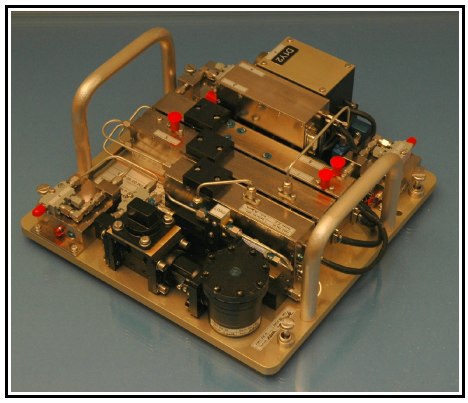
Spectral Line Systems Ltd

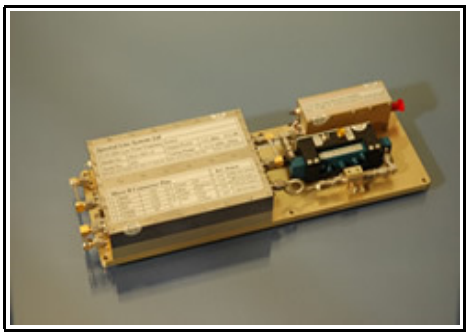
High Spectral Purity Microwave & RF Signal Sources

Research, Custom Design and Manufacture in Microwave, RF and Analogue Engineering

Ultra-Low Noise Signal Sources



Microwave / RF Sub-Systems

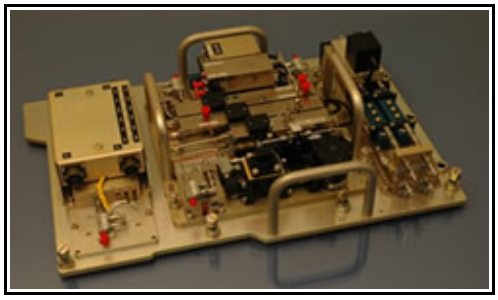


Custom Design Service

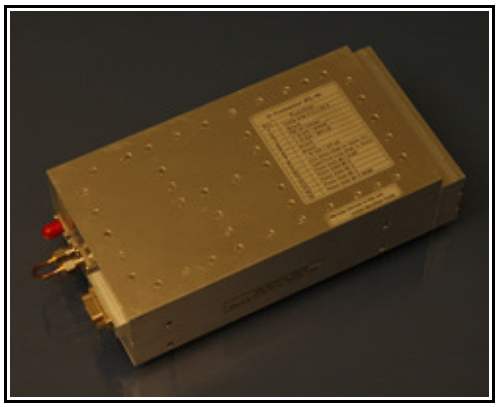
Manufacturing Capability

Company Profile

Spectral Line Systems Ltd specialises in the design and manufacture of low phase noise high spectral purity microwave and radio frequency sources for professional markets in radar, communications, instrumentation and research.



The Company was formed in 1990, and is now well established as a reliable supplier of sources and sub-systems for demanding applications.



Almost all of our products are custom-designed to meet customers' exact requirements with regard to frequencies, power levels, spurious signals, phase noise and packaging. We offer this service regardless of whether the order is for a one-off or for a substantial production run.

Although we have few standard products we have a large library of standard proven designs and techniques, which is constantly being expanded by private venture research and development work. In response to a customer's specification we are able to draw upon this stock to provide an efficient route to meeting the requirement. Part of our design library is made available to Universities and Colleges through our "Curikela" range of RF Circuit Development Kits.

Designing for reliable and cost effective production is an important part of our business. We manufacture all of our products in-house, production runs varying from one-off to several hundred. All stages of design and production are subject to a strict quality control system, ensuring that the customer receives a product which will function reliably throughout its service life.

In addition to the core business of Microwave and RF Sources and Sub-Systems, we are always pleased to consider other work utilising our experience in general microwave, RF and analogue engineering. A recent example, our Electronic Pole Sounding Hammer, is included in this web site.

Now in 2010, our 21st year in business, we take this opportunity of thanking all our customers, large and small, who have supported us over the years.

Location

Spectral Line Systems Ltd is located on the Isle of Harris in the Western Isles of Scotland. The Company enjoys a central position in Tarbert, the main centre of population in Harris. Tarbert may be easily reached by flights from Edinburgh, Glasgow, Aberdeen and Inverness to Stornoway. Visiting customers can find comfortable accommodation in the Harris Hotel, which lies only 50 metres from the premises, or in the Hotel Hebrides at the ferry terminal, only 5 minutes walk away.

The Tarbert facility is housed within a modern purpose-built building divided into three areas, these being the Research and Development Laboratory, the Electronic Production area and the Machine Shop.

We are always pleased to welcome visitors with a professional interest, whether or not there is any immediate prospect of work. When we first re-located R & D and Production to Harris in 1996 we could see many advantages of such a move, but were somewhat concerned that customers and potential customers would be reluctant to travel so far to visit us. We need not have worried – our visitor book now runs to several volumes!

Customers flying from the main Scottish airports can easily visit us for a 4-hour meeting and return the same day by early evening. When travelling from other U.K. Airports it is better to allow for an overnight stop in Harris, or alternatively in or around Stornoway for an early return flight the next morning. Visitors travelling by road can reach Tarbert by car ferry from Uig in Skye (1h 40min) or Stornoway from Ullapool (2h 45min).

We also maintain a Sales and Design Office in the village of West Linton near Edinburgh. This facility is useful for meeting customers and suppliers who may not have the time to travel to the Western Isles.

The telephone numbers and links below will provide useful information for intending visitors:

Ferries:	www.calmac.co.uk
Airlines:	www.hial.co.uk/stornoway-airport.html
Car Hire:	www.stornowaycarhire.co.uk www.lewis-car-rental.com www.mackinnonselfdrive.co.uk
Hotels (Tarbert):	
Harris Hotel	www.harrishotel.com
Tel:	01859 50 2154
Hotel Hebrides	www.macleodmotel.com
Tel:	01859 50 2364
Hotels (Stornoway):	
Caberfeidh Hotel	www.caberfeidh-hotel.co.uk
Tel:	01851 70 2604
Tourist Information:	www.visithebrides.com
Main Branch Tel:	0845 22 55 121
Tarbert Branch Tel:	01859 50 2011
Stornoway Branch Tel:	01851 70 3088

News - Exhibitions

ARMMS Conference 2009

Spectral Line Systems Ltd exhibited at the Automated RF & Microwave Measurement Society (ARMMS) Conference and Exhibition on the 23rd and 24th of November 2009.

We also presented a paper entitled "Low Cost Production Phase Noise Measurements on Microwave and Millimetre Wave Frequency Sources" at the conference.

EMRS DTC Conference 2009

Spectral Line Systems Ltd exhibited at the Electromagnetic Remote Sensing and System Engineering for Autonomous Systems Defence Technology Centre Conferences and Exhibition in Edinburgh this year on 7th / 8th July 2009. These conferences serve to disseminate the research work of the ERMS and SEAS DTCs over the preceding period.

Held in the prestigious Edinburgh International Conference Centre (EICC), the venue provided an excellent and convenient city centre location for the occasion. Although small in terms of participating companies, the exhibition was very successful in that a large number of conference delegates visited the SLS stand.

Our central exhibit this year was our Ultra-Low Phase Noise Transmitter Drive System developed for a naval radar application. This system has proved very successful in service following completion of the production contract in October 2008. Also on show were our Ultra-Low Phase Noise Crystal Multipliers and Discriminator Stabilised Sources, plus our R.F. Constructional Kits for University and College use.

Research and Development

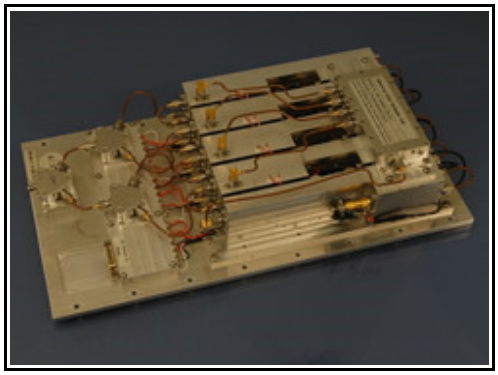
Being a small company in a relatively remote location we rely heavily on innovation to continue to win business. Maintaining an up to date well equipped R&D Laboratory is crucial to our success, especially in our particular field of expertise, Ultra Low Noise Microwave and RF Sources. Although the R&D Lab is concentrated on source development work, the wide range of microwave, RF and more general instrumentation available allows us to tackle components and sub-systems of many types involving frequencies from DC to over 20 GHz.

Our R&D activities consist of both internally and externally funded work. Current internal research topics include low noise directly swept frequency sources for FMCW radar and extensions to previous work on ultra low phase noise sources.

The outcome of our private venture R&D work may be either complete products or particular circuits and techniques which are added to our library of proven designs. Since change in the microwave and RF business is generally somewhat slower than in other areas of electronics, it is usually possible to derive many years of benefit from this work.

Although mainly focussed on frequency sources and related sub-systems, a certain amount of internally funded R&D is also devoted to innovative projects in other fields aimed at diversification of the business. We have, for example, recently developed a number of Impact Testers for applications ranging from assessment of wooden utility poles for rot to measuring the cushioning properties of elastomer's.

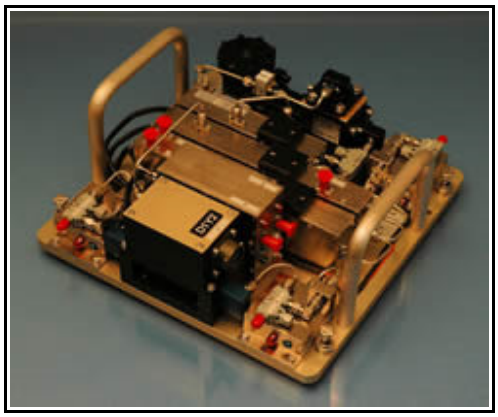
Throughout our nineteen years of trading we have also performed many customer funded research studies in a wide variety of topics in the microwave, RF and general analogue field. Examples include Emergency Radio Beacons, Radar Waveform Generation Studies and Deflection Amplifiers for Radar Displays.



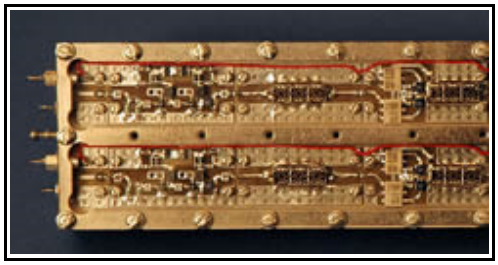
In the interest of retaining Intellectual Property Rights in our core business of low noise signal sources we generally finance fundamental research work in this area from our own resources.

Design

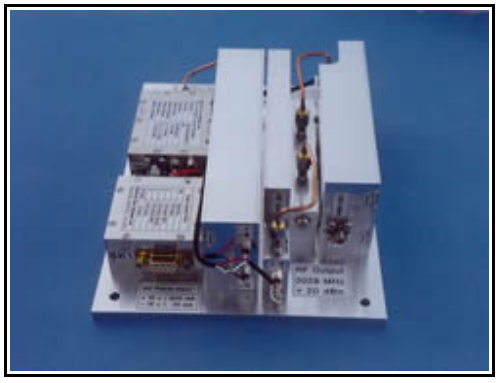
Custom designed Microwave and RF sources form around 75% of the Company's business. This type of design work usually involves adapting an existing design to meet the customers' particular requirements in respect of configuration, performance and packaging. Alternatively, where there is no existing overall design similar to that required, the system can be built up from proven circuitry and modules. Spectral Line Systems Ltd possesses a large library of such items at circuit board, sub-assembly and complete system level, enabling efficient design with a minimum of new R & D being required on each project. We are therefore able to quote firm prices for almost all such work.



Design projects vary enormously in complexity and hence in time to completion. Straight forward adaptations of existing designs for commercial purposes may take only a few days or weeks, whereas a complex systems project often runs through several years involving experimental and pre-production trials models before the final drawings are signed off for production.

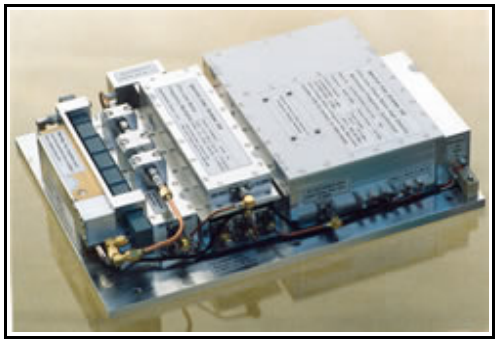


Our design knowledge lies mainly in the fields of Microwave, RF and Analogue Systems. Where a software or digital hardware element is necessary we have a collaborative agreement with Tirna Electronics Ltd, who have a wealth of experience in these areas.

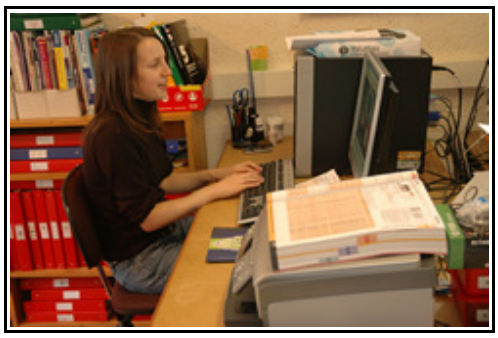


Designing for production is a serious part of our business, years of experience having shown that designing a new product for reliable operation and cost effective, trouble-free manufacturing is often more challenging than the initial step of getting the prototype to work on the lab bench.

In the case of relatively complex custom designed products, production quantities rarely exceed 100 off in our particular line of business. Having successfully completed a number of major production runs for demanding systems applications, we are fully confident of our ability in this area. Production quantities for simpler items such as Ultra-Low Noise Crystal Oscillators and VCOs may reach several hundred. Our maximum production quantity of a single product to date is approximately 400 off over several years.



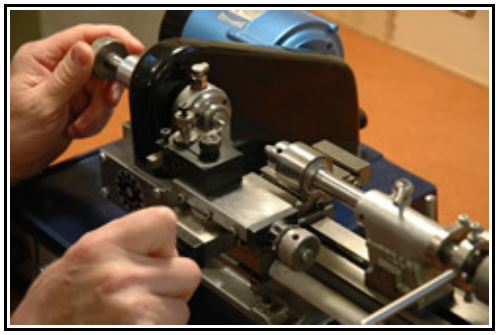
Production



Manufacturing starts with **Procurement**, often one of the most time-consuming stages of the job. Working from the components lists, parts lists and schedules of fasteners forming part of the drawing set, the various items required are ordered and consigned to a production store as they are received. Some commonly used items may be drawn from general stock and transferred to the production store, provided that all parts in the store are covered by a supplier's Certificate of Conformance.

In the case of single-sourced components, long lead items or devices suspected of having a short market lifetime, a generous spares allowance is made. Where such items are expensive the situation is discussed with the customer and a spares holding specified in the contract for warranty repair purposes. Sometimes it is necessary to have a component specially developed for the job by another company, and here Spectral Line Systems Ltd has extensive experience of preparing suitable sub-contracts. In low phase noise work reliance is often made on the noise performance of some component even although this parameter is unspecified in the data sheet. In such cases it is necessary to measure component batches for added phase noise and select for production.

Machined parts are either procured outside or manufactured in house according to quantity. Our in-house machining facilities although good are more on the scale of a tool room than a production machine shop. We have two such facilities similarly equipped, one in our Tarbert works and one in our South of Scotland base, the latter being used mainly for R & D prototypes. The Tarbert workshop produces small production batches of parts, and is invaluable when faced with excessive lead times quoted by outside machining companies.



We machine mainly in aluminium alloy, copper, brass and plastics, and are capable of manufacturing any mechanical part or assembly used in our designs, including waveguide components as well as items such as housings and baseplates. Our range of machine tools varies from CNC mills down to a minute watchmaker's lathe for work on small coaxial parts and semi rigid cables.

Unusually for a microwave and RF engineering company, we also have a substantial woodworking shop in which we manufacture all our own packing cases as well as high quality cabinets and enclosures for our "Curikela" range of RF constructional kits, and for some items of production test gear which do not require electromagnetic screening by the outer protective case.

Assembly & Test

The small batch sizes associated with our business result in most electronic assembly and test being performed manually. All components and pcb finishes are now lead-free, although tin/lead solders are still employed on some RoHS exempt work. Great care is taken to segregate the two types of soldering operation. The need for good ground planes in microwave and RF work gives rise to a high degree of heat sinking during soldering, making it frequently necessary to employ background heat, particularly in the lead free-case.

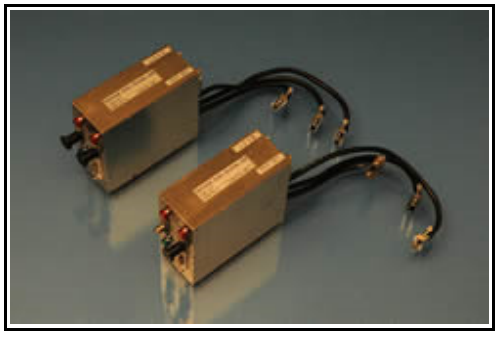
Anti-static precautions are taken in all stages of electronic assembly, and we consider it good design practice to include high-valued resistors to ground on all pcb input and output lines.

All assembled pcb's are fully inspected under the microscope before being installed in housings and powered up. We have found that virtually all potential faults due to assembly problems can be identified and rectified at this stage. Following final assembly and test, all sub-units are visually inspected once more before the units are sealed.

All production test gear is maintained in good order and kept in calibration. As with R & D instrumentation, we only buy new or refurbished items directly from the manufacturer, and use the manufacturers' calibration facilities wherever possible for all microwave and RF instruments.

In many production contracts, particularly for more complex sources and sub-systems, considerable effort is put into building special test gear for both sub-unit and final test to ensure production proceeds as smoothly and quickly as possible.

Following test, all sub-units and final assemblies are inspected, sealed and labelled, the label carrying the signatures of the persons responsible for test and inspection.

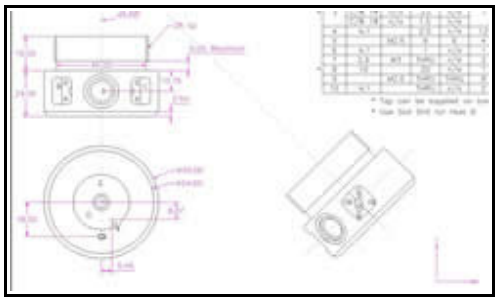


Production test gear requiring RF modules can often be assembled quickly using our "Curikela" range of RF constructional kits.

Quality Control

Our reputation and hence continuing business prospects depend heavily on ensuring that a reliable product is delivered to the customer. Effective quality control is essential to achieving this end.

Quality control starts at the design stage. Since engineers' working log books can be difficult to interpret at a later date (even by the author!), all initial design work and breadboard results for a project are formally documented in the form of typed up reports prior to the first design review.



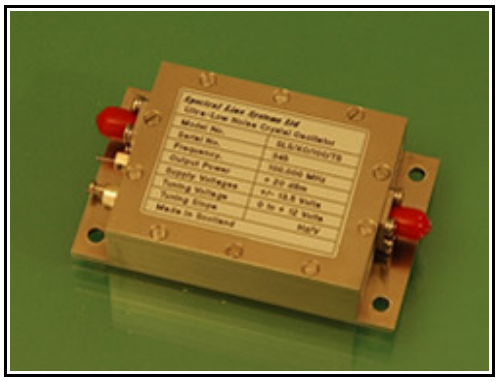
Once the bench model is working satisfactorily the production drawing set is created, each drawing being numbered according to a well established in-house numbering system. Drawing number P65C AD 02 03 00, for example, would denote that the item was the Assembly Drawing of Module 3 on Sub-Assembly 2 of Project P65 at the Production (C) stage. For each module, sub-assembly and the overall system the drawing set includes Functional, Outline, Assembly and Machining Drawings together with PCB Layouts, Test Specifications etc. Working rigidly to this system ensures that all products are properly documented and can be reproduced easily should a repeat order be received some time after the main production batch. Creation of a drawing set to this standard is a major part of the work involved in a project, but is regarded as of vital importance both by our customers and by ourselves.

Other aspects of Quality Control such as instrument calibration, stock control, inspection, etc have already been covered under Procurement, Assembly and Test. Our Quality Control is regularly monitored during important contracts by quality inspectors from our customers and also from their customers.

Upon completion all products are thoroughly tested and despatched with a Certificate of Conformance, full Test Results and Warranty. Great care is taken in packaging to ensure that items are not damaged in transit, many deliveries being made in high quality wooden packing cases manufactured in our own workshop.

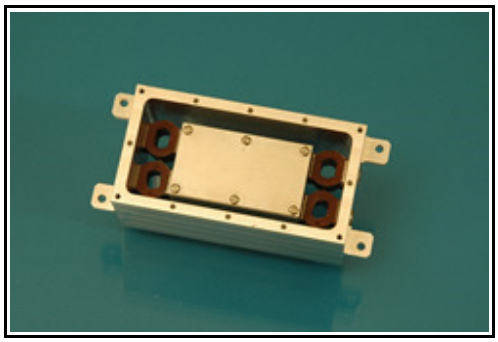
Crystal Multipliers

Crystal Multiplier Sources consist of a crystal oscillator (XO) followed by a frequency multiplier. Spectral Line Systems crystal multipliers are based on our long established series of ultra-low phase noise voltage controlled crystal oscillator (VCXO) designs. These designs are also available packaged as stand alone units, and can be supplied to the customer's specification of frequency, output power, supply voltage, tuning voltage range, packaging, etc. A 100 MHz version is shown opposite (photo 1), packaged for general use.



Photograph 1

All oscillators based on piezo-electric crystals are by their nature subject to phase noise degradation by vibration and acoustic noise. This can be mitigated by anti-vibration mounting, as shown here (photo 2), and by building acoustic absorbers into the outer enclosure walls and covers.



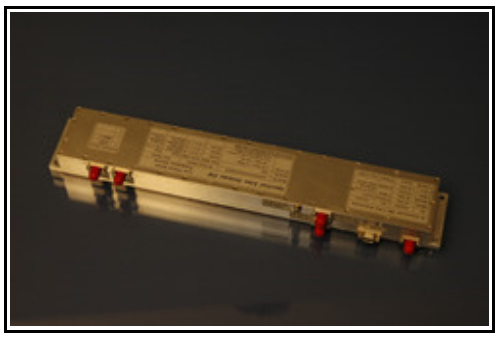
Photograph 2

For best phase noise performance above 100 Hz from carrier the oscillator frequency is normally chosen to lie in the range of approximately 75 to 130 MHz. Voltage tuning allows phase locking to a lower frequency reference signal (e.g. 10 MHz), to improve long term stability and phase noise in the sub 100 Hz from carrier region.

Multiplication of the crystal frequency to that of the desired output signal is normally based on either diode frequency doublers or step recovery diode (SRD) impulse generators. Doublers tend to be used for frequencies up to a few GHz, combinations of doublers and mixers sometimes being employed in order that any harmonic of the crystal frequency may be obtained. Photograph 3 shows a 1.0 GHz crystal multiplier implemented as 8 X 125 MHz, the unit being mounted on an anti-vibration suspended plate.

Photograph 3

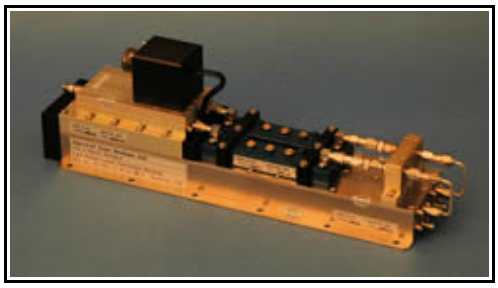
Photograph 4 shows a 640 MHz low noise crystal multiplier based on a 128 MHz VCXO. Auxiliary outputs are provided at 128 MHz and 512 MHz, and the 128 MHz VCXO is phase locked to an internal 10 MHz oven-controlled crystal oscillator (OCXO) via a low bandwidth loop for improved long term stability. Switching is provided to allow the use of an external 10 MHz reference if required.



Photograph 4

Crystal Multipliers (Ctd)

Photograph 5 shows a 2-channel microwave crystal multiplier with a common output amplifier. The lower unit contains two independent switched crystal multiplier chains producing 1,000 MHz and 1,040 MHz from 125 and 130 MHz crystals. Harmonics of the 1000/1040 MHz signals are generated by a pair of coaxial SRD's and the desired harmonics at 12.0 and 12.48 GHz selected by waveguide coupled cavity band-pass filters and combined in the output amplifier.

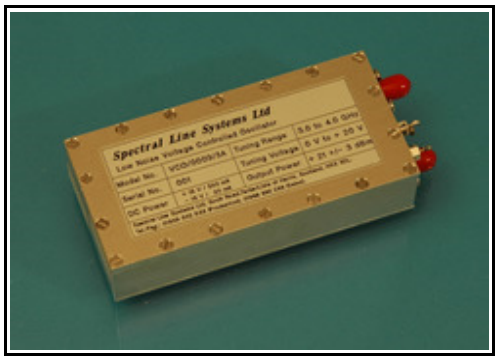


Photograph 5

The phase noise performance of a crystal multiplier unit can be theoretically predicted by increasing the oscillator noise by 20 log10 (multiplication ratio). In practice, the result will be degraded by the added noise of the multiplier. An oscillator of frequency 100 MHz with a noise floor of -170 dBc/Hz, for example, will result in a floor of around -127 dBc/Hz at 10 GHz.

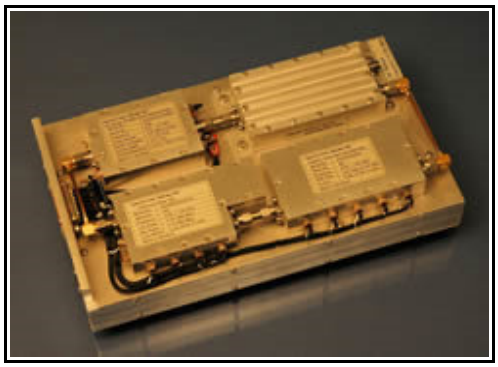
Discriminator Stabilised Sources

Discriminator Stabilised Sources consist of a voltage-controlled oscillator (VCO) stabilised by a frequency discriminator in a feedback loop from the source output to its tuning terminal. To obtain high loop gain and hence a high degree of phase noise reduction the source tuning slope and the discriminator sensitivity must both be as high as possible.



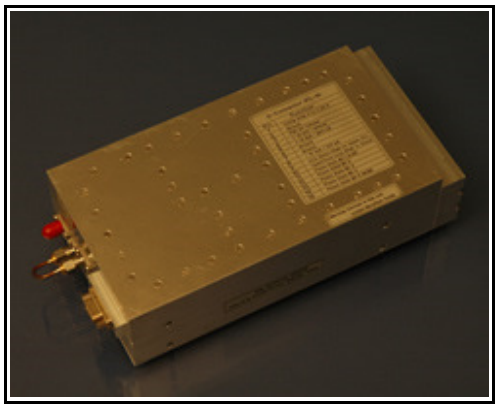
Photograph 1

Spectral Line Systems Ltd Discriminator Stabilised Sources are based on a series of low noise, high tuning sensitivity and high output power VCO designs. These designs are also available packaged as stand-alone units, and can be supplied to individual customers' specifications. The model shown in photograph 1 is typical of octave-band units in the 500 MHz to 2.0 GHz range with +20 dBm of output power.



Photograph 2

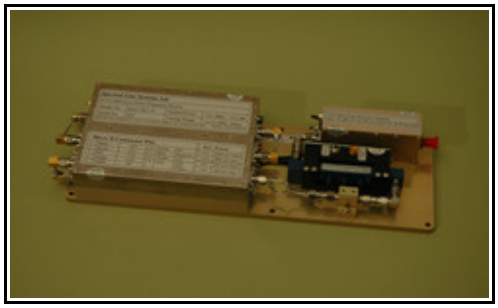
Frequency Discriminators are normally based on either delay line or resonator designs. Delay line discriminators tend to be used in the lower microwave region, and have the advantage of allowing the stabilised source to be tuned to any frequency over a wide operating bandwidth. This is done by including a suitable phase shifter in the feedback loop. Photograph 2 shows a 0.5 to 1.0 GHz source of this type. A similar source tuning over 0.75 to 2.0 GHz is shown in photograph 3. The latter source contains two VCO's to cover the wider frequency range.



Photograph 3

Photograph 4 shows a Ku-Band source based on a 1.0 GHz delay line discriminator stabilised VCO followed by a X 15 SRD frequency multiplier and output amplifier. For good long term stability the 15.0 GHz signal can be locked to an internal or external crystal controlled reference.

Photograph 5 also shows a microwave source module, this time based on a resonator discriminator. The technology employed in an X-Band version of this type of source is capable of providing 10 to 15 dB lower phase noise than the best available crystal multiplier in the 10 KHz to 100 KHz offset from carrier region. Ku Band versions show a similar improvement.

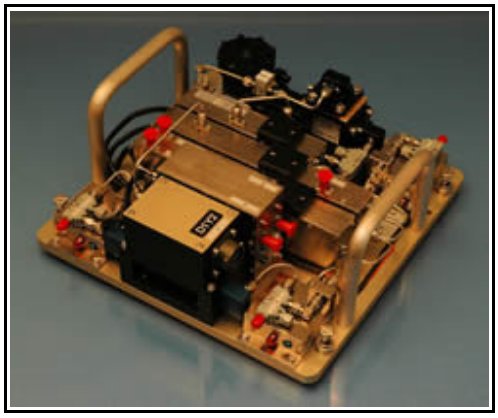


Photograph 4

Discriminator Stabilised Sources (Ctd)

In general, discriminator stabilised sources have lower far from carrier phase noise than crystal multiplier sources, at the expense of inferior close to carrier noise. Unlike crystal multiplier sources, however, a discriminator stabilised source can be tuned or frequency modulated over a relatively wide range from its design centre frequency.

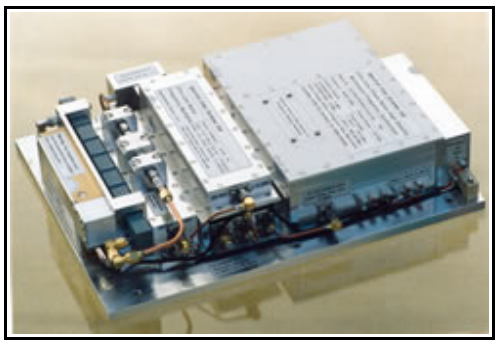
A further advantage of discriminator stabilisation is that any power amplification following the source can be included within the feedback loop. This greatly reduces the added phase noise requirement of the power amplifier, which is often a problem when amplifying other types of low phase noise source to high power levels. Discriminator stabilised sources are therefore ideal for use with high power tubes, where both the tube and the drive amplifier can be included within the loop. Note that the effects of tube high voltage power supply ripple giving rise to FM spurious signals are also greatly reduced by including the tube within the loop.



Photograph 5

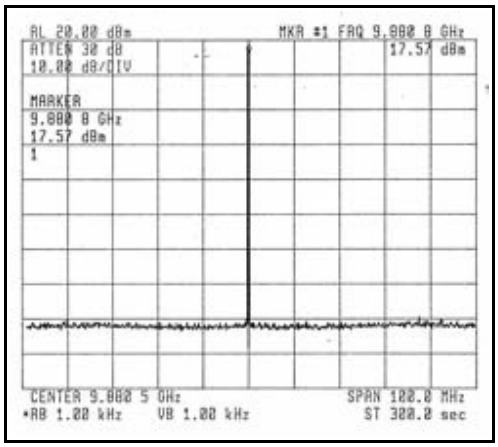
Frequency Synthesizers

Spectral Line Systems Ltd specialises in high spectral purity low phase noise synthesizers generating a relatively small number of channels. This type of synthesizer finds applications in Doppler radar and other systems where noise and spurious signals must be kept to a minimum.

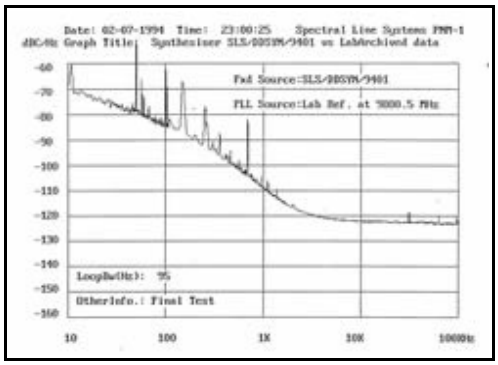


Synthesizer Example

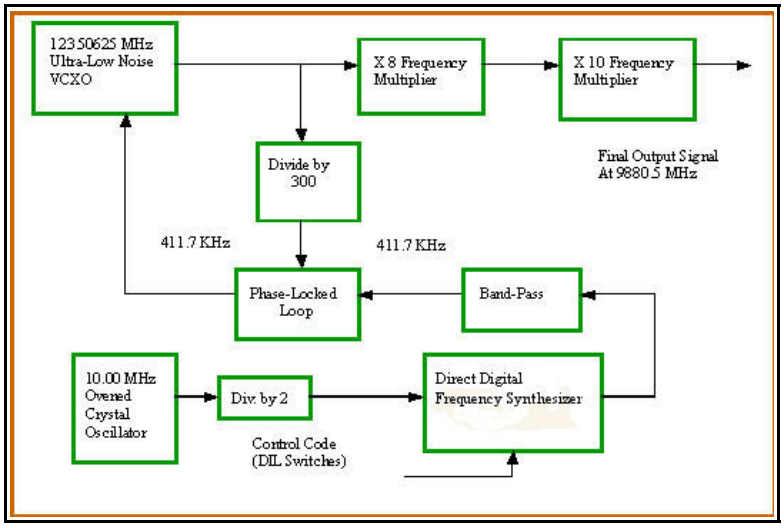
The photograph opposite shows an example of a low noise synthesizer generating a number of frequency channels centred on 9880.5 MHz.



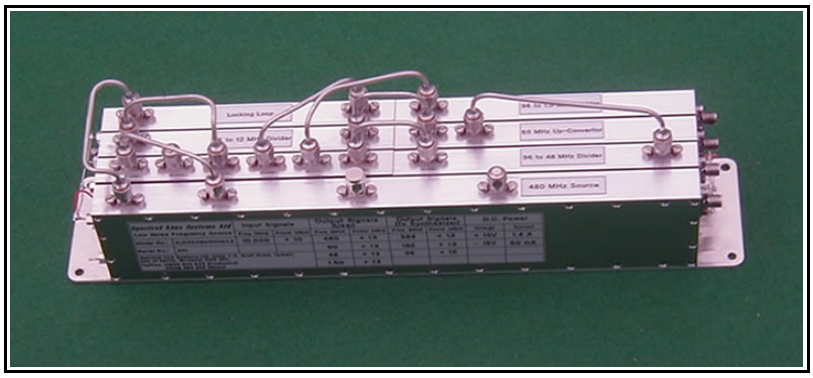
This synthesizer was made for use as the receiver local oscillator in a customer's research programme investigating the effects of phase perturbations in the propagation path of signals received from communications satellites. In addition to a requirement for exceptionally low phase noise and spurious signals, the output signal long term frequency stability had to be much better than obtainable from the ultra-low phase noise crystal oscillator multiplied up to the final output frequency. A further requirement was that the output frequency should be adjustable in 7 KHz steps over a small range, to compensate for ageing and Doppler shift in the signal transmitted by the satellite. An auxiliary 10 MHz output signal locked to the microwave signal was also required for the synchronisation of other instrumentation.

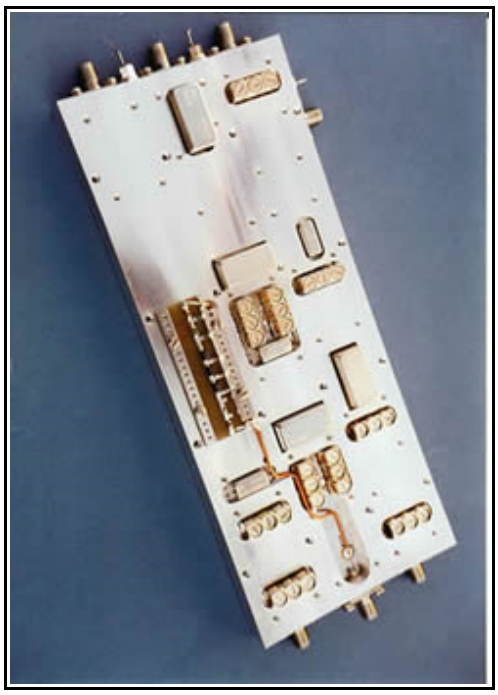


The block diagram below illustrates the technique employed to meet all of the above requirements.



Microwave and RF Sub-Systems

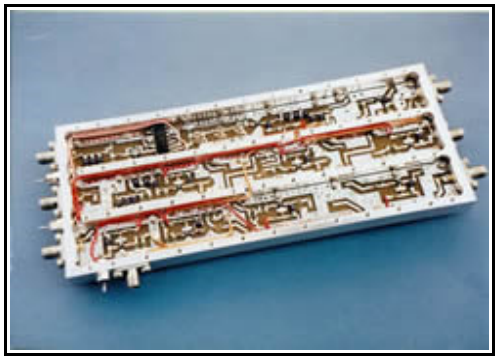




Spectral Line Systems Ltd has designed and manufactured a wide variety of microwave and RF sub-systems over the company's 19 years of trading. The photograph above, for example, shows a receiver / local oscillator unit designed for use in a navigation system.

Note that the construction, although compact, allows full access to all of the input and output signals on each module, greatly simplifying servicing. Another noteworthy feature of all of our sources and sub-systems is that each unit carries a label providing full details of all DC, logic and RF input and output signals, avoiding the need for the service engineer to consult manuals while performing field tests.

A further advantage of the above construction is that all semi-rigid coaxial cables are formed as U-pieces, enabling their removal and replacement without risk of damage, and without having to loosen any housings. This interconnection principle is firmly adhered to in all of our products.



The photographs to the right show a typical RF module from a sub-system such as that shown above. Building in narrow linear channels wherever possible minimises signal leakage, and is important in all RF work, especially in the case of sources and receivers. Note also that the design allows all of the filters to be tuned with the covers in place on the circuitry side of the module.

Once completed, all sub-systems are exceptionally thoroughly tested to ensure full compliance with the specification, the complete set of test results being despatched with the unit, along with a Certificate of Conformance.

Academic RF Constructional Kits

Sold under the brand name of **“Curikela”** (pronounced "coor é kéla") Spectral Line Systems Ltd manufactures RF Development Kits for use in universities, colleges and industrial training. Although primarily intended for educational use, the kits also find applications in research and development work and in the construction of specialised production test equipment. The name “Curikela” is derived from the Scottish Gaelic "Cuir ri Cheile“, meaning "to assemble”.

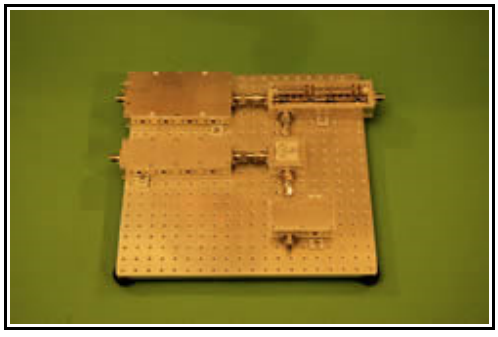
Curikela RF Circuit Kits are based on a comprehensive directory of commonly used RF circuit designs. Each page in the directory contains a circuit diagram, design notes and at least one PCB layout for the design. An extract from the directory may be viewed in pdf format. Extract from directory.pdf

Printed circuit boards for all of the layouts shown in the directory are supplied with the kit. The boards are designed such that they may be cascaded in any order within precision machined aluminium alloy housings pre-drilled and tapped for the installation of SMA connectors and feed-through capacitors.

Completed housings may be mounted on a baseplate drilled with a rectangular matrix of holes at 10mm pitch. The design of the housings is such that they may be directly inter-connected with SMA male to male coaxial adaptors when mounted on the baseplate.

The complete kit is supplied in a rugged beech case. With the exception of electronic components, everything necessary for the assembly of RF systems based on the PCBs supplied is included, enabling construction to proceed rapidly without any metalworking or PCB manufacturing operations.

The content of each kit is individually tailored to each customer's need, according to academic requirement and budget.

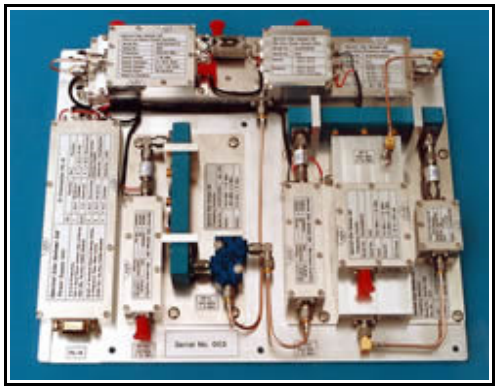


Test Gear

We have a frequent need to design and manufacture special test gear for use in our production, and are pleased to offer this service to other companies. A few examples of specially made test gear are shown below.

Delay Line Discriminator Test Set for use in measuring phase noise of SLS VCO's. Two units were made, one being supplied to the customer and the other retained for our own testing.

Three of these units were supplied to a customer to provide low phase noise test signals at a number of frequencies. Starting with an ultra-low phase noise crystal oscillator at 100 MHz, this is multiplied up through 200, 400 and 800 MHz to 1.0 GHz, outputs at each of these frequencies being made available to the user. The 1.0 GHz signal is then multiplied to 10 GHz in an SRD multiplier, and subsequently down-converted by mixing with the 400 MHz to give a further output at 9.6 GHz.



Sub-Unit Test Sets for use in a production contract.

Special Test Benches constructed for final test of a complex ultra-low phase noise microwave sub-system.

Electronic Pole Sounding Hammer

Wooden Utility Poles are susceptible to rot as shown in the photograph below, cavities or soft rotten zones usually occurring between the heartwood and the preserved outer shell. When attempts to detect this rot by microwave and RF methods failed we decided to investigate other means of detection, which led to the idea of the Electronic Pole Sounding Hammer.

Developed in conjunction with Tirna Electronics Ltd, the hammer detects rot by sensing and analysing the impact dynamics as the head of the hammer strikes the pole, displaying the result as a single numeric readout on an electronics capsule attached to the head. Conventionally a hammer is used to detect rot by listening for a hollow sound on striking the pole. The electronic detection method may therefore be used simultaneously with the manual acoustic technique.

The Electronic Pole Sounding Hammer is now at the stage where development has been completed and the first batch of production models have been built and exhaustively tested. The tool is of great value in risk assessment before poles are climbed and in rapid pre-screening of poles prior to testing by more invasive techniques such as boring.

Each hammer is supplied in a case which includes a battery charger and other ancillary items. A optional rugged display unit is also available. This enables the result of the test to be analysed in more detail if required. Full technical information is available on request.

A major part of the development of the Electronic Pole Sounding Hammer and associated Display Unit was designing units which would stand up to the environmental conditions likely to be experienced in field use. All production hammers and display units are tested against ingress of water by immersion for one hour at 300 mm depth.

Contact Us

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