Synthesised 50-950MHz source

Programmable via ttl logic levels, Nick Wheeler's 50 to 950MHz signal generator is simple since it revolves around a highly integrated c. stal-controlled synthesiser chip.

This design uses the Synergy *SY89430V* synthesiser to provide any crystal-referenced frequency from 50MHz to 950MHz

Using a 16MHz crystal, the frequency can be selected in 2MHz steps Internal frequency division by 1, 2, 4 or 8 can be selected, providing reduced coverage in smaller steps Any crystal in the range 6.26MHz to 25MHz can be used The *SY89430V* is specified up to 950MHz, but the three samples I have had work up to 1008MHz at least, but not consistently.

These parts use emitter-coupled logic, or ecl, but the programming inputs operate at 3.3V or 5.0V logic levels While I have described a free-standing source capable of driving a 50Ω load this circuit can clearly be integrated into any logic system, as a clock for example.

Using the *89430* synthesiser

A phase-locked loop operates at 2MHz, derived from a 16MHz crystal. This controls the frequency of a voltage-controlled oscillator which has an operating range from 400MHz up to the specified 950MHz.

As I mentioned earlier, this part may extend above 1GHz, but this is not guaranteed A 9-bit ttl-level word M_{0-8} sets the modulus, M, of a frequency divider in the range 250-510. With a 16MHz crystal the voltage-controlled oscillator is held at 2×*M* (MHz)

Output frequency of the device is then determined by the 2-bit word N(1,0), also at ttl level. **Table 1** shows the effect of varying N(1,0). Values on M(8,0) and N(1,0) are read into the appropriate internal registers by a low-high transition of /PLOAD.

In my version of the circuit, I tie /PLOAD, on pin 7, to ground via 4.7kΩ and a normally closed press-button switch. When this switch is operated the internal pull-up resistor takes /PLOAD high.

I have found that after setting in a frequency change, using this for a few moments ensures that the internal registers are set properly The latches of the register inputs are specified as being transparent when /PLOAD is low.

No difficulty will be experienced if the output frequency is monitored as I suggest The circuit does, however, sometimes misbehave by locking onto a wrong frequency if M settings outside the range 250-510 are applied.

Bearing in mind that the voltage-controlled oscillator runs at 2×M (MHz), settings in accordance with the table below do, however, invariably work.

There is a lower-frequency version of this part, the

Table 1. SY89430's four output ranges are selected via logic levels on N_0 and N_1.

N_1	N_0	Div. ratio	Range (MHz)	Step (MHz)
1	1	1	400 to >950	2
0	0	2	240 to >500	1
[illegible]	1	4	120 to >250	0 5
	0	8	<50 to >120	0.25

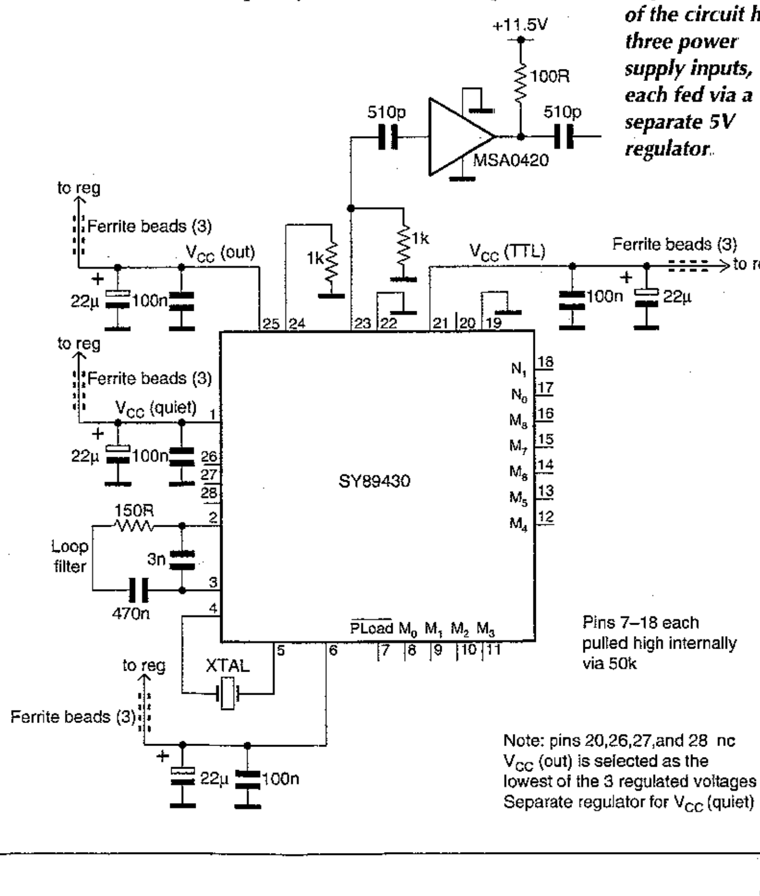

Fig 1. Complete programmable signal source for 50-950MHz with 50Ω output. The ecl synthesiser chip at the heart of the circuit has three power supply inputs, each fed via a separate 5V regulator.

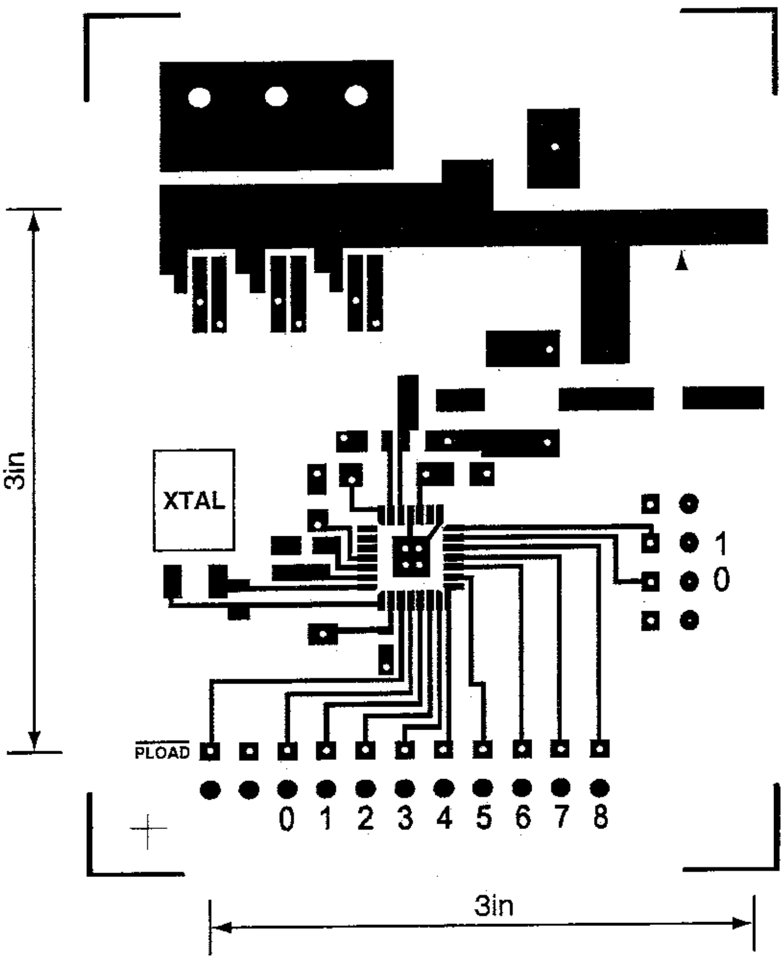

Fig. 2. Layout of the signal source is critical; this one works. The small circular dots are 1mm holes while the three holes at top left are 3mm. 15 circular blobs, right and bottom, are guides for drilling 2 mm holes. The board is connected by ribbon cable to the selector. The strands of cable pass through these holes for strain relief.

SY89429V. This is guaranteed up to 400MHz and has a divide-by-16 range selected by N(1,1).

Phase-locked loops require a filter for stability, and the three components of this are shown in **Fig. 1**.

The selected-frequency outputs are at ecl levels and have to be properly terminated. In this case, since the layout is very compact a simple 1kΩ to ground is sufficient. One of the outputs is buffered by an *MSA-0420* MMIC to give an output of at least 1V pk-pk when terminated in 50Ω. The *MSA-0420* is a premium-grade part. Cheaper types are available.

All the remaining external parts relate to power supplies which are carefully decoupled. The supply to Pin 25 must be lower than that to pins 6 and 21.

Supply to the vco, pin 1, is separate and should be as noise-free as possible, since noise on this line is translated into frequency jitter. The requirements are met by having three separate 7805 regulators, that for pin 25 being selected as having the lowest output voltage.

Synergy parts with a 'V' part-number suffix will work with V_{CC} down to 3.3V, but I have not tried them.

Implementing the design

Circuits operating at 1GHz can be based on double-sided GRP boards such as G10. This is fortunate, since Teflon-based board is both costly and difficult to work with.

I used conventional photo-etching techniques for my prototype. These involved no more than a modest pc-compatible, Windows 95, a low-cost package called Serif Draw Plus 2 and a suitable ultra-violet exposure box.

No specialised equipment was necessary. The artwork I developed is reproduced as **Fig. 2**. One side of the board is a continuous ground plane and is not illustrated.

Tidy layout is achieved by distributing V_{CC} from the three regulators on the underside of the board. vias are created at the appropriate points using Vero pins, small areas being etched to insulate these.

If the board is to be manually prototyped, these holes can be counter-bored on the groundplane side. This avoids the need for etching on the groundplane side and also the need for registration.

The numerous earth points on the parts side are connected to the groundplane using track pins such as Maplin FL82D. Each lead from the via at each regulator output threads three

Using plccs

Plastic leaded chip carriers, or plccs, are becoming increasingly the format of choice for moderately complex ICs, i.e., those having 20-84 leads. The square design minimises the length of the connections between the actual chip and the output terminals.

Plastic leaded chip carrier parts can be mounted directly on the circuit board, using one of the many smd technologies. The big advantage of plcc technology, for development or experimental work, is that excellent smd sockets are available. These enable costly parts to be retrieved without difficulty for re-use.

Manufacturers data, such as reference 4, specify the dimensions of the necessary solder pads. But these dimensions really relate to the design of the screen-printing of solder paste for volume production. It is perfectly feasible to assemble sockets such as the 28-way RS203-9448 – as used for this design – by hand, using a fine-tipped iron and surface-mounting solder paste.

The small plastic square at the base of the socket should be removed to make access easier. This square is attached at its corners by thin plastic spokes. The material is quite soft and can be cut with a scalpel, care being taken not to deform the solder tabs.

Also take care not to deform the socket from squareness while doing this. Soldering is made much easier if a modified design of pad is used. **Figure 3** shows such a pad for the 28-way part. Dimensions for other parts can be found in the RS Catalogue.

Essentially, the pads are extended inwards by about 1mm. This provides a small area of copper to which the solder paste can be applied using a hypodermic syringe and a coarse needle. Solder paste usually comes with a thin plastic nozzle, but I find these nozzles a trifle clumsy. Note the bevelling of the corner pads.

The use of sockets creates a 'no-go' area of 0.7in square for the 28-way part. Inside this square, no parts, such as decoupling capacitors, can be mounted. When laying out the circuit, I find it convenient to mark out this square with a hairline trace. Such a trace disappears in the etching process.

I make my transparencies using a colour printer. If the trace is in blue, it is effectively transparent to the ultra-violet used for the photographic process.

Note that plcc sockets are also available for through-hole techniques. They have an array of through-pins on a 0.1in grid. But surface mounting is virtually essential for designs of this sort.

i. .ce beads There is a 22μF tantalum capacitor at each via adjacent to the four V_{CC} inputs to the synthesiser, on the groundplane side of the board.

The *SY89430V* comes in plcc and soic options I chose the former. A note on using plcc format appears in the panel entitled 'Using plccs.' Essential decoupling components, mounted as close to the IC as the socket will allow, are 1206-format 0 1μF parts Their earthy ends are on pads grounded via pins to the ground plane.

The three loop-filter components are also located as close in as possible. Pins 23 and 24 are grounded through 1kΩ as close in as possible, too. The square inside the plcc footprint provides ground, via four through pins in parallel, for pins 19 and 22.

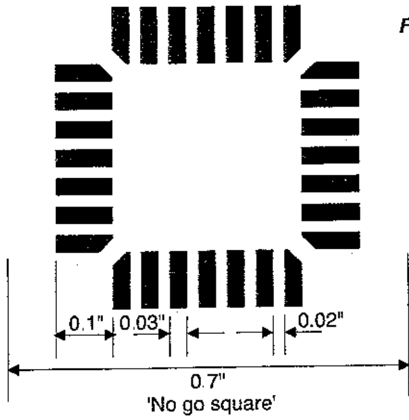

Fig 3. Dimensions of the plcc pad.

Loading data serially

Pins 20, 26, 27 and 28 support a facility for serially loading the programming data and for some test functions These are not used and should be left *open*.

The broad 0 11in traces associated with the MMIC are, on the 0 0625in board used, 50Ω striplines An SMA jack is mounted on the pcb and this is connected via a length ˋG405 semi-rigid co-axial cable to a jack mounted on the front panel. Including mains power supply, the whole instrument fits into a die-cast box 190 by 110 by 60mm

The modulus M(8,0) is selected by nine small toggle switches and N(1,0) by a four-position rotary switch.

The power supply is conventional. An LM317, thermally coupled via an insulating washer to the diecast case, is set to provide 11.5V for the MMIC This is reduced to 5V by the three regulators mentioned above.

Designer deal

Electronics World readers wanting to experiment with this design can obtain the pcb, plcc socket and *SY89430* at the special fully inclusive price of £38 95. This is an exclusive reader offer – the normal package selling price would be £70. For overseas readers, the inclusive price is £35 50 (no VAT).

Note that the package includes data sheets, design notes and other useful information on high-speed circuit layout. Please send your cheque to Nic Houslip at NJ Houslip Ltd, 16 Swinbrook Way, Shirley, Solihull B90 3LZ. Tel 0121 733 8033, fax, 0121 733 7772, e-mail nic_houslip@compuserve.

Control and application

A feature of ttl programming inputs on Synergy ecl parts is that they are normally tied either high or low internally via resistors in the region of 50kΩ. In the case of the *SY89430* they are tied high. They can be forced low by grounding them though 4.7kΩ or less.

The simplest method of programming this part is by a dual-in-line switch to set the 'M' and 'N' inputs low as required Some people can effortlessly do binary to decimal conversions in their head. I cannot, so I use a prescaler[2] and frequency meter to check the settings. This is less of a chore than doing the calculation, and gives one confidence that no mistake has been made.

he fact that the modulus is set by a 9-bit word makes such approaches as using bcd thumbwheel switches and an eprom to decode them into a proper form, impracticable except at prohibitive cost. I have also built a system using three cascaded LS193 up/down counters which can either be incremented or decremented one count at a time or clocked at a slew rate.

Parallel outputs from the counters form the modulus word, and leds on each line indicate the selection. This however involves ten ICs. And, naturally, the indication is a binary number

The output is specified as a square wave of 45%-55% duty ratio, but of course on my 100MHz oscilloscope, even at the lowest specified selectable frequency using a 16MHz crystal looks very much like a sine wave.

Rise and fall times are specified as 300-800ps. Setting the frequency to an arbitrarily-chosen 53 5MHz yielded harmonics detectable on my home-made spectrum analyser[3] right up to 850MHz.

The oscillator circuit calls for a series-resonant crystal If a crystal calibrated for parallel resonance is used, it will work just as well, but the frequency will be slightly w.

Assuming my frequency meter is accurate, a selected frequency of 125MHz measures out at 124 941MHz This is 472ppm low. In many applications though, such an error is irrelevant

I set the frequency to several quiet points in the vhf broadcast band A suitable receiver was fully quieted at a distance of several metres There was no perceptible noise I think this proves that there is no jitter in the phase-locked loop

The synthesiser IC consumes just under a watt at 5V It gets quite hot A 24-hour soak test at an ambient temperature of 20°C led to a final air temperature inside the box of 40°C

Operating outside the limits

Guaranteed frequency limits for the *SY89430V* are 50MHz to 950MHz. These are readily achieved.

At the lower limit, which is obtained in the divide-by-eight mode, the waveform is a fair approximation to a square wave. Lower values of M can be selected, operation down to 48MHz being possible. However, frequencies as low as this are easily generated by other means

I have found that 973MHz is the highest frequency at which this part can consistently be asked to operate, although I have sometimes achieved 1008MHz.

In summary

The simplicity and low parts-count of this useful signal source are attributable to the use of emitter-coupled logic ■

References

1 Synergy Semiconductors Information Pack, Europe Sales, Synergy Semiconductor, 16 Swinbrook Way, Shirley, Solihull, West Midlands B90 3LZ. Tel 0121-733-8033

2 Wheeler, N 'Gigahertz Prescaler,' *Electronics World*, Sep 1996

3. Wheeler, N. 'Spectrum analysis on the cheap.' *Electronics World*, March 1992

4 Motorola. 'High Performance ECL Data' (DL140/D Rev 4).

Technical support

The circuit and much useful application data is fully set out in reference 1, which can be obtained gratis from Synergy.[1] The company has a Website on http://www.synergysemi.com.

The specialised parts for this design are not currently available in small quantities from any usual suppliers.