

TMD

...the power in microwaves!



TMD

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When you choose a partner in the sophisticated field of microwave transmitter technology, your reputation for quality is in their hands. That is why it is essential for your partner to have a proven reputation of their own.

With 6 decades of experience behind us and some of the world's top engineers on board, TMD Technologies Limited has all the in-house skills and resources to bring you an impressive range of products and services that can be customised into the totally dependable solutions you need. All of which contributes to our reputation as a world leader in our field: **a reputation you can trust with your own.**



The power in microwaves

TMD Technologies Ltd (TMD) is the world's foremost supplier of rugged high power amplifiers and transmitters for Radar and Electronic Warfare (EW) applications. The company supplies most of the major Radar and EW systems companies worldwide, where it has gained an unrivalled reputation for technical innovation, particularly in the area of low noise performance. We are also an important supplier to the EMC Testing, Communications, Scientific and Medical markets.

In addition to rugged amplifiers and transmitters, our product range and capability covers microwave tubes, cathodes and electron guns, high voltage power supplies, instrumentation microwave amplifiers and special assembly projects.

History

The origins of TMD can be traced back to the high power klystron group of EMI which was involved with development of the first airborne radars during the 1940s. Since then, as part of EMI and later THORN, TMD has been responsible for many of the major technical advances in the microwave tube industry, and over the last 25 years has expanded into the areas of switched mode power supplies and transmitters with worldwide success.

In 1995 we completed a management buyout from THORN EMI to form an independent company conveniently located only 10 minutes drive from London's Heathrow airport. In the last 15 years we have expanded our markets, which had traditionally been military, to include more commercial applications.

TMD provides its customers with a powerful design and engineering capability, based on over 60 years' experience in the complex field of high power

microwave technology, supported by an experienced, worldwide network of local representatives.

We continue to invest in engineers of superior calibre and experience, which, together with our innovative design philosophy, ensures that the company stands technically at the forefront of the industry.

In 2004 we were delighted to win our first UK Queen's Award for International Trade, having achieved £18 million of overseas sales over three years. This was closely followed in 2005 by another Queen's Award for Innovation, relating to our work in low noise power supply design.

The world's first high power klystron developed by EMI Electronics in the 1940s.



Precision electron gun assembly.

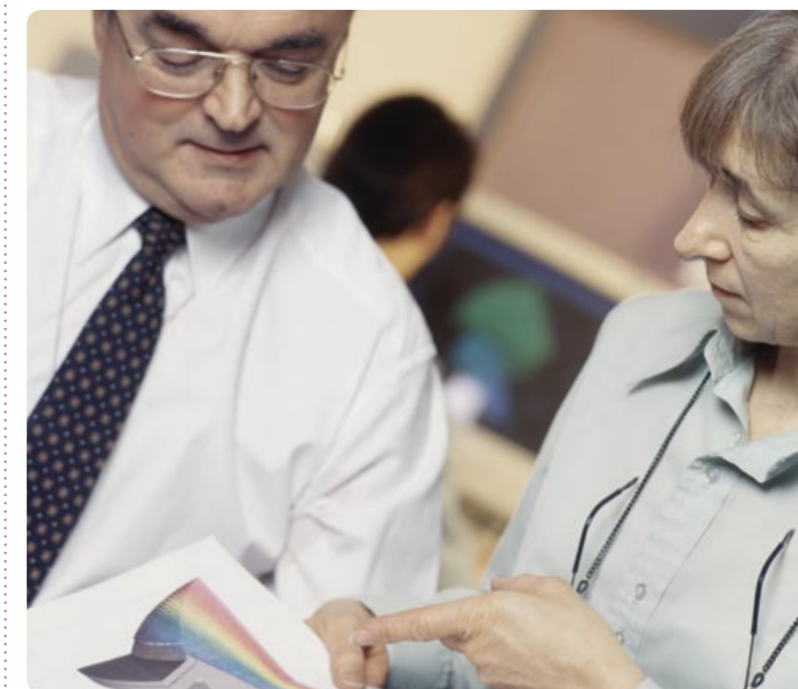
Commitment to research and development

Since 1989, we have invested more than 8% of our annual sales in research and development of new products and technologies. This investment is more than doubled by customer-funded developments of products specific to major programme needs. As a result, we have introduced many new products into the marketplace.

We work closely with many universities and research and development agencies, for example in such programmes as "The Faraday Partnership". This initiative brings together industry experts, members of academia and research laboratories involved in RF engineering. Applications are wide ranging, and include linear accelerators, radiography, broadcast and multi-media distribution, X-ray and electron medical therapy. The programme is managed by CLRC (Central Laboratory of the Research Councils).

We also provide opportunities for students through sandwich courses and by offering vacation placements.

TMD provides its customers with a powerful design and engineering capability, based on over 60 years' experience...



Discussing the electron optics.



TMD transmitters were developed for the Search and Surveillance Supervision 2000 Radar on the Advanced Light Helicopter. (Photo from aviation-images.com)

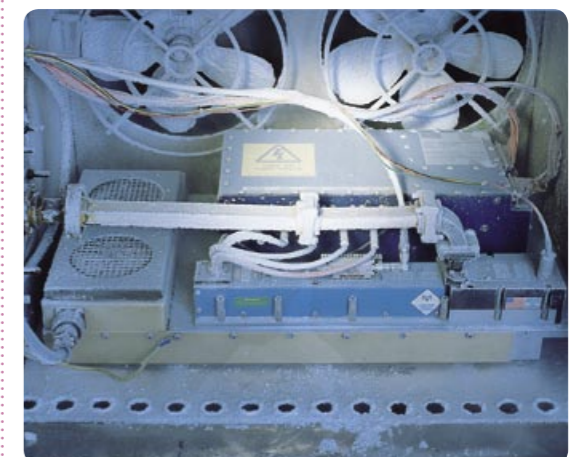
Rugged transmitters for radar, EW, and communications

We have used our understanding of both tubes and power supplies, and the complexity of their integration, to build a highly successful amplifier and transmitter subsystem business. The product range has grown rapidly and we are now accredited with the design and development of numerous subsystem products for land, air and naval operations, including complete transmitters. Our product range is driven by system technology and is customised to meet specific platform needs.

Many configurations are possible, according to customers' individual requirements; tube and power supply supplied separately; mounted on a base plate or supplied as a fully integrated rack-mountable unit including cooling fan, built in test facilities and other associated electronics.

One of our latest new developments is a range of CW and pulsed 2-18 GHz microwave power modules (MPMs) which combine compact power supply and mini TWT into an ultra-compact plug-in unit. This simplifies system design and installation, increases reliability and minimises safety hazards. The MPMs also feature excellent thermal management and high electrical efficiency.

'TMD's reaction was not only the best from the technical point of view, but also in time. So thank you very much, you have proved that it was the best decision to work with TMD.'



Power supply and TWT being tested at -40°C.

The following section describes the various markets in which our rugged amplifiers/transmitters/MPMs are used:

Radar

TMD's achievements in the radar transmitter subsystem market are numerous, covering L, S, X and Ku band products for land, air and sea environments. Various different forms are available including separate tube and power supply, 19" rack format and integrated units to specific customer outline. The radar market can be divided into several main areas:

Air Traffic Control

Since the 1970s, TMD has successfully supplied high reliability TWTs to Watchman radar users worldwide. A satisfied European customer recently commented: '...TMD has been giving outstanding work and support in maintaining the Watchman S band radar and has solved a significant problem in one of our radars by providing a brand new tube in a very short period of time...'

With the company's continued progress in power supply design, the latest natural development has been a complete S band transmitter for ATC which includes TWT, power supply, BITE (built in test electronics) and cooling integrated into a standard cabinet.

Advantages for the radar system user include: high reliability, high efficiency, excellent low phase noise, ease of maintenance and through-life support. The transmitter is available in a single tube format or

with multi-tubes which accommodates the "graceful degradation" often required by the operator.

General Surveillance

This subsection includes such applications as search and rescue, airborne early warning (AEW), ground mobile air defence, anti-submarine warfare (ASW), terrain following radar (TFR) and maritime patrol aircraft (MPA).

TMD can supply amplifiers and, as for ATC, more complete transmitters if required.

Our S band transmitter used by a South American Navy vessel for general medium range surveillance is currently out-performing all other onboard radar.

A particularly challenging surveillance radar specification was demanded by the power amplifier module (PAM) at the heart of the Sentinel radar - the US Army's premier ground based air defence radar. The ultra low phase noise requirement was eventually achieved by our power supply development engineers. Following delivery of the first PAMs the customer remarked '...the performance is so good we are dancing on the table!' This work won us a large order from the US Army and a Queen's Award for innovation in 2005 (see power supply section for more details).

Synthetic Aperture Radar (SAR)

This technique provides for ground imaging at night, or in poor weather conditions.

A good example is a recent order we received for a new MPM from a major UK customer. This particular customer had been searching with some difficulty for a transmitter source to meet his specification and was delighted to find, on witnessing a unit on test, that TMD had just developed exactly what he needed. In this case the platform for the radar was a Britten Norman Islander aircraft but we also provide similar equipment for SAR applications on UAV platforms such as "Global Hawk".

...multi-tube transmitters accommodate the graceful degradation often required by the operator.



Synthetic aperture radar dome (courtesy EADS Astrium) on the Britten Norman Islander aircraft (courtesy DSTL).

Fire-Control and Guidance

A fire-control radar provides information (mainly target azimuth, elevation, range and velocity) to a fire-control system in order to calculate a solution which directs a weapon to hit the required target. This type of radar typically emits a narrow, intense beam of RF ensuring accurate tracking information and minimising the chance of losing track of the target. The performance is highly dependent on the resolution of the radar.

RF Missile Seekers

The technology is similar, but in this case the fire control radar is integrated within the missile itself. There is a major growth area for TMD in the supply of transmitters built around high duty Ku band TWTs. We have designed and developed a special ring loop structure resulting in a much lighter, more compact assembly and are now supplying large production volumes to customers worldwide.

EW

Electronic Countermeasures (ECM)

This refers to any sort of electrical or electronic device designed to confuse or distract radar, sonar, or other detection systems.

This can be broadly divided into Jamming in which the purpose is to transmit a signal which interferes with the performance of the enemy's radar or Decoy in which a signal is transmitted to confuse an incoming missile. This is usually achieved by a towed decoy on an aircraft or ship or alternatively by firing the transmitting decoy into the air or sea.

TMD has been very active in the ECM market since 1990 and in 1994 we won a large power supply development contract for the towed decoy for Eurofighter which resulted in a large production order.

As with the radar market we have developed complex transmitter subsystems, CW, ICW or pulsed from 0.5 - 40 GHz, and have supplied many customised units worldwide - for naval, ground based and airborne ECM. Airborne applications are either on-board, pod mounted or towed (for decoys). Many platforms require full MIL-SPEC products although for certain ground benign and naval sheltered applications our instrumentation amplifiers may be suitable (see page 13).



TMD's new MPMs offer many user benefits for ECM, radar and communications applications.

Signals Intelligence Receivers (SIGINT)

Complementary to transmitter technology for radar and EW is the microwave receiver used for interception, direction finding and analysis of communications signals. Since the early 1980s TMD has been designing and manufacturing receiver systems for a variety of SIGINT applications, both tactical, strategic and for communications intercept.

Communications

TMD transmitter products are used in various harsh environment military communications systems (analogue or digital) from S through to Ku band. These include satellite uplinks from ground or airborne platforms (UAV or inhabited) and downlinks from airborne platforms (UAV or inhabited). In particular TMD's new ultra-compact, lightweight MPMs are especially suitable for wing mounted airborne platforms.

'...the performance is so good we are dancing on the table!'



Inspecting a high voltage power supply.

In 2005 our technical achievements in power supply design were recognised with a second UK Queen's Award - this time in the Innovation category.

High voltage, low noise **power supplies**

In the 1980s we began building a highly skilled team of power supply engineers and, in 1989, launched the first in a range of ruggedised military power supplies. These can be configured to drive virtually any manufacturer's TWT for use in a wide range of radar and EW applications worldwide.



Serving the radar and EW markets.

Eurofighter Typhoon (Courtesy BAE SYSTEMS) uses TMD high voltage power supply.



Potting a high voltage power supply.

The basis of the design is innovative switched mode technology, which offers many features desirable for modern radar and EW applications; high efficiency, ultra low voltage ripple (low noise), high inverter frequencies, ultra low pulse-pulse jitter, low throughput delay and high power density. The units are lightweight and compact with excellent thermal management, and employ a modular design for ease of maintenance. Modern software design tools are regularly employed including Protel, Orcad and PSPICE.

Many environments are extremely hostile in terms of vibration and temperature and we have designed TWTAs to operate from +120°C down to -60°C. Complex innovative solutions are often required and we are committed to continuously pushing the limits of our technology to serve our customers more effectively - for example by using highly accelerated life testing programmes (HALT) to expose any design weaknesses.

In recognition of TMD's high status within the aerospace and avionics industries, in 1994 we were awarded the contract to design and manufacture a new PSU for the Eurofighter Programme which led to several subsequent production contracts.

Pushing the boundaries of technology

There are many examples of how we have successfully tackled difficult challenges; for example, an EW customer required a power supply with throughput delay of 40 ns (the best they had been able to achieve was 76 ns). Although we considered this to be highly challenging, the contract was accepted and after nine months the target was achieved.

Other examples include the development of highly novel ceramic PCB substrates and silicon dipped components to reduce thermal expansion problems; and, as a result of one customer's need to dissipate considerable heat very quietly, we have designed one of the best heat management systems available.

We have also developed a new automated method for high voltage potting which consistently produces a very smooth and uniform texture. This significantly improves the reliability of the high voltage sections and, when necessary, is also easy to remove.

In 2005 our technical achievements in power supply design were recognised with a second UK Queen's Award - this time in the Innovation category. The subject of this award was a radar power supply with a noise figure of better than -140 dBc/Hz CW equivalent single sideband random noise and better than -80 dBc spurious noise. Current state-of-the-art, prior to this innovation, was typically -100 to -120 dBc/Hz random - TMD had achieved an improvement of better than 20 dB or a factor of 100 times. Again this resulted in a major contract from the US Army (see page 7).

We have developed a new automated method for high voltage potting which consistently produces a very smooth and uniform texture.



Assembling a high voltage power supply.

Instrumentation TWTAs and Solid-state amplifiers

Developed alongside the rugged amplifiers for radar has been a range of instrumentation amplifiers using TWTs or Solid-state technology for such applications as EMC/RF testing, radar simulation (training and calibration), jamming, satellite communications, Passive Intermodulation Testing (PIM) for space components, scientific experimentation and medical LINACs.



Assembling an instrumentation amplifier.

Exceptional reliability comes as standard

These products are based on the same switched mode power supply technology as the rugged amplifiers - with all the advantages of performance and reliability, but have been re-packaged for less demanding physical environments into compact, lightweight and affordable rack-mountable units, typically at 4U or 3U high.

A set of standard amplifiers covers the range between 1-40 GHz in both pulsed and CW versions. In addition, unusual products can be designed to customers' specific requirements if a slightly longer lead-time and higher price is acceptable.



At the cutting edge of innovation

Over the past 15 years TMD has proved itself to be a world leader in TWTA design innovation, offering particularly unusual products for a variety of markets and applications, many of which have proven to be unobtainable elsewhere. We have particular strength in the area of high power pulsed TWTAs (up to 40 kW) for HIRF testing, and have recently launched a new range of high power pulsed amplifiers at L band - providing over 6 kW.

Our strong involvement with science

For many years TMD has been providing TWT and Solid-state Amplifiers for scientific establishments such as CERN, and is an active member of the High Power Faraday Partnership.

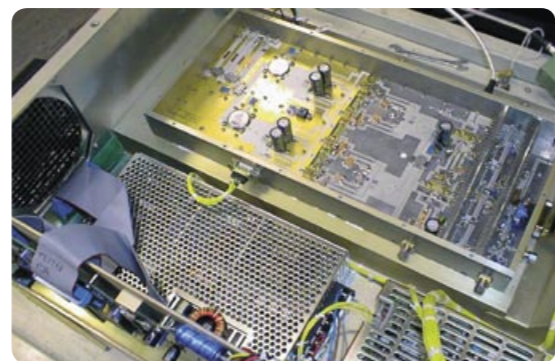
Projects we have been involved with have included: Driver Amplifiers for Anti-matter Experimentation (CERN in collaboration with Riken Laboratory, Japan), Amplifiers for the CERN CLIC Test Facility CTF3 and Kicker Amplifiers for Oxford University.

Repair service

We are able to provide a repair service for amplifiers - not necessarily of our own manufacture. Repairs have often been carried out at customers' premises at short notice - and for overseas customers, our close proximity to Heathrow airport is very helpful.

Solid-state Amplifiers

TMD also produces a range of Class C (high power, narrow band) Solid-state amplifiers covering the frequency range L-X band for radar IFF, UAV and medical and scientific applications. Options include phase control, pulsed or CW units.



TMD Solid-state amplifier.

...unusual products can be designed to customers' specific requirements...

Microwave tubes

TMD has over 60 years' experience in the design and manufacture of a wide range of pulsed and CW microwave tubes, which have gained a worldwide reputation for high reliability and long life. The extensive product range includes Klystrons, Travelling Wave Tubes (TWTs) and Magnetrons at frequencies from 1-18 GHz at peak power levels up to 1000 kW (pulsed).

We also operate a comprehensive evaluation and repair service for a wide range of tubes, not necessarily of TMD original manufacture, offering full warranty and enhanced performance.

Cathodes and Electron Guns - European Centre Of Excellence

During the 1970s and 1980s, the company was funded by UKMoD, ESA and US DoD to investigate the fundamental chemical and physical properties of impregnated tungsten dispenser cathodes, with the aim of extending the life of microwave tubes.

As a result, TMD is the recognised European Centre Of Excellence for dispenser cathode and electron gun

technology producing some tubes with lives of more than 90,000 hours. Our particular cathode expertise relates to the emission enhancing coating applied to the cathodes, which increases the emitted current density at a given temperature by over three times.

In order to maintain quality, cathode samples are evaluated for emission and surface purity prior to further tube processing. Cathode research continues today to ensure that we remain at the forefront of the technology. Current projects concern the development and manufacture of ultra fast-warm heaters, and very small cathodes for high duty Ku band TWTs.

We also provide a stand alone cathode and gun design and manufacturing service for customers. We can either work from drawings provided, or offer design assistance if required. This service includes batch sampling emission testing to ensure that the cathodes achieve the specified emission current density.



TMD TWTs have been designed for the demanding environment of the EH101. (Photo from aviation-images.com)

L Band air traffic control radar at Heathrow (Courtesy NATS).



Travelling Wave Tubes for high reliability

TMD manufactures three main types of TWT - ring loop, ring bar and coupled cavity. Applications include naval surveillance radar, air traffic control radar and airborne radar. Our TWTs are often combined with our own switched mode power supplies to produce TWTAs used in a variety of markets, both military and commercial, and in particular as part of radar transmitter subsystems.

The coupled cavity TWTs we produce for the Watchman air traffic control radar are providing up to 90,000 hours of service. This reliability is largely a consequence of our expertise in dispenser cathode technology. Latest TWT developments include rugged Ku band ring loop tubes for very demanding airborne environments.

Investment in tube design software

We have made significant investment in 'state-of-the-art' software design tools, including "Vector Fields" microwave modelling software, "SDRC Ideas" and "OneCNC" 3-D modelling CAD systems, "Cosmos" finite element analysis and MAFIA for simulation of design performance. This enables us to consistently design new products with optimised efficiency and high reliability, in a relatively short time.

Magnetrons for tough environments

TMD manufactures a wide variety of magnetrons with conventional and coaxial structures; fixed frequency or tunable, using dither or shutter tuning mechanisms. The latter, which achieves especially high agility rates, is unique to TMD and was developed during the 1970s and 1980s as part of many refinements to magnetron design, including work on improved frequency stability, reduced spectral noise and increased life.

Our magnetrons have proven their worth in many applications, including arduous helicopter environments for search and rescue radar and in fixed wing aircraft for terrain-following radars. An evaluation and repair service is provided for the many mature platforms still requiring support.

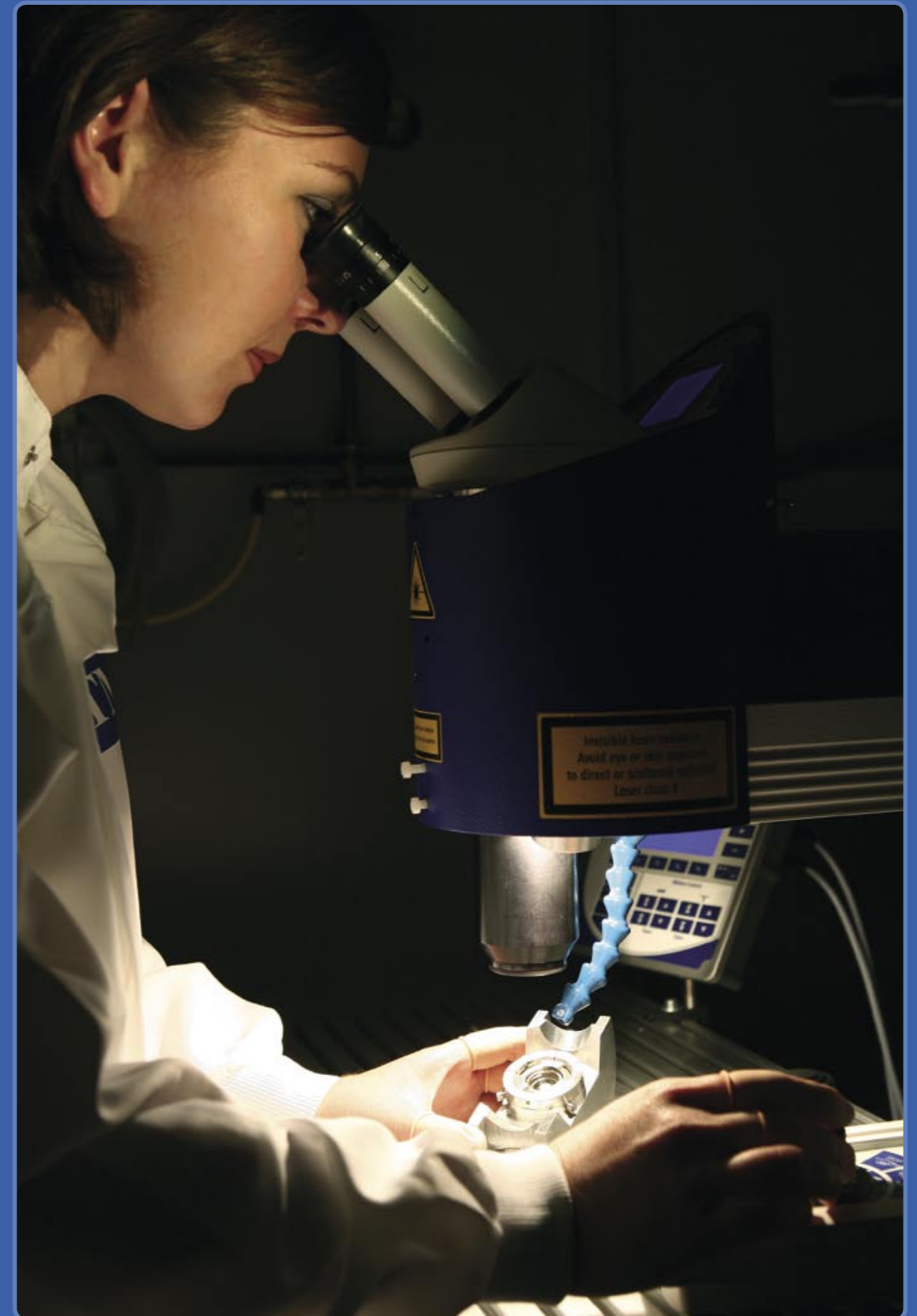
Klystrons that lead the world

Our klystron technology leads the world in terms of performance and reliability. We were responsible for much of the important development work on multi-cavity klystrons and resonant coupled cavity output in the 1960s, which enabled increased efficiency and wider bandwidths to be achieved. Markets are wide ranging and include military airborne radar, CW tubes for Satcom and high power linear accelerators for scientific research and medical applications.

TMD makes the world's only electro-statically focused klystron (ESFK), developed during the 1960s, which is at the heart of the Rapier Short Range Air Defence System (SHORADS). Current developments include new BBK's (broad band klystrons) for airborne radar and very high power tubes for particle accelerators.

Cathode research continues today to ensure that we remain at the forefront of the technology.

Cathode manufacture and test laboratory.



High precision laser welding.

Rugged Ku band ring loop tubes for very demanding airborne environments.

Special assembly projects

In order to fulfill the complex requirements of manufacturing microwave tubes, TMD has available a wide range of specialist skills, processing techniques and sophisticated equipment working to quality standard BS EN ISO9001:2000.

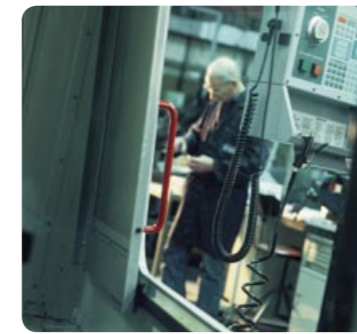
We offer these services to many other industries to produce simple or complex sub-assemblies for the telecommunications, laboratory/scientific, medical, automotive and ultra high vacuum industries. We combine many processes under one roof, with final inspection facilities and full traceability of materials, which is a particular advantage for the customer.



Precision assembly in clean environment.



Chemical cleaning.



Precision machining capability.



Brazing in hydrogen - fast cooling from 1100°C.

Typical services offered are as follows:

Precision machining - manual or CNC machining from customers' computer files

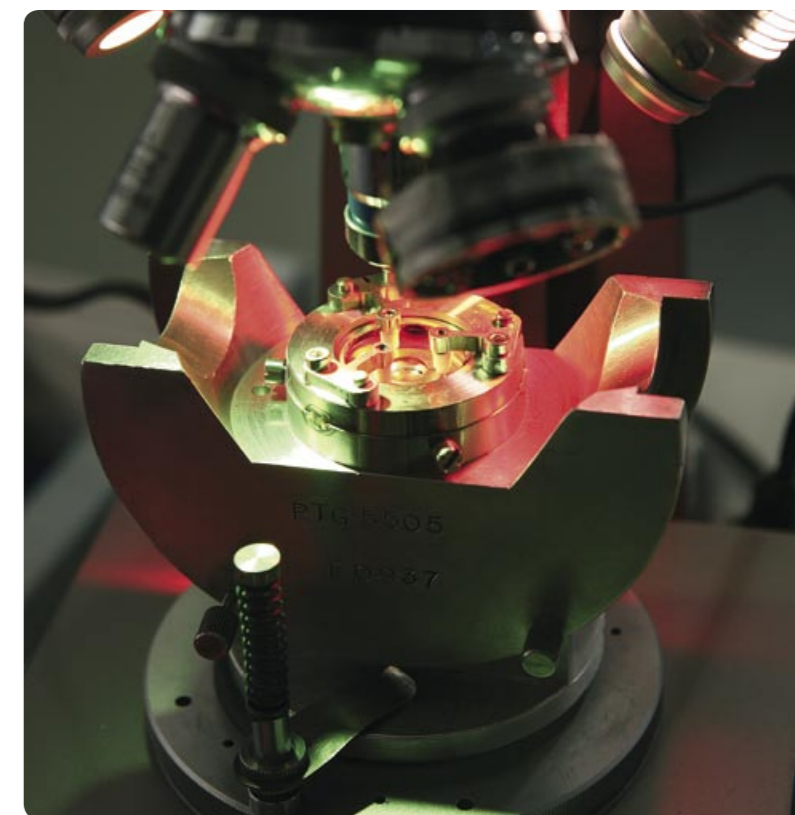
Chemical cleaning - static or ultrasonic cleaning by aqueous/detergent or other approved solvents, to standards in excess of BS7773

Heat treatment in hydrogen, vacuum, argon or air

Brazing in hydrogen, hydrogen/nitrogen or vacuum at temperatures ranging from 705 – 2000°C

Precision Assembly in a clean, controlled environment

As an example of one of our special assembly projects, a European manufacturer approached us with the challenge of producing a precision sub-assembly containing both metal and ceramic components. We were able to provide a complete service in-house, from machining the parts, through cleaning and surface treatment to the eventual assembly of the product. The customer was quick to report his satisfaction with the service, commenting that 'dealing with TMD has taken a weight off my mind. It is a quality company delivering a quality product.'



Precision 3D microscope.

'Dealing with TMD has taken a weight off my mind. It is a quality company delivering a quality product.'

Microwave tube technology for the next generation

What does the future hold for the microwave tube industry? It is true that some of the traditional areas of the industry are in decline and Solid-state technology has found a firm niche for low power applications below 3 GHz.



However a lot of nonsense has been talked during the last ten years regarding the ability of Solid-state to replace Tube Technology in high powered, high frequency microwave applications in both Radar and EW transmitters. Much of this is based on wishful thinking - especially in the realms of Radar at S Band and above and any form of high powered broadband EW application.

The plain fact is that - above these levels of operation Solid-state cannot 'cut the mustard', largely due to

gross inefficiency and weight. The average efficiency of a tube based solution in S Band is twice that of a similar configuration for Solid-state, and at X Band the tube solution is nearly three times more efficient!

This means lower energy consumption, a saving in fuel and ultimately fewer green house gas emissions. The cost of ownership is therefore lower with less damage to the environment.

Overall, tube technology has repeatedly and dramatically proved its superiority for high power, high frequency requirements in terms of reliability, performance, efficiency, cost and long-term support.

We are committed to remaining at the forefront of these new tube based developments, and are now developing multi-tube systems which offer the one advantage of Solid-state technology (graceful degradation) with none of the many disadvantages, with the bonus of improved energy efficiency!

TMD - green as well as blue!

In response to the requirements of new EU legislation "Restriction of Hazardous Substances" we are in the middle of a two year research and development programme to completely eliminate lead in our PCB assemblies; this is despite the fact that, as a supplier

of military equipment we have a partial exemption in the short term. This DTI funded project is being undertaken as a Knowledge Transfer Partnership (KTP) between TMD and CRDM Research, a Department of Buckinghamshire Chiltern University College.

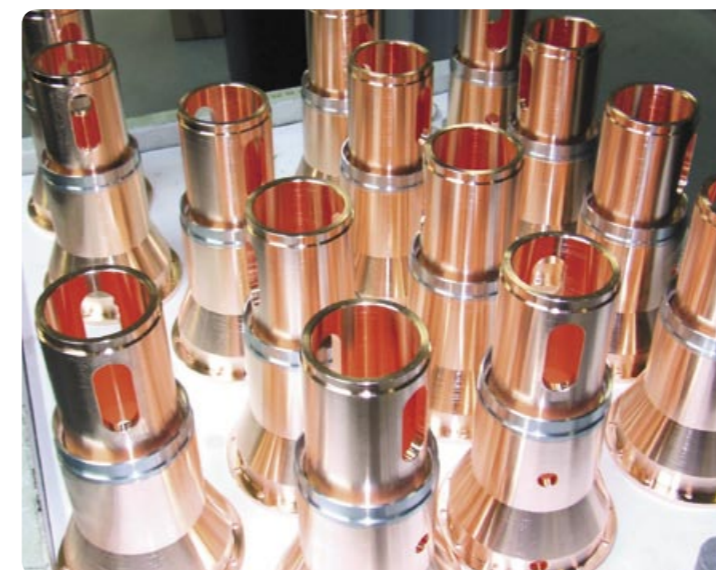
TMD means quality

TMD Technologies is regularly audited against, and approved to the rigorous quality standard BS EN ISO9001:2000. However our quality philosophy goes beyond this – seeking to instill quality awareness and continuous improvement in all departments and at all levels of the organisation.

The following are some of the most important aspects:

- Expert design of products at the outset, equates to optimum performance and reliability.
- Supplier improvement initiatives and ship to stock policies.
- The application of ESS (Environmental Stress Screening) and HALT (Highly Accelerated Life Testing) to expose any design or component weaknesses.
- Inspection and quality control during production and test.
- Photoflow quality control systems to reduce ambiguity and improve consistency.
- Development of 5S Initiatives taken from the Japanese approach to quality – (Sort, Set in Order, Shine, Standardise and Sustain).
- Systematic cause & effect failure analysis to enable problems to be solved quickly.

TMD operates a continual product and process improvement policy using customer feedback and live, regularly updated quality databases.



our commitment to you

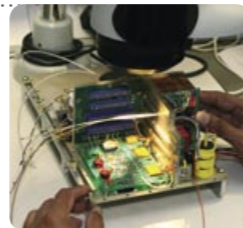


Teamwork to achieve a common goal

We believe that teamwork inspires individuals to achieve higher levels of performance through sharing knowledge and experience, and that working in teams provides greater support for us all to achieve our common objectives.

Quality in everything we do

Quality is an attitude of mind that drives us to eradicate inefficiency, waste and bureaucracy. We only accept the best, in the products we make and the work we do. Quality is thus about how we serve our customers and each other. We take pride in our work. TMD is accredited to BS EN ISO9001:2000

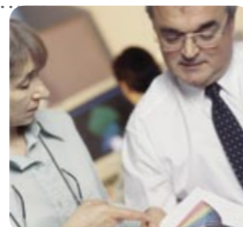


Constantly innovating

We value innovation and actively encourage new ideas. Our commitment to innovation helps us to improve continuously the way we work, the products we make and the standard of service we offer our customers.

Putting the customer first

TMD only exists for its customers. Our survival and prosperity depend solely on how well we meet their needs. We will behave with the highest level of professionalism, honesty and integrity and thus create a feeling of mutual respect.



our expertise

		Rugged Amplifiers & Transmitter Sub-systems	Microwave Power Modules (MPMs)	Instrumentation Amplifiers	Microwave Tubes				High Voltage Power Supplies	Special Assembly Projects	Microwave Receivers
					Broadband Klystrons (BBKs)	Travelling Wave Tubes (TWTs)	Magnetrons	Cathodes & Electron Guns			
RADAR	Surveillance	✓	✓	✓	✓	✓	✓	✓	✓		
	Guidance/ Fire Control	✓	✓		✓	✓	✓	✓	✓		
	Air Traffic Control	✓	✓		✓	✓	✓	✓	✓		
	SAR Imaging	✓	✓		✓	✓	✓	✓	✓		
	Simulation	✓	✓	✓	✓	✓	✓	✓	✓		
ELECTRONIC WARFARE	ECM	✓	✓	✓	✓	✓		✓	✓		
	SIGINT									✓	
	Simulation	✓	✓	✓	✓	✓		✓	✓	✓	
COMMUNICATIONS	Satellite Uplinks/ Downlinks	✓	✓	✓	✓	✓		✓	✓		
LABORATORY	EMC Testing		✓	✓	✓	✓	✓	✓			
	Scientific Research & Colliders		✓	✓	✓	✓	✓	✓	✓		
	Medical Accelerators		✓	✓	✓	✓	✓	✓	✓		
	High Power Component Testing		✓	✓	✓	✓	✓	✓			

✓ Market served by TMD product