15	-105	85 to -40	100 to -55	250x232x35	3	1. High pulse width and high output power gives more transmission power. 2.high PRF 3. good temp range 4. Low phase noise makes easy detection of target by radar system.	

Electronic Warfare (EW) MPM:

Electronic Warfare is a military action involving the use of electromagnetic energy to determine, exploit, reduce, or prevent the hostile use of electromagnetic spectrum as well as action which retains friendly use of electromagnetic spectrum.

EW is divided into three types:

1. Electronic Support Measures (ESM).
2. Electronic counter Measures (ECM).
3. Electronic Counter-counter Measures (ECCM).

1. **Electronic support Measures (ESM):** Electronic Support Measure is that division of electronic warfare which involves actions taken to search for , intercept, locate, record and analyze radiated electromagnetic energy, for the purpose of exploiting such radiations to support military operations.

2. **Electronic counter Measures (ECM):** Electronic Countermeasures are the actions taken to prevent or reduce the enemy's effective use of the electromagnetic spectrum. Two major actions of ECM are
   1). Jamming
   2). deception.

3. **Electronic Counter-counter Measures (ECCM):** The actions taken to ensure friendly, effective, use of the electromagnetic spectrum despite the enemy's use of EW are known as ECCM.

EW specification parameter and their effects:

1. **RF output power:** to increase the detection range of the target, high amount of average power is illuminated on target in jamming environment.
2. **Pulse Width:** long pulses are transmitted to increase the energy on the target with no loss in range resolution.
3. **Throughput Delay or pulse delay:**
   - The Pulse delay is the difference in time from when the TTL Pulse trigger is applied to the Pulse input connector to when the RF pulse is present. This is the time for the propagation through the system to activate the TWT Modulator as well as the time for the RF pulse to transmit through the TWT.
   - Pulse delay is an important parameter in range gate pull-off (RGPO) jamming. Here RGPO signifies that the jammer, upon receiving a radar signal duplicates after a certain regular pulse delay, a false signal larger than the radar return wave and transfers it to the radar so as to destroy normal range tracking of the target.

We have done market survey based on these applications. Below table shows specification of MPM from different manufacturer.

Electronic Warfare based MPM

			Performance Characteristics								Environment Characteristic		Mechanical Characteristic			
Sl No	Manufacturer	Model	Frequency range in G Hz	RF input power in dbm	RF output power in W	Small signal Gain in dB	Pulse width in sec	PRF in Hz	Duty cycle %	Pulse delay	Operating temp	Storage temp range	Size(LxHXW) in mm	Weight in kg	Advantages	Limitation
1	TMD	PTM6597	NA	NA	1.5K	NA	100n to 10u	400K	4	38n	71 to -54	90 to -54	308x152x129	14	1. High output power. 2. Less pulse delay. 3.High PRF	1. small pulse width
2	TMD	PTM6259	7.5 to 18	NA	200	NA	0.4u	15K	100	400n	60 to -30	65 to -54	323.8x175x103	16.6	1. High output power. 2.High PRF	1. High pulse delay 2.
3	TMD	PTX8200	4.5 to 18	0 to±1	100	58	0.1 to ∞	100K	100	150n	85 to -40	100 to -54	260x200x32	4	1. High output power and pulse width gives more transmission power. 2. high PRF 3. Small size and low weight.	1. High pulse delay.
4	TMD	PTX8207	4.5 to 18	0 to±1	140	60	0.1 to ∞	100K	100	130n	85 to -40	100 to -54	260x200x32	3.5	1. High output power and pulse width gives more transmission power. 2. high PRF 3. Small size and low weight.	
5	TMD	PTX8320	26 to 40	0	20	50	0.1 to ∞	20K	100	130n	85 to -40	100 to -54	250x200x40	4	1. High pulse width. 2. Low pulse delay. 3. Moderate PRF. 4. Small size and low weight.	1. Low output power hence low energy is illuminated on target
6	Applied System engineering	Model117	2 to 18	NA	1K	NA	0.07 to 15u	100k	1.5	200n	NA	NA	178.08x432.48x 546.96	29.25	1. High output power and pulse width gives more transmission power. 2. high PRF	1. High pulse delay. 2. Large size and heavy weight.

7	Applied System engineering	Model127	2 to 18	NA	1K	NA	0.07 to 15u	100k	2	200n	0 to 50	NA	178x483.26x648.36	31.5	1. High output power and pulse width gives more transmission power. 2. high PRF	1. High pulse delay. 2. Large size and heavy weight. 3. Poor temperature range.
8	Applied System engineering	Model167	1 to 18	NA	250	NA	0.05 to 100u	1M	50	200n	0 to 50	NA	223.26x483.36x725	41.4	1. High output power and pulse width gives more transmission power. 2. Very high PRF	1. High pulse delay. 2. Large size and heavy weight. 3. Poor temperature range.
9	Applied System engineering	Model174	1 to 18	NA	1K	NA	0.05 to 15u	400k	4	200n	0 to 50	NA	222.6x483.36x725	40.5	1. High output power and pulse width gives more transmission power. 2. Very high PRF	1. High pulse delay. 2. Large size and heavy weight. 3. Poor temperature range.
10	Applied System engineering	Model176	1 to 18	NA	1K	NA	0.07 to 100u	400k	6	200n	0 to 50	NA	311.64x483.36x725	58.5	1. High output power and pulse width gives more transmission power. 2. Very high PRF	1. High pulse delay. 2. Large size and heavy weight. 3. Poor temperature range.
11	Applied System engineering	Model177	1 to 18	NA	10k	NA	0.1 to 100u	100k	5	250n	0 to50	NA	356.16x483.36x776	121.5	1. Very high output power and pulse width gives more transmission power. 2. Very high PRF	1. High pulse delay. 2. Large size and heavy weight. 3. Poor temperature range.
12	Thales	TH24445	6 to 18	±2	200	NA	150n	NA	NA	NA	85 to -40	100 to -55	250x232x35	3	1. High output power. 2. Small in size and light weight.	1. Low pulse width.
13	L3 communication	M1282	26 to 40	0	20	45	100n	50K	0 to 100	NA	70 to -40	NA	190.8x216.24x31.25	2.7	1. High PRF 2. Small in size and light weight.	1. Low output power. 2.Small pulse width
14	L3 communication	M1221	6 to 18	0 ±1	60	50	NA	50K	NA	NA	85 to -54	NA	198.44x190.8x31.25	2.47	1. High PRF 2. Small in size and light weight. 3. Good temp range	1. Low output power.
15	L3 communication	M1201	6 to 18	0 ±1	80	50	NA	50K	NA	NA	85 to -40	NA	273x178x31.25	2.7	1. High PRF 2. Small in size and light weight. 3. Good temp range	1. Low output power.

Communication MPM and their specifications:

Military communications is no different than the rest of the world's communications they want it smaller, lighter, covering more bands and carrying more voice and data.

Communication transmitters are used for the following type of communication:

1. Point to point line of sight communication.
2. Space borne communication.
3. Satellite uplink and downlink.

Group delay: Group delay is a measure of the time delay of the signal envelope propagating through the device. Flat group delay is required for avoiding waveform distortion. This signal distortion can degrade the Bit error rate (BER) of the system.

Intermodulation distortion:

- Intermodulation distortion occurs from tube nonlinearities and in multichannel communication system the third order Intermodulation distortion changes by 3db for every 1db change in the input level.
- This causes interference in the adjacent channel and also decreases output power without any corresponding changes in the prime power required to supply the TWT. This decreases the efficiency.
- Intermodulation products are most easily measured using a spectrum analyzer. Proper care must be taken to isolate the various signal sources from each other.

AM/PM conversion:

- It is measure of the amount of undesirable phase deviation (the PM) which is induced by amplitude variations inherent in the system.
- This undesired PM is caused by unintentional amplitude variations such as power supply ripple, thermal drift, or multipath fading.
- This is critical parameter where phase (angular) modulation is employed because undesired phase distortion causes analog distortion or increases BER in digital system.
- AM/PM conversion is one of the fundamental contributors to BER, and so it is important in qualify this parameter for communication system.

Communication based MPM

			Performance Characteristics								Environment Characteristic		Mechanical Characteristic			
Sl No	Manufacturer	model	Frequency range in G Hz	RF input power in dBm	RF output power in W	Small signal Gain in dB	Pulse width in sec	Band width in Hz	Duty cycle %	Group delay in sec	operating temp	storage temp range	Size(LxHXW) in mm	Weight in kg	Advantages	Limitation
1	TMD	PTX8208	7.9 to 8.4	0	100	58	0.1 to ∞	500M	100	2m	71 to -40	100 to -54	260x200x60	3.7	1. High output power gives more transmission power. 2. Good temp range 3. Small size and low weight.	1. High group delay.
2	TMD	PTX8209	13.5 to 14.5	0	110	58	0.1 to ∞	1G	100	1n	71 to -40	100 to -54	260x200x32	3.7	1. High output power gives more transmission power. 2. Good temp range 3. Small size and low weight.	
3	CPI	MKT164	7.9 to 8.4	NA	3K	77	NA	500M	100	0.1n	50 to -10	80 to -40	485x445x711	81.7	1. High output power gives more transmission power. 2. Small group delay.	1. Poor temp range. 2. Large size and heavy weight.
4	CPI	T04X0	7.9 to 8.4	NA	400	52	NA	500M	100	0.01n	55 to -40	75 to -40	260x267x521	25	1. High output power gives more transmission power. 2. Good temp range 3. Small group delay.	1.Large size and heavy weight
5	CPI	S5X1	7.9 to 8.4	NA	200	70	NA	500M	100	0.03n	50 to -10	NA	483x178x661	39	1. High output power gives more transmission power. 2. Small group delay.	1.Large size and heavy weight 2.Poor temp range
6	CPI	VZX-6986J4/J6	7.9 to 8.4	NA	2.5K	79	NA	500M	100	0.02n	50 to -10	70 to -20	483x310x610	41	1. High output power gives more transmission power. 2. Small group delay.	1.Large size and heavy weight 2.Poor temp range
7	CPI	VZX-6987V7	7.9 to 8.4	NA	750	75	NA	500M	CW	0.01n	55 to -40	75 to -40	368x333x610	39.5	1. High output power gives more transmission power. 2. Small group delay. 3.Good temp range	1.Large size and heavy weight
8	CPI	TL05X0	7.9 to 8.4	NA	500	72	NA	500M	CW	NA	60 to -40	71 to -40	267x216x432	14.5	1. High output power gives more transmission power. 2.Good temp range	

9	CPI	T01T0	14 to 14.5	NA	70	41	NA	500M	100	0.01n	55 to -40	NA	219x219x400	13.6	1. low group delay	1. Low output power. 2. Poor temp range.
10	CPI	VZX-6987A7	7.9 to 8.4	NA	750	78	NA	500M	100	0.01n	50 to -10	70 to -40	483x222x610	43	1. High output power gives more transmission power. 2. Small group delay.	1.Large size and heavy weight 2.Poor temp range
11	CPI	VZX-6984A4	7.9 to 8.4	NA	400	78	NA	500M	100	0.01n	50 to -10	70 to -40	483x133x610	31.8	1. High output power gives more transmission power. 2. Small group delay.	1.Large size and heavy weight 2.Poor temp range
12	Thales	Th24068	14.5 to 15.5	0	100	NA	NA	1G	CW	0.01n	85 to -40	100 to -55	250x232x35	3	1. High output power gives more transmission power. 2. Small group delay. 3.Good temp range 4. Small size and light weight.	
13	L3 communication	M1021	14 to 14.5	22 ±2	40	30	NA	500M	NA	2n	55 to -30	NA	260x240x60	4.5	1. Low group delay. 2. Small size and light weight.	1. Low output power. 2.poor temp range
14	L3 communication	M1030	14 to 14.5	18 ±3	125	30	NA	500M	NA	2n	55 to -30	NA	260x240x50	4.5	1. High output power gives more transmission power. 2. Small group delay. 3.Good temp range 4. Small size and light weight.	1. Poor temp range.
15	L3 communication	M1125	27.5 to 31.5	14 ±2	40	45	NA	4G	NA	2n	70 to -30	NA	305x255x50	5.3	1. Low group delay. 2. Small size and light weight.	1. Low output power. 2.poor temp range
16	L3 communication	M1025	14 to 14.5	22 ±2	80	30	NA	500M	NA	2n	55 to -30	NA	260x240x50	4.5	1. Low group delay. 2. Small size and light weight.	1. Low output power. 2.poor temp range
17	Xicom	XTRD-100K	13.75 to 14.5		100	70	NA	750M	NA	0.01n	50 to -10	70 to -50	595x482.6x133.6	21	1. High output power gives more transmission power. 2. Small group delay.	1.Large size and heavy weight 2.Poor temp range
18	Xicom	XTRD-100T	14 to 14.5		95	62	NA	500M	NA	0.01n	50 to -10	70 to -50	660.4x482.6x132.6	23	1. High output power gives more transmission power. 2. Small group delay.	1.Large size and heavy weight 2.Poor temp range
19	Xicom	XTRD-4000DB	14 to 14.5		400	65	NA	500M	NA	0.01n	50 to -10	70 to -50	660.4x482.6x132.6	23	1. High output power gives more transmission power. 2. Small group delay.	1.Large size and heavy weight 2.Poor temp range
20	Xicom	XTRD-450D	13.75 to 14.5		450	75	NA	750M	NA	0.01n	50 to -10	70 to -50	609x177x431.8	34	1. High output power gives more transmission power.	1.Large size and heavy weight 2.Poor temp range

															2. Small group delay.	

4. Scientific and industrial MPM:

Scientific and industrial transmitters are used in following application:

1. Linear accelerator.
2. Radio therapy.
3. Microwave heating.
4. Instrumentation amplifier.

- For linear accelerator and radio therapy application Cw klystron or long pulse klystron with pulse width of 10us or more can supply the high power.
- Both klystron and magnetrons are used for microwave heating application for selective heating and irradiation.