Electronics & Technology Today

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Canada's Magazine for High-tech Discovery

April 1988

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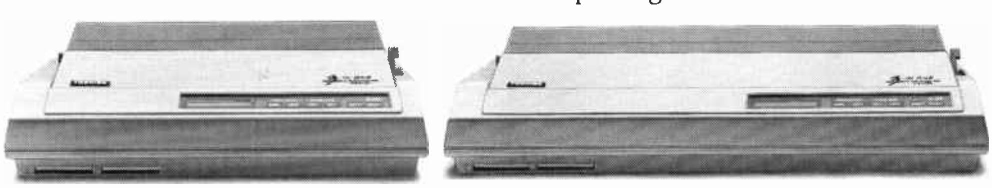

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The Daetron MM100 was photographed by Bill Markwick; the VCR photo is courtesy of JVC.

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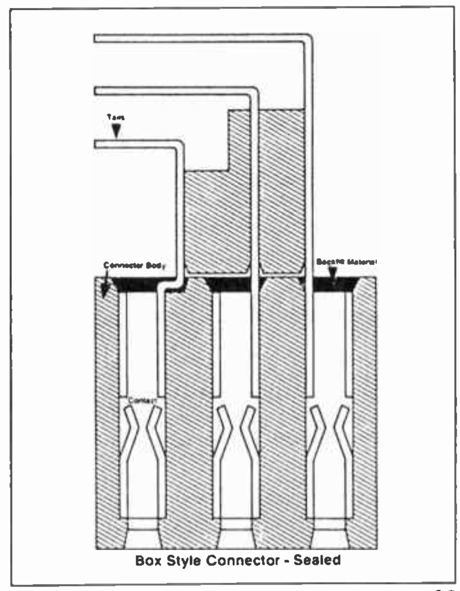

Box Style Connector - Sealed

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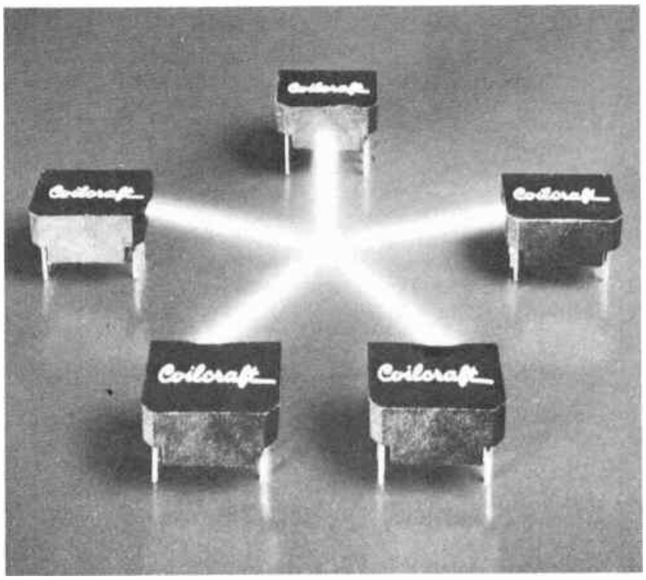
For Your Information

LAN Transformers



Anyone involved in designing local area network equipment might be interested in a new low cost, off-the-shelf LAN transformer.

Coilcraft's LAX-ST100 transformer interfaces both node and hub driver circuitry to the twisted pair wiring and provides impedance matching, 2000 volt isolation, and 60 dB common mode rejection.

The device measures only 0.35" x 0.50" and is suitable for use in LANs described by the IEEE 802.3 standard.

For more information about the LAX-ST100 contact: Paul Liebman, Coilcraft, 1102 Silver Lake Road, Cary IL 60013. (312) 639-6400.

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Precision Resistance Box

Selecting any resistance value from 1 ohm to 9999 ohms is easy with the Brunelle Model 63 Precision Resistance Decade Box.

It's suitable for use in electrical measurements, as a substitution resistor to aid in designing and for experimentation in schools and research institutes. Resistors are formed with manganin wire wound elements and the unit has low zero resistance and low inductance.

For more information on the Precision Resistance Box contact: Brunelle Instruments Inc., 73 - 6th Range S., St. Elie D'Orford, Quebec J0B 2S0. Ph: (819) 563-9096.

Circle No. 68 on Reader Service Card

In-Circuit Emulator

A new in-circuit emulator that will allow development support for a full range of CPUs, 8 to 32 bits, with simple module exchanges is available

The AXION emulator will support real time emulation up to 20 MHz including initial support of INTEL's 80386 chip set.

In addition to its speed and flexibility, AXION maintains up to 768K of emulation memory, both real address and protected modes are supported, and GPIB, RS-232C interfaces are provided for fast downloading.

Contact John Arata, Ziltek Corporation, 1651 East Edinger Ave., Santa Ana, California 92705-5001.

Circle No. 63 on Reader Service Card

Two-In-One Bus Expander

A GPIB product from Britain is available for use as a IEEE-488 bus expander and a cost effective RS-232 to IEEE-488 converter.

The Model 2010 from Prism Electronics is designed to provide extra flexibility to IEEE-488-based instruments and systems through two modes of operation.

Mode 1 offers control and monitoring of two independent IEEE-488 buses from a single RS-232 serial port permitting 28 GPIB instrument to be controlled from the 232 port of a single computer. Mode 2 expands, from 14 to 27, the number of instruments which may be controlled in the IEEE-488 bus of a single controller.

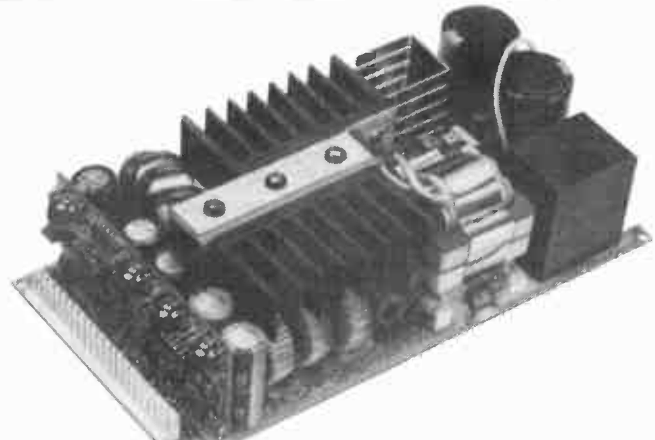
For more information on the Model 2010 contact: Matt Duncan, Duncan Instruments Ltd., 121 Milvan Drive, Weston, Ontario M9L 1Z8. Ph: (416) 742-4448 or FAX (416) 749-5053.

Circle No. 71 on Reader Service Card

Amoco Laser Address

In our October 1987 issue we featured an article on semiconductor lasers in which products from the Amoco Laser Co. were mentioned. However, we failed to give the address for Amoco, so here it is: Amoco Laser, 1809 Mill Street, Naperville, Illinois 60540 (312) 369-4190

For Your Information



Compact PSUs

Two new models of convection cooled switching power supplies with several standard output configurations are available in a compact 4.25" and 8.50" footprint.

The models PSI 135 and PSI 225 are rated at 135 and 225 watts respectively. There are over 20 options available for customizing the units including up to four fully regulated outputs, L-brackets for special mounting, and input voltage autoranging.

For more information contact: Richard Milne, PSI/STD, Power Systems Inc., 45 Griffin Road South, Bloomfield, CT 06002 (203) 726-1300.

Circle No. 74 on Reader Service Card

Experimental Mechanical Pacer

The athlete pace-maker who runs every circuit of the track with tireless efficiency whenever needed has not yet been born. But for serious athletes wishing to improve their stamina, speed and pace judgement engineers in Northern Ireland have designed a mechanical pacer.

Resembling a child's pedal car, the 0.9m-long, three- wheeled remotely guided vehicle is designed to alongside, or ahead of, an athlete and can cover 400m in 40 seconds - faster than any human.

The pace car has a guidance mechanism with light activated sensors that follow a pre-selected single white line, such as a track lane marker. The speed is set by the runner or his/her coach through digital codes keyed into an on-board computer by portable telephone. The telephone also assists communication between coach and athlete when the runner is out of earshot. Once a lap has been completed, the pacer can be made to repeat its performance exactly or be adjusted to meet requirements.

For more information contact: Tom Keating or William Beattie, Queens University of Belfast, University Rd., Belfast BT7 1NN Northern Ireland.

Continued on page 21.

Daetron MM100 Multimeter

A comprehensive multimeter that can test four voltages at once, plus many other features.

By Bill Markwick

The Daetron MM100 4-in-1 multimeter follows on the success of the MC300 Capacitance Meter, using microprocessor control as well to give a multitude of features, including multiplexed scanning of four input channels into the same A-to-D converter. The flexibility of use makes it ideal for troubleshooting, educational use, quality control or the laboratory.

Basics

When first switched on, the MM100 shows two lines of 16 characters on its LCD display; the default display is four voltage measurements using seven characters each in the 3 1/2 digit mode. The autoranging goes from 0.2V to 500V on DC volts for full scale, with a basic accuracy of 0.1% with an input impedance of 10 megohms.

AC volts are read on channel 1 only, with ranges of 2, 20, 200 and 500V. Basic accuracy is 2% with an input impedance of 10 megohms. Resistance is read on channel 3 only, from 2k to 20M full scale. DC current is read on channel 1 only, with ranges of 20mA and 200mA.

The displays add a V, v, m or K to the reading to indicate DC volts, AC volts, milliamperes or kilohms, respectively.

The 4" by 7" case has a 16-key membrane keyboard and seven color-coded banana jacks. The unit is powered by a 9V battery or optional AC adapter. The contrast of the LCD display can be altered to suit the viewing angle by adjusting a trim pot in the battery compartment.

The MM100 is made in Canada and costs $189.95 with a manual and a pair of test leads. Optional equipment includes a case, extra leads, and an AC adapter.

Tryout

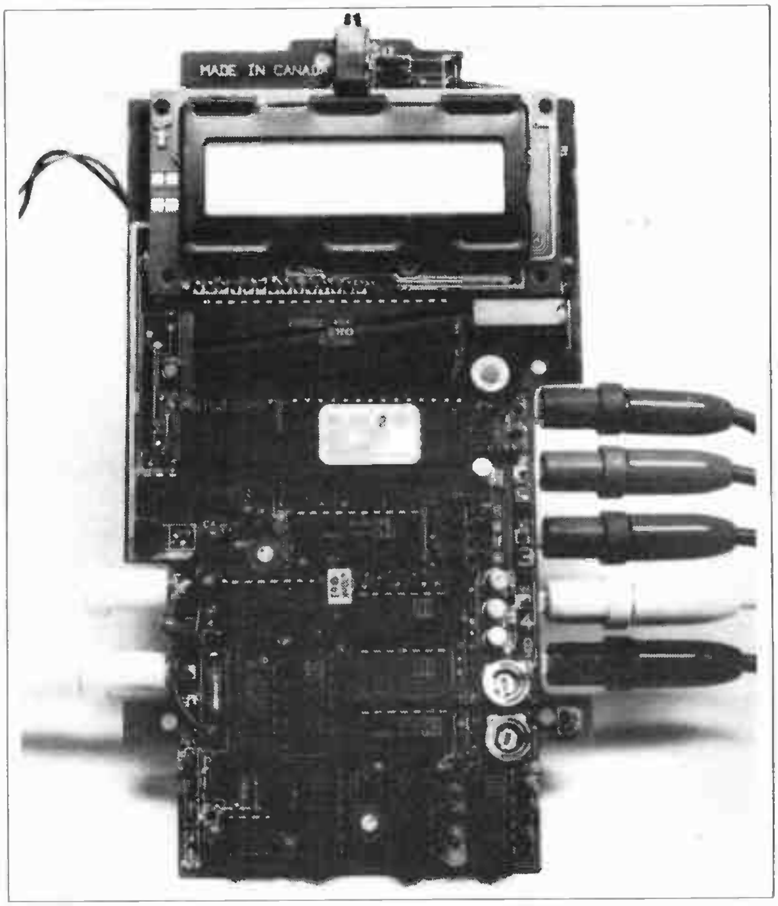
The first thing you'll notice in using the MM100 is that a 4- channel meter just naturally creates a tangle of cords. For this reason, it's well worth investing $39.95 in the optional 6-lead color-coded set, available with either EZ hooks or alligator clip termination.

When the unit is powered up, only channel 1 is programmed to respond to commands like Hold or manual ranging; we'll get back to the programming mode shortly; here's a quick tour of the keyboard. Pressing the Hold key brings up a tiny "H" on the display of channels that are programmed for this feature, and the display locks at whatever value was displayed at the time. A second press deselects the Hold feature.

The Rel key switches the channel(s) from regular voltage measurement to the Relative mode; whatever voltage is on the display when the key is pressed is taken as the new zero volts and subtracted from the reading (which will now be zero). For example, you could have one of the channels monitoring the output of a power supply while the others do regular measurements; the power supply channel in the Relative mode will display only the changes, not the supply voltage itself. The plus and minus signs indicate whether the change has been an increase or decrease.

The Relative function is also useful for zeroing the meter if there's a lot of constant noise in the circuit.

The AC/DC key toggles channel 1 only; there's only one internal rectifier. The Auto/Man key lets you manually set the range on preselected channels.



The MM100 is built on a single printed circuit card, using standard CMOS switches, a commercial CPU and a custom ROM chip.

The Pan key switches channel 1 to a display that looks like 000.000.000; these groups represent volts, millivolts and microvolts. If you need more resolution than the necessarily small 4-channel display, the Pan feature gives you 9-digit performance.

The 4 1/2 digit key is a compromise between 4-channel and the 9-digit Pan; it gives you two channels (1 and 3) with four decimal places each.

The Bargraph switches the display to channel 1 only, with a 4 1/2 digit readout and a 16-segment analog bargraph underneath. If you've ever tried to adjust a circuit in which the voltage levels are constantly changing, you know that a digital readout is very difficult (or impossible) to decipher. The bargraph lets you see graphically what's happening to the level, simplifying the adjustment of tuned circuits or any device where the output changes are not slow and stable.

The current and resistance features have their own jacks on the left side. Channel 1 is for milliamps and channel 3 is for ohms; the separate leads eliminate unplugging your setup if you want to measure these parameters. A 250mA fuse (with a spare) is located in the battery compartment.

The Setup Menu

Pressing Setup displays "mchr" in each channel's place. This stands for Manual, Comparative, Hold and Relative; the lower case letter indicates that the feature is not selected yet, and upper case indicates that the feature will now be toggled by the appropriate control key. For instance, you could have channels 1 and 2 held when you press the Hold key, or channels 2 and 3 toggled in and out of the Relative mode, or various other combinations.

The features are selected and deselected by cursoring over to the letter and pressing Enter (the 7, 8 and 9 keys do double duty for this in the Setup mode).

The ability to set each channel's characteristics individually increases the meter's versatility considerably. You could have the meter monitoring a breadboard setup, with some channels measuring absolute voltages and some measuring only changes at certain test points. Some channels could be put on Hold for later comparison.

The Comparative Mode

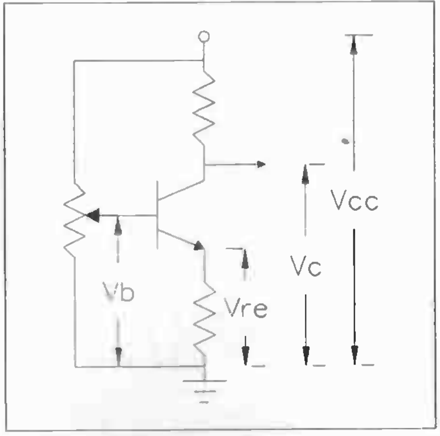
If you'd like to be notified that a quantity has fallen, risen, or passed through specified limits, you can set any of the four channels into the comparative mode from the Setup menu. When the comparative mode is activated, right and left arrows appear; you then enter the greater-than and/or less-than values for that particular channel.

If the measured volts, milliamps or ohms exceed the limits that you've entered, the meter's internal beeper will sound rapidly. The comparative feature will save you from having to watch a circuit closely when you think that changes might be happening; the audio signal frees you to do something else.

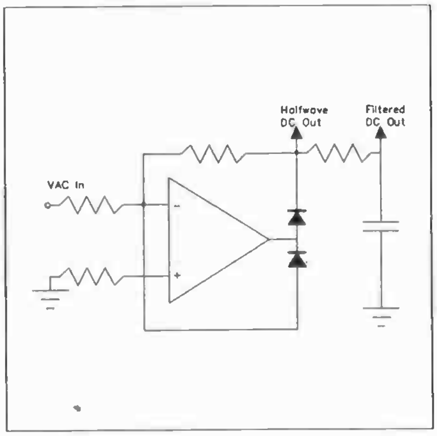
The lower of the two setpoints can be changed without going through the setup menu by pressing the Rel key; the reading on the display at the time becomes the lower setpoint.

Continuity

The usual resistance meter plus continuity beeper has been expanded in the MM100. From the Setup menu, you can specify upper and lower setpoints for the resistance range that appears on channel 3. The beeper will pulse whenever the resistance tested lies between these values, a good fea-



The MM100 would be ideal in educational applications for simultaneously watching the effects of changing transistor biasing, as in the above example.



The ability to watch both AC and DC voltages on one readout would be ideal for the halfwave rectifier circuit shown above; the MM100 could monitor the AC input, the halfwave DC output, and the filtered DC output.

ture for selecting resistors. Entering 0.0001 ohms will produce a regular continuity beeper that sounds on any resistance. Being able to set the upper breakpoint on continuity tests is useful, because you often want to know if you have a path with a suitably low resistance.

Impressions

The meter is very well made and performed as promised. The scanning and updating isn't the fastest, but it gives a very stable display, without digits toggling and flickering. Watching four readouts at once is a bit confusing at first, but you soon get onto it, and the pleasure of not having to juggle and swap the test leads is a big one.

Any negative points are small ones. I've never been a fan of membrane keyboards because the operation is so imprecise, but then they do keep the cost and complexity down. There's no automatic power-down, something I appreciate on battery-powered instruments. The keystroke sequences, while easy to learn, are not always self-evident from the layout and you'll spend some time at first thumbing through the manual. The cursor keys lack auto-repeat, which makes using the bottom row in the Setup mode a bit slow.

The meter would be ideal for educational uses: I can't think of a better way to demonstrate transistor or op amp biasing than to hook up a 4-channel meter and watch the effect of changing something. Troubleshooting would be simplified, especially if you have to make a lot of interdependent voltage measurements; the Relative, Hold and Comparator functions should let you keep track of those fleeting glitches and their resulting changes. Production lines which have to do several adjust-on-test alignments could do it all without having to move a meter around.

Daetron meters are now being exported to the Far East, certainly a reversal on the usual flow of electronics. The reason is that they're unique; they exploit the power of the microprocessor to do an excellent job of performing special functions at a reasonable price.

For further information, contact Daetron, a division of Bergeron Technologies, 935 The Queensway, Box 641, Toronto, ONtario M8Z 5Y9, (416) 676-1600. ■

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The Sine Wave

The sine wave and how it works — dissecting and reassembling it with vectors.

By Paul Chappell

There are a number of ways of representing a sine wave. **Fig.** 1 shows two possibilities. The first is the usual graphical representation. A diagram like this gives a good deal of information about the wave: its shape, amplitude, frequency and phase at the chosen starting point, just about all you could ever want to know about it.

Fig.1b shows a more abstract representation of the same wave. The frequency is shown by the position of the line along the horizontal scale and amplitude is given by the height of the line. This diagram is more concise than Fig. 1a (and takes less drawing skill) but some of the information is lost. The shape of the wave is not shown, so to interpret the diagram you have to know what a sine wave looks like. Another loss is phase information. There's also a slightly less obvious loss — see if you can spot it. (Look for a way to alter Fig. 1a to give another wave which would have the same representation in Fig. 1b).

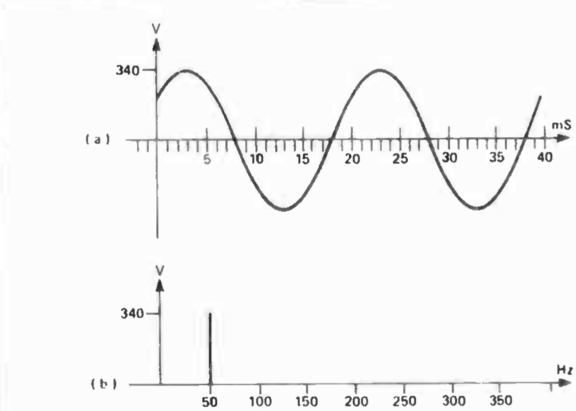


Fig. 1(a). The normal view of a sine wave, and (b) an alternative representation.

The loss of phase information means that if two or more sine waves are shown on the same diagram, it is impossible to say exactly what time domain waveform they represent. **Fig. 2a** may represent either Fig. 2b or Fig. 2c or something else entirely. Without knowing the relative phases of the two sine waves, there is no way to decide. (Strictly speaking it makes no sense to speak of the phase difference between two waves of different frequencies since it changes at every instant. What you can do is to compare each component with a sine or cosine of its own frequency at a particular instant in time which will give enough information to decide the time relationship of the two waves.

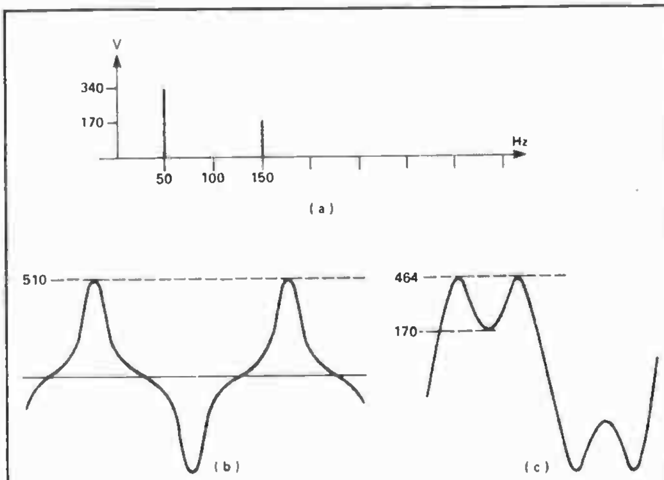


Fig. 2 (a). Two sine waves which can represent either of the waves (b) or (c).

For example, if both waves were exactly in phase with the sine of their own frequency at some instant in time, Fig. 2c would be the correct time domain waveform. On the same pedantic note, I'd better explain that I'm using the phrase "sine wave" to mean "any wave which is sinusoidal in shape" and unadorned "sine" and "cosine' to mean waves that begin at 0 and 1 respectively at some instant $t=0$. Phase relationships are difficult to talk about without sounding too text-booky and I don't want to confuse you in my attempts to do so.

In many situations the frequency spectrum of a wave form is the most important characteristic. An example is frequency interlacing in colour TV systems. The frequency spectrum of a monochrome TV signal has the strongest frequency components at multiples of the line frequency on either side. **Fig. 3a** is an idealized diagram of a portion of this spectrum. The gaps in the spectrum allow a rather clever trick to reduce the bandwidth needed for colour TV transmission. Instead of avoiding interference by putting the colour subcarrier at some frequency way above the monochrome information, it can be slotted in to fill up the gaps.

Suppose the colour subcarrier frequency was chosen to be 200.5 times the line frequency. The main additional frequencies introduced would be the subcarrier and its sidebands separated by multiples of the line frequency, which neatly fills the gaps left by the monochrome spectrum (**Fig.3b**). The half-line offset means that the subcarrier frequency will cancel out to some extent on successive pictures and too high an amplitude would still cause some very unpleasant effects.

The moral is that it is very important to keep an eye on the practical interpretation of abstract information. The offset used in the European PAL system, by the way, is 1/4 line rather than 1/2 line; this simple explanation leaves out some other rather significant considerations which mean that 1/2 line offset is not the best choice, but the principle still applies.

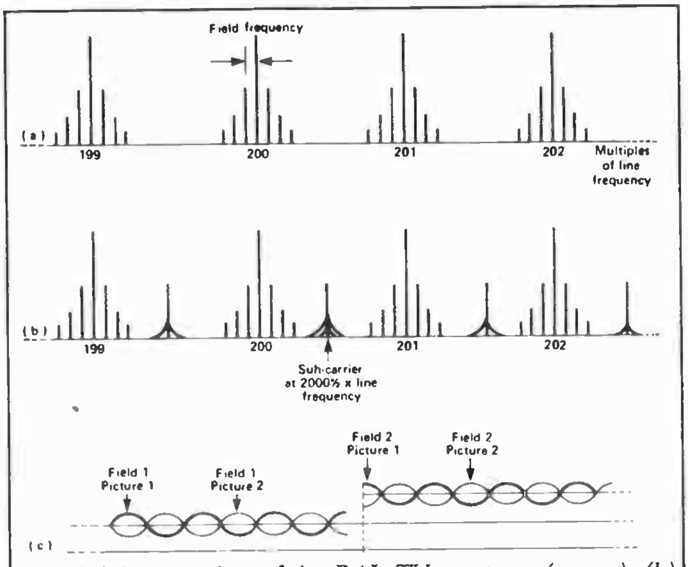


Fig. 3 (a). A portion of the PAL TV spectrum (mono), (b) the colour subcarrier slotted in the gaps, and (c) the effect on the mono picture.

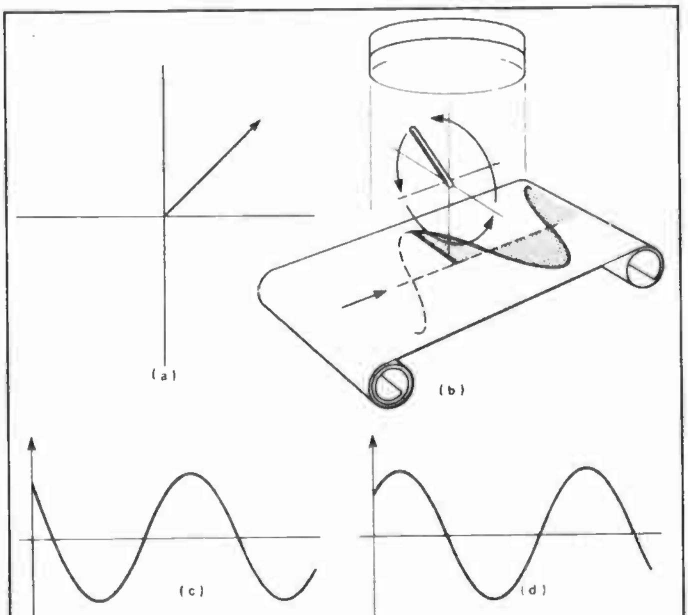


Fig. 4 (a) A vector, (b) the wave-drawing machine, (c) a counterclockwise wave and (d) a clockwise wave.

Yet another representation of a sine wave is shown in **Fig. 4a**, and it's this one I really want to concentrate on. If you haven't seen this kind of diagram before, it will take a little imagination to see how it works. Just suppose for a moment that the arrow on the diagram is actually a piece of wood baton pivoted at the origin, which its free end moving steadily in an counterclockwise circle. Now suppose that there's a spotlight above it and a screen below. As the baton moves, the shadow on the screen will shorten until the rod becomes vertical, then lengthen again in the opposite direction, then shorten again until the rod is pointing downwards, and so on.

Now suppose that instead of a screen, the shadow is cast on a strip of photographic material that is exposed by darkness (don't ask me where you can buy it). The photographic strip is moved along by the same invisible motor which is turning the baton (I said you'd need a good imagination.). When the paper is developed, it will have a trace on it as **Fig.4b**. A Sine wave!

A complete cycle of the sine wave corresponds exactly to one rotation of the baton. The amplitude will be equal to the longest shadow cast by the baton which will happen when it is horizontal and so will be equal to its length. The phase relative to a cosine will be equal to the angle the baton makes with the horizontal when the machine is started up. In other words, if I gave you a photograph (or a diagram) of the initial position of the baton and told you the speed of rotation, you could predict exactly what sine wave the machine would draw. That brings us back to Fig.4a.

The direction of rotation of sine-wave drawing machines is important. Figure 4a could draw either Fig. 4c or Fig. 4d depending on which way it was turned. By convention, sine wave drawing machines always turn counterclockwise, so Fig.4c is correct.

Diagrams like Fig.4a are called vectors. The most significant loss of information here is frequency; I have to tell you how fast the rod is rotating. This may seen like rather an important piece of information to lose but often it can be assumed from the context. At other times it can be useful to know how a circuit responds to a certain frequency. In all these cases, frequency is part of the background information

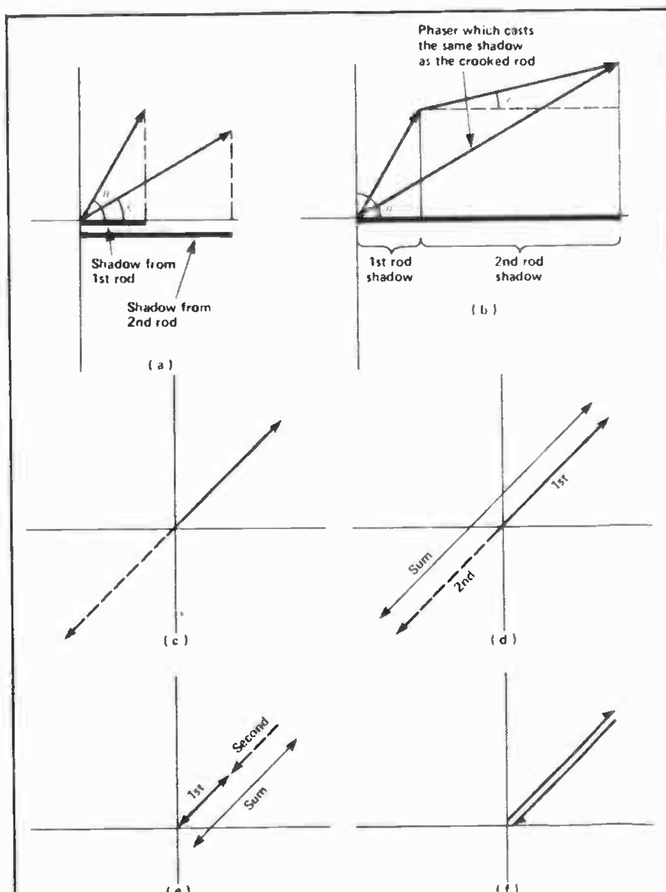


Fig. 5 (a). Adding two waves on the vector diagram, (b) the resultant wave, (c) adding out of phase waves, (d) the wrong result, (e) the correct answer, and (f) cancellation.

and it's the phase and amplitude of the waves that we want to investigate. This is where vector diagrams come into their own.

Just as several waves of different frequencies can be included in the same frequency spectrum diagram, waves at the same frequency but with different amplitudes and phase can be drawn on the same vector diagram (**Fig.5a**). Since both waves are at the same frequency, the two rods are locked together and rotate at the same speed. This gives an easy graphical way to find the sum of the sine waves of the same frequency.

To find the result of adding the two waves of Fig.5a, we want a rod which casts a shadow equal to the sum of the two individual shadows. A crooked rod that will do the trick can be made simply by nailing the two rods together, keeping their angles with the horizontal axis the same. The result is shown in **Fig. 5b**.

The final step is to notice that a straight rod from the origin to the tip of the crooked rod will cast the same shadow, so this is the vector representing the sum of the two original waves.

If you think about it for a moment, you'll see that it makes no difference which vector is drawn first when adding. If you try both ways on the same diagram, you'll end up with a parallelogram with the sum as one of the diagonals.

One thing to remember is that you must draw the vectors in the right direction. Take the extreme case of Fig.5c, for instance. The sum of these vectors is Fig.5d and not Fig.5e. If the two vectors had the same length, adding them would bring the end point right back to the origin (Fig.5f). This is the equivalent to saying that two sine waves of the same frequency and amplitude but 180° out of phase will cancel each other out when added.

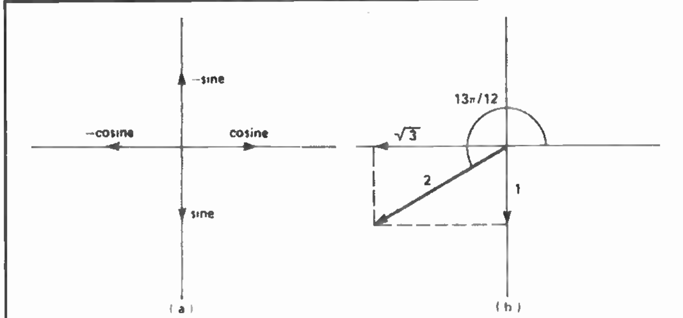
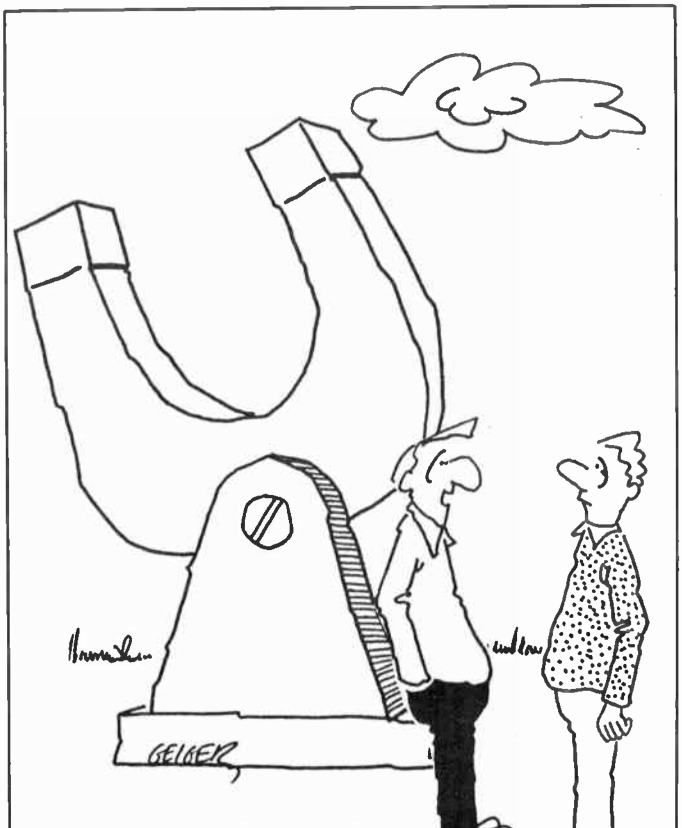


Fig. 6 (a). The vectors for sine, cosine, -sine and -cosine, and (b) expressing a wave as a sum of sine and cosine.

The vectors for a sine, cosine, -sine and -cosine are shown in **Fig.6a**. A sine wave of any phase you choose can be expressed as the sum of a sine and a cosine. Figure 6b shows a particular example:

$$2\cos(\omega t + \tfrac{13\pi}{12}) = \sin(\omega t) - \sqrt{3}\cos(\omega_s)$$

The phase angle 13pi/12 disappears. The Fourier series contain both sine and cosine terms to avoid the need for phase angles and this is how the trick is done. Another piece of the jigsaw falls into place. It's rather like resolving a force into two orthogonal components. ■



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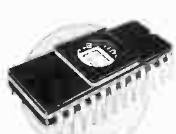

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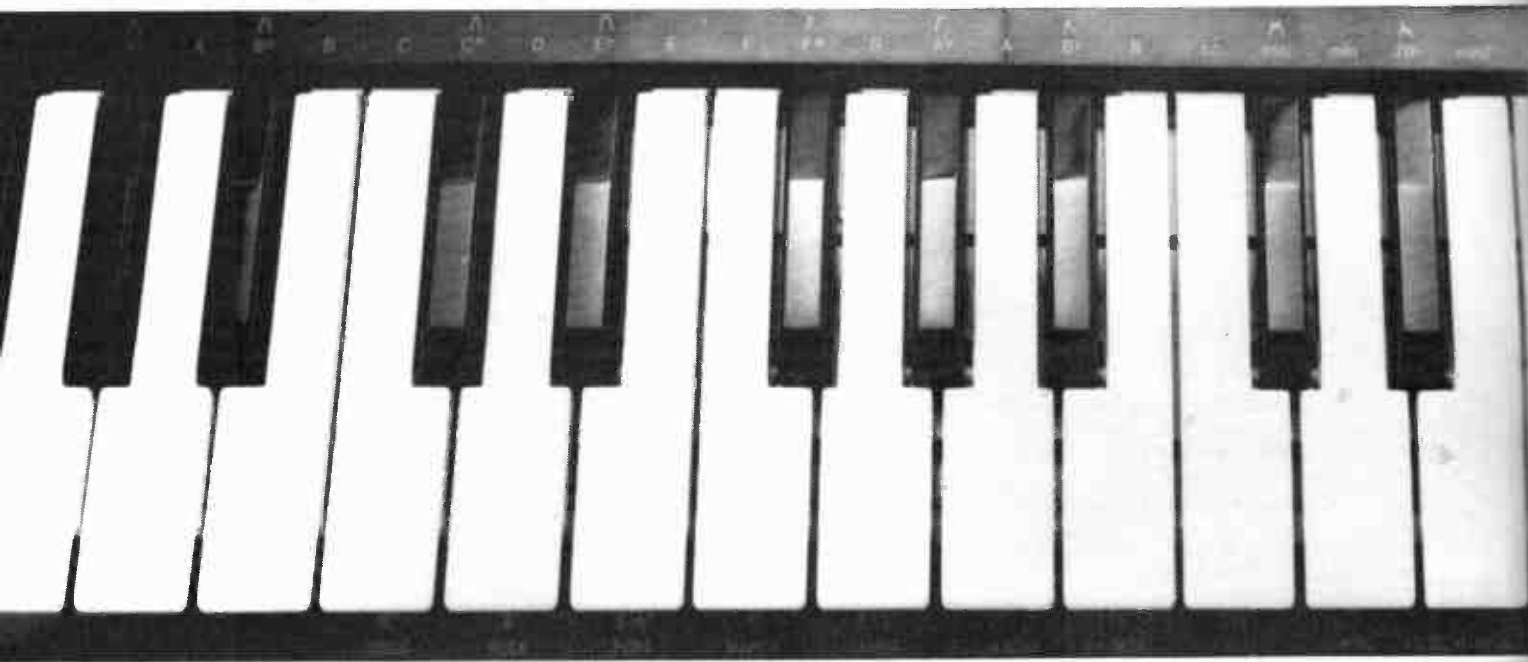
The Physics of Music, Part 6

The natural scale, the equal-tempered scale and where they come from. By Bill Markwick



The notes of the musical scale, the do-re-mis planted in our heads from childhood, are so familiar to us that we take it for granted that these building blocks of music are just part of nature, a given, like *pi* or Newton's laws.

Not so. The choice of pitches for the note series could be based on anything: the year of your birth, your favorite number, you name it. The resulting music would sound weird to Western ears, or anyone's ears, but you could do it, and if it caught on for a generation or so, people would assume that *that* was the way music has to be.

However, we pointed out in past articles that any musical instrument produces harmonics, extra notes that combine with the fundamental to give the instrument its characteristic timbre (or flavor, if you like). These harmonics are usually integer multiples of the fundamental: twice the frequency, three times, four times, and so on up to inaudibility. The harmonics occur simultaneously to give the sound its character.

Suppose that you decided to have eleven notes in your scale, and that each ascending note was going to be 10% higher than the one below because you liked nice round numbers. If you had never heard any music before, you'd be as pleased with your scale as the person who invented the wheel (hey, the wheel is simple. How about the person who invented the *axle?*).

The trouble is, your strings and tubes and horns and whatnot are going to continue with their integer harmonics: the octave will be twice the fundamental, the next will be three times (or half again as high as the octave harmonic – a musical fifth). Horns, for instance, will still continue to play a scale based on the harmonics. To further plague your new invention, humans have the odd ability to detect when something is half or twice something else. People who have trouble tuning their guitars or violins can lock right onto the octave or fifth.

So when your music starts up, there'll be quite a mixture of your new notes and the harmonics determined by the physics of resonators. Since you've decided on an 11-note scale, a fundamental note of 100Hz will have an octave of 259.4Hz. When you play this octave for your listeners, they'll say "No, it isn't", because their brains want them to hear 200Hz for the octave. Most of your instruments will sound out of tune with themselves, as the integer harmonics grate up against the fundamentals that you've chosen.

This is not to say that your scale is wrong, not by any means. Various societies have concocted various scales throughout history, though I imagine most of them recognized the existence of the octave and fifth right away. The point is that if you want to be an original scale designer using a new system of temperament, you're bucking a very strong headwind. Composers who have come up with new scales, such as the twelve-tone, are really just rearranging the standard western chromatic scale; after all, their music has to fit on existing instruments.

Concert Pitch

Before we get into any number-crunching, it's best to clear up a misunderstanding that happens whenever anyone writes about musical frequencies. If you look in physics books and articles like this one, you'll find certain frequencies given for certain notes. If you look in music books, you'll find a different set of values for the same notes.

The reason for this is the science writer's wish that you understand the numbers without having to plug everything into a calculator. If we take a note as 100Hz, as we did above, the harmonic series is instantly apparent: 100, 200, 300, 400 and so on. The 100Hz note, however, doesn't exist on the piano.

In 1939, rather late in the history of music, there was international agreement to standardize the frequencies of the musical scale, and 440Hz for A above middle C was chosen as the reference point. We'll shortly come to the explanation of how to derive the rest of the notes.

When you see scales explained in terms of middle C being 256Hz, which it isn't, indulge the author of the work;

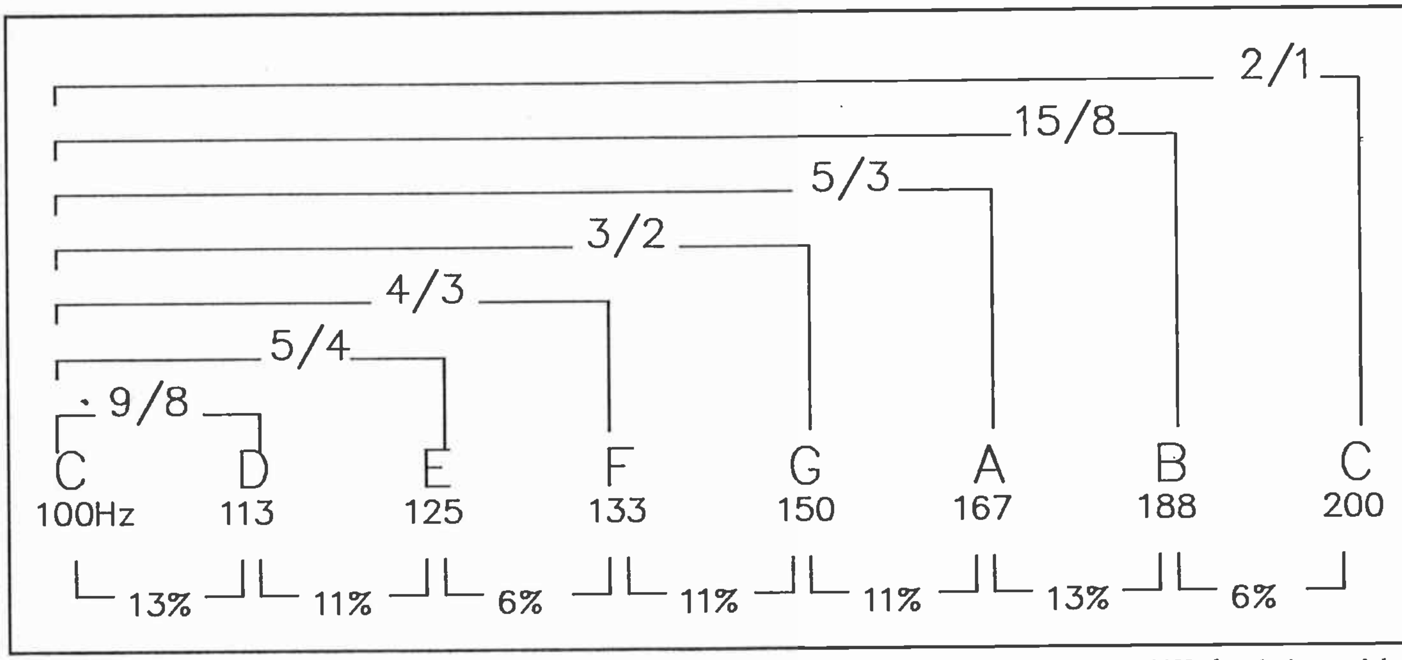


Fig. 1. The natural harmonics derive from simple integer ratios as shown above the scale. C is taken as 100Hz for clarity, and the frequencies of the other notes shown below them. The last row shows the percentage change from one note to the next; there are three types of intervals in the natural scale. The numerical values are rounded off to integers.

he or she is saving you from having to look at C being 261.63Hz, which it is.

Incidentally, it's of interest to note that technology has raised the pitch of music over the centuries. The early pianoforte, for instance, was limited in the amount of tension the older strings could stand, and the same probably goes for other stringed instruments as well. The A above middle C was about a semitone lower than 440Hz, about 415 to 425Hz according to tuning forks from the late 18th century.

Early Scales

Once you discover the fundamental, octave and fifth notes (1,2, and 3 times the fundamental), usually by experimenting with a simple whistle or horn, you might decide to expand your scale a bit by seeing what other notes you can make, and which of these sound good with the others. The next few notes in the harmonic series will be another octave, the third above this, and the fifth above this, corresponding to 4,5 and 6 times the fundamental. In terms of today's notation, here's what we have so far if we take the fundamental as C:

C-C-G-C-E-G

This note sequence will be familiar to horn players; it's the note sequence a horn will play without valves or slides. Continuing on with the process, primitive musicians would have found the second (D above C) and the fourth (F above C). Now we've really got something here: five notes, six if you count the octave: C-D-E-F-G-C. The problem is that they span a very large frequency range, about three octaves worth of very forceful horn or whistle playing, not to mention the gaps between some of the notes; a closely-spaced scale doesn't appear until rather high in the harmonic series where it's hard to play unless you have lungs of steel. To make the notes easier to get, folk musicians (as opposed to today's Folk Musicians, a different thing entirely) would have brought their newfound notes into the space of an octave by means of holes drilled in the whistle, or separate strings mounted on a frame, as with the harp.

Modes

These simple, gap-toothed scales are called *modes*, and a great deal of music has been obtained from them in many different cultures throughout history, and they're still in use today. If you have a harp that's strung C-D-E-F-G-C, you can play all sorts of simple tunes. As a trivial example, you can play *Mary Had a Little Lamb* with only C-D-E-G. There's no reason that you have to have C as the root note; a harp could be tuned D-E-F-G-C- D; this rearranges the tone\halftone sequence and produces a haunting sound somewhere between our major and minor scales. Different modes are easily obtained by starting on different keynotes. To illustrate this, trying playing on the piano from A to A, using only the white keys; this is the Aeolian mode, better known as our modern minor scale.

Naturally, musicians began to experiment with changing and expanding the five notes. By changing the note that you take as the root, they noticed that different-sounding "scales" were produced; no doubt they became dissatisfied with the large gaps between some of the notes, and added some more. The note A is from the harmonic series and fits nicely; in the key of C, this gives us a sequence close to the major scale with a gap just before the octave C. This gap was filled in one

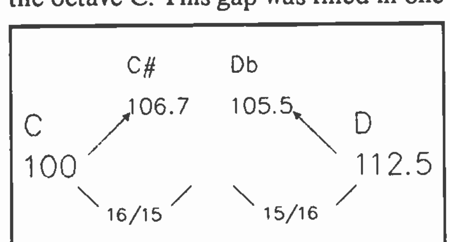


Fig. 2. The natural scale has both a sharp and a flat between the whole notes, as explained in the text.

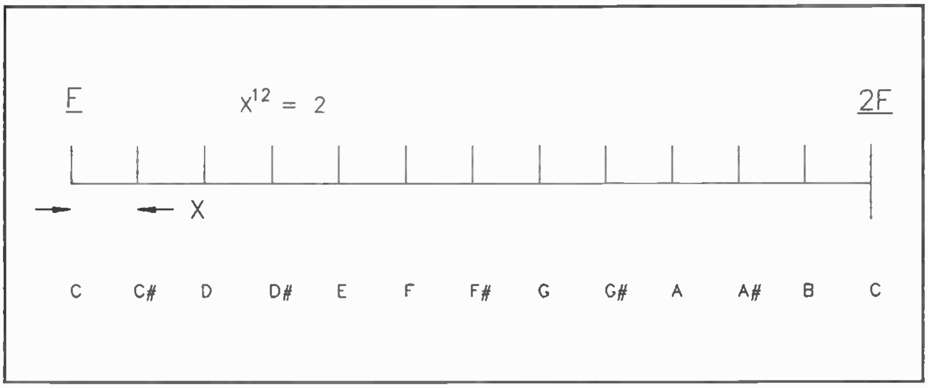


Fig. 3. The division of the octave into 12 equal sections produces the equal-tempered scale. X is a multiplier that will give us an octave frequency of twice the fundamental when multiplied by itself 12 times.

of two ways; musicians sometimes inserted a small interval above the A, giving the equivalent of C-D-E-F-G-A-Bb-C (Mixolydian mode, or flatted-seventh scale), and sometimes they added a whole tone, giving a major scale.

With an instrument tuned to an eight-note major scale, you can get all sorts of effects. If you have a keyboard handy, try taking different notes as the root, but stay on the white keys. If you play from A to A, for instance, you have our modern minor scale. G to G will produce the Mixolydian mode mentioned above. *Old Joe Clark* is a classic example of this mode; play it in G on the white keys only, starting with a D note. There are many other modes that can be constructed on the white keys, and they were all used to flavor the music with sharps and flats back when there *weren't* any sharps and flats; you slide the intervals around by changing your selection of root note.

Modal music tends to confuse a bit these days because the sound isn't quite major or minor, but seems to have characteristics of both. *The Wreck of the Edmund Fitzgerald* is an excellent example of modern songwriting in the Dorian mode: play it on the white keys from D to D, with the first note being A.

Changing Keys

Here's where we come to the main stumbling block with our major scale that we've created out of the harmonic series. Changing keys means to raise or lower the pitch while keeping the note relationships the same. Singers prefer different keys, and instrumentalists would have wanted more keys to avoid having to carry many single-key instruments.

Even if you add the necessary sharps and flats to our harp or flute, it isn't possible to switch to another key without encountering sour notes. The reason for this should be clear if you ponder the intervals shown in **Fig. 1.**

With our familiar equal-tempered scale, we're used to building music out of the tone and the semitone (half a tone). The tone increase from C to D, for instance, is the same percentage increase in pitch as from G to A; a tone is a tone. Further, sharping a note produces exactly the same pitch as flatting the note above; D# is the same as Eb and so on. Not so in the natural scale generated according to the laws of acoustics. Note that there are a number of unique percentage changes (the frequencies and percentages are rounded off to integers). Instead of the tone and halftone, we now have the major tone (about a 13% increase), the minor tone (about an 11% increase) and the semitone (about 6%).

The intervals of the natural scale are Tone, Minor Tone, Semitone, Tone, Minor Tone, Tone, Semitone. Even if you add sharps and flats, changing keys is going to mess up the order; imagine that you have a C# and F# available, and you try to play in D simply by playing a major scale starting on the D note. You're into sour trouble right away. The first interval, D to E, is a minor tone when it's supposed to be a major.

And if that's not enough confusion, consider that sharps and flats are completely different creatures in the natural scale. A semitone is defined by the harmonic series as an increase of 16/15, or a decrease of 15/16. Taking C as 100Hz, C# becomes 106.7Hz. Coming down from the D note of 122.5Hz, Db becomes 105.5. A keyboard tuned to the natural scale would have to have keys for both the sharps and the flats. In fact, an organ builder in past centuries actually made such a thing. I don't suppose it was very popular with organists. I've also heard that a guitar-maker in the US is bringing out a guitar with an 18 or 19 fret neck to accommodate the natural scale, but I haven't been able to find out any more about it. No doubt it's a fun exercise for the builder, but the improvement in temperament must be rather subtle for such complication.

So the natural scale gives the sweetest sound, agreeing as it does with all the harmonics ringing from the various notes. It just isn't very practical.

The Cure

Long before Bach did such a marvelous public relations job for equal temperament with his *Well-Tempered Clavier*, people had been experimenting with dividing the scale into 12 equal sections (along with the mean-tone system, which was a compromise that allowed a few keys to work well and the others badly). Each section is a semitone and each tone is two semitones. Since there is no bother with the major-minor-semitone sequence, the

C 100
D 112.2
E...... 125.9
F...... 133.5
G 149.8
A...... 168.2
B...... 188.7
C 200

C 261.6
D 293.7
E...... 329.6
F 349.2
G 391.9
A....... 440
B...... 493.9
C 523.3

Fig. 4. The upper column shows the frequencies of the equal-tempered scale for C = 100Hz, which is not a musical pitch and was chosen for convenience. The lower chart shows concert pitch for A = 440Hz.

root note can be anywhere; every scale in every key is identical to all the others except for pitch.

Fig. 3 shows how the intervals are derived. F is the frequency of any note, and 2F is the octave frequency above it. To find the frequency of the next semitone, F has to be multiplied by a number X that will give 1/12 of the octave. If you multiply our semitone by X, you should get the next note, and so on until the last note is twice F.

Looking at it another way, X times itself·12 times has to equal 2.

$$X^{12} = 2$$

Solving for X by taking the 12th root of both sides, X becomes the 12th root of 2. Poke this into your calculator or computer (easiest way: 2 to the 1/12 power) and you'll get 1.059463094.

If you multiply any note by this, you get the next semitone up. Multiply any note by the reciprocal (.943874313) and you get the semitone below.

Multiply it by 100 and you get the percentage change in frequency between notes: 105.946%, if we round it a bit. Thus any note is 5.946% higher than the semitone below.

The Catch

There's always a price to be paid in compromises, but in the case of the equal-tempered scale, it isn't much. In fact, as complex compromises go, it's a miracle.

Musicians with *very* good senses of pitch will argue that the notes are never exactly on, especially the pesky seventh or leading tone. Others complain that the natural harmonics from the instruments clash with the equal-tempered fundamentals. You can hear this last effect on a very well-tuned piano: sound a C and the G in the next octave above it and listen as the notes fade away. You should hear rapid beats weaving in and out of the sound. They're caused by the tiny difference between the natural harmonic G (off the C string) and the equal-tempered G string.

Still, all the differences are extremely small, small enough that you rarely hear a complaint about this. People who play continuous-tone instruments (violin, trombone) will often bend the notes to suit themselves anyway. I'm not much of a violin player, but on occasions when I'm having a good saw at it, I like the leading tone very close to the octave, as do a number of other players. Perhaps we've invented our own musical scale.

Fig. 4 gives you two frequency charts. The first is the equal-tempered scale of C with C taken as 100Hz because it made the arithmetic easier. The second is the proper equal-tempered scale, in real concert pitch, starting on middle C; I derived it by taking A as 440Hz and using the 1.05946 method outlined above.

The Cent

To simplify working with small pitch changes, the octave is further divided into 1200 *cents*, with each semitone being equal to 100 cents. A semitone should really be called a dollar, then, and while we're at it, we need a name for 1.05946, like *fleen*.

The cent rarely turns up in music except on the readouts of electronic tuners.

Continued from page 8.

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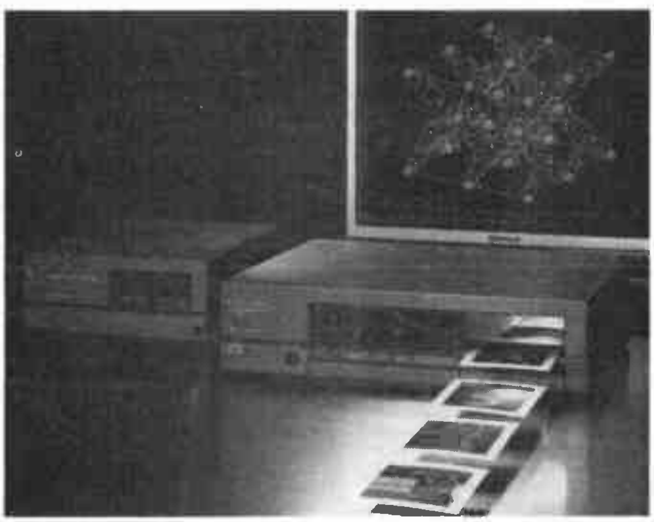

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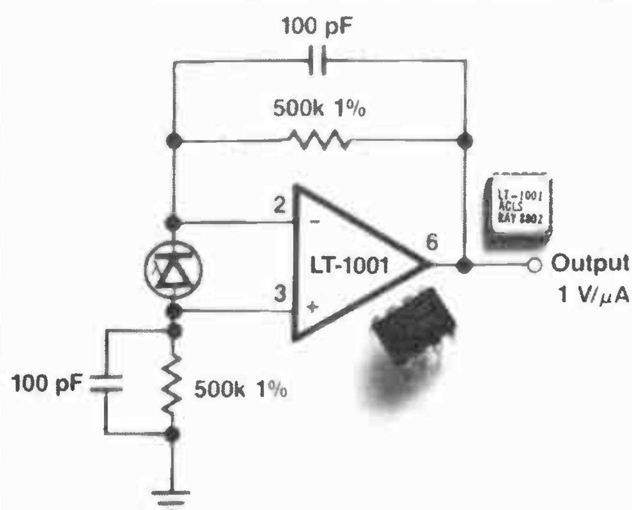

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We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

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R.A. Penfold
Although one of the more recent branches of amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category. The purpose of this book is to provide the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as a Fuxx Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser Units, Tremelo Generator etc.

BP 234: TRANSISTOR SELECTOR GUIDE $15.00
Listings of British, European and eastern transistor characteristics make it easy to find replacements by part number or by specifications. Devices are also grouped by voltage, current, power, etc., includes surface-mount conversions.

BP50: IC LM3900 PROJECTS $4.25
The purpose of this book is to introduce the LM3900 to the Technician, Experimenter and Hobbyist. It provides the groundwork for both simple and more advanced uses and is considerably more than just a collection of simple circuits or projects.

BP233: ELECTRONIC HOBBYIST HANDBOOK $15.00
A single source of easily located information: colour codes, pinouts, basic circuits, symbols, etc.

BP101: HOW TO IDENTIFY UNMARKED IC's $1.95
An unusual and fascinating chart that is highly recommended to all those interested in electronics and which will hopefully pay for itself many times over, by enabling the reader to use IC's that might otherwise have been scrapped.

BP121: HOW TO DESIGN AND MAKE YOUR OWN PCBs $5.85
The purpose of this book is to familiarise the reader with both simple and more sophisticated methods of producing printed circuit boards. The emphasis of the book is very much on the practical aspects of printed circuit board design and construction.

BP180: ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF MODEL RAILWAYS $9.00
Shows how home computers can easily be applied to the control of model railroads and other quite sophisticated control. A variety of projects are discussed as well as circuits for train position sensing, signal and electric points control etc.

BP185: ELECTRONIC SYNTHESISER CONSTRUCTION $9.00
With this book a relative beginner should be able to build, with the minimum of difficulty and at a reasonably low cost, a worthwhile monophonic synthesiser and also learn a great deal about electronic music synthesis in the process.

BP115: THE PRE-COMPUTER BOOK $5.85
Aimed at the absolute beginner with no knowledge of computing, this entirely non-technical discussion of computer bits and pieces and programming is written mainly for those who do not possess a microcomputer but either intend to one day own one or simply wish to know something about them.

BP72: A MICROPROCESSOR PRIMER $5.25
In an attempt to give painless approach to computing, this inexpensive book will start by designing a simple computer and then the shortcomings of this simple machine will be discussed and the reader is shown how these can be overcome. A glossary of microprocessor terms is at the end of the book.

BP78: PRACTICAL COMPUTER EXPERIMENTS $5.25
The aim of this book is to enable the reader to simply and inexpensively construct and examine the operation of a number of basic computer circuit elements and it is hoped gain a fuller understanding of how the mysterious computer "chip" works.

BP86: AN INTRODUCTION TO BASIC Programming Techniques $5.85
This book is based on the authors own experience in learning BASIC and also in helping others, mostly beginners to programming, to understand the language.

BP42: 50 SIMPLE L.E.D. CIRCUITS $5.85
Contains 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components.

BP85: INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE $9.00
This book is designed to help the user find possible substitutes for a popular user-oriented selection of modern transistors and includes devices produced by over 100 manufacturers.

BP140: DIGITAL IC EQUIVALENTS AND PIN CONNECTIONS $15.00
Shows equivalents and pin connections of a popular user orientated selection of Digital Integrated Circuits. Includes European, American and Japanese devices.

BP131: MICRO INTERFACING CIRCUITS - BOOK 2 $9.00
Intended to carry on from Book 1, this book deals with practical applications beyond the parallel and serial interface. "Real world" interfacing such as sound and speech generators, temperature and optical sensors, and motor controls are discussed using practical circuit descriptions.

BP100: AN INTRODUCTION TO VIDEO $5.85
This is a book for the person who has just, or is about to buy or rent some video equipment but is not sure what it is all about.

BP125: 25 SIMPLE AMATEUR BAND AERIALS $5.85
This book describes how to build 25 amateur bank aerials. The designs start with the simple dipole and proceed to beam, triangle and even a mini-rhombic.

BP136: SIMPLE INDOOR AND WINDOW AERIALS $7.00
People living in apartments who would like to improve shortwave listening can benefit from these instructions on optimising the indoor aerial.

BP141: LINEAR IC EQUIVALENTS AND PIN CONNECTIONS
ADRIAN MICHAELS $23.80
Find equivalents and cross-references for both popular and unusual integrated circuits. Shows details of functions, manufacturer, country of origin, pinouts, etc.,. Includes National, Motorola, Fairchild, Harris, Motorola, Intersil, Philips ADC, AMD, SGS, Teledyne, and many other European, American, and Japanese brands.

BP156: AN INTRODUCTION TO QL MACHINE CODE $10.00
The powerful Sinclair QL microcomputer has some outstanding capabilities in terms of its internal structure. With a 32-bit architecture, the QL has a large address range, advanced instructions which include multiplication and division. These features give the budding machine code programmer a good start at advanced programming methods. This book assumes no previous knowledge of either the 68008 or machine code programming.

See order form in this issue.

See order form in this issue.

Reaction Timer

Actually two projects demonstrating high-speed logic techniques.

By Owen Bishop

Circuits built using integrated circuits have several advantages over circuits built from separate transistors, resistors and other components. They occupy less space, they are simpler to assemble and often cost less too. Another advantage is that most ICs are designed to operate at high speed.

All of these advantages explain why the arrival of low-cost home computers depended upon the availability of ICs. This month we have two projects that depend upon the high speed operation of ICs. The ICs used are not the fastest available but, even so, are more than adequate for the purpose.

Project One — Reaction Timer

The circuit diagram shown in Fig. 1 allows you to measure your reaction time to the nearest tenth of a second. It is an oscillator followed by a counting chain. The difference here is that this circuit is stopped and started under the control of a bistable. In the non-running state the bistable holds the reset input of the 555 timer (IC2) low, so it does not oscillate.

The 7493 binary counter IC3 is first reset by pressing switch S3. All lamps go out. Now your friend presses the "start" button (S1). Instantly the bistable changes state. The reset of the 555 goes high and it begins to produce 10 pulses a second. These are counted by the 7493.

At the same time as counting begins, the light emitting diode (LED) D6 comes on. You should be watching for this and *as soon as you see it come on,* you press the "Stop" button (S2). When you press this, the state of the bistable is reversed, the counter stops counting and D6 goes out.

The count indicated by LEDs D1 to D5 tell you how many tenths of a second elapsed between the instant when your friend pressed the Start button and the instant you pressed the "Stop" button. This is a measure of

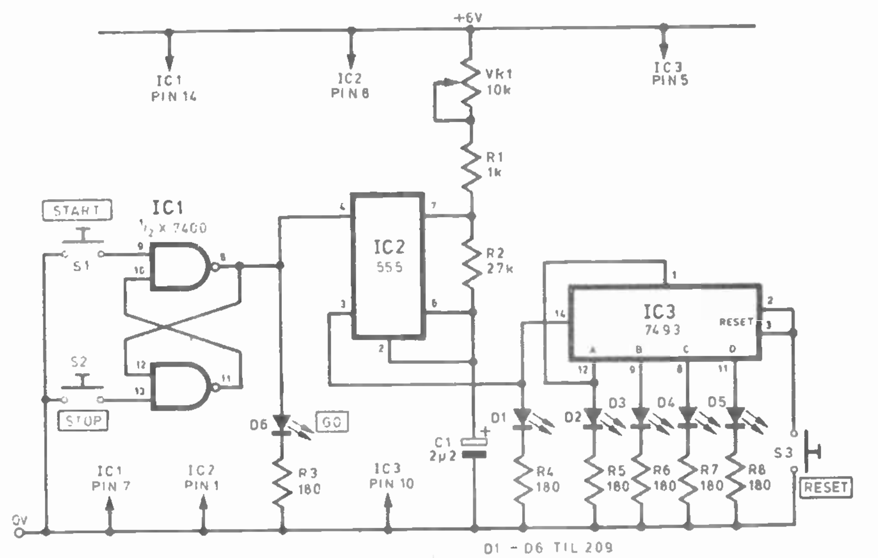


Fig. 1. Circuit diagram for the Reaction Tester using the 555 timer IC.

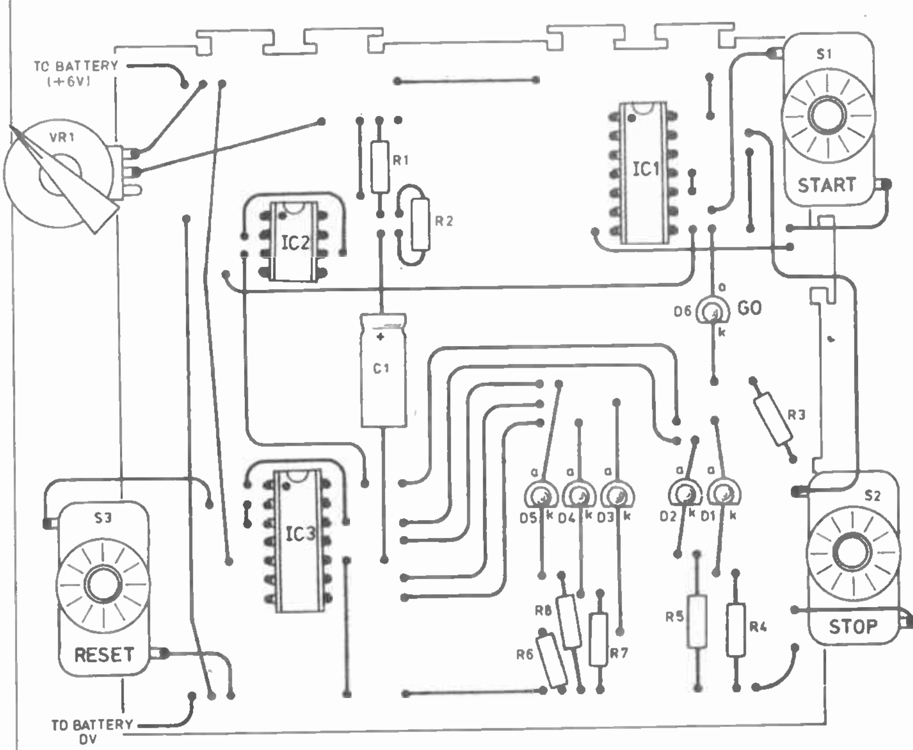
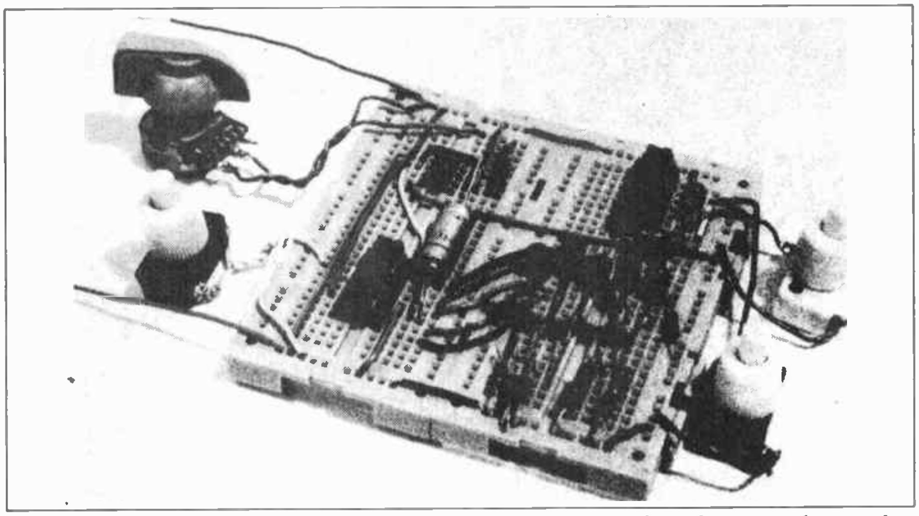


Fig. 2. Demonstration breadboard component layout for the Reaction Timer.



your reaction time.

Construction

The demonstration breadboard component layout for the Reaction Timer is shown in Fig. 2. If possible, place the start button out of sight, so that you can not tell when your friend is about to press it. When the circuit is assembled, let it run steadily and watch the final LED of the sequence. This should go out every 3.2 seconds.

You will need to adjust potentiometer VR1 to make the 555 timer run at the correct frequency. The easiest way is to watch the fifth LED as it goes out. Measure how long it takes to go out 10 times; this should be 32 seconds exactly. Then you know that the count indicated on the LEDs is your reaction time in tenths of a second.

Variation

Here is a problem for you to work on. How can you adapt the timer circuit so that it can be used as a lap-timer for races, for example with model racing cars?

Project Two — Who Was First?

It is all too easy to disagree about who did something first. With the circuit diagrams shown in Fig. 3 there can be no argument — even when one person is only 25 seconds before the other.

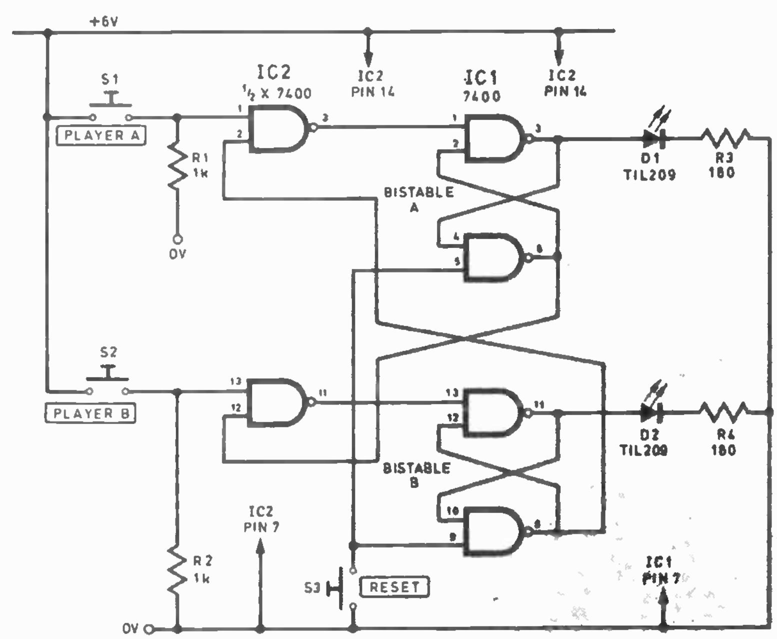


Fig. 3. Circuit diagram for a simple Who Was First using the 7400 quad NAND.

Parts List

Reaction Timer
Resistors
R1 .... 10k
R2 .... 27k
R3-R8 180
All 0.25W 5% carbon
Potentiometer
VR1 10k linear, carbon track potentiometer
Capacitors
C1 .... 2u2 electrolytic
Semiconductors
D1-D6 TIL 209 (or similar) LED
IC1 7400 quad 2-input NAND gate
IC2 555 timer
IC3 7493 4-bit binary counter
Miscellaneous
S1-S3 .... Push-to-make

Breadboard (2 small or 1 large); connecting wire; knob for VR1 and 5V to 6V supply

Who Was First?
Resistors
R1, R2 .... 1k
R3, R4 180
Semiconductors
D1, D2 TIL209 (or similar) LED.
IC1-IC2 7400 quad 2-input NAND gate
Miscellaneous
S1-S3 Push-to-make push-button switch

Breadboard (e.g. Verobloc); connecting wire and 5V to 6V supply.

Since a nano second is only a thousand-millionth of a second, most close ties can be decided easily.

The circuit (Fig. 3) is triggered by push-buttons operated by two players — perhaps they are playing "Snap" or some other game in which it is necessary to know who was first. It could instead be triggered by two phototransistor light sensors and be used in deciding which model car was first to cross the finishing line. For each player there is a bistable, which operates an LED. When the circuit is reset (press S3) and ready for action, both LEDs are out.

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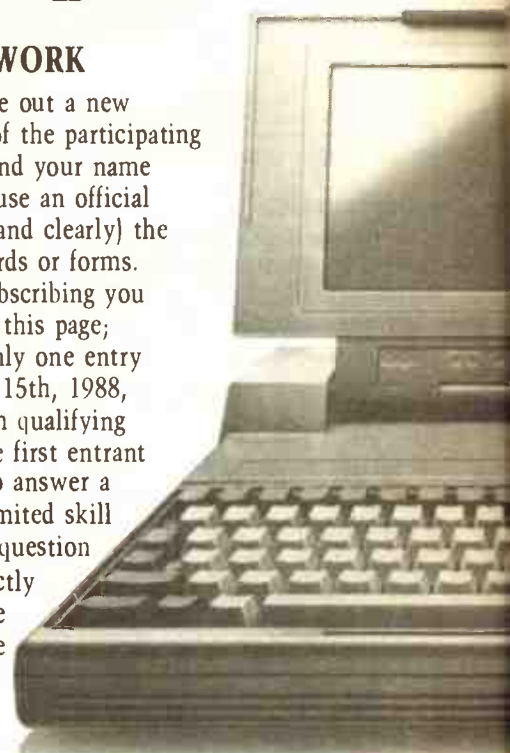

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If you wish to enter without subscribing you may use the Official Entry Form on this page; photocopies are NOT acceptable. Only one entry per envelope is acceptable. On May 15th, 1988, a random draw will be made from qualifying entrants. The first entrant drawn to answer a time limited skill testing question correctly will be declared the winner.*

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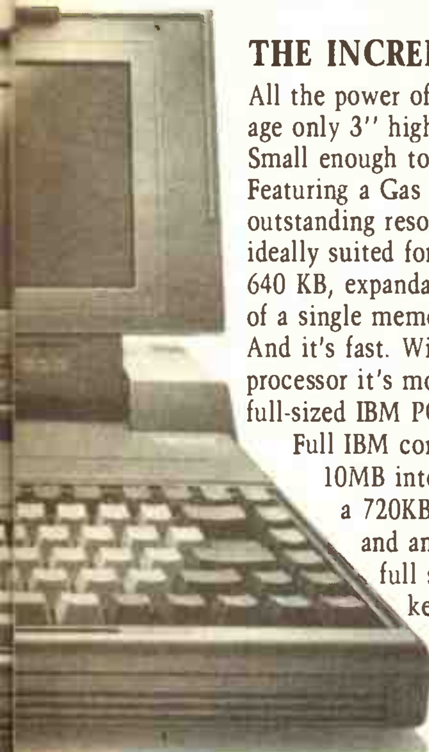

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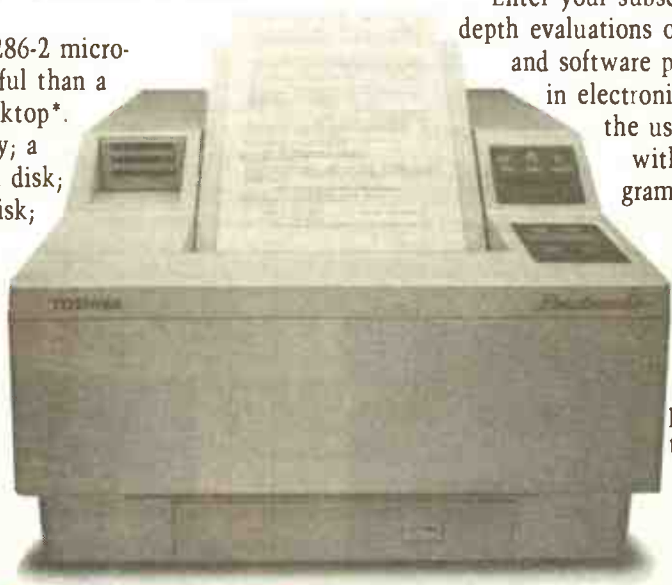

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Reaction Timer

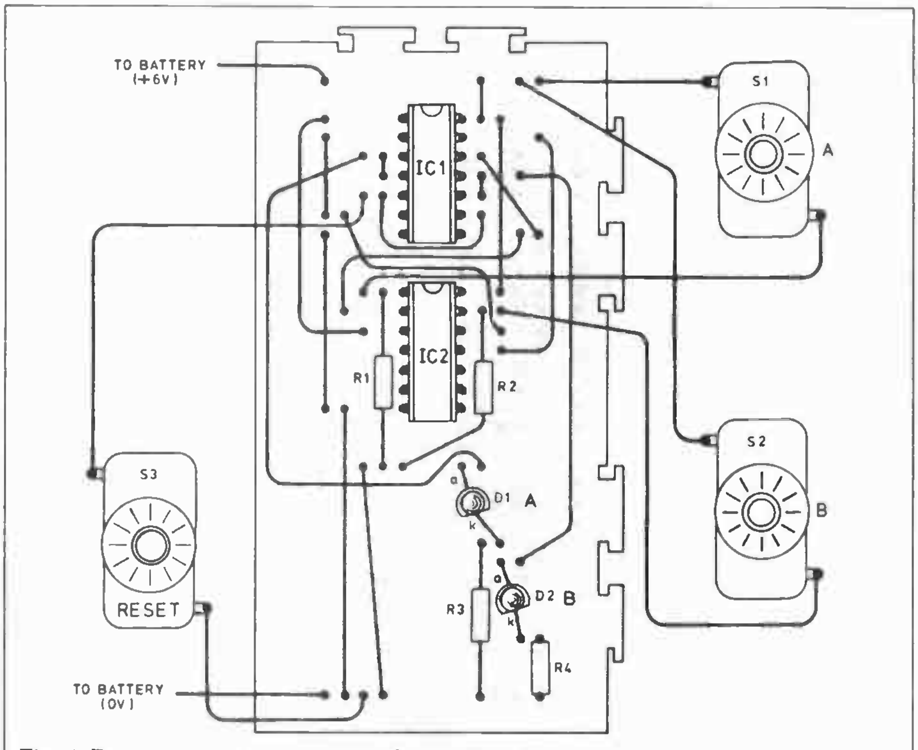


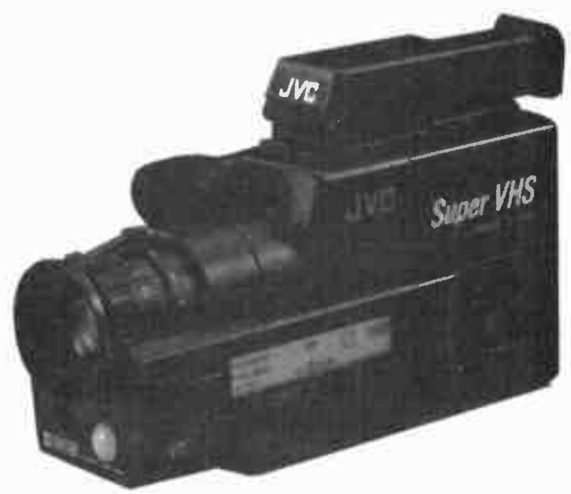
Fig. 4. Demonstration breadboard for the Who Was First circuit.

Between each push-button and the corresponding bistable is a NAND gate. One input to the gate comes from the player's push-button. The other input comes from the bistable *of the opposing player.* Each bistable feeds a "high" input to the NAND gates, so that if the other input is made high, by pressing the button, the output of the gate goes low. This triggers the bistable.

Suppose that player –A changes state and the lamp comes on, to indicate the winner. At the same time a "low" input is fed to the NAND gate belonging to player – B. Now it makes no difference if *B* presses the button or not. The output of that NAND gate is bound to be "high" whatever *B* does and it is impossible for B's bistable to be triggered. If *B* had pressed the button first, then the opposite would apply and *A* would be unable to trigger the bistable. So the lamp lights for whoever was first, and stays lit until the whole circuit is reset.

The demonstration breadboard component layout for the Who Was First? circuit is shown in Fig. 4. Commence construction by inserting all the link wires followed by the on-board components. Finally insert the switch and battery leads. ■

For Your Information *Continued from page 21.*



Super VHS

The GR-S55 from JVC is a versatile, compact camcorder/player with the latest in Super VHS circuitry at its heart.

This lightweight unit (1.1 kg) sports the following features: horizontal picture resolution of more than 400 lines, separated Y/C output terminals (S-VIDEO OUT) and AV IN/OUT connector; selectable shutter speeds of 1/60, 1/250, 1/500, 1/1000 of a second; one-button operation of focus, exposure, and white balance; and two-speed 6:1 power zoom lens.

Other features include a dubbing mode switch for better editing results and a trigger alarm for warning of record start/stop changes preventing recording errors.

For more information contact: Greg Parsons, JVC Canada Inc., 21 Finchdene Sq., Scarborough, Ontario M1X 1A7

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AV Dissolve

The 1100 Series from Taylor Electronic Designs features a self-contained Synchronizer with long/short pulse system enabling the programming of any preset dissolve rate (1 to 10 seconds) plus a cut.

Specifications are as follows: lamp output, 500 watts max. per projector; slide advance, 30V @ 1 amp maximum; and weight, 1.8 kg.

Other standard features include: a standard 5 pin jack for remote control or when using an external programmer for expansion, and a phono jack for the connection of a stereo tape deck when using the internal synchronizer.

For more information contact Roy Taylor, Taylor Electronic Designs, 2831 Dundas Street W., Toronto, Ontario M6P 1Y6

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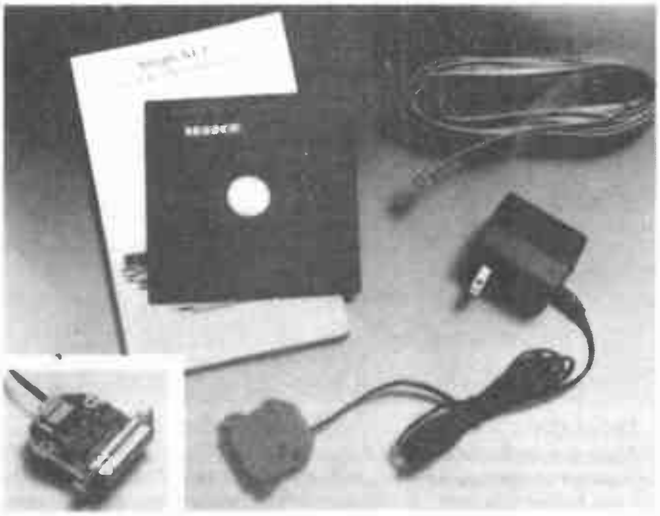


Zero Slot LAN

With SimpleNET ONEPLUS, data transfer rates of 9600 to 115,200 bps are possible via existing serial ports. This zero slot device also features built-in electronic mail, high- performance assembly language software, NETBIOS, and the SimpleWare Network Manager.

Also included: a comprehensive user's manual, 25 feet of twisted pair cable with standard RJ-11 telephone jacks, all software and SimpleNET's innovative small form RS-232 connector which uses a proprietary on-board circuit card utilizing surface mount technology. Price: $174.95US per node.

If you'd like more information on the SimpleNET LAN device contact: SimpleNET Systems, 545 W. Lambert Rd., Brea, CA 92621 or phone (714) 529-2413 or ...

Circle No. 49 on Reader Service Card

Technology Notes

Largest TV Picture-Tube

Matsushita Electric Industrial Co. has unveiled the world's largest, and perhaps heaviest, color picture-tube television featuring a 43-inch direct-view screen. The complete TV tips the scales at 180 kg (360 lbs).

Other features include: 110° deflection angle, non-glare flat aberration reducing triode CRT; three sets of stereo audio/video inputs and two sets of output jacks; stereo output power of 10W + 10W; and a learning remote control.

Don't look for this set on the shelves of your local dealer just yet though; only two working models exist and current production is only one set per day.

Western Gets Supercomputer

The University of Western Ontario recently celebrated the acquisition of its new Control Data ETA10-P supercomputer, making it only the third Canadian university to own such a machine.

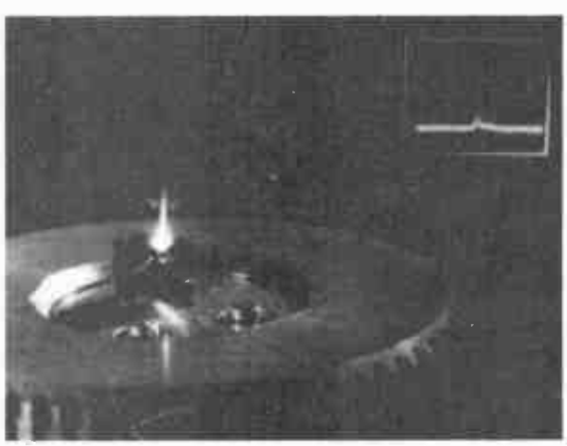
The new, low-cost supercomputer can perform 375 million operations per second and will be the basis of networked multiple user system on campus. The cost of the system will eventually total more than $2,000,000, inexpensive by supercomputer standards, and the U of W expects that it won't have to rely on outside clients to help support the system.

Fibre Optics At McGill

McGill University in Montreal has become the first university in Canada to take advantage of CNCP's fibre optic technology to communicate between two campuses. A single strand of glass fibre, no wider than a human hair, is being used to communicate data information between the downtown Montreal campus and the Faculty of Agriculture campus in Ste. Anne-de-Bellevue, 30 km away.

The system has two Northern Telecom SL-1 switches. The larger, an SL1-XT, is located on the downtown campus and has about 4600 connections to it. The other unit, with about 400 connections, is located at the Macdonald College.

Semiconductor Laser Emits Visible Light



A high-efficency semiconductor laser emitting light visible to the human eye has been developed at Philips Research Laboratories. This laser, made of mixed crystals of aluminum, gallium, indium and phosphorous, emits light at a wavelength of 650 nm, and is particularly suitable for digital optical recording. The peak output power of the laser is more than 0.1 watts.

Semiconductor lasers are used in professional products such as optical telecommunication and digital storage, as well as in consumer products such as the Compact Disc player. For reading stored information, a semiconductor laser that emits light at a wavelength of about 800 nm is used at present, but reducing the wavelength down to the 600 nm range can considerably increase the information density on a disc.

The new semiconductor laser consists of a number of single-crystal layers of compounds of aluminum, gallium, indium and phosphorous of different composition and with different doping. These layers are then deposited on a gallium-arsenide substrate by means of a chemical reaction in a gas mixture. As a result, the materials obtained are of such purity and have such a perfect structure that the internal losses in the laser are minimal.

Contributions to the new technology were made by researchers from Eindhoven (Netherlands) and the Laboratoires d'Electronique et de Physique (L.E.P), both part of the Phillips international research organization.

Happenings

Event: AutoCAD Expo '88
Date: May 2 - 5, 1988
Location: McCormick Pl. North, Chicago, IL
Contact: Autodesk Inc., 2320 Marinship Way, Sausalito, CA 94965. (415) 332-2344 ext. 799.

Event: Midwest Electronics Exposition
Date: May 4 - 5, 1988
Location: St. Paul Civic Center, St. Paul Minnesota
Contact: MG Expositions Group, 1050 Commonwealth Avenue, Boston, MA 02215 (617) 232-3976 FAX: (617) 232-0854

Event: Worst Case Circuit Analysis Training Seminar
Date: May 9 - 11th, 1988
Location: Washington, D.C.
Contact: Design & Evaluation Inc., 1000 White Horse Rd., Suite 304, Voorhees, NJ 08043. (609) 770-0800.

Event: Canada's International Telecom Exhibition and Telecom Futures Conference. (C.I.T.E.X.)
Date: May 18 - 19, 1988
Location: The International Centre, Mississauga, Ontario
Contact: ECM, 324 Lakeshore Rd. E., Mississauga, Ontario L5G 1H4 (416) 274-5505

Event: ATE & Instrumentation Conference East
Date: June 7 - 9, 1988
Location: World Trade Center, Boston, MA
Contact: MG Expositions Group, 1050 Commonwealth Avenue, Boston, MA 02215 (617) 232-3976 FAX: (617) 232-0854

Event: Meeting Tomorrow's Competition (EEMAC Annual Conf. and National Conf. on Electronics merged)
Date: June 8 - 10, 1988
Location: Loews' Le Concorde Hotel, Quebec City
Contact: EEMAC Communications Dept., 10 Carlson Court, Suite 500, Rexdale, Ontario M9W 6L2. (416) 674-7410

Event: The Third Pan Pacific Computer Conference
Date: August 15 - 19, 1989
Location: Beijing, People's Republic of China
Contact: For information contact: Halbrecht Associates Inc., 1200 Summer St., Stamford, CN 06905 (203) 327-5630

TV/VCR Portable

With the dawn of April we will see the release of the Casio VF-3000 3.3" TV with built-in VCR — at least in the U.S. anyway. (You can bet that Casio Canada won't be far behind.)

First introduced at the Winter Consumer Electronics Show, this past January, the VF-3000 is a portable 3.3" color LCD TV with a built-in VCR unit, 93,720 pixel resolution, VHF channels 2 - 13 and UHF channels 14 - 69. The VCR portion of the unit accepts a standard 1/2" VHS video cassette and jacks are provided for video and audio in/out, earphone, external power and external antenna. The VF-3000 operates via battery pack, household current or car battery — all with optional adaptors. The weight of the unit is 2.2 kilograms and it measures approximately 203mm x 152mm x 76mm. It's introductory price is expected to be $1399.00US.

More information, including projected Canadian pricing, may be obtained from: George Staleos, National Sales Manager - Audio/Video, Casio Canada, 2100 Ellesmere Rd., Suite 240, Scarborough, Ontario M1H 3B7.

Circle No. 52 on Reader Service Card

Drive-On

Starting with the 1989 model year, all automobiles sold in Canada will be required to operate with headlights on at all times. Vehicles manufactured before that date will be exempt from this law, but, a simple add-on device is available for those who wish to be safety conscious in their older vehicles.

Drive-On is easily installed by the do-it-yourselfer using everyday hand tools. Once connected, the unit turns your vehicle's headlights on when it's started, then off when the engine is turned off.

In Finland and Sweden where the law has been in effect for some time now, driving with headlights on has proven to reduce multiple vehicle collisions by as much as 27%. Numerous tests have shown that vehicles are easier to see and judging distance between vehicles is easier with headlights on during daylight hours.

The Drive-On! device is available for $29.95 (CDN) from Multinational Marketing Associates Inc., P.O. Box 3160, Reston, VA 22090-1160. Dealer inquiries are welcomed.

Circle No. 53 on Reader Service Card

Movie-Box

The Movie-Box is a combination VHS video cassette player and 14 inch color monitor, ideally suited for A/V presentations. It's a portable unit weighing less than 18 kilograms and it can be plugged into any 115 VAC outlet.

The unit features a front-loading deck with still, fine still tuning, tracking, frame-by-frame forward, five-times speed search, auto repeat, 6-hour timer, and external video and audio connections.

The Movie-Box is ideal for sales meetings, in-store demonstrations, instructional sessions, school programs etc. The list price of the Movie-Box is $1095.00. For more information contact: Bert Pantrey, Len Finkler & Co., 80 Alexdon Rd., Downsview, Ontario M3J 2B4. Ph: (416) 630-9103.

Circle No. 54 on Reader Service Card

Temp Controlled Iron

The Antex Model XTC 50 watt soldering iron features a thermocouple in the tip combined with a sliding potentiometer in the station for precise temperature control with positive feedback. Designed for use with heat and voltage sensitive components, the tip is positively grounded and zero crossing electronic switching in the station eliminates RF interference and magnetic fields.

Temperature can be controlled from 140° to 815°F with ±2% accuracy. The unit heats up in 45 seconds and has quick recovery times because the heating element is directly under the tip. Three tip sizes are available: 3/32", 1/8" and 3/16". The price: $167.70US.

More information about the Antex soldering station can be obtained from Charles Loutrel, Sales Manager, M. M. Newman Corp., 24 Tioga Way, P.O. Box 615 Marblehead, MA 01945. Ph: (617) 631-7100.

Circle No. 55 on Reader Service Card

IEEE-488 to Parallel Converter

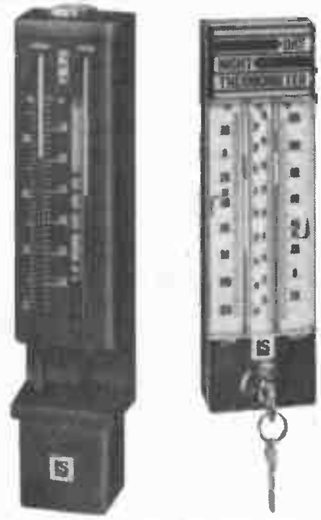
The GPIB-PRL is an 8-bit microcomputer-based interface tailored for use as an IEEE-488 bus to parallel (Centronics) bus converter providing transparent data conversion in either direction.

The unit can be connected to a GPIB listener, such as a printer or plotter, to a computer with Centronics-type output port or it can be used to add a standard Centronics-type printer to a GPIB network. The standard GPIB-PRL includes an integrated DMA controller which transfers the data directly to a 64K memory buffer (expandable to 256K) at rates as high as 900K bytes/second.

The unit comes complete with on-board firmware, self- test circuitry, and switch selectable IEEE-488 address for configuring the device as a dedicated talker or listener. The price of the unit is $695 for the 64K version and $995 for the 256K version.

For more information contact: David Green, Allan Crawford Associates, 5835 Coopers Avenue, Mississauga, Ontario L4Z 1Y2. (416) 890-2010.

Circle No. 56 on Reader Service Card



Temperature and Humidity Instruments

Two new products from Lab Systems offer temperature and humidity monitoring in critical environments.

The Day and Night Thermometer automatically records low and high temperature extremes, using markers sealed in the capillary tubes. The markers can easily be reset by turning a knob or by using an optional keyed reset. The price is $24.95US.

The Hygromat direct reading hygrometer gives accurate "wet bulb" readings of relative humidity without the use of complex charts. When the drum inside is turned so the current temperature appears in the window at the top, the correct relative humidity appears beside the right thermometer tube. The price of the Hygromat is $79.95US.

For more information contact Lab Systems, 555 Grizzly Peak Blvd., Berkeley, CA 94708. Ph: (415) 525-0947.

Circle No. 57 on Reader Service Card

Amstrad PC1640

Europe's best selling personal computer is now available in Canada. The Amstrad PC1640 is a 16-bit, 8 MHz 8086 machine with 640K memory, one 5 1/4" 360kB disk drive, mouse, joystick port, and light pen port. Three IBM-PC compatible expansion slots are also included; hard disk controller and mouse connections do not require the use of any slots. An optional 20 Mb hard disk is also available.

Serial and parallel ports are included, as well as full compliment of software including Microsoft MS-DOS V3.2, GEM Desktop, GEM Paint, Calculator, Clock-Alarm, Print Spooler and GEM Basic 2.

The standard 1640 comes with MIGA Hercules monochrome output and a paper white monochrome monitor; EGA and CGA are optional. Also included are a tilt and swivel monitor stand and an XT-style keyboard.

The price? A very reasonable $1499.95 (CDN). For more information contact AudioVideo Specialists Inc., 2134 Trans Canada Hwy. S., Montreal, Quebec H9P 2N4. Ph: (514) 683-1771 or FAX (514) 683-5307.

Circle No. 58 on Reader Service Card.

New 1553 Interface

The PC1553 is a low-cost MIL-STD-1553 plug-in interface board for the IBM-PC, XT, AT, or compatibles. By providing an interface to the 1553 data bus protocol, the PC1553 enables PCs to be used to test, operate and simulate equipment and systems using that standard.

The unit is capable of connecting a PC to a 1553 network, and as a functional tester, can be used during the development, production and maintenance of products using 1553 interfaces.

For more information on the PC1553 interface contact Ballard Technology, 1216 NW 75th Street, Seattle, WA 98117. Ph: (206) 782-8704.

Circle No. 59 on Reader Service Card

Gold-Ens Cables

Discwasher has re-introduced its 4m and 5m length Gold-Ens Connector Cables at the recent Winter Consumer Electronics Show.

These cables are high-quality RCA-style connectors that feature gold-plated ends, pure copper conductors and special age-resistant insulation.

The 4m set carries a suggested retail price of $17.95US while the 5m Gold-Ens sell for $19.95US. These cables are also available in .5m, 1m, and 2m sets and in triple cable sets as well for hi-fi/VCR hookups.

Available from Discwasher dealers across Canada at slightly higher prices.

Contact: Donna Austi, HWH Enterprises, Inc., (212) 355- 5049.

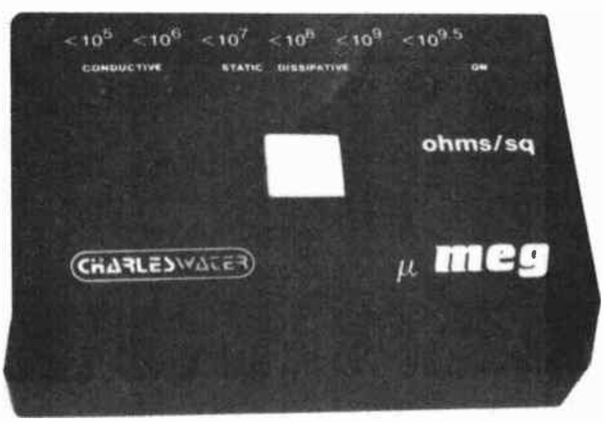
Digital Pressure Gauges

The Beta Products series of digital pressure gauges offer an accuracy of æ0.5% full scale reading, and æ1 count.

The Model 311 is for use in the low ranges of 0 - 5psi whereas the 312 is for use in pressures of 3 - 15psi. Both units also measure milliamps in the range of 0 - 100 mA with 1 mA resolution on the 20 mA scale. These units are compact (6" x 3.6" x 1.9") and light-weight, weighing only 15 oz. Standard equipment includes: padded case with handle; built-in NiCad batteries; battery charger; test leads; and instruction manual.

For more information contact Reggie Newton, Beta Products, 2029 McKenzie Drive #150, P.O. Box 115004, Carrollton, TX 75011-5004. Ph: (214) 241-2200.

Circle No. 67 on Reader Service Card



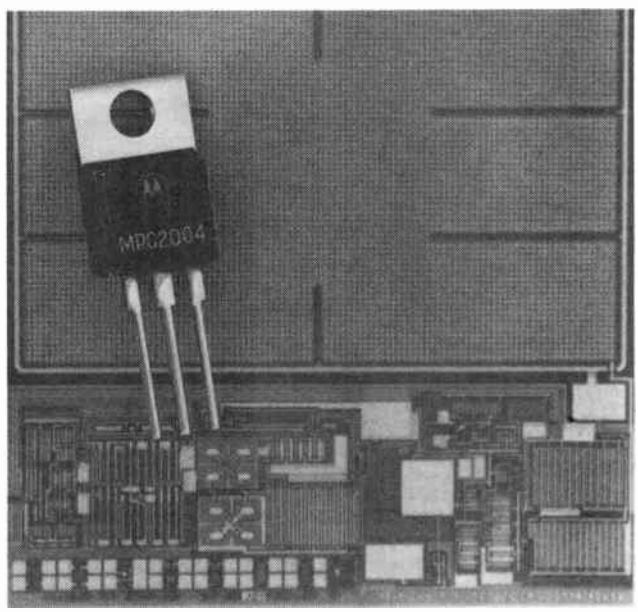
Pocket Megohm Meter

The U Meg Pocket Megohm Meter si capable of testing static dissipative and conductive materials over a ^{5} to $^{9.5}$ sensitivity range. Simple to use, just place its bi-electrode sensors on the surface being tested, press a button and a series of six colored LEDS will illuminate indicating whether the material is antistatic, static dissipative, or conductive.

The meter is suitable for testing static dissipative floor wax and laminates, portable work surfaces, transparent shielding bags, foam, and wrist/grounding straps. It comes supplied with a rechargeable NiCad battery and performs 1,000 tests per charge. The unit is small, lightweight, and there are no wires, cables or electrical hazards. The price is $249US .

More information is obtainable from: Pauline Bendana, Marketing, Charleswater Products Inc., 93 Border Street, West Newton, MA 02165. Ph: (617) 964-8370.

Circle No. 69 on Reader Service Card



Motorola SMARTMOS

Motorola offers a complete line of SMARTMOS overvoltage and overtemperature protection circuits to cover 5, 12, and 15-volt power buses for protection against overvoltage. The product family is made up of six components, rated at 7.5 Amps and 15 Amps. The devices are capable of high peak capacitance discharge currents, 75 and 150 Amps, or ten times their continuous current ratings.

More information can be obtained from: New Product Inquiries, Motorola Semiconductor Products, Canada, 4000 Victoria Park Ave., North York, Ontario M2H 3P4.

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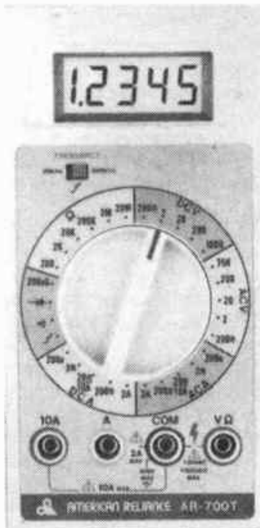


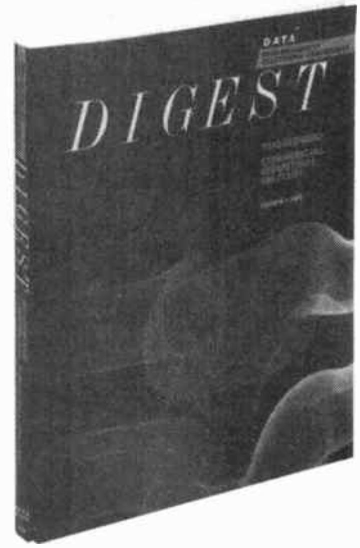
True R.M.S. Meter

The model AR700T is a 4 1/2 digit True R.M.S. meter with a DC volt accuracy of 0.05%. This meter also features a two range built-in frequency counter to 200 KHz, diode test, conductance, current measurement up to 10A AC and DC and an audible continuity tester.

All ranges are overload protected and battery life is typically 200 hours on an alkaline battery. The unit is also capable of bench operation with a standard 9V AC adaptor. It comes complete with test leads, battery, carrying case and is covered by a 1 year parts and labor warranty.

For more information on the AR700T contact Arthur C. Baier, BCS Electronics Ltd., Units 6 & 7, 980 Alness Street, Downsview, Ontario M3J 2S2. Ph: (416) 661-5585, FAX (416) 661-5589 or Telex at 065-28169.

Circle No. 51 on Reader Service Card



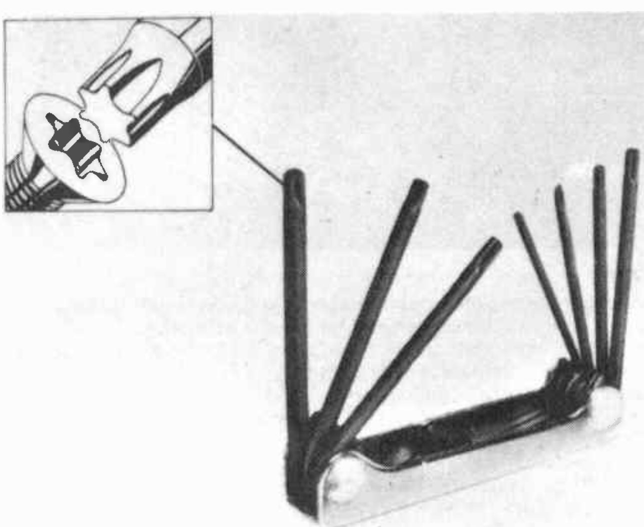
High-Rel Guide

D.A.T.A. Business Publishing has announced a new reference digest, High Reliability Electronic Components Digest, which contains detailed component information for High-Rel ICs and discrete semiconductors.

A single annual edition of the new publication can be subscribed to for $90 in Canada. Quarterly updates are $25 each and a special two-year subscription which includes two annual editions plus six updates is available for $300, $30 off the regular one-year subs rate.

For additional info or to place an order write to: D.A.T.A. Business Publishing, c/o Tech-Trek Ltd., 1015 Matheson Blvd., Unit #6, Mississauga, Ontario L4W 3A4. Ph: (416) 238-0366

Circle No. 60 on Reader Service Card



Key Set

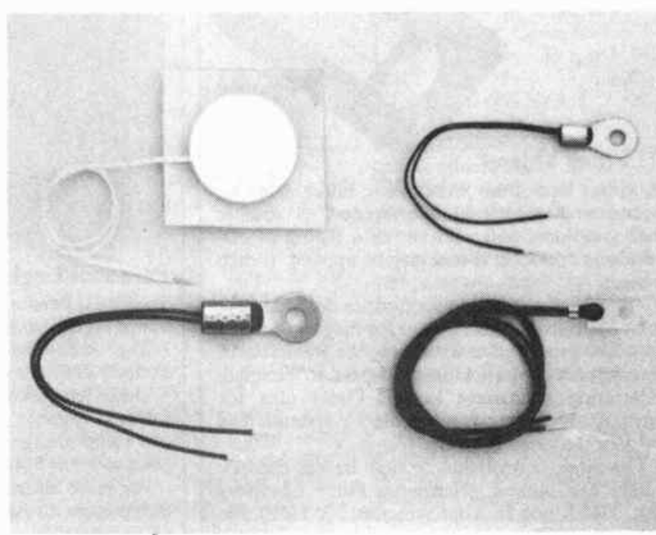
Unbrako's folding key set contains keys for seven of the most popular sizes of TORX keys in a single convenient handle.

Each key is made of precision-machined and hardened chrome-nickel alloy steel. The keys range in size from T-10 to T- 40 and can be used straight out or at right angle for extra leverage.

The six-pointed star shaped recessed fasteners have become increasingly popular for automobile and truck interior and exterior fittings, as well as for appliances, electronic equipment, locking screws in carbide tooling, power tools and office machines.

For more information contact: Larry Simpson, President, Standco Canada Ltd., 101 Spinnaker Way, Concord, Ontario L4K 2T2. Ph: (416) 738-4050.

Circle No. 66 on Reader Service Card

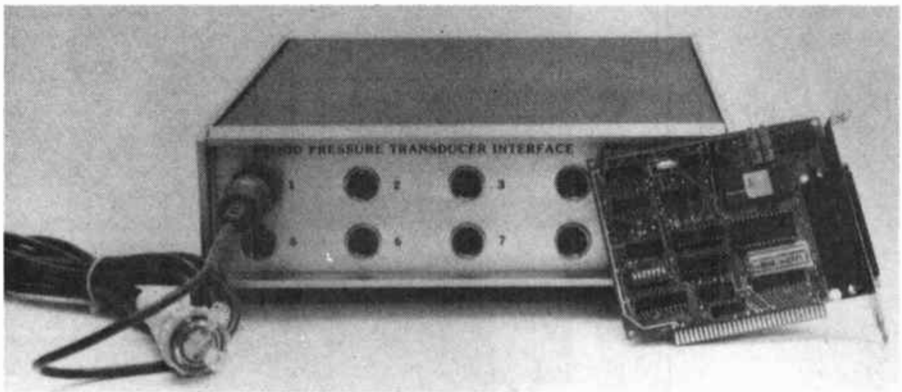


Thermistor Surface Housings

Fenwal Standard Surface Housings are designed to position and protect NTC or PTC thermistors which are mounted and operated in a given medium. These special probe assemblies can be readily attached or mounted with screws, threaded into surfaces, or cemented, soldered or taped to a surface. Housings may be made of stainless steel, aluminum, brass, plastic or other material. The most common types of thermistors used in the Surface Housings are NTC Uni-Chips, beads, glass probes, discs and PTC thermistors.

If you'd like some free technical information on Fenwal thermistor products contact: Fenwal Electronics, 450 Fortune Blvd., Milford, MA 01757 USA. Ph: (617) 478-6000 or FAX (617) 473-6035.

Circle No. 70 on Reader Service Card



PC Waveforms

The Datamax is a general purpose waveform recording system for IBM PC/XT/AT compatible computers. Up to eight channels of analog information may be monitored using your own transducers. High resolution waveforms may be displayed on the screen in real time and displayed parameters can be adjusted to suit the waveform.

The unit includes an 8-channel universal transducer interface, an A/D card (12 bits) and comprehensive software. Snapshots of any waveform may be saved to disc and later retrieved for analysis or printing. The system requires CGA, EGA or Hercules display, and 640K RAM. Sampling rate for each channel is adjustable in the range from 10 to 1000 samples per second. Transducer inputs provide 10V excitation and accept full scale signal +/- 10, 20, 40 and 80mV; inputs from unipolar sources accept +/- 5V. The cost of the Datamax is $3990.00US including hardware and software.

Contact Columbus Instruments, 950 North Hague Avenue, Columbus, OH 43204 USA. Ph: (614) 488-6176.

Circle No. 61 on Reader Service Card

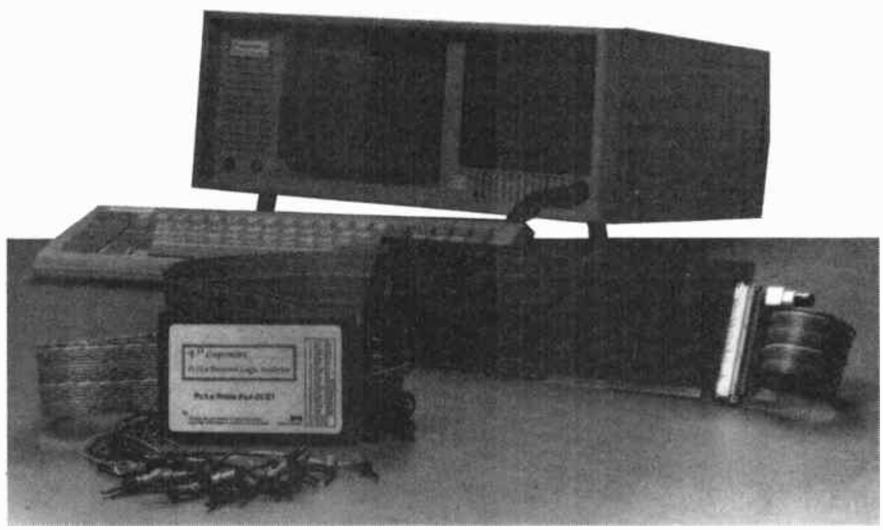
TI Filter Video

A video tape from Microwave Filter gives an overview of terrestrial interference, its sources and symptoms and also shows a listing of 500 receivers and what filters may be applied to each system.

Other equipment and accessories described are a kit of filters and accessories for diagnosing TI, a standard gain horn to determine the frequency of interference and stick-on absorbers to dissipate interfering microwave energy. Great idea for anyone trouble shooting satellite TV systems. The price of the video is $9.95US.

For more information or tape orders contact: Linda DeCoursey, Microwave Filter Company Inc., 6743 Kinne St., East Syracuse, NY 13057. Ph: (313) 437-3953.

Circle No. 62 on Reader Service Card



Personal Logic Analyzer

The Pc/La Personal Logic Analyzer features the acquisition speeds, triggering capabilities and number of input channels that are normally associated with high performance instruments.

The basic unit supports 32 acquisition channels, external clock, and two clock qualifiers. It samples data at a rate of 40 MHz on all 32 channels simultaneously.

Other features include: 4 channel glitch detect per group of 32 channels; 4096 sample data buffer for each channel; user definable pre-trigger buffer size; and storage and retrieval of sampled data and setup configurations. The unit is packaged as a single plug-in card for the IBM PC family. The price starts at $2495 (FST not included).

For more information on the Pc/La contact Rayonics Scientific and Techmatron Ltd., authorized distributors, or Alan Simmons at V^3 Corp., 285 Raleigh Ave., Scarborough, Ontario M1K 1A5. Ph: (416) 266-5511.

Circle No. 65 on Reader Service Card

Five Gigahertz Circuit

Bell Northern Research of Ottawa, Ontario, recently announced the development of an exploratory gallium arsenide (GaAs) circuit that can handle signals at 5,000 cycles per second (5 GHz).

The circuit attains its extremely high speed through the use of a BNR chip design that employs gallium arsenide and air bridge technologies. Air bridges form a complex network of highly conductive metal pathways that direct information through the circuitry on the chip. Made of gold, air bridges are supported above the circuit by posts to avoid contact with the chip's surface.

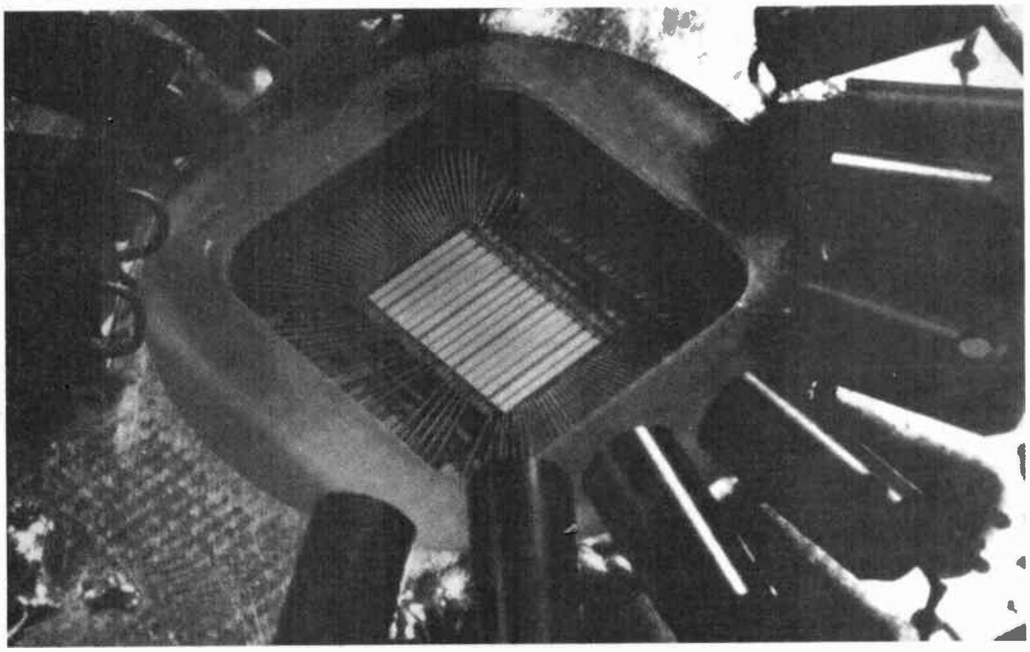
The circuit, known in the industry as as 4 x 4 space switch, creates direct electrical paths between the chip's four input and output channels, with data passing through the channels in a continuous stream.

Chinese Get Direct Dial

The end of 1987 saw the dawn of a new age in technology in the People's Republic of China. On December 24th, China opened its first direct dial telephone exchange between Beijing and the outside world.

According to an official at the Ministry of Posts and Telecommunications, the project has a 400 circuit telephone switching exchange and a 3,000-line telex switching exchange manufactured by Siemens of the Federal Republic of Germany, and microwave systems made by GTE of Italy.

The official also claimed that callers from Beijing will be able to call 19 countries and regions using direct dialling including Japan, Hong Kong, the United States, France and Italy.



World's Fastest Chip

IBM researchers recently announced that they have what is believed to be the world's fastest DRAM chips. These experimental IBM chips can retrieve a unit of information (bit) in just 20 billionths of a second - three times faster than the current generation of advanced DRAMs.

The advanced design directs power on the chip more precisely, supplies faster circuits at critical points in the chip's access paths and provides more sensitive circuits to detect and amplify the almost infinitesimal signals on the chip to useful levels.

IBM RISC Processor

IBM is also doing research into Reduced Instruction Set Computer (RISC) microprocessors which are said to increase both the speed of memory and logic while decreasing the physical dimensions of the chips.

One such experimental RISC chip, called a fixed-point processor, ran 60 per cent faster than the same chip in a conventional form.

RISC is a concept invented by IBM Fellow John Cocke in 1975 and is applied today in the microprocessor engine of the IBM RT PC engineering workstation as well as in other IBM processors. The RISC concept has also been adopted by the computer industry as the basic blueprint for a number of advanced microprocessors.

Anti Noise Car Stereos

From Britain we bring you this little piece on car stereos that stifle engine boom as they play music.

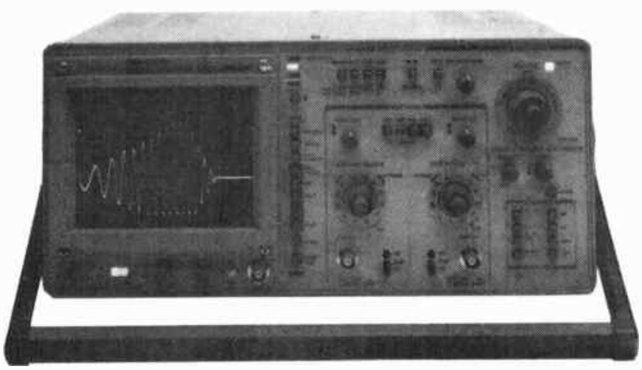
Engine boom is a problem in most modern cars and happens when the engine vibrates at the same frequency as body panels, seats or even the air inside the vehicle. It's usually the loudest when cruising at engine speeds of around 4,000 RPM.

Lotus, a British engineering company, believes that its adaptive noise control system, which instantly responds to engine boom by generating sound of equal amplitude but opposite phase, could be incorporated into conventional car stereos.

The system has been perfected over the past 18 months as a result of collaboration between Lotus and Southampton University scientists.

The recently demonstrated Lotus system used a computer to simulate the engine boom, and four microphones with two 80W loudspeakers to suppress it. A Lotus spokesperson says the amplifier and speakers of car stereos installed in many cars are good enough to support the anti-noise system, so only the inexpensive microphones and a small computer need be added.

If you'd like more information on the anti-noise car stereo system, contact: Lotus Group, Norwich, Norfolk, England NR14 8EZ. Ph: +44-953 608000 or FAX +44-953 606884.



New Intron Scope

The Intron DSO-2020A features 20M samples per second as well as 20 MHz real-time bandwidth. The DSO-2020A also has an 8-bit by 2K memory per channel, X-Y storage and X-Y(t) plot output.

For more information contact RCC Electronics Ltd., 310 Judson Street, Unit 19, Toronto, Ontario M8Z 5T6. Ph: (416) 252- 5094 or FAX (416) 252-3031.

Circle No. 73 on Reader Service Card

Computers and Roses

At the University of Guelph, roses will soon be programming computers. Researchers in horticultural science who listened to plants to determine their need for water no plan to let these plants regulate their own greenhouse environment through an automated computer control system.

"Plants are the ultimate environmental sensors," says horticultural science professor Michael Dixon. They can tell us what their needs are in terms of light, temperature, humidity and soil moisture.

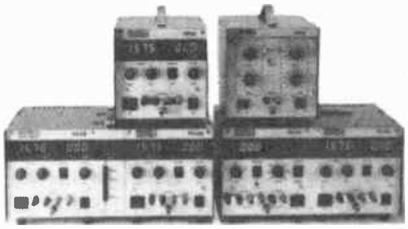
The current project will investigate the effectiveness of a computer-automated control system that responds to changes in a plant's water status. One result of this research will be the development of a set of minimums and maximums, reliable parameters that will enable growers to make better use of sophisticated computer equipment.

"The greenhouse industry's rapid adoption of computer technologies has created a management dilemma," Dixon says. "While an automated greenhouse can maintain an environment, the grower may not know the optimal settings for variables such as temperature, humidity and light intensity. Unfortunately, the development of sensor technologies has lagged behind control hardware and software," he added.

Dixon hopes to change that situation by improving sensor technology and evaluating the problems and advantages of computer-automated greenhouse environments. The department has received much assistance from North American rose growers, and more than $270,000 from the Ontario Ministry of Agriculture and Food will provide the necessary technical expertise needed to operate the program throughout its three-year duration.

It is the ultimate objective of the project to evaluate the plant's response to the whoe environment and then use that response to trigger the automated system that controls the environment.

For Your Information

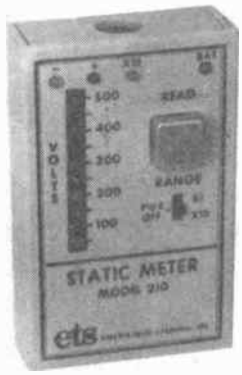


Precision PSUs

The PS732 series from O.K. Industries feature dual 3 3/4 digit display for simultaneous metering of current and voltage. Output controls provide 0.1% accuracy for voltage readings and 0.3% accuracy for current readings.

The PS732 has a single output of 0-30V/0-2A while the PS732-Q features a dual output/quad mode which includes: 2 x 0- 30V /0-2A; 0-30V/0-4A; 0-60V/0-2A; or 0±30V/2A. The third model in the series has three output capabilities including 0-30V/0-2A; 0-30V/0-1A; and ±5V/7A. Prices start as low as $345US and more information is available from O.K. Electronics Division of O.K. Industries Inc., 4 Executive Plaza, Yonkers, NY 10701.

Circle No. 79 on Reader Service Card



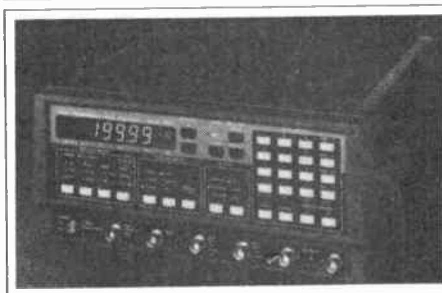
Electrostatic Field Meter

This compact, lightweight meter utilizes a four color array of twelve solid state LEDs to indicate the magnitude and polarity of electrostatic fields.

It features a single range selector switch that enables the user to select either a 0 to ±500 volt range or a 0 to ±5KV range. A yellow X10 indicator illuminates when the 0 to ±5KV range is selected to remind the user to multiply all readings by 10. Polarity indication will automatcally switch whenever the field polarity changes.

For more information contact: Sharon Sandy, electro-tech systems inc., 115 E. Glenside Ave., Glenside, PA 19038.

Circle No. 80 on Reader Service Card



50 MHz Pulse Generator

The Tabor 8500 is a GPIB pulse generator which is fully programmable and is capable of generating high power pulses with rise times of less than 5nS.

Using a 7 digit LED display the 8500 can operate within a period range of 20nS to 2S. At a slightly reduced amplitude level this range can be extended to 14nS (above 70 MHz)

Also featured are a burst generator function, reciprocal counter/time, and storage for up to 30 pre-programmed set up states in non-volatile memory.

Contact Bruce Petty, Duncan Instruments, 121 Milvan Drive, Toronto, Ontario M9L 1Z8.

Circle No. 81 on Reader Service Card

Assistant Editor Moves On

Edward Zapletal, Assistant Editor of Electronics & Technology Today is moving on to become Editor of a new Moorshead Publication titled - Business Computer News. Mr. Zapletal began with Electronics Today as Editorial Assitant in May of 1984 and later became Assistant Editor in September of 1985.

Business Computer News will publish its first bi-weekly issue on April 15th, 1988.

Continued on page 46.

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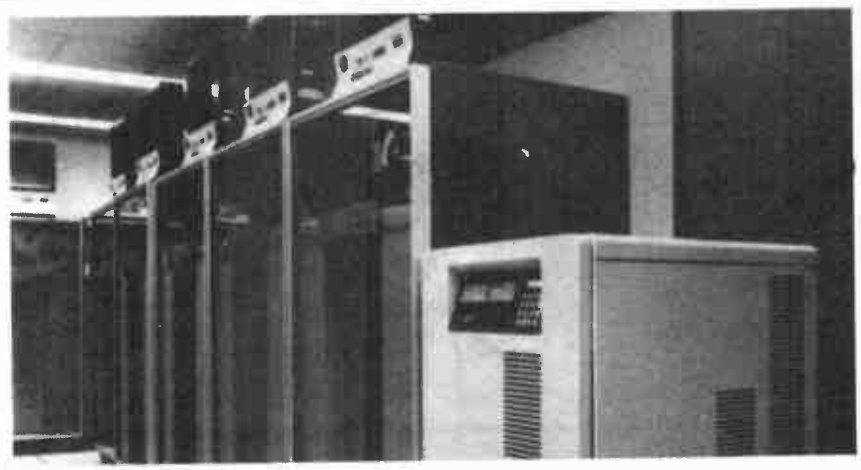
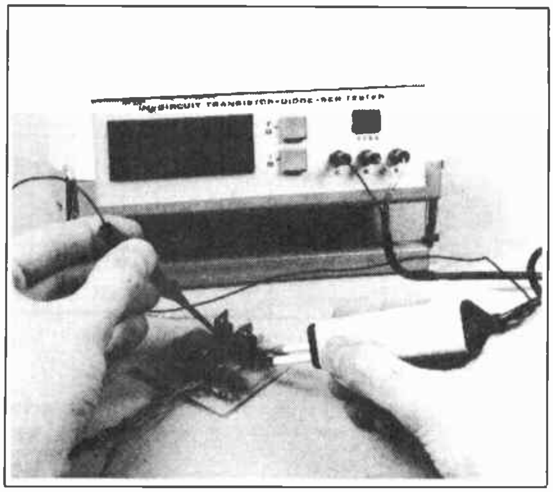


The UPS
A parcel service? The Uninterruptible Power Supply keeps computers and other equipment going during power failures. Here's how they work, from mainframes to micros.

Build a Pseudo Echo Unit
The simplest echo unit going — it's actually a special form of tremolo circuit.

Shockmounting electronic cabinets — Build a capacitance meter — E&TT reviews a superconductor kit that you can buy.



Transistor Tester

An in-circuit transistor tester that will test your components rather than your patience.

By Allan Wilcox

How many hours have you spent testing transistor after transistor in a ponderous search for the monstrous component that has blackened your golden PCB? How often do you wish for a device that could tell good from bad with a single prod from a probe?

Wish no longer. This tester will confirm a single measurement if a diode, transistor or thyristor is OK as well as showing its polarity (PNP/NPN for a transistor and PN/NP for a diode). It is tolerant of in-circuit resistance of the order of 40R across the junctions so you can flit from component to component without once reaching for your soldering iron. There is even a buzzer which sounds whenever a healthy piece of semiconductor is tested.

The Test

To test a transistor a 5Hz square wave is applied to the collector-emitter terminals of the device being examined (see Fig.1). Forward bias is supplied to the base, again with a 5Hz square wave.

The low saturation voltage of a good transistor is taken as the indication of a good device but is differentiated from a short circuit by checking that conduction occurs in one direction only.

If conduction occurs on the positive half-cycle (relative to the emitter) this is interpreted as being a good NPN transistor.

Conduction on the other half-cycle would be due to a good PNP device.

The design criterion here is that the collector-emitter voltage must fall below 500mV for a good indication to be given. This ensures the tester ignores any diodes that may be in circuit. This is particularly important in order to detect a collector- base short which would act as a diode, conducting on one half- cycle only and erroneously indicating a good device.

Diodes, thyristors and Darlington transistors have a forward voltage drop between 500mV and 1V so to test these a separate range is provided. On this range the threshold for a good indication is increased to approximately 1V.

The Display

A 4-digit LCD is used to show the status of the device under test. The first three 'digits' can show either an n or a p, and indicate the device type. The first digit is blanked when testing diodes.

The fourth digit shows either a t or a d to indicate transistor or diode range. It also serves as an 'on' indicator. Failed devices will give a display of nnn on the LCD if the test terminals are short circuited. If they are open circuit, the first three letters of the LCD are blank.

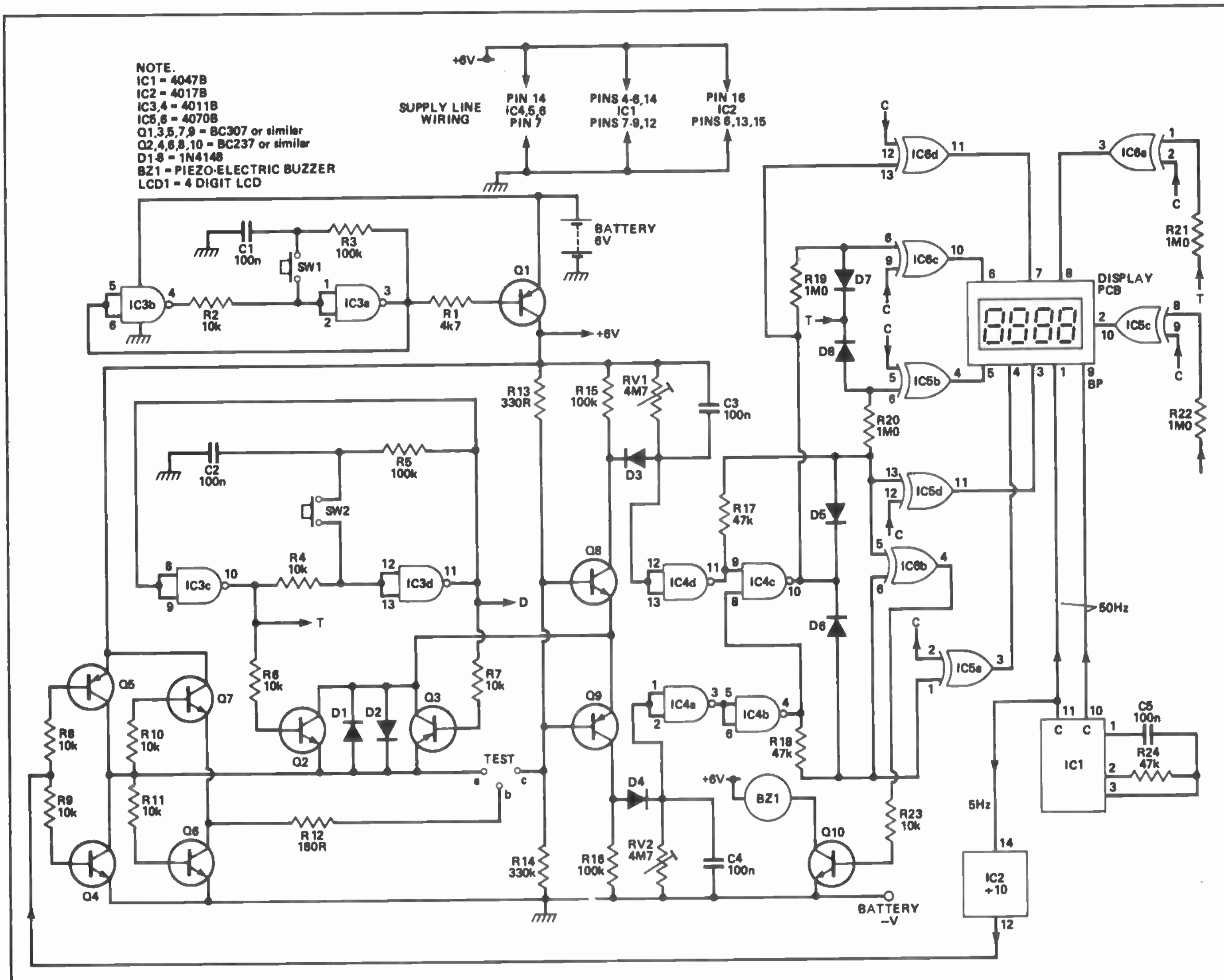
Construction

The component overlay for the main PCB is shown in Fig. 2. All ICs are CMOS and so the usual precautions against static should be taken. Note that they all face the same way on the board.

All odd numbered transistors are PNP and even numbered are NPN. The presets RV1, RV2 may be replaced by 4M7 fixed resistors with just a small increase in the response time resulting.

Avoid any stress on the LCD display, taking care not to overtighten any fixing nuts. The mounting bezel specified comes complete with two socket strips on a board. These were removed and used on the display PCB (fig.3). Take care to observe the polarity of the ribbon cable when connecting the main PCB to the display PCB.

Note that the two switches are momentary push to make, similar to a keyboard type. The ones used on the prototype were from the junk box.



The complete circuit diagram.

Shock, Horror, Probe

Testing a transistor involves connecting into the circuit at three separate points. Manipulating three individual probes with only two individual hands can be a practical problem. To overcome this, a special collector-emitter test probe was constructed using a small Eveready torch case into which were fitted two short lengths of curtain wire to form the probes. Dart points were filed down to fit tightly into these. The result can be seen in the photograph.

The probe used for the base connection is one commercially available. In addition to sockets for the circuit probes, a transistor socket was fitted to the from panel of the case to ease the testing of devices out of circuit.

Testing And Setting Up

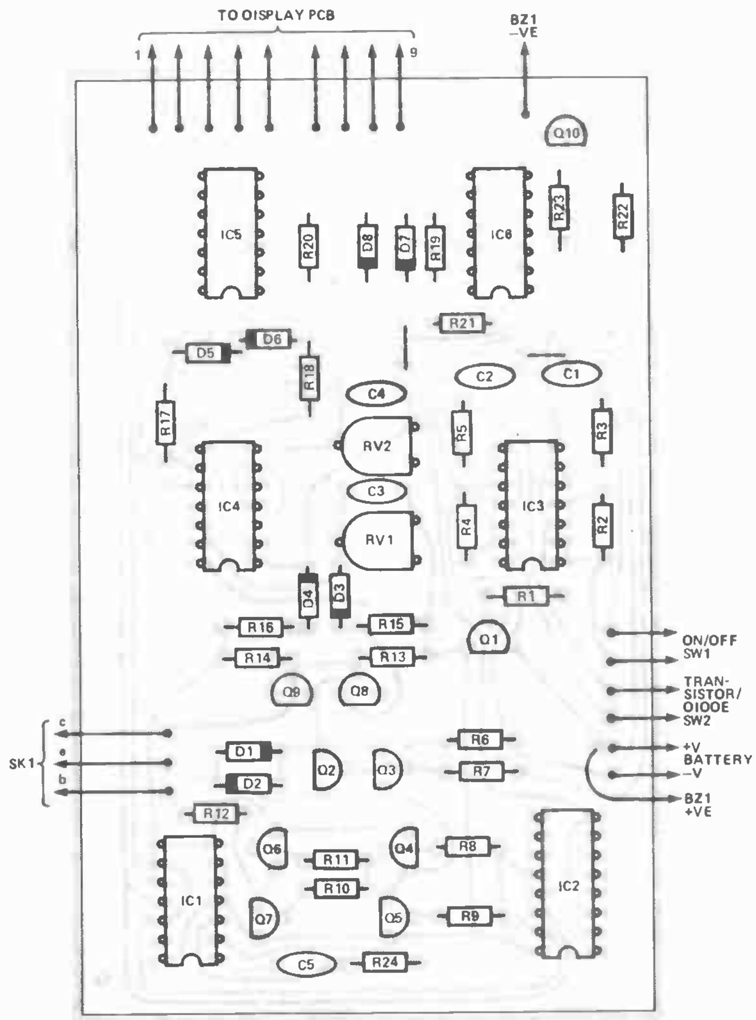
If the presets (RV1,2) are fitted, turn both counterclockwise and connect up the batteries. When on, the display should blank apart from the mode indication which should be a d or t. This should alternate each time SW2 is operated.

Now select the diode mode and advance a preset until the display starts to flash, then back off until the display just blanks. Repeat this procedure with the other preset.

To test the unit connect a diode across the collector-emitter terminals. The display should show **pn** when the diode anode is connected to the collector terminal and **np** when the diode is reversed. There should be no response from the connection of the diode when the unit is in the transistor test mode.

Check the transistor mode using a good transistor of each type. The display should remain blank until the base connection is made. Now short the collector-emitter probes together and check the display shows **nnn**.

Note that the buzzer will sound continuously while a good device of any type is connected. This is useful for rapid testing of components on a board when there is no regard for polarity. Thyristors should be tested on the diode range due to their higher saturation voltage. The collector, emitter and base terminals become anode, cathode and gate respectively. A good device will show pn (it does of course act as a diode) but only when the gate connection is made. Confirm that point otherwise it is faulty. If the



The component overlay the main PCB.

Parts List

Resistors (.25W, 5%)

R1 4k7
R2,4,6-11,23 .... 10k
R3,5,15,16 .... 100k
R12................................ 180R
R13,14 .... 330R
R17,18,24......................... 47k
R19,20,21,22 .... 1M0
RV1,2..................... 4M7 trim

Capacitors

C1-5 .... 100n

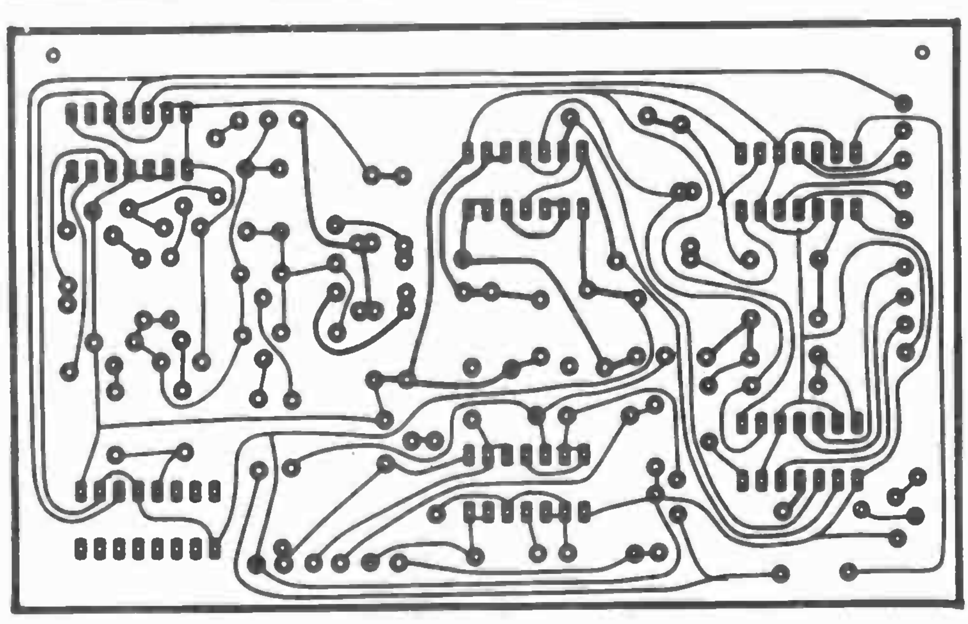
Semiconductors

IC1 .... 4047B
IC2 .... 4017B
IC3,4 .... 4011B
IC5,6 .... 4070B
Q1,3,5,7,9 ...2N3905 or equiv
Q2,4,6,8,10. 2N3094 or equiv

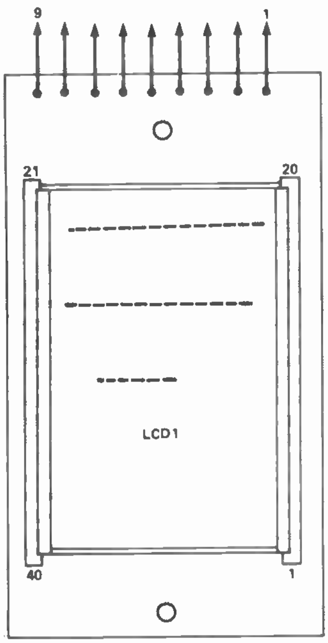
Miscellaneous

BZ1 .... piezo buzzer
LCD1.......... ICM7211AIPL
4-digit
direct-drive LCD
SW1,2............ push-to-make

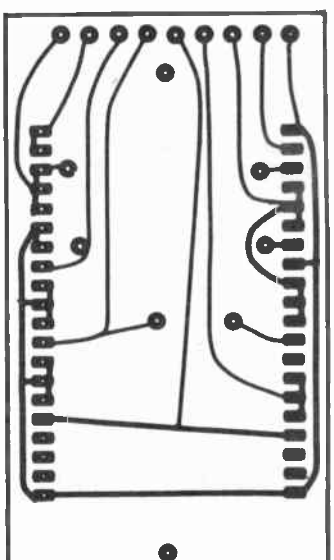
Battery holder, LCD bezel, case. The LCD is available from Electrosonic, 1100 Gordon Baker Rd., Willowdale, Ont. (416) 494-1555.



The main PCB.



Component overlay for the LCD.



The LCD printed circuit board.

thyristor has an internal diode then it will show np before the application of the gate connection due to the conduction of the internal diode.

Once the gate connection is made in this case, the display will show nn (which would normally indicate a short circuit) due to a legitimate conduction in both directions. The display will similarly show nn when testing two diodes which are connected 'back to back'. A check can be made that this is due to conduction through two good diodes rather than a short circuit by switching to the transistor range and checking the display blanks off.

Darlington transistors also have a high saturation voltage and can be tested in the same way on the diode range. Darlingtons with internal diodes mean that an NPN device for example will display np due to an internal diode which updates to nn upon application of the base connection in both directions.

A flashing display at any time should normally be interpreted as being a good device of the type indicated but with the presence of a large value electrolytic capacitor across a junction. The presence of such a component in circuit will give some conduction in the opposite direction to the semiconductor being tested and cause this effect. As a result, this unit is not really suitable for checking mains supply rectifiers. Because of the low resistance of the supply transformer winding, the reservoir capacitor is effectively across the diode as far as the tester is concerned. If the capacitive reactance is below 40R or so at 5Hz, a short circuit indication will result even though the rectifier may well be OK. A low battery will first show up as the display flashing at all times.

How It Works

Gates a and b in IC3 are wired as a bistable that changes state each time the on/off switch SW1 is pressed. When pin 3 is low, Q1 is turned on through R1 and power is supplied to the rest of the circuit. Gates c and d are also connected as a bistable, this time changing state when the transistor/diode switch SW2 is pressed. In the transistor test mode Q2 and Q3 are biased on, effectively shorting out diodes D1,2. (Some features of the display are also controlled by this bistable). These diodes come into effect in the diode test mode, raising the threshold voltage for testing as mentioned above.

IC1 is connected in the astable mode having a frequency set at 50Hz by R24 and C5. This provides the waveform to drive the display and is divided by IC2 to give the 5Hz square wave used to drive the bridge circuit formed by Q4-7. The result of this is that the collectors of Q4,5 have a 5Hz square wave that is the inverse of that on the collectors of Q6,7. A 1V peak-to-peak waveform is this generated providing an AC supply ot the test terminals.

The potential to the collector-emitter terminals is limited to 600mV in each direction by the base-emitter junctions of Q8,9 across these terminals in the transistor text mode. In this mode Q2 and Q3 are always on as the Q4 and Q5 collectors switch between the supply lines because IC3 pin 10 is high while pin 11 is low.

Assuming no device is connected tot he test terminals, Q8 and Q9 will conduct alternately, again at 5Hz. When the common emitter line is low Q8 is biased on through R13 and when it is high, Q9 received its bias via R14. It is the conduction or otherwise of Q8 and Q9 that is monitored by IC4 to provide information on the device being tested. Q8 charges C3 each time it conducts, and the time constant C3-RV1 is such that the input to gate IC4d remains below its switching threshold, thus holding the output pin 1 high. Conduction through Q9 on the other hand charges C4 so the input to gate a stays just above the switching threshold, keeping output pin 3 low.

The collector-emitter junction of a transistor being tested is effectively across the base-emitter junctions of Q8 and Q9 so if, say, a good NPN transistor is in circuit the bias to Q8 is diverted and it will switch off. Forward bias to the test transistor at this time is through Q7 and R12.

Similarly Q9 will be turned off by the application of a PNP device, this time biased by Q6 and R12. A short circuit across the collector-emitter connection will of course turn off both Q8 and Q9. A diode across these connections will draw some current but this will be insufficient to effect conduction of Q8 and Q9. This ensures a transistor with a base-emitter or base-collector short will register.

In the diode test mode, the bistable IC changes state, reverse biasing Q2,3. D1 and D2 are effectively in series with the bias feed to Q8 and Q9. A diode connected across the collector-emitter terminals will be able to turn off either Q8 or Q9 depending on which way around is connected.

The time constant RV1-C3 and RV2-C4 is dictated by the choice of

5Hz as the rate at which the supply to the test terminals is reversed. This in turn is a trade off between the response time of the instrument and reasonable immunity to the effect of any large value electrolytic capacitor that may be in circuit across a junction.

Good immunity to in-circuit resistance is achieved because the resistance across the junction must fall below one tenth of the value of R13, 14in the case of the collector-emitter connection and one tenth of R 12 in the casê of the base-emitter connection before the conduction of Q8,9 or the transistor being tested is affected.

In-circuit resistance below this will reduce the bias in each case to under the 600mV required for conduction.

A conventional 4-digit LCD us used to indicate the status of the deice being tested. The display is driven by a perfect square wave from the bistable output of IC1. The individual segments required to represent the desired letters are driven by the exclusive-OR gates of IC5 and IC6.

The clock output from pin 10 of IC1 is connected to one input of each EX-OR gate and also to the backplate of the LCD. If the second input to any gate goes high, a square wave will then turn on any segments connected to the output of that gate.

Open circuit across the test connections blanks the first three letters of the LCD since both inputs to IC4 from Q8 and Q9 are high, forcing a low on pin 10 and the five control inputs of the relevant gates. If a good NPN transistor is tested, Q8 turns off, sending the output of IC4d low and IC4c high, displaying nnn and releasing control of the lines through R17 and R18. Since Q9 is o, IC4b is high and the display npn is completed.

With a PNP transistor, the output of IC4b goes low as Q9 turns off, leaving n showing on the second digit. A p is completed each side from IC5b and IC5d, since the output IC4d is high.

In short circuit, both Q8 and Q9 are off, sending the lines through R17 and R18 low. This leaves a display of nnn from the high output of IC4c.

In the diode mode, the first digit of the LCD is blanked by sending the control inputs of IC5b and IC6c low through D7 and D8. The bistable ICs turns off Q2 and Q3 placing diodes D1 and D2 in series with the bias path to Q8 and Q9. The voltage across the collector-emitter test connections is now about 1.2v and the application of a diode will cause the cutoff either Q8 or Q9 depending on its direction. This displays either pn or np as described above.

The buzzer sounds if the inputs of gate IC6b are different, which only occurs when a good device is in circuit. ■

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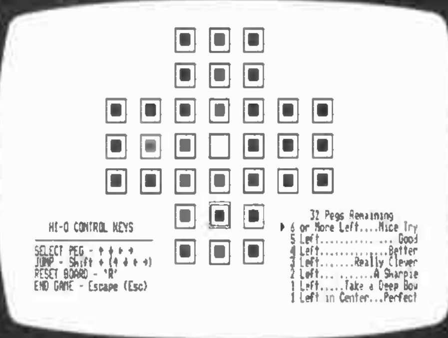

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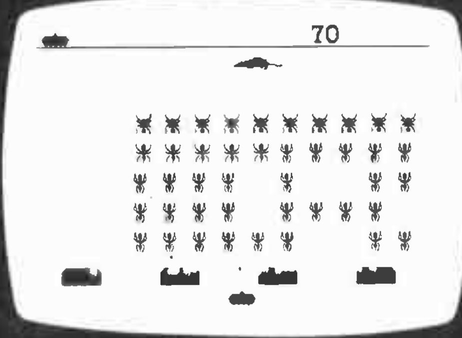

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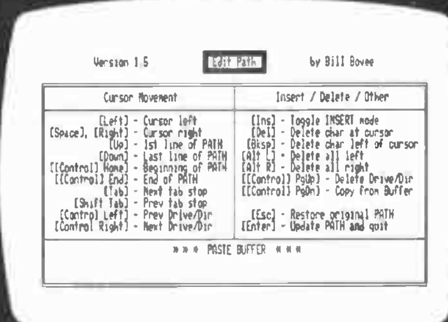

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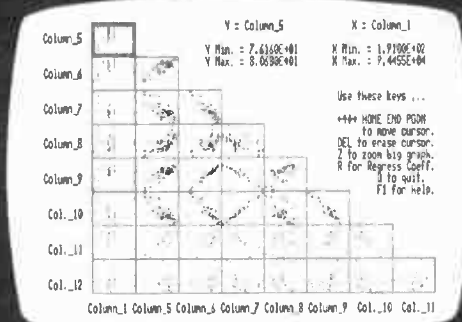

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The Scientists Tell Me...

By David Dempster

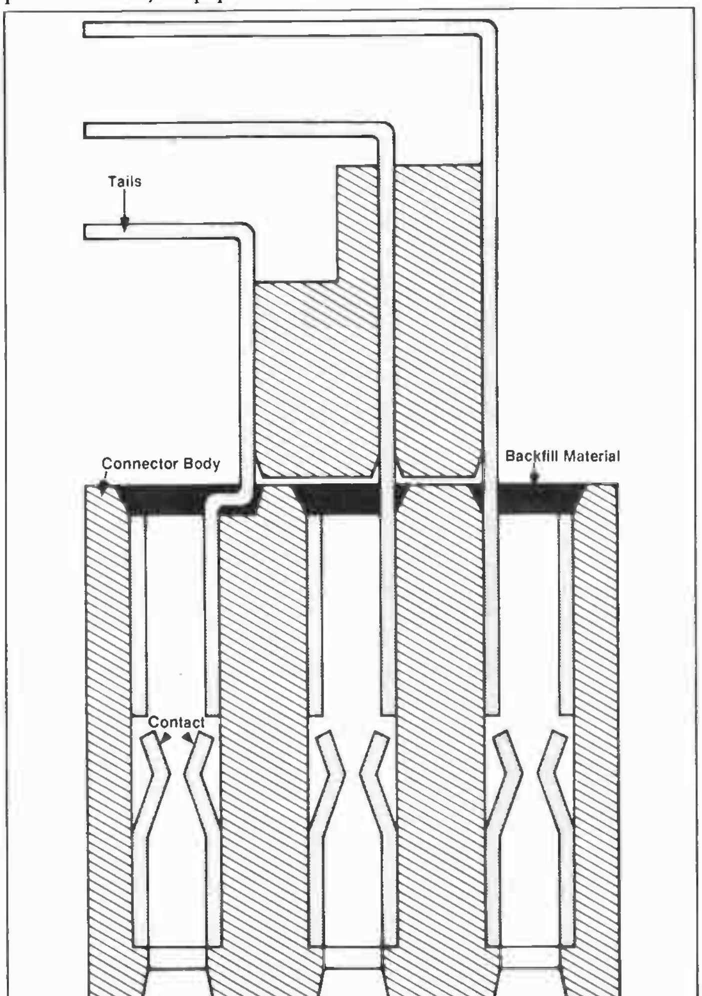
Getting Well With the Ginko Tree

For more than 5,000 years the Chinese have used ginkgo leaf extract because of its unique healing powers. In fact, so popular is the medicinal properties of the ginkgo, Europeans and Asians spend over $640 million annually on over-the-counter ginkgolide compounds. Doctors in Europe and Asia prescribe ginkgolides for a variety of diseases, from asthma to Alzheimers.

But now a Harvard University professor and his colleagues have synthesized a chemical that replicates the ancient healing power of the Chinese ginkgo tree, a breakthrough that could have important medical applications.

Professor Elias J. Corey recently announced that after more than two years of research, they have synthesized ginkgolide B, the most potent medicinal compound in the ginkgo tree.

Despite attempts by laboratories around the world to synthesize the medicinally potent chemical, most have failed and thrown in the sponge. Not so Professor Corey. He is the Sheldon Emery Professor of Organic Chemistry and his lab, which has synthesized more than 80 complex molecules in the past 30 years. Corey says tha ability to make the chemical will help scientists evaluate the specific health benefits of each ginkgolide compound and make it easier for drug companies to obtain large amounts of those that are most promising. Without this capability, only small amounts of the compound can be extracted from the leaves by a time-consuming process.



Box Style Connector - Sealed

However, says Corey and other researchers, medical application of the synthetic chemical is still some way down the road. However, he is content to let pharmaceutical companies explore its potential for future medical use while he concentrates on the synthesis of similar molecules.

"My lab provides the chemistry to make it possible to synthesize similar, but simpler, related molecular structures whose therapeutical use may be even greater than ginkgolide B," said Corey. "Our role was the discovery."

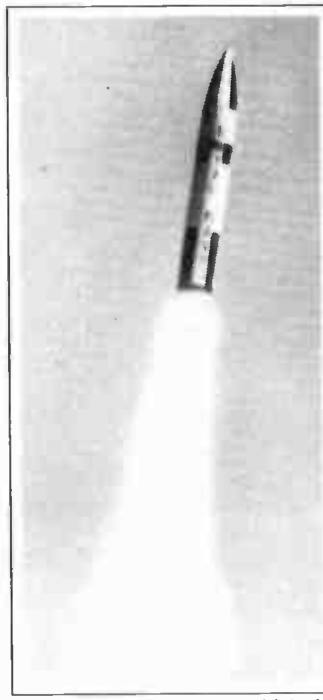
Corey is of the opinion that the ginkgolide B discovery may have many applications. Doctors in England have already tested ginkgolide B on humans, for treating asthma and allergy-type responses. The positive results, which agree with many centuries of casual observation, suggest that ginkgolides could make good medicines for those maladies, says Corey and others.

UV Curable Encapsulant Seals Connectors

The post and box style connectors widely used for today's multiple lead printing wiring assemblies pose new challenges for protective conformal coating. An unsealed connector can open a pathway for unwanted moisture and contaminant to reach the circuitry. Additionally, during the coating process material can wick into the contact area and interfere with the insertion of mating parts, forcing manufacturers to scrap boards worth thousands of dollars.

But now there is an answer to the problem. A new encapsulating material has been developed to overcome these difficulties. An ultraviolet heat curable encapsulant is especially designed to backfill or preseal connectors which can then be used for printed wiring assemblies requiring conformal coating.

A product of Dow Corning, the encapsulant is a methacrylated/acrylated urethane supplied in one component. It is dispensed directly into the contact tail and cavity area and is formulated to be used in automated dispensing systems. The thixotropic material, known as UVEXS 605-A, flows just far enough into the connector cavity to seal it before returning to a high viscosity. It cures in seconds on exposure to UV radiation and the one-step dispensing and curing operation is said to be accomplished in as little as 15 seconds.



Dow Corning is also developing a new testing system to locate leaks in sealed connectors and determine their size. It is claimed the new testing device will overcome many of the problems associated with solenoids, and will verify that a connector is sealed in a fraction of the time previously required.

New technologies Needed for Future Space Missions

New rocket engines that can carry heavier payloads into higher orbits at lower cost, nuclear propulsion and power systems, and flexible robots that can maneuver in zero gravity — these and more are some of the new technologies needed in years ahead if the United States wishes to retain its competitive status in space. So says a National Research Council Committee in their report to the National Aeronautics and Space Administration (NASA). The committee pointed out that many basic research programs were terminated or allowed to wither before he technologies were ready for use. Since the close of the Apollo program, it added, "little has been done to enhance or develop the basic technologies that will enable future missions or provide the nation with a variety of options for the space program. The shuttle, itself, was built largely with existing technology."

The committee recommended that NASA place its highest priority on advanced propulsion technologies. The space shuttle main engine is the only significant development in space propulsion for the past 20 years, the committee said.

Although Saturn heavy-lift vehicles has been successfully deployed, they have been discontinued, as have research programs in nuclear propulsion. If United States wants to explore nuclear-propelled spacecraft, the report says that the country must start over because much of the technical base was lost.

Facilities were mothballed or converted to other uses. Today a great deal of the present knowledge "resides in memories of now retiring scientists, metallurgists, and engineers," the committee stated.

What does all of this mean in dollars? The committee sees the need for the U.S. to retain its competitive status, not necessarily its pre-eminence. For the past eight years, the U.S. has ejoyed a positive balance of trade in aerospace with a surplus of more than $10 billion (US) annually. But now there is strong competition from Europe, Japan, and the Soviet Union.

And the solution. According to the committee, 7 percent of NASA's budget should be allocated to R & D over the next decade to help develop breakthrough advances. As well, such funds should be protected from short-term requirements of special operations such as the space station.

In making its selections, the panel of 16 aerospace experts considered future demands in four co-called "driver missions": space science, national security, and humans-in-space. It identified eight key technologies that, it said, had been "relatively neglected" during the past decade or longer. According to the committee, advances will be needed in propulsion, technology for humans in space, life support systems, automation and robotics, power, materials and structures, information and control systems, and sensors.

Space transportation. Future missions will require reusable, economical engines that can put humans into space and return them to Earth; and rockets to boost payloads from low to high orbits. If humans are to be involved in long missions, to Mars, for example, high-thrust systems with shorter transmit times will be needed, the committee said. Planned for the late 1990's, work on the main engine would have to begin immediately, it said.

Space Science. Among space science missions the committee identified as technology "drivers" for the mid-1990's are the Earth Observing System, a group of telescopes in space to study the Earth's atmosphere, surface, and interior; the Large Deployable Reflector, a space telescope about 10 times larger than the Hubble Space Telescope that would have to be assembled in space; and the Mars Sample Return Mission to collect samples of the Martian surface and bring them back to Earth.

Looking ahead to the early 21st century, the committee urged NASA to begin now to develop technologies for larger arrays of telescopes in space, solar probes, Venus sample return, and human exploration of Mars.

Humans in Space. The committee identified research needed in physiology, psychology, and sociology to better support humans in a space environment. Humans will be involved in a number of proposed missions from constructing a space station in the 1990's to that possible manned mission to Mars in the early years of the 21st century. New technologies needed for space station work include improved space suits and "space taxis" for out-of-craft activities, better protection against cosmic radiation, and fine-tuned robots. New technologies needed for a Mars mission include environmental systems that generate or recycle their own air, eat, water, and food; better technologies for handling human waste; and use of resources found in space to resupply colonies on Mars and the moon.

National Security: While civilian space pursuits are NASA's principal concern, the agency can contribute technical know-how to some areas of national security such as developing clearer and more reliable communications; remote sensing of the oceans; low- cost, heavy-lift space vehicles; and advanced composite materials.

And in some of the foregoing, it could be that Canada could continue to play a role, as it has in the past with Spar Aerospace's Canadarm and the University of Toronto's Aerospace Institute. Who knows what tomorrow will bring? ■

How VCRs Work

Courtesy JVC Canada

Follow along on a trip through the inner workings of one of the most popular home entertainment devices.

By Timothy B. Palmer-Benson

Despite their flimsy plastic facias and fluorescent flashing displays, VCRs are little miracles of electronic and mechanical engineering. It is true they are known for producing waxy faces, color shifts, poor resolution and picture noise but on the other hand as one broadcasting engineer told me; "they are still not that bad and they are getting better." The latest VCRs introduced by Sony and JVC prove that an already sophisticated and complicated recording process can be improved to yield results that match or exceed the performance of the laser disc. In order to appreciate how these new machines work, it is necessary to first understand some of the basics of video tape recording. You'll also be able to appreciate what is hype and what is a real improvement.

A video cassette machine is basically an audio tape recorder with helical scanning video heads. (A helix resembles a coil or spring.) Instead of the tape passing at right angles in front of a head as in audio cassettes and open reels, a minimum of two heads are used (except for Sony's Beta movie camcorder) and the tape is looped in something akin to an omega shape around a drum or cylinder that rotates at high speed.

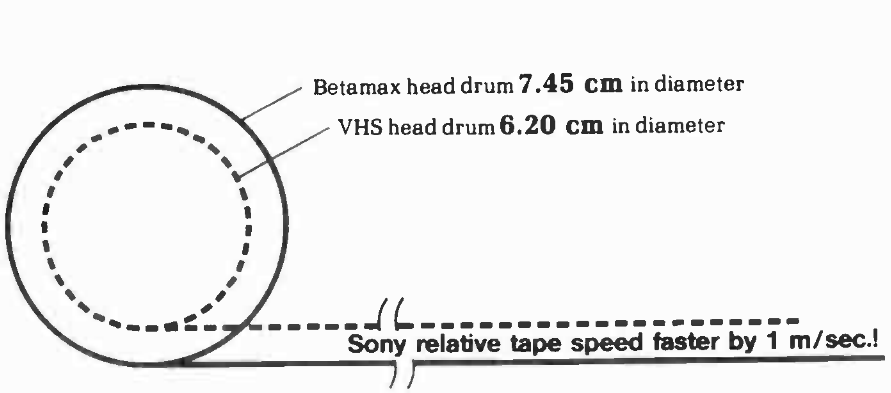
The drum is mounted at an angle (approximately 6°) so that a pair of video heads, mounted on its surface 180° apart, move in a helical fashion as the drum rotates. The angle of the drum, as well as some tape guides, force the tape to touch the bottom part of the drum when it first makes contact and to leave the drum at its top. This results in the two heads either recording or picking up a continuous series of slanted or diagonal signal tracks. In VHS and Beta machines, a track is scanned or recorded at the rate of one every 1/60th of a second by two heads. As the one head completes a track, a second is beginning a second track and so on. Two tracks or fields make up a single frame of a television picture.

Although VCRs are precision pieces of equipment and tolerances are measured in microns, the laying down of tracks next to each other still poses some problems especially since the width of the tracks is so small. Each track on a Beta Two tape, for example, is only 0.03 mm wide! How is it possible that the heads are able to scan the same tracks exactly on playback or to pick up the tracks made by another machine? This has been made especially tricky in consumer VCRs since the so called "guard bands", used in professional machines to separating each track, have been eliminated to make more efficient use of tape. And, how are slight speed differences between machines resolved? The answer to these problems are taken care of with servo systems, control heads, phase inversion and azimuth recording.

Azimuth Recording

In azimuth recording, the angle of the gap in each pair of video heads is mismatched slightly so that each head can only record and pick up high frequencies from the track made by that particular head. Thus in a sequence of tracks, head A will pick up information from track one and three, while head B, on the other side of the head drum will pick up tracks two and four. In 8mm camcorders the head gaps are angled away at +12° and -12°. On Beta machines, the head gaps are angled away from the perpendicular by +7° and -7° while VHS uses +6° and -6°. A strong signal is received from a particular track only when it is scan by a head having the same azimuth. It may scan a bit of an adjacent track but high frequencies won't be picked up because the azimuth in the adjacent track will always be different.

There is another means of ensuring that only the right track gets picked up at any given time and that is with phase- inversion recording. Again it is used by both VHS and Beta and is designed to take care of that portion of the video signal that is so low in frequency that azimuth recording won't



The relationship between Betamax and VHS head drum sizes

Courtesy Sony Canada Inc.

work so well. It achieves the same end - reducing crosstalk between adjacent tracks - by shifting the phase of the lower frequencies (in this case the chrominance signal) by 180° for each track in Beta, and by 90° for each track in VHS. Having adjacent tracks recorded with different phase relationships helps to prevent the video head from picking up information from an adjacent track.

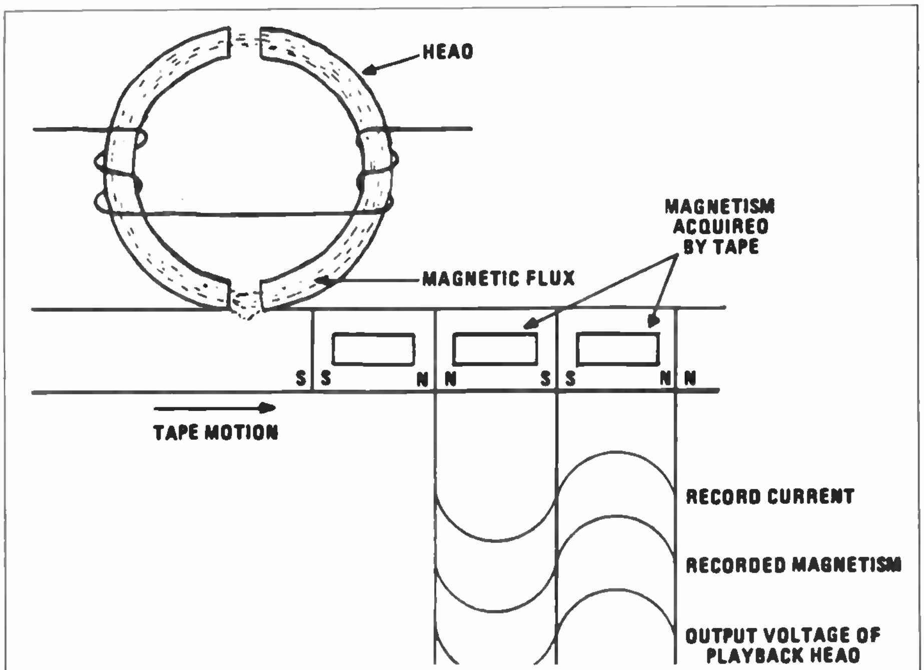
Speed and Heads

Speed accuracy is also very important in VCRs and it's taken care of with various servo systems. Sync pulses that are part of the video signal are used to synchronize the speed of the head drum with the movement of the tape. The pulses, (a 60Hz square wave), are recorded onto a stationary or longitudinal track along the edge of the tape by a control head. This occurs after the tape has left the head drum and is on its way to the take up reel. When a tape is played back, these control pulses (square waves) are detected at the control head. If the shape of the square wave is altered because the mechanism is running too fast or too slow, this distortion of the wave will cause a servo system to adjust the speed of the capstan motor. A tracking control is provided to compensate between slight distortions in square recorded by different machines.

VCRs depend very much on something called "relative speed" to achieve wideband frequency response. Because the heads on the drum are whizzing around at a tremendous rate (1,800 rpm) in a helical fashion, they are able to "simulate" a high recording speed. (The 1,800 rpm is enough to cause the tape to ride on a cushion of air as it travels around the head drum at the infinitesimal distance of only 35 microns. Only the heads are actually in contact with the tape.) This relative speed or "writing speed" as its called, along with special heads helps to ensure that video's high frequency information, which extends out to beyond 4 MHz, is recorded onto a tape even though it is moving passed any given point in the VCR at less than the speed of an audio cassette. (VHS SP or Standard Play speed is 1.31 ips, while Beta's popular Beta Two speed is 0.79 ips.) All video cassette recorders, even the 8mm camcorders, use this system for recording the video portion of a signal though drum sizes are different.

Naturally, this is not the complete story in the process of getting a video signal on or off a piece of tape. Merely spinning a drum containing record/playback heads won't accomplish much unless the heads are specially designed for recording high frequency information. Also the video signal must be "treated" before it gets to the heads in order to ensure equal amplitude or strength for its various components.

If you remember the theory behind recording heads in audio tape recorders, you'll know that as the gap between opposing poles in the head becomes smaller, the greater the ability for the machine to reproduce and record high frequencies. It's the same in video which has taken things somewhat further. Modern manufacturing has managed to produce a gap that is so small that it can be seen only with a powerful microscope. The gap is so small (typically .6 microns) that it ap-



Simple representation of how the tape is magnetized by the head. Courtesy Sony Canada Inc.

proaches the same gap contained in a 4 MHz sine wave displayed on an oscilloscope. If you've ever seen even a 1 MHz signal displayed on an oscilloscope, you'll really appreciate how small these gaps are! Another way of illustrating these head gaps is to compare them with the 100 micron diameter of a human hair. Small head gaps are laudable, but there comes a point in the existence of any head gap when it can no longer record a particular frequency unless tape speed is increased. This is the main reason why Beta One or VHS SP speeds in consumer VCRs produce recordings that have greater bandwidth. The other reason for increased bandwidth and general picture quality at the faster speeds is that more tape is being used (the actual size of the heads is larger) to record the information than at the slower speeds - the tracks of video information are actually wider apart.

Although super narrow head gaps, helical scanning and fast play/record writing speeds are of major importance in VCRs the system still wouldn't work properly without frequency modulation in the same way that an audio signal is transmitted over the broadcast FM band. One of the reasons frequency modulation must be used is because the output voltage from tape recorder heads varies with frequency and the frequencies involved here are particularly high. Another reason is that FM ignores random amplitude variations in playback signals. A tape can be driven into saturation during signal peaks and any amplitude distortion is simply ignored.

There are many similarities between the Beta and VHS systems but at the same time there are some major differences particularly in the way tape is handled. Until just recently for example, you couldn't fast cue in VHS the way you can in Beta. Beta machines use a head drum that's about 20% larger than a VHS one. If you go back to the discussion of "relative speed" you'll realize that a larger drum means a higher relative speed, or writing speed, and a higher writing speed means better high end frequency response for the video signal. Both formats use azimuth and phase inversion techniques and frequency modulate the video signal before it's put onto tape.

Audio Techniques

In audio, both formats began with so called "drag heads" or "longitudinal heads" mounted in part of the control head. But because the speed of the tape is so slow, frequency response was and still is limited despite equalization circuitry. Noise levels are high. VHS has followed with stereo longitudinal heads but with two tracks of hiss, the noise becomes intolerable, so in addition to equalizing the signal VHS has added Dolby noise reduction. The consumer was confused: "Stereo Dolby....Wow!" Salesman rarely pointed out that high end frequency response on VHS stereo machines is limited to approximately 10kHz +3db, little better than a Lloyds cassette machine!

Then came Beta Hi-Fi; simply put Beta Hi-Fi reprocesses the video signal. It separates video's two main signal components, luminance (crispness and brightness) and chrominance (color), to squeeze a frequency modulated stereo signal in between. Then everything gets recorded on the video heads just as before. This method results in a wide band audio response of 20Hz to 20kHz, a dynamic range of more than 80 dB and very low wow and flutter. While this is still not hi-fi in the true sense of the word Beta Hi-Fi is quite satisfactory for watching movies. JVC followed Sony's lead with VHS Hi-Fi and obtained similar specs. But, JVC was forced to use a more complex system because of the way the VHS video signal must be recorded onto tape. There isn't room in VHS signal to squeeze in an FM audio signal and so VHS uses "depth multiplex recording," In this system, the audio is frequency modulated and then sent to separate audio heads positioned 180° apart on the head drum. The process uses the entire tape width to lay down the information but because the azimuth of the head gaps is different (+30° and - 30°) the audio is not picked up by the video heads. The requirement for two additional heads naturally raises the cost of VHS Hi-Fi machines over their Beta counterparts. As you can imagine, the tolerances involved here have become much tighter. If you've ever wondered why some VHS Hi-Fi movies seem to be afflicted with unexplained sputtering on their hi-fi tracks these tolerances are the reason. It only take's a dubbing house to have machines that are slightly out of adjustment and the hi-fi track is ruined. When you're dealing in microns it can happen!

Higher Technology

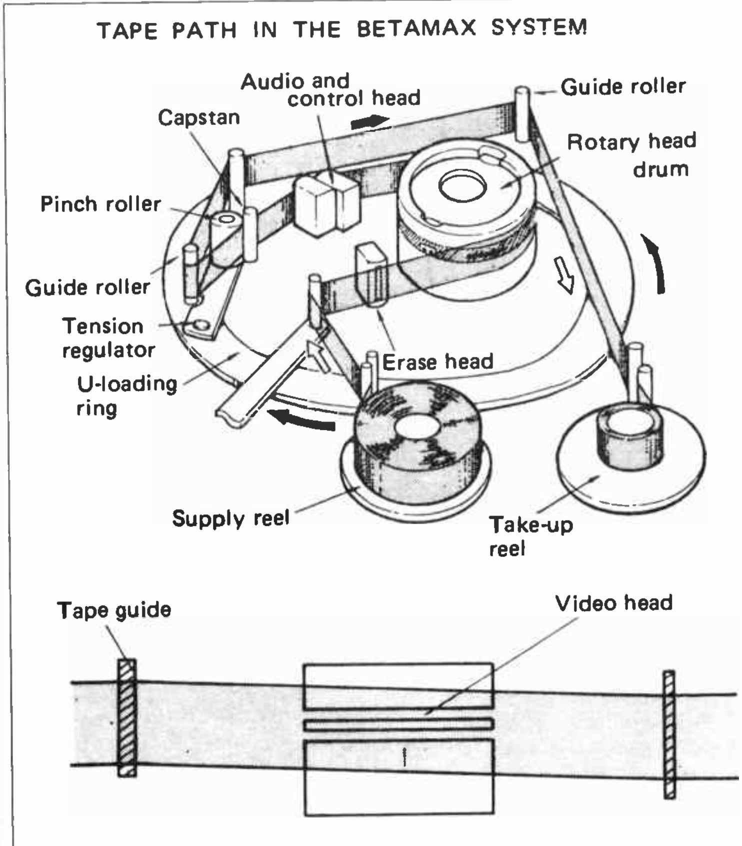
Back in video, Sony's Beta system continues to lead the way in pure technology even if Sony can't do so well in sales. Sony's first step was Super Beta. In this system the frequencies of the luminance signals are boosted by

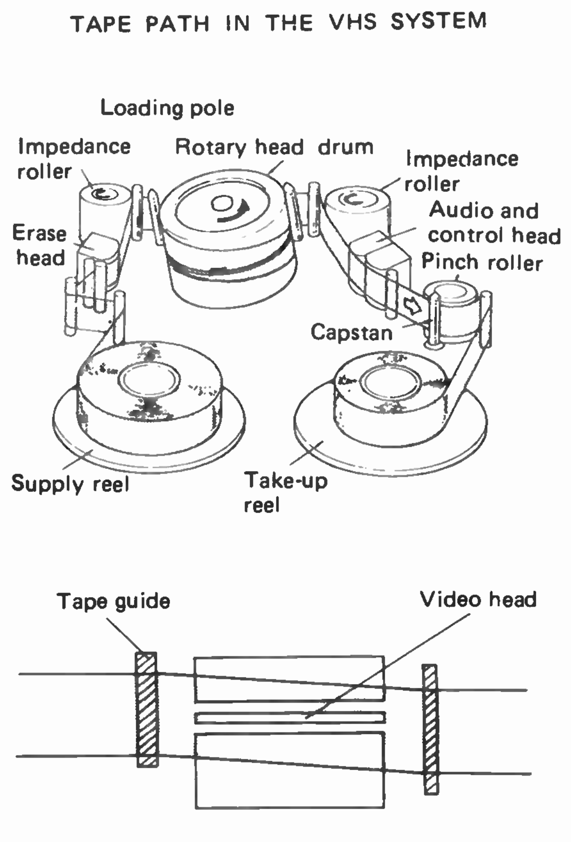
800kHz resulting in a 20% increase in resolution. Only the luminance part of the signal, the part that gives you that crisper, clearer picture, gets boosted. You get 290 lines of resolution with a Super Beta VCR compared to 240 lines for regular Beta. JVC's reply was HQ (High Quality). This is a package of improvements that include a reduction in noise levels contained in the luminance and chrominance signals as well as an increase in the ceiling or what is termed "the white clip level" of the video. On VHS VCRs without HQ images that have bright edges against a dark background tend to smear because the full video wave form has been clipped in order to get it recorded onto tape. Raising the white clip level enhances the apparent contrast and detail in the picture. Despite these improvements, the horizontal resolution of HQ remains at 240 lines as opposed to Super Beta's 290. On the other hand, VHS HQ is completely compatible with regular VHS while Super Beta sometimes causes difficulty for standard Beta machines because they don't have video heads capable of picking up the higher frequencies used by Super Beta.

No look at how VCRs work would be complete without mentioning the battle for over the video heads themselves, freeze frames and slow motion. Thanks to manufacturing hype, the average VCR buyer has been left with the impression that the more heads a machine has the better its performance but if you've understood this article you'll know that you can only use two heads at a time and that extra heads (aside from the ones for VHS Hi-Fi) are for special effects only. A single pair of heads won't work because when the tape is stopped only one of the heads can scan a track accurately. The other head is unable to pick up the video information because its azimuth setting is wrong, but with one or more heads a second reading of a particular track becomes possible and thus a full frame for a tv is obtained since two fields, or track scans, make up a frame.

It is true that the resulting tv picture is in reality only half a frame (a normal frame is made up of two fields or tracks) but manufacturers discovered several years ago that a single field, scanned twice gives the best jitter free picture.

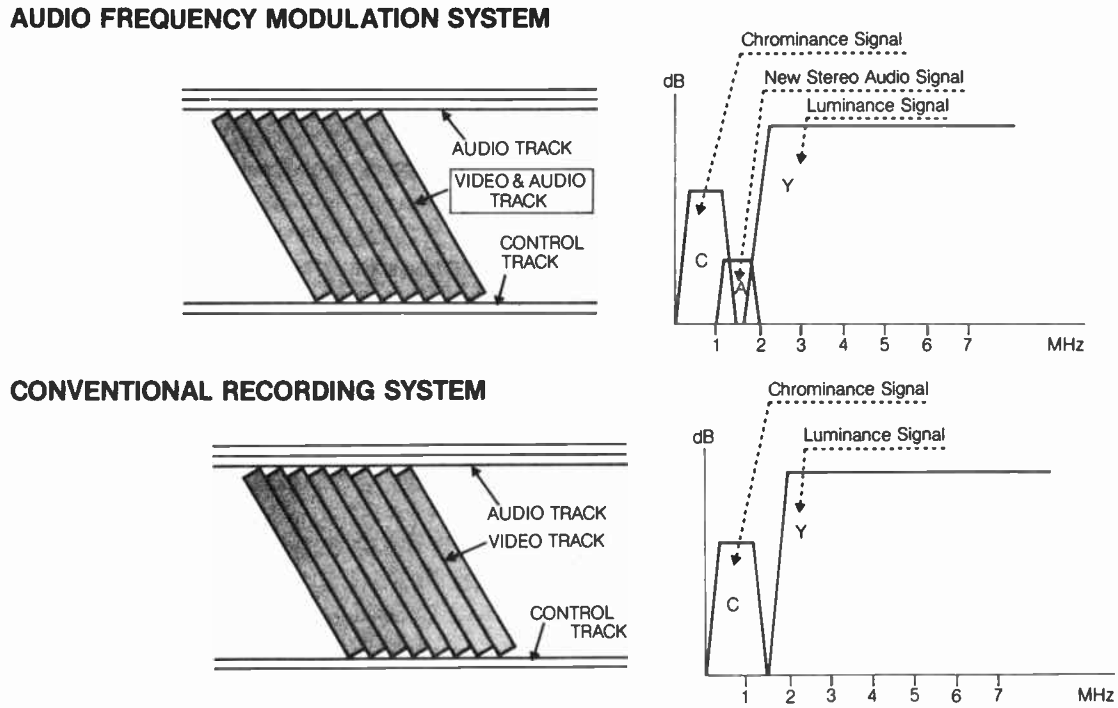
The simplest way of scanning a single track twice is to add a third head, thus we have a "three headed VCR." The azimuth of the third head is the same as the azimuth of a head on the other side of the drum. When the drum rotates both this third head and one of the regular heads is able to scan a track or field perfectly and produce a jitter free still picture. This works fine for a tape that has been recorded at one speed and played back at the same speed but what about VCRs that have three speeds such as VHS EP (Extended Play), LP (Long Play) and SP (Standard Play)? One of the most important answers to this problem is Matsushita's Tech 4 system (Panasonic). It places a pair of heads in a single housing on each side of the head drum. Each housing has an SP head with a positive azimuth gap while the one next to it has a negative azimuth gap for EP. The two heads on the other side of the drum have azimuth gaps that are exactly the opposite of the first pair. When a freeze frame is required either an extra EP or an extra SP head is switched in electronically to provide that second, crucial scan of a single track. The gap





Detail of tape path through the works of the Betamax system (left) and through the VHS system (right).

Courtesy Sony Canada Inc.



Audio frequency modulation system used in stereo recorders (top) and in conventional machines (bottom). Courtesy Sony Canada Inc.

on each head is carefully chosen so that good results are obtained not only with still frames on each speed but also with slow motion. One of the latest ways of doing things is with Mitsubishi's 4 head logic system. It works in the same way as the Matsushita system except that Mitsubishi has taken things further by using a digital system to provide not only video tracking during high speed search (similar to Betascan) but also audible cueing in EP. Mitsubishi calls its digital auto-tracking and mercifully refrains from calling its machines digital VCRs.

Other manufacturers are a little more brazen with their digital technology especially when it comes to making still frames from a digital signal or using a data chip for noise reduction. Digital freeze frame is achieved by a computer-like RAM chip that is constantly fed fields of information as the tape passes over the video heads. There is so much information in a single picture frame that it requires a lot of RAM - 550 Kilobytes for a full frame - to light up every pixel on a television screen. The RAM must constantly memorize and then dump the video information as new tracks are scanned by the video heads at the rate of 60 per second. The advantages of this system are that extra heads aren't needed and special features like picture-in-a-picture (PIP for short) come at very little extra cost to the manufacturer. But, there are some disadvantages. First, it takes 1/60th of a second for the RAM chip to fill up with information, so it is always lagging slightly behind what is being picked up by the video heads. Second, on some machines the tape goes on rolling while the memorized freeze frame is being viewed which can be annoying if you want to pick up where you left off. There's a third question; are all manufacturers using the required amount of RAM to do a proper job?

Meanwhile, what promises to make the current controversy over DAT recorders look insignificant, is the planned introduction of Super VHS and Sony's ED (Extended Definition). Simply put, both systems significantly boost the frequency at which the luminance signal is put onto tape. Instead of this information being carried at between 4.4 MHz and 5.6 MHz as it is in Super Beta, the Super VHS system raises the frequency to between 6MHz and 7MHz. A special tape formulation is required for the system. Sony has replied with the ED Beta VCR which carriers its luminance signal even higher at 6.8MHz to 8.6MHz. Both systems provide extremely good resolution - far better resolution than what is obtainable off air with the best possible broadcast signal. For example, typical resolution for a broadcast signal received at home is 330 to 350 lines. Conventional VCRs provide resolution up to 290 lines, but with super VHS it is claimed the resolution is 430 lines in EP! But, what is more significant is that both systems completely separate the luminance and chrominance and provide separate inputs and outputs thus avoiding the cross color interference produced by combining these signals at the outputs and inputs of VCRs and the inputs of tvs. This will enable anyone owning two of these VCRs to obtain almost perfect dubs. "The question of copyright infringement because of DAT is nothing compared to what this new technology will do to the video market," says a spokesman for Mitsubishi who would like to remain anonymous.

Ed. Note: It should be noted that Sony has announced that it will begin manufacturing VHS video cassette recorders. Although BETA units will continue to be produced, it certainly appears as though the future of BETA is in doubt.

Tim Benson is a Montreal-based freelance writer specializing in areas of audio and video. ■

Introducing Microprocessors Part 2

The basic terms of the microprocessor system.

By Mike Tooley

Learning Objectives

The general learning objectives for part two of *Introducing Microprocessors* is that readers should be able to:
(a) draw a block diagram showing the internal architecture of a representative 8-bit microprocessor and state the function of each of the principal internal elements (2.1)
(b) state and explain the function of each of the principal external connections of a representative 8-bit microprocessor (2.1)
(c) explain the need for a clock and state typical frequencies and periodic times for microprocessor clocks (2.1)
(d) make appropriate use of manufacturers' data sheets (2.1)
The specific objectives for the part are as follows:
2.1 Internal Architecture of a Microprocessor
2.1.1 Draw and interpret a block diagram showing the internal architecture of a representative 8-bit microprocessor.
2.1.2 State and explain the function of each of the principal internal registers of a representative 8-bit microprocessor.
2.1.3 State and explain the function of each of the principal external connections of a representative 8-bit microprocessor.
2.1.4 Explain the need for a clock and distinguish between external and internal microprocessor clocks.
2.1.5 State the range of typical clock frequencies and periodic times for common 8-bit microprocessors.
2.1.6 Use manufacturers' literature to determine the supply voltage, pin-out, and internal features of any common 8-bit microprocessor.

Microprocessors

In Part 1 we briefly mentioned that a microprocessor performs the functions of a central processing unit (CPU) within a microcomputer. We also stated that the microprocessor provides control and synchronization signals for the rest of the system. From this, it should be obvious that the microprocessor is the single most important component within any microcomputer system.
The basic internal elements of a microprocessor are as follows:
(a) registers for temporary storage of instructions, data, and addresses
(b) an arithmetic logic unit (ALU) able to perform a variety of arithmetic and logic functions
(c) control logic which accepts and generates external control and supervisory signals (such as RESET and READ/WRITE) and synchronizes data transfers within the system.

Registers

Internal registers can be thought of as arrangements of pigeon holes into which data (in binary form) can be placed during processing. Some registers are directly accessible to the programmer (i.e. he can set to read their contents at will) whilst others are reserved for the machine's own use. Registers may also be classified as "dedicated" (i.e. they have a specific purpose such as pointing to a memory location or holding the results of an ALU operation) whilst others are described as "general purpose".

In the case of an 8-bit microprocessor, most of the general purpose registers will be capable of storing eight bits. Furthermore, since each of the bits may be either 0 or 1, there will be a total of 256 possibilities for the contents of such a register, ranging from 00000000 to 11111111. Registers used for "pointing" to memory locations, on the other hand, will generally be capable of holding sixteen bits and consequently their contents may range from 0000000000000000 to 1111111111111111 (ie, 0 to 65535 decimal).

The data bus lines in an 8-bit microcomputer are labelled D0 to D7. The most significant data bit (i.e. that with the greatest binary weight) appears on D7 whilst the least significant bit (i.e. that with the least binary weight) appears on D0. In the case of a 16-bit address bus, the lines are labelled A0 to A15 and the most and least significant address bits are respectively those which appear on address lines A15 and A0. The most and least significant bits are often referred to as the MSB and LSB last (see Part 1).

Unfortunately, there is some considerable variation in both the internal architecture and terminology used by different microprocessors manufacturers. Despite this, there are a number of common themes. The major microprocessors families, for example, tend to retain a high degree of upward compatibility both in terms of internal architecture and the software "instruction set" and that is clearly an important consideration in making a new product attractive to the equipment manufacturer.

Introducing IMP

IMP stands for introductory microprocessor, a hypothetical device

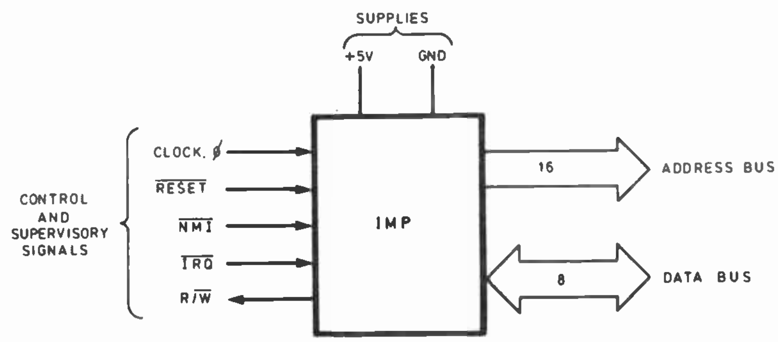


Fig. 2.1. IMP's external connections. Note that a bar over a particular signal indicates that it is active-low (logic 0 when activated).

which we shall be using to explain some of the fundamental concepts of microprocessors. We have chosen to follow this route, rather than tailor our description to real microprocessor, in order to keep the explanation as simple as possible. IMP contains many of the features found in a real 8-bit microprocessor without favouring the architecture of any particular processor family. By this means, we hope to provide readers with a gentle introduction to microprocessor avoiding superfluous or processor specific information which may otherwise serve only to confuse the newcomer.

Important differences between IMP and real microprocessors will be discussed as we progress but readers who require detailed information on particular microprocessors need not worry as we shall be presenting this information in the current series of Data Cards. These cards will feature all the most popular 8-bit microprocessors (6502, 6800, 8085 and Z80) and will build to provide a useful library of microprocessor related data.

IMP has an 8-bit data bus, 16-bit address bus and five control and supervisory signal lines. Like most 8-bit microprocessors, IMP has a 40-pin d.i.l. package and operates from a +5V supply. IMP's connections with the outside world are shown in simplified form in Fig. 2.1

Internal architecture

The internal arrangement (architecture) of the IMP is shown in Fig. 2.2. At first sight this diagram may look rather complex so we will spend some time explaining each individual feature and how it relates to the working of the unit as a whole.

The majority of IMP's internal registers are linked together by means of an internal data bus. This bus can be thought of as a highway along which bytes are transferred from one register to another. Since we are dealing with an 8-bit microprocessor, the internal data bus is naturally eight bits wide.

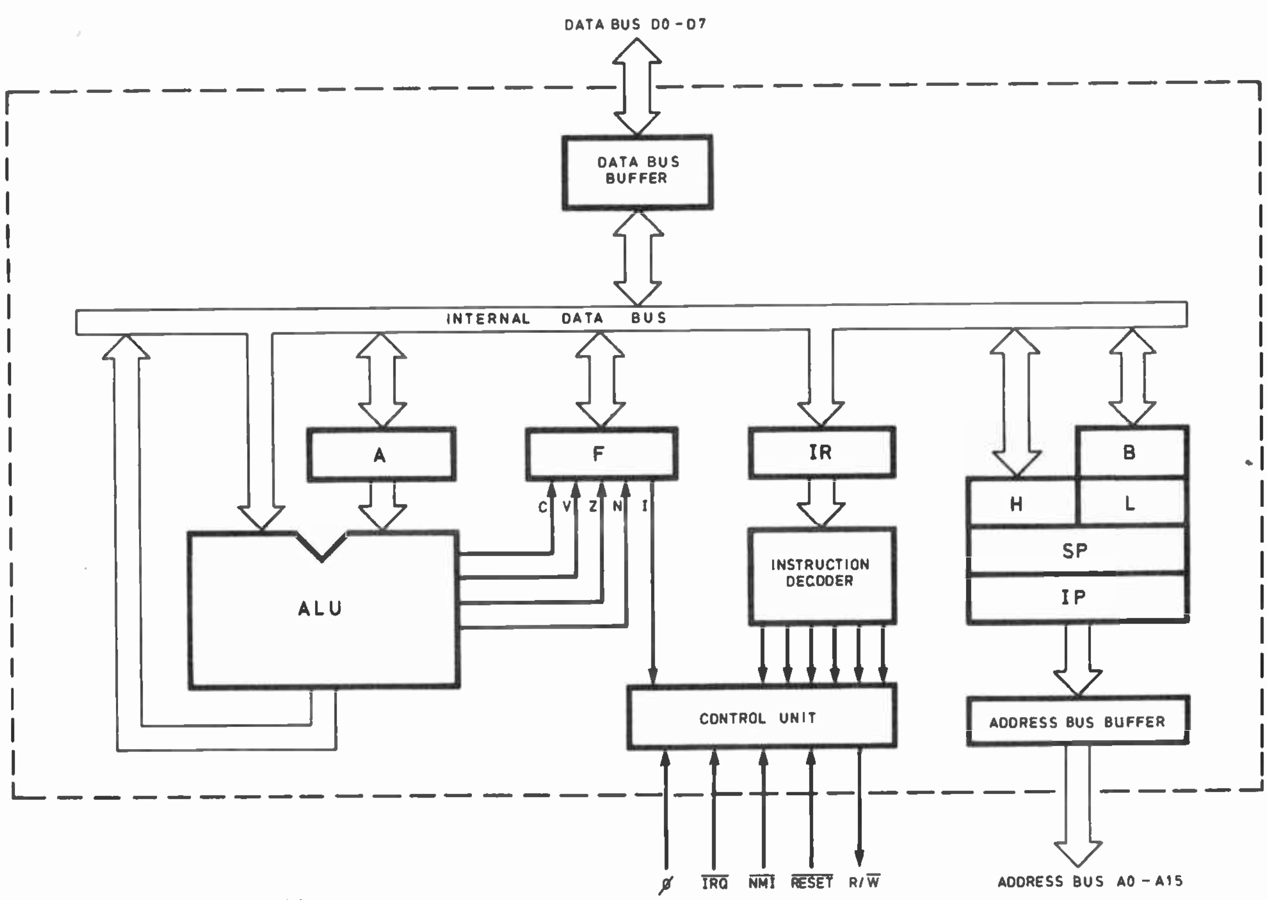


Fig. 2.2 The IMP's internal architecture.

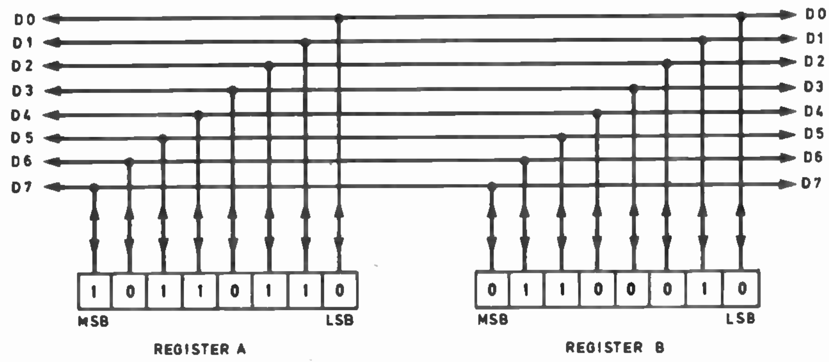


Fig. 2.3. Connections to the internal data bus.

Fig. 2.3 shows how two 8-bit registers (A and B) are coupled to the internal bus. Separate lines from the control unit (not shown on either Fig. 2.1. or Fig. 2.3) are used to determine whether:
(a) the contents of the register are to be made available on the bus (so that it may be copied elsewhere),
or (b) the data currently present on the bus is to be latched into the register (replacing whatever was there before),
or (c) the register is to be isolated from the bus (preserving its contents for future use).

Now, consider the process of copying data from register A to register B. We would need to make the data in register A available on the bus (case (a) above), latch the data into register B (case (b) above), and ensure that every other register connected to the bus was currently isolated (case (c) above). If this is beginning to sound rather complex, there is no need to worry as the generation of the necessary internal control signals is both implicit in a particular instruction and entirely automatic.

Data Bus Buffer

The data bus buffer separates the internal data bus from the external data bus and it incorporates eight individual bidirectional current amplifiers. The buffers may be made to receive data from the external bus or transmit data to the external bus in response to control signals (not shown in Fig. 2.2). The buffer helps regularize the logic levels received by the microprocessor and provides a reasonable amount of current gain for "driving" the external bus. The data bus buffer thus provides a means of isolating the microprocessor from the harsh world outside!

[Some microprocessors allow the microprocessor to isolate itself from the data bus by placing the data bus buffer in an open- circuit (i.e. disconnected) or "tri-state" condition. This allows other "intelligent" devices to place information on the data bus.]

Address bus buffer

The address bus buffer behaves in a similar fashion to that of the data bus buffer. It is, however, important to note that the individual address bus buffers are unidirectional since address information is only generated by the microprocessor and not received by it.

[Some microprocessors allow the microprocessor to isolate itself from the address bus by placing the address bus buffer in an open-circuit (i.e. disconnected) or "tri-state" condition. This allows other "intelligent" devices to place information on the address bus.]

Instruction Pointer (IP)

The instruction pointer is a 16-bit register which contains the address of the next instruction byte to be executed. The contents of the register is thus said to "point" to the next instruction byte. The contents of the instruction pointer is automatically incremented each time an instruction byte is fetched.

[Note: Many microprocessors refer to this register as a Program Counter (PC)]

Accumulator (A)

The accumulator is an 8-bit register which functions both as a source and destination register; not only is it the source of one of the data bytes required for an ALU operation but it is also the location in which the result of an ALU operation is placed.

Flag Register (F)

The flag register contains information on the internal status of the microprocessor and, in particular, signals the result of the last ALU operation. It is important to note that the flag register is not a register in the conventional sense; it is simply a collection of bistable latches which can be "set" or "reset" depending upon the result of an ALU operation. The output of each bistable can be considered to act as a "flag". IMP has the following flags:

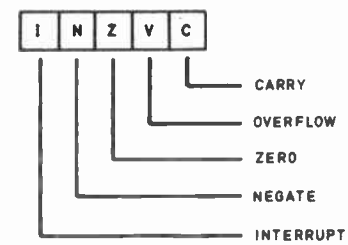


Fig. 2.4. IMP's flag register.

CARRY (C) – set to 1 when the last ALU operation has produced a carry
OVERFLOW (V) – set to 1 if the last ALU operation resulted in an overflow
ZERO (Z) – set to 1 if the result of the last ALU operation was zero
NEGATE (N) – set to .1 when subtraction has taken place, otherwise reset to 0
INTERRUPT (I) – set to 1 when interrupts are disabled (in this state the microprocessor is unable to accept and "interrupt request" generated by an external device).

The composition of IMP's flag register is shown in Fig. 2.4. It is important to note that once changed, the various flag bits remain either set or reset until a further change occurs. The programmer is only able to directly affect the state of the CARRY and INTERRUPT flags. The others change state indirectly as a result of program execution.

Stack Pointer (SP)

IMP needs to have access to an external area of read/write memory (RAM) which permits temporary storage of data. This area of memory is known as a "stack" and it may typically occupy between 16 and 256 bytes of memory. (Note, however, that the stack is a dynamic structure and its size varies continuously during processing.)

The stack operates on a "last-in first-out" (LIFO) basis; data is "pushed" onto the stack and later "pulled" off it. The "stack pointer" keeps track of the extent of the stack by holding the address of the last used stack location.

[Note: Some popular microprocessors (e.g. 6809) have two independent stack pointers; a "system stack pointer" (SSP) and a "user stack pointer", (USP).)

Instruction register

The instruction register is a temporary storage location which is used to contain the current instruction byte whilst it is decoded. The instruction register is not directly accessible to the programmer (i.e. it cannot be loaded directly nor can its contents be copied to other locations).

Instruction decoder

The instruction decoder, a complex arrangement of logic gates with outputs which are fed to the control unit, operates on the instruction currently held in the instruction register. The instruction decoder informing the control unit of the actions demanded by the current instruction (e.g. the need to take the R/W line low and latch the contents of the HL register pair into the address bus buffer).

Control Unit

The control unit generates internal control signals (not shown in Fig. 2.2) which determine the direction, source and destination of internal data transfers, activates external control lines when required, and responds to external signals which arrive on the control bus. The control unit is also responsible for internal synchronization.

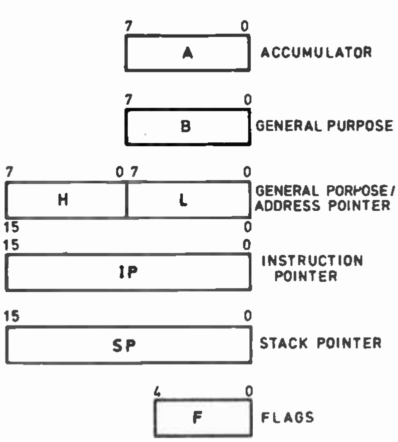


Fig. 2.5. IMP's register model.

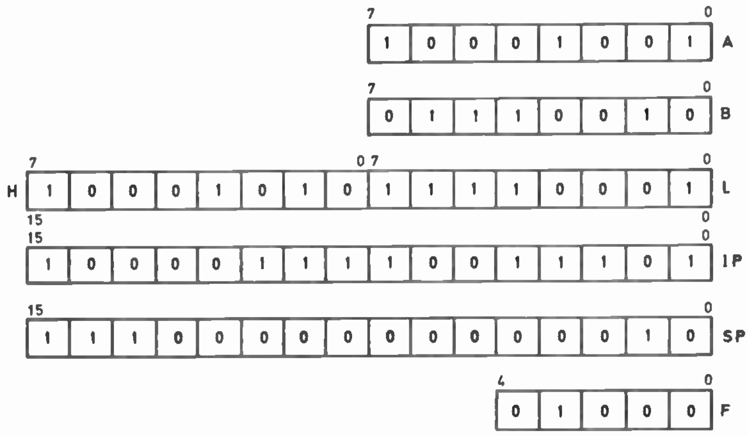


Fig. 2.6. The state of the registers for problem 2.1.

General purpose registers

Apart from the accumulator (A), IMP has three 8-bit registers which may be classed as "general purpose". These are B, H and L. Register B is often used as an "alternative accumulator", results which appear in the accumulator being regularly transferred to and from register B. The H and L registers can be used as individual 8-bit registers and may also be used "end- on" to provide a 16-bit general purpose register (referred to as the "HL register pair"). In this mode, HL can be used as a pointer to data stored in memory (i.e. the 16-bits in HL from an address at which data is to be stored or from which data is to be fetched). The HL register pair can thus be used as an "address pointer" and, in this context, the H register contains the "high" (most significant) byte of the address whilst the L register contains the "low" (least significant) byte of the address.

Register model

Whilst Fig. 2.2 provides us with some idea of IMP's internal arrangement, it is unnecessarily complex from the point of view of the programmer. The programmer is neither concerned with the links between registers nor need he/she be aware of internal features over which he/she has no direct control. In this context, the "register model" depicted in Fig. 2.5 provides a more useful representation of IMP and this merely shows the registers which are directly accessible to the programmer and over which the programmer has control.

Problem 2.1

Fig. 2.6 shows the state of IMP's internal registers at a particular point in the execution of a program. The MSB of each register (with the exception of the flag register) appears on the left and the layout follows that shown in the register model of Fig. 2.5.

(a) What is decimal value of the data in the accumulator?

(b) What is the hexadecimal value of the data in the accumulator?

(c) Which one of the three 8-bit general purpose registers has the GREATEST value?

(d) What hexadecimal address is pointed to by the Instruction Pointer?

(e) What decimal address is pointed to by the Stack Pointer?

(f) In which of the 8-bit registers is the MSB set?

(g) In which of the 8-bit registers is the LSB set?

(h) Which of the flags is set?

(i) Which of the flags is reset?

(j) If the HL register pair is currently being used as an address pointer, what hexadecimal address is it pointing to?

(k) Are-interrupts currently enabled or disabled?

Control Signals

IMP has five control bus signals. Four of these are inputs and one is an output. We shall briefly discuss the function of each:

Read/Write (R/W)

(output)

This line is taken low (i.e. to logic 0)

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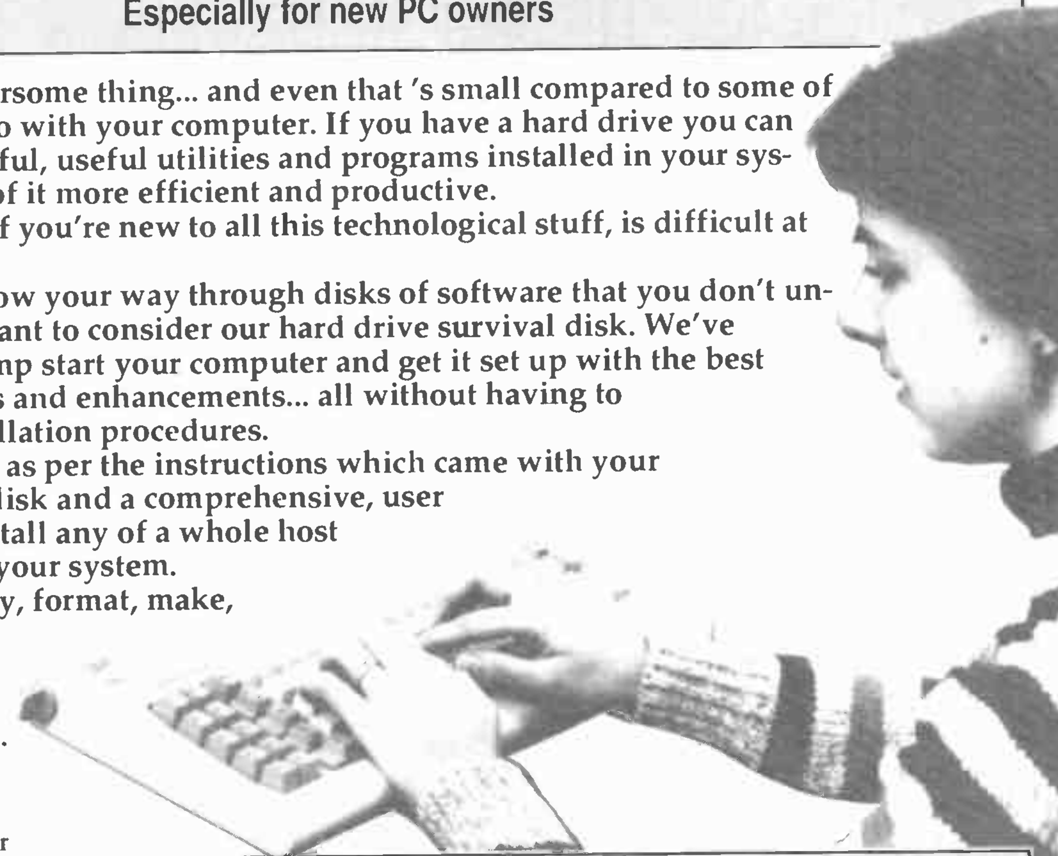

A DOS manual is a fearsome thing... and even that 's small compared to some of the things you could do with your computer. If you have a hard drive you can have all sorts of powerful, useful utilities and programs installed in your system to make your use of it more efficient and productive.

Getting this together, if you're new to all this technological stuff, is difficult at best.

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This disk includes

SIZE	File size finder
ADDRESS	Resident envelope addresser
WHEREIS	Hard drive file finder
HGC	Colour card emeulator for Hercules
SETUP	Resident Epson printer setup
RENDIR	Sub-directory renamer
POPCAL	Resident perpetual calendar
PINPRESS	Prints things very small
NOTEPAD	Resident notepad
FREE	Free space finder
D	Sorted directory
CLOCK	Screen clock
EDWIN	WordStar like editor
NANSI	Screen driver
CACHE	Disk cache
RAMDISK	RAM disk program
LPTX	Printer redirection
MURPHY	Foolishness and wisdom
LOCKERUP	Security system
BOTH	Printer paper saver
PCWINDOW	Resident grab bag
HOTDOS	Multiple tasker
BLANK	Screen blanker
K9	Another resident grab bag
LAZY	Menu generator
UNWS	WordStar converter
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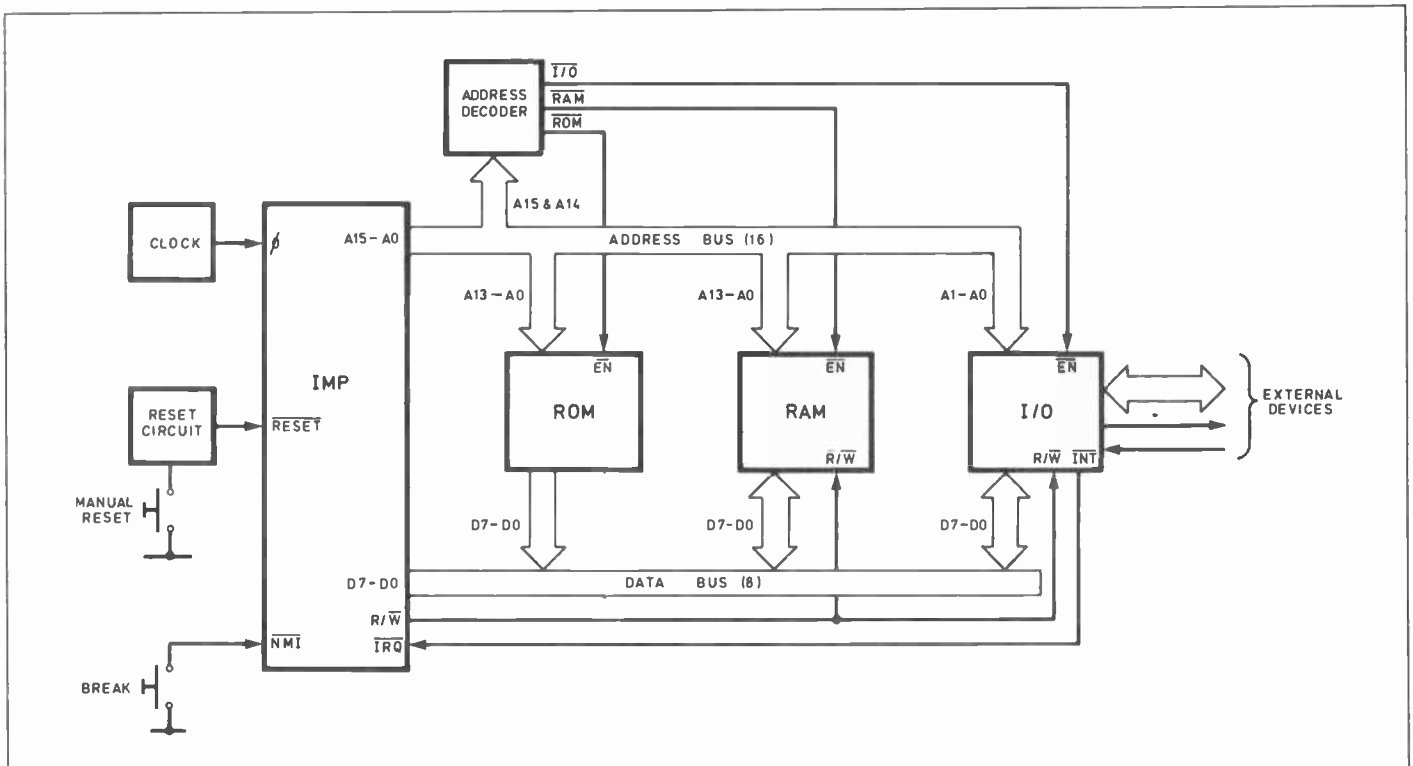

Fig. 2.7. The architecture of a simple IMP-based system.

when IMP is performing a "write" operation (e.g. when data is to be transferred from one of IMP's internal registers to an address in RAM). IMP takes the line high (i.e. to logic 1) when a "read" operation is being carried out.

[NB: Some microprocessors (e.g. Z80) have separate READ and WRITE lines.]

Interrupt request (IRQ)

(input)

This line serves as an input to the microprocessor and is taken low by an external device wishing to signal the fact that it requires attention. Provided the "interrupt flag" is reset (i.e. logic 0) this request will be honoured and the microprocessor will cease normal processing and execute the required "interrupt service routine". The interrupt line is said to be "active-low" (i.e. it is taken to logic 0 when asserted).

Non-maskable interrupt (NMI)

(input)

As we have seen, the response to an ordinary interrupt (IRQ) is determined by the interrupt status flag and thus the interrupt may be "masked". Instructions may be placed within the program which "set" or "reset" the interrupt flag hence disabling or enabling interrupts. This technique provides us with a flexible method of responding to interrupts; we can accept them or reject them at will. There are, however, some situations in which it is desirable that an interrupt should

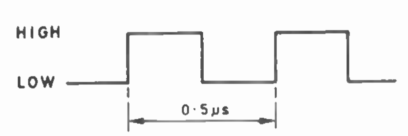

Fig. 2.8. Idealized 2MHz clock signal.

be serviced regardless of what else is going on. Hence a separate "non-maskable interrupt" line is provided. When this line is taken low, normal program execution is interrupted regardless of the state of the interrupt flag (i.e. regardless of whether interrupts are currently enabled or disabled).

Reset (RESET)

(input)

This active low input to the microprocessor is used to initialize the system into a known state prior to normal execution of the program. When the RESET line is taken low, the program counter (PC) is placed in a defined state (by loading it with zero) and interrupts are disabled.

Clock (O)

(input)

IMP requires an accurate and stable square wave clock having a frequency of typically 2MHz. The clock is used to provide an accurate time reference for the control unit (see below).

[Many microprocessors have internal clock oscillators and merely require that a quartz crystal of appropriate resonant frequency be connected to two of the microprocessor's pins. The vast majority of 8-bit microprocessors operate with clock frequencies between 1MHz and 8MHz.]

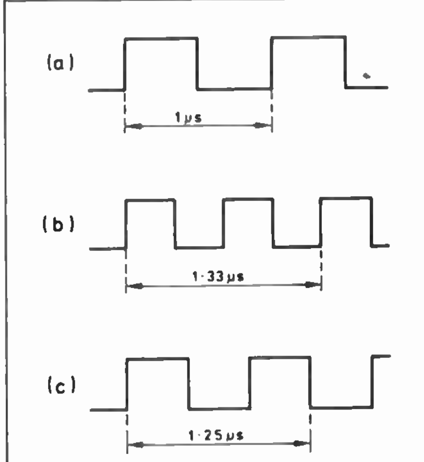

Fig. 2.9. Clock waveforms for problem 2.2.

Problem 2.3
The data sheet in Fig. 2.10 relates to the Intel 8080A microprocessor. Read the data sheet carefully (don't worry if you don't understand all of it) and answer the following questions:
(a) How many address lines are provided?
(b) How many addresses are available for input/output?
(c) What pin number is used for the RESET input?
(d) What pin number is used for the INTERRUPT input?
(e)How many clock inputs are required?
(f) Are the clock inputs TTL compatible?
(g) What supply voltages are required?
(h) Is the WRITE line "active-high", or "active-low"?
(i) What is the logical state of the WRITE line when a write operation is being carried out?
(j) From what address does execution commence when the RESET input is activated?

Fig. 2.10 Data sheet for Problem 2.3.

intel

8080A/808A-1/8080A-2
8-BIT N-CHANNEL MICROPROCESSOR

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The Intel® 8080A is a complete 8-bit parallel central processing unit (CPU). It is fabricated on a single LSI chip using Intel's n-channel silicon gate MOS process. This offers the user a high performance solution to control and processing applications.

The 8080A contains 6 8-bit general purpose working registers and an accumulator. The 6 general purpose registers may be addressed individually or in pairs providing both single and double precision operators. Arithmetic and logical instructions set or reset 4 testable flags. A fifth flag provides decimal arithmetic operation.

The 8080A has an external stack feature wherein any portion of memory may be used as a last in/first out stack to store/retrieve the contents of the accumulator, flags, program counter, and all of the 6 general purpose registers. The 16-bit stack pointer controls the addressing of this external stack. This stack gives the 8080A the ability to easily handle multiple level priority interrupts by rapidly storing and restoring processor status. It also provides almost unlimited subroutine nesting.

This microprocessor has been designed to simplify systems design. Separate 16-line address and 8-line bidirectional data busses are used to facilitate easy interface to memory and I/O. Signals to control the interface to memory and I/O are provided directly by the 8080A. Ultimate control of the address and data busses resides with the HOLD signal. It provides the ability to suspend processor operation and force the address and data busses into a high impedance state. This permits OR-tying these busses with other controlling devices for (DMA) direct memory access or multi-processor operation.

NOTE:
The 8080A is functionally and electrically compatible with the Intel® 8080.

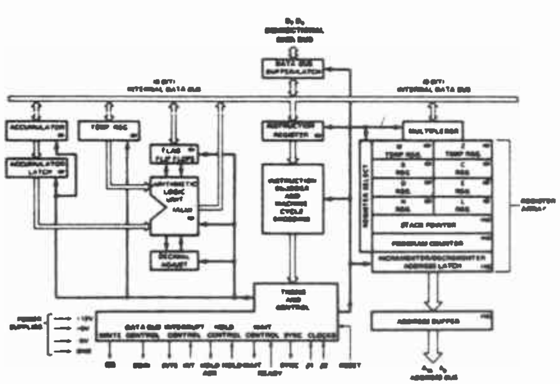

Figure 1. Block Diagram

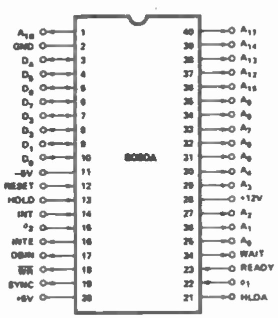

Figure 2. Pin Configuration

Table 1. Pin Description

Symbol	Type	Name and Function
A_{15}-A_0	O	**Address Bus:** The address bus provides the address to memory (up to 64K 8-bit words) or denotes the I/O device number for up to 256 input and 256 output devices. A_0 is the least significant address bit.
D_7-D_0	I/O	**Data Bus:** The data bus provides bi-directional communication between the CPU, memory, and I/O devices for instructions and data transfers. Also, during the first clock cycle of each machine cycle, the 8080A outputs a status word on the data bus that describes the current machine cycle. D_0 is the least significant bit.
SYNC	O	**Synchronizing Signal:** The SYNC pin provides a signal to indicate the beginning of each machine cycle.
DBIN	O	**Data Bus In:** The DBIN signal indicates to external circuits that the data bus is in the input mode. This signal should be used to enable the gating of data onto the 8080A data bus from memory or I/O.
READY	I	**Ready:** The READY signal indicates to the 8080A that valid memory or input data is available on the 8080A data bus. This signal is used to synchronize the CPU with slower memory or I/O devices. If after sending an address out the 8080A does not receive a READY input, the 8080A will enter a WAIT state for as long as the READY line is low. READY can also be used to single step the CPU.
WAIT	O	**Wait:** The WAIT signal acknowledges that the CPU is in a WAIT state.
$\overline{WR}$	O	**Write:** The $\overline{WR}$ signal is used for memory WRITE or I/O output control. The data on the data bus is stable while the $\overline{WR}$ signal is active low ($\overline{WR}$ = 0).
HOLO	I	**Hold:** The HOLD signal requests the CPU to enter the HOLD state. The HOLO state allows an external device to gain control of the 8080A address and data bus as soon as the 8080A has completed its use of these busses for the current machine cycle. It is recognized under the following conditions: • the CPU is in the HALT state. • the CPU is in the T2 or TW state and the READY signal is active. As a result of entering the HOLD state the CPU ADDRESS BUS (A_{15}-A_0) and OATA BUS (D_7-D_0) will be in their high impedance state. The CPU acknowledges its state with the HOLD ACKNOWLEDGE (HLDA) pin.
HLDA	O	**Hold Acknowledge:** The HLDA signal appears in response to the HOLD signal and indicates that the data and address bus will go to the high impedance state. The HLDA signal begins at: • T3 for READ memory or input. • The Clock Period following T3 for WRITE memory or OUTPUT operation. In either case, the HLDA signal appears after the rising edge of ϕ_2.
INTE	O	**Interrupt Enable:** Indicates the content of the internal interrupt enable flip/flop. This flip/flop may be set or reset by the Enable and Oisable Interrupt instructions and inhibits interrupts from being accepted by the CPU when it is reset. It is automatically reset (disabling further interrupts) at time T1 of the instruction fetch cycle (M1) when an interrupt is accepted and is also reset by the RESET signal.
INT	I	**Interrupt Request:** The CPU recognizes an interrupt request on this line at the end of the current instruction or while halted. If the CPU is in the HOLD state or if the Interrupt Enable flip/flop is reset it will not honor the request.
RESET[1]	I	**Reset:** While the RESET signal is activated, the content of the program counter is cleared. After RESET, the program will start at location 0 in memory. The INTE and HLDA flip/flops are also reset. Note that the flags, accumulator, stack pointer, and registers are not cleared.
V_{SS}		**Ground:** Reference.
V_{DD}		**Power:** +12 ±5% Volts.
V_{CC}		**Power:** +5 ±5% Volts.
V_{BB}		**Power:** −5 ±5% Volts.
ϕ_1, ϕ_2		**Clock Phases:** 2 externally supplied clock phases. (non TTL compatible)

A complete IMP Microcomputer System

Fig. 2.7 shows the internal architecture of a complete microcomputer based on the IMP. Since this diagram is somewhat more complicated than that in Fig. 1 of Part 1, we shall attempt to justify the additional features which have appeared.

The reset circuitry is designed to take IMP's RESET input low for a short time (typically 20ms) when the power is first applied to the system or when the manual reset button is pressed. This ensures that the system initializes itself in an orderly fashion as IMP always commences program execution from address 0000H when its RESET input is taken low.

In order that data flow within the system is orderly and that there is no uncertainty as to whether the data present is valid or not, it is necessary to synchronize all data transfers using a reference clock signal. This signal, a symmetrical square wave, is generated by an external oscillator. For accuracy and stability, the clock is crystal controlled the functions at a fixed frequency of 2MHz.

The relationship between the frequency and periodic time (period) of a microprocessor clock is given by:

$$f = \frac{1}{t} \qquad \text{or} \qquad t = \frac{1}{f}$$

Where *f* is the frequency (in Hz) and *t* is the periodic time (in seconds). In practice, it is often more convenient to work in terms of MHz and us, and th same formula will apply. As an example, suppose the clock in Fig. 2 operates at 2MHz. Its periodic time (period) will be 1/2 us (i.e. 0.5us or 500ns) and its idealized waveform is shown in Fig. 2.8.

The clock cycle (often known as a T-state) is the fundamental timing interval used by the microprocessor. A "machine cycle" (M-cycle) is the smallest indivisible unit of microprocessor activity and usually comprises between three and five T-states. An instruction cycle (i.e. that associated with fetching an instruction, decoding and executing it) normally requires between one and five M-cycles.

To put this into context, suppose that IMP is operating at its maximum clock frequency of 4MHz. The periodic time of the clock (T-state) will be 250ns. A machine cycle (M-cycle) will then occupy from 0.7us to 1.25us whereas an instruction cycle will require some 1.25us to 6.25us depending upon its complexity. To put this another way, IMP is capable of executing between 160,000 and 800,000 instructions every second!

The two most significant address lines are fed to an address decoder which generates active low signals to enable the ROM, RAM and I/O devices (more of this in Part 5). At this stage it is merely necessary for readers to understand that ONLY one of these devices is enabled (i.e. linked to the data bus) at any particular time.

The all-important "break" key is connected to IMP's non- maskable interrupt (NMI) input. This allows the user to regain control WITHOUT having to reset the system (and erase the data and/or program currently present in RAM). The general topic of interrupts is outside the scope of *Introductory Microprocessors* and therefore readers need not at this stage concern themselves with the action which takes place when an interrupt is received.

Problem 2.2

What is the frequency of each of the microprocessor clock signals depicted in Fig. 2.9?

Glossary for Part Two

Accumulator
One or more registers associated with the ALU which temporarily store the results of ALU operations.

Arithmetic Logic Unit (ALU)
One of the essential elements of a CPU. The ALU performs various forms of addition, subtraction and logical operations.

Buffer
A hardware device which provides isolation between two parts of a circuit and which usually increases the drive capability of a signal. In the context of software, the word refers to a contiguous area of memory used for temporary storage of data when performing I/O.

Clock
The clock provides a reference timing source within a microcomputer system. The output of a clock comprises regular pulses of accurately defined frequency and period.

Flag
A bit contained within a flag (or status) register which indicates the internal status of the microprocessor or which signals the outcome of an ALU operation.

Instruction
A single command within a program. A complete sequence of instructions constitutes a program.

Interrupt
A signal generated by an external device which requires the services of the microprocessor or which needs to alert the microprocessor to a particular condition (such as imminent power failure).

Stack
The stack is a contiguous area of read/write memory that is accessed on a last-in first-out (LIFO) basis by the microprocessor and used for temporary storage of data and addresses.

Answers to Problems

2.1 (a) 137
(b) 89
(c) L
(d) 879D
(e) 57346
(f) A, H and L
(g) A and L
(h) N
(i) C, Z, V and I
(j) 8AF1
(k) enabled

2.2 (a) 1MHz
(b) 1.5MHz
(c) 1.2MHz

2.3 (a) 16
(b) 256 for input and 256 for output
(c) 12
(d) 14
(e) 2
(f) no
(g) +5V, +12V and -5V
(h) active-low
(i) 0
(j) 0(0000H)

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