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We regret that owing to circumstances beyond our control, the articles ‘PC interface for Centronics port’ and ‘Passive VU meter’ had to be carried over to a future issue.

Front cover
Last month we described a low-cost Programmable Logic Controller system, the Micro PLC. This system uses an instruction set which is similar to that of the well-known SAIA PCs from Landis & Gyr. The short course we start this month begins with a general description of a typical industrial PLC. Next, we leave the hardware altogether and concentrate on software only.

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HANDS-ON PLC PROGRAMMING
(PART 1)

Last month we described a low-cost Programmable Logic Controller system, the Micro PLC. This system uses an instruction set which is largely similar to that of the well-known SAIA PCs from Landis & Gyr. The short course we start this month begins with a general description of a typical industrial PLC. Next, we leave the hardware altogether, and concentrate on software only.

PART 1: THE INDUSTRIAL PLC

Software by J. Joostens

IN last month's article on the Micro PLC it was explained that a PLC is basically a computer which has a host of facilities geared to controlling an industrial process in a simple but most efficient way. This applies equally to the Micro PLC, although you have to take its modest setup into account. Arguably, the Micro PLC is not suitable for the control of a complex industrial process involving a large number of operations. It is great, however, for many smaller applications, for instance, a traffic lights controller.

General layout of a PLC

Before attempting to explore the exact operation of a PLC, it may be useful to have a look at the block diagram in Fig. 1. This diagram shows all major parts of the unit, arranged in a logical layout.

The control system of the PLC is the program core which arranges the overall operation of the PLC. This core is usually located in a ROM or EPROM. With the Micro PLC, it is loaded in the processor's internal EPROM memory. Thanks to the control program, the user is able to write an application program which may be read, interpreted and, of course, executed by the PLC. Apart from that function, the control system also takes care of the communication with the I/O functions and the peripherals connected to the system. With an industrial PLC, the control system is usually so powerful that the user is given the opportunity to debug his/her software.

---

Fig. 1. Block diagram of a typical industrial PLC. The function of the blocks shown here is discussed in the text.

ELEKTOR ELECTRONICS JANUARY 1996
Bit and register memories may be found in most PLCs. These memories enable current values of variables to be stored while the program is being executed. A special location is reserved for the accumulator, which is a register used by nearly all instructions.

The register memory allows the storage of different types of number, both binary and BCD. The size of the memory location may be 8 bits (byte) or 16 bits (word). Register memories are mainly used for the processing of analogue signals, and the reading and processing of BCD values. If available in the PLC, timers, counters and shift registers also make use of the internal registers.

The user memory contains the code for the application program to be run by the PLC. Usually, this is a RAM area with battery backup. In many cases, PLCs also allow the user program to be stored in EPROM or EEPROM. A special ZIF socket then enables system developers to supply a PLC which is tailored and ready-programmed for a specific application.

The text memory is used to define a number of messages which the PLC, depending on certain situations, sends to a terminal or a printer, with or without additional information. It is usually possible to incorporate the register contents or the time into the message. Here is an example of such a message:

```
*** ERROR 04 *** Oven temperature too high!
```

The watchdog increases the stability of the applications running on the PLC. As soon as the watchdog activates, the PLC program is forced to address the timer at certain intervals. If that does not happen in time, for instance, when the system has crashed, the watchdog is actuated, and generates an alarm signal for the user. If desired, the watchdog may also generate a signal to re-initialize the PLC, and restart the user program.

**PLC modes of operation**

A PLC may operate in different modes which may be actuated via a switch, or a command received via the RS232 port. The main modes found on most PLCs are:

- **Programming Mode**: this mode enables the user to put the application program into the PLC's memory.
- **Execute Program**: in this mode, the PLC actually executes the user program.
- **Single-step mode**: this allows the user program to be executed step-by-step. In some cases PLCs may use breakpoints. This mode is very useful for the debugging of a program.

**Manual mode**: this enables outputs to be switched on and off manually. This function comes in handy while testing fans, valves, signal lights, etc which are connected to the PLC's output.

**About inputs**

Ordinary PLC inputs play an important role in the process of reading switch states and detector states. Depending on the application, PLC inputs may be realized in a number of ways. Most inputs, however, are compatible with direct voltages between 0 V and 24 V. In rare cases, PLC inputs may even be suitable for direct connection to the mains. Figure 2 shows the input characteristic of a typical PLC input using switching levels of 0 V and 24 V. Note that the range between 8 V and 15 V is not defined. Apart from differences as regards the input voltage levels, PLC inputs may also be classified according to the presence or absence of electrical isolation. The drawing in Fig. 3 shows how a 24-V PLC input may be provided with electrical isolation. The permissible input voltage may lie between −40 VDC and +10 VDC. The inputs are symmetrical for direct voltages as well as RF noise. The integrated RF filter suppresses noise caused by electromagnetic interference. The actual electrical isolation goes on account of an opto-isolator, whose output signal is filtered by a simple RC network which introduces a delay of 8 to 10 ms. Thanks to this delay, even pulsating signals applied to the input are recognized as a direct voltage.

**About outputs**

The outputs of a PLC are used to switch loads such as magnetic valves, small motors and signal lights. Just as with the inputs, PLCs differ in respect of the practical realization of their outputs. Usually, the outputs have either an open collector, a relay or a triac. Most open-collector outputs are capable of switching voltages between 5 and 36 VDC at a maximum current of 1 A. Here, too, there are versions with and without electrical isolation.

In practice, there is a large difference between switching the positive voltage and switching ground via open-collector outputs. With switching
ground, a short-circuit to ground (system chassis) may cause unwanted actuation of the load (Fig. 4a). This may give rise to very dangerous situations. Switching the positive voltage (Fig. 4b) has no such risks. If such an output is active, and a short-circuit to ground occurs, the protection in the supply line will be actuated. It is then impossible for the actual load to be actuated erroneously. It will be clear that this type of safety precaution is essential in the industrial environment where cables and equipment are subject to heavy mechanical stress.

Counting quickly

As a result of their relative slowness, PLC inputs can not be used to count more than about 100 pulses per second. Hence, special cards have been developed for this purpose. Such cards are capable of counting up to 10,000 pulses per second, independent of the PLC's microcontroller, and may be programmed to warn the PLC if a predetermined number of pulses is reached. Most of these cards may be used to read the position of incremental angle encoders, often coupled with the detection of the rotational direction.

Sometimes these cards are equipped with special outputs for the control of one or more stepper motors. If that is the case, a number of parameters for the driving of stepper motors, such as acceleration and deceleration, may be defined by the user.

A-D and D-A cards

These cards are employed whenever the PLC has to process analogue quantities such as pressure, electrical voltage and current, temperature, speed, rotational speed, etc. The opposite is also possible, i.e., a card may be used to drive analogue loads such as frequency controls, power controls, and positioning systems. The A-to-D card converts an analogue electrical value (voltage or current) supplied by, for example, a sensor, into a digital value (at a resolution of 8, 12 or sometimes even 16 bits). With the aid of a D-A card, the PLC is capable of generating analogue voltages. The voltage and current ranges used for analogue signal processing in the industry are, in general, as follows:

**Voltage**
-5 to +5 V
-10 to +10 V
0 to +5 V
0 to +10 V

**Current**
-20 to +20 mA
0 to +20 mA
±4 to +20 mA

Finishing touches

It is sometimes required for the user to be able to change certain parameters, for instance, delay times, while the program is running. For that purpose, most PLCs have an externally accessible switch whose state is interrogated frequently by the program. Thanks to this arrangement, it is not necessary to re-program the PLC any time one of the parameters has to be changed.

The PLC is usually programmed via a special programming console. This separate unit contains a display and is only connected to the PLC during programming. It allows parameters to be modified, a program to be loaded, the memory to be examined, and any errors to be removed from the program.

A standard feature on all modern PLCs is a communication interface in the form of a serial port. This may be an RS232, RS485, or current loop type. Using this port, the PLC communicates with peripherals such as terminals, printers, measurement equipment, or a PC. An optional barcode reader is an important aid when
the system is programmed to sort products on a conveyer belt in a warehouse.

Vanity features

Today’s PLCs may be taken up in a network just like PCs, but only if a special network card is installed. In principle, it is even possible to incorporate PLCs into an existing PC network. Furthermore, a number of special buses are in use. These so-called field buses, for instance, Interbus-S or Profibus, see rapid acceptance and increasing popularity. Most PLCs have a modular structure. They consist of a basic system which can be given extra functionality by adding insertion cards. The basic system comprises a power supply, a CPU, some memory and a limited number of inputs and outputs. In some cases, there is even a fast counter input and an AD/DA card. Modern PLCs can be fitted with 128 inputs and outputs without problems.

The Micro PLC

After a cursory look at the structure and applications of industrial PLCs it is time to get back to our Micro PLC. In the previous installment we already printed a quick rundown of the instruction set. This month we discuss each instruction in detail.

NOP no operation

STH reads the specified input, output or the specified auxiliary memory, and copies the contents to the accumulator.

DEC decrements counter by 1.

CCR compares contents of counter to specified operand. If the two are equal, the accumulator is cleared (reset).

JMP jumps unconditionally to the specified location. Location should be between 16 and 63.

JIO jumps to specified location if accumulator has a high level. Location should be between 16 and 63. If the accumulator has a high level, the program simply continues with the next instruction.

JIZ jumps to specified location if accumulator has a low level. Location should be between 16 and 63. If the accumulator has a high level, the program simply continues with the next instruction.

WIF wait as long as specified input is high. This instruction may not refer to outputs or aux. memories.

WIL wait as long as specified input is low. This instruction may not refer to outputs or aux. memories.

WTO writes specified operand (between 0 and 63 binary) to the outputs (6 to 11).

SEA set accumulator.

REA reset accumulator.

RPM return from run mode to program mode.

VER transmits software version number via the serial interface.

External instructions in programming mode

chr(0) to chr(250): data; increased by one (for acknowledgement) and returned.

chr(251): returns the status of inputs 0 to 5 as a binary number (0-63), followed by a 'hash' character (#).

chr(252): returns the status of outputs 6 to 11 as a binary number (0-63), followed by a 'hash' character (#).

chr(253): expects a number between 0 and 63. Followed by a 'hash' character (#.

chr(254): transmits the software version number in the form CR/LF<str> CR/LF #.

chr(255) ends programming mode, and switches to run mode.

About MicroPLC.exe

The program is launched as follows:

microplc.exe [options] <enter>

where the options are -com2, -com3 and -com4. The default option is com1. If a colour screen is used, you should use the DOS command SET COLOR=ON <enter> before running ‘microplc’. Colour use may be switched off again by typing SET COLOR=OFF <enter>. After starting the program
you are presented with a number of options, which may be selected via a menu.

Load Buffer with File
prompts you for a file name, and copies this file into the buffer. The length of the file must be 48 bytes (as generated by microlc).

Save buffer to File
writes data contained in the buffer to a file specified by the user. If the specified file name already exists, the user is notified.

Edit Buffer Contents
Mnemonics
allows the user to enter the program with the aid of mnemonics. Microlc always starts from location 16. The program can be made to return to the main menu by typing END. The program as entered is then available in numerical form in the buffer. Non-used program locations in the buffer are automatically filled with the value 26 (RPM, return to Program Mode). Because it is practically impossible to enter invalid instructions, this is the best way to enter PLC programs.

Numerical
allows the contents of one specific location in the buffer to be modified. This method may be used to make minor changes to the program. The user should ensure however that no invalid program steps are created.

Program Microlc
Download & Autostart
Buffer data are sent to the PLC via the serial link. When this option is selected, the program waits for the user to reset the PLC. If the transmission of the buffer contents does not start within two seconds after the PLC has been reset, the serial link has been checked. In that case, you may interrupt the program by pressing any key.

Restart Program
allows you to switch the PLC to run mode when the program to be executed is already in the PLC's memory and the PLC itself is in programming mode.

Preset Outputs
ON
if on, this option causes the PLC outputs to be initialized with a certain value (preset value) before the actual program is started. This initialization is performed automatically when the menu options 'Download & Autostart' and 'Restart Program' are selected.

OFF
Turns the above option off. All outputs are off when the program is started.

Reset Value
Enables the preset value on the outputs to be modified. The value is indicated in binary form.

Serial Port
allows you to change to another serial port than the one stated when the program was invoked. You may select one of COM1 through COM4.

Exit Microlc
leaves the program, and returns the PC to DOS.

That concludes the description of the instructions offered by the program. Some practical programming examples will be discussed in next month's instalment.
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ELEKTOR ELECTRONICS JANUARY 1996
The copybit eliminator published in the February 1994 issue of this magazine has two drawbacks. The first of these is that it cannot be used without modifying the digital audio equipment. The second is clear from the revisit to the eliminator in the September 1995 issue: from time to time, the eliminator needs updating – it is not ‘future-proof’. The copy-permit converter described in this article does not have these drawbacks.

Design by W. Foede

Like the copybit eliminator published in this magazine in the February 1994 and September 1995 issues, the copybit inverter is an inexpensive and simple-to-build circuit for inverting the copybit in a digital S/PDIF* audio signal to enable users to copy (digitally) their own musical work many times without degradation by the SCMS**.

The inverter can be included in the S/PDIF link between any digital a.f. signal source (such as a DCC recorder, a CD player, a DSR receiver) and a (second) DCC recorder without the need of opening or modifying any of the equipment. During the copying, any copybit is inverted and at the same time the category code is altered. This means that the S/PDIF signal so modified is accepted by the recorder as if it comes from a CD player (so that unlimited copying of the signal becomes possible). The inverter also offers a number of other facilities, such as S/PDIF detection.

** Serial Copy Management System.
The left-hand and right-hand channels each build a subframe of 32 bits, which together form a frame of 64 bits.

The digital a.f. signal - 0.5 Vpp into 75 Ω is coupled capacitively to inverter IC₁₃, which is arranged as an amplifier. The standard circuit is an inverter with feedback, but this has the disadvantage that the circuit tends to oscillate with open input. In the present circuit, the operating point is set permanently with P₁. Inverter IC₁₃ is followed by a delay circuit with a delay time of 120 ns.

To ensure that both inputs (optical and coaxial) provide equal signal levels, the output of the opto-receiver, which is about 1.5 Vpp, is applied to the coaxial input via R₆. A changeover switch is not needed, since R₆ couples both inputs adequately. In optical operation, the signal can thus be taken straight from the coaxial socket.

The direct and delayed signals are XOR-gated in IC₂. This makes the sig-

**Fig. 1. Flow diagram of the evaluation process of the copybit in an S/PDIF signal.**
nal independent of the polarity at the input, since all subsequent steps are related to the XOR signal. The spacing of the positive edge is in case of a logic 0 is 354 ns and in case of a logic 1, 177 ns—see Fig. 5.

Normally, the clock is retrieved by a phase-locked loop, PLL, which, as far as time and phase ratios are concerned, is not easily kept stable. Moreover, the voltage-controlled oscillator, VCO, remains operational in the absence of an input signal, which makes decoding of the block and subframe clocks more complicated.

The XOR signal starts non-retriggerable monostable IC3b, which has a dwell time of about 240 ns. To count the subframes and that of the block clock and reset by the subframe clock.

To count the subframes, a 9-bit counter is timed by the subframe clock and reset by the block clock. The 5-bit counter for the subframe bits is in synchrony with the bit clock and is reset by the subframe clock.

Filtering the desired bits (bit 30 in subframes 4, 5, and 10-31) is effected by programmable IC2. The INVERT pulse has the correct position when signal IN1 is delayed by about 60 ns (IN2). A logic 1 is indicated when the relevant LED is driven by the level detector signal output by IC2. This signal is generated in a manner similar to that of the block clock. Each D-bistable associated with a given LED is reset by the block clock and set.

The 5-bit counter for the subframe

The XOR signal starts non-retriggerable monostable IC3b, which has a dwell time of about 240 ns. To count the subframes and that of the block clock and reset by the subframe clock.

To count the subframes, a 9-bit counter is timed by the subframe clock and reset by the block clock. The 5-bit counter for the subframe bits is in synchrony with the bit clock and is reset by the subframe clock.

Filtering the desired bits (bit 30 in subframes 4, 5, and 10-31) is effected by programmable IC2. The INVERT pulse has the correct position when signal IN1 is delayed by about 60 ns (IN2). A logic 1 is indicated when the relevant LED is driven by the level detector signal output by IC2. This signal is generated in a manner similar to that of the block clock. Each D-bistable associated with a given LED is reset by the block clock and set.

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The 5-bit counter for the subframe
with the 1-signal. The period to the next reset is long enough to enable the LED indicating the 1 in a stable way (without flickering).

Inversion of the bit is accomplished by an XOR gate and the 354 ns long INVERT pulse that is located halfway between the C-bit and P-bit—see Fig. 6. The change from 0 to 1 presents no difficulties, since the edges of the INVERT pulse in signal IN2 meet at the centre of the bit at equal levels. Short spurious pulses at the centre of the bit can, however, not be avoided entirely. This does not matter, however, since the biphase-modulated signal is always sampled at the centre of a bit-cell, that is, at 1/3 and 2/3 of the bit.

When bit C8 and C9 in the input signal are logic 1 (magnetic tape drive), they will not be affected. All other signal sources are assigned the code of a CD player.

Moreover, bits 0 and 1 of the channel status are held at logic 0. Although this is not really necessary in domestic equipment (since the bits then are always logic 0), it makes it possible for professional recordings or other recordings marked by these bits (which are inhibited) to be copied—but see warning at beginning of this article.

With switch S1 open, the inverter accepts sampling frequencies of 44.1 kHz and 48 kHz, but with 32 kHz it must be closed to alter the time constants of the monostables. If this switch is in the wrong position, D9 and dimly lit D10 indicate that the signal is unchanged: the unit functions as a converter. A no-signal condition is indicated by D9 lighting.

It is highly improbable that only the generation bit, which does not count in the equipment coding, is encoded. Anyway, there is always D10 as a controlling element.

The output is buffered by inverter IC1F. Resistors R4 and R5 lower the signal level to about 0.5 Vpp into 75 Ω. Capacitor C1 blocks any direct voltage.

**Timing the monostables**

Construction of the inverter on the
printed circuit board in Fig. 9 should not present any undue difficulties. All ICs, except IC6, should be seated in sockets. Be careful with inserting IC2 into its PLCC socket. Do not forget the wire bridge underneath IC3.

After the board has been finished and thoroughly checked, set the presets to the centre of their travel. Apply an audio signal, preferably from a CD player set to PAUSE (which ensures a very stable signal) to the coaxial input socket. Set switch S1 to 44.1/48 kHz, whereupon D3 (category code CD) should light. If an oscillo-
If a scope or logic analyser is not available, adjust presets P1, P2 and P3 (in that order) on to the centre of the stable LED indication.

With S1 in position 32 kHz, the signal source must be a DAT recorder, set to the long-play analogue recording mode, or a DSR tuner. Carefully re-adjust P3 (which should not be much) and re-check the settings with a signal from a CD player. For most practical purposes, these settings are fine.

If more accurate settings of the presets are required, an oscilloscope is needed. Apply an a.f. signal at a level of 0.5 Vpp to the coaxial, not to the optical, input. Set the oscilloscope time base to 100 ns cm⁻¹ and connect the instrument to pin 9 of IC3. Adjust P1 so that all edges cover one another as well as possible. This ensures that the operating point of the unit is centralised and that the delay of the rising edge of signal IN2 is equal to that of the trailing edge.

With P2, set the pulse width of the subframe clock at pin 7 of IC3 to 100-150 ns. If there is an appreciable difference in dwell times between the standard and long-play settings, the value of R12 may be adapted accordingly.

If the oscilloscope has a second time base or x-multiplier x10, the copybit (bit 30) corrected to logic 1 in subframe 4 or 5 can be timed in the output signal with P3 (time base set to 10 (1) μs cm⁻¹ and triggering to start the block at the leading edge of the cathode signal of a lighted LED (D1-D9)).

The high and low level portions of the C-bit set to logic 1 should be equal or very nearly so. If the P-bit is inverted from logic 0 to 1, it should be virtually undistorted.

If the bits away from the block start are to be checked, the LED voltage (trigger at trailing edge) associated with the P-bit can be used for marking them.

During the setting up, make sure that the LEDs light over a fairly wide range. Appreciable differences can be negated by adapting the value of R13.

As a final check, record the output of the copybit inverter on a DAT or DCC recorder. Some DAT recorders show the ID6: this must be 00 both during recording and subsequent playback of the recording—see Fig. 1. Make sure that D1 lights as an indication that the unit has correctly inverted and processed the input signal.

Parts list

Resistors:
R₁, R₂ = 10 kΩ
R₃, R₄, R₅ = 100 Ω
R₆ = 270 Ω
R₇, R₈ = 680 Ω
SYNCHRONOUS OSCILLATORS

When a digital-to-analogue converter (DAC) is used in conjunction with a CD player, their clocks must be in synchrony to make sure that the DAC can process the data error-free. In practice, this means that the clock of the CD player has to be applied to the DAC.

If the DAC is built into the CD player, the CD player clock can be applied as shown in the upper diagram. The clock signal is available at TTL level at the output of IC1b. The DAC clock, IC2a, is synchronized with IC1a via P1 and C6. In practice, P1 is set just past the point where synchrony commences: this ensures that oscillator IC2 continues to work when IC1a is disabled for whatever reason.

An important advantage of the design is that the circuit does not influence the operation of the electronics in the CD player (which thus retains its original functionality).

If the DAC is used as a stand-alone unit, a transmission line for the data and clock signals is required. As usual, this is a 75 Ω coaxial cable. The lower diagram shows how this setup can be arranged.

The chosen signal level of 1.5 Vpp is more than sufficient to ensure synchrony. The values of coupling components P2 and C10 are, however, different from those of P1 and C6 in the upper diagram.

A drawback of this setup is that the oscillator no longer starts spontaneously owing to the increased damping. Fortunately, this can be remedied readily. Resistor R6 limits the energy transferred from the buffer amplifier to the crystal. If the value of this resistor is greatly reduced, even down to 0 (wire bridge), it will be found that the oscillator starts spontaneously again. Note that in some CD players R6 is replaced by a wire bridge.

Another remedy is reducing the turns ratio of the transformer, which decreases the level of the clock signal.

If this is done, the value of P2 can be increased an that of C10 reduced. The load on the oscillator is then smaller, so that it starts spontaneously.

The oscillator circuit draws a current of about 10 mA.

Design by T. Giesberts 1996

R9 = 8.2 kΩ
R10 = 1 MΩ
R11 = 390 Ω
R12, R13 = 2.2 kΩ
R14 = 330 Ω
R15 = resistor array, 8.1 kΩ
P1 = preset, 2.2 kΩ
P2, P3 = preset, 4.7 kΩ

Capacitors:
C1-C4, C10-C15 = 100 nF, ceramic
C6, C12 = 100 pF
C11 = 22 pF
C13 = 1000 µF, 16 V, vertical

Semiconductors:
D1, D10 = LED, low current, 3 mm
D1-D14 = IN4148

Integrated circuits:
IC1 = 74HC04
IC2 = EPM7032LC44-15 (Altera), programmed with software 956513-1*
IC3 = 74HC4538
IC4 = TOTX173 (Toshiba)
IC5 = TOTX173 (Toshiba)
IC6 = 7805

Miscellaneous:
K1, K2 = audio socket for board mounting
K3 = 2-way spring-loaded terminals for board mounting, pitch 7.5 mm
S1 = toggle switch with on contact
B1 = B80C1500, round
Tr1 = mains transformer, 6 V, 300 mA
44-pin PLCC socket for IC2
Enclosure 120x40x70 mm
PCB Order no. 950104*

Sources:
Sony SCMS Handbook DTC-55ES
Valco T187101
DIN EN 60 968

* Combination packet Order no. 950104C

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The circuit described in this article is, in principle, an add-on for the popular Picture-in-Picture (PIP) Processor featured in the October and November 1995 issues of this magazine. Because the PIP processor has only a PAL decoder, it is unable to display a colour inset picture in countries where the SECAM TV system is used. That problem may be overcome by inserting the present converter between the inset source and the PIP processor. The circuit offers more goodies, however, particularly for owners of satellite TV receiver systems.

**SECAM dissected**

The SECAM/CVBS signal which arrives on socket K1 is applied to pin 16 of SECAM decoder IC1 via jumper JP4. The outputs of the decoder (pins 9 and 10) supply the modulated colour difference signals. Since only one colour difference signal is transmitted per line in the SECAM system (the two colour difference signals are actually transmitted alternately), a delay line is necessary to join the two signals again for each TV picture line. That is, admitted, not ideal, but it is inherent to the SECAM system (see the inset box). The result is that one of the colour difference signals is never actually up to date. Obviously, that creates errors in determining mixed colours. By contrast, the current colour differences do get transmitted in the PAL system, resulting in much better picture quality.

For proper operation of the SECAM decoder it was found necessary to put the levels of the horizontal and vertical blanking at about half-way the sand.
castle pulse. Only then is it possible for the decoder to suppress all kinds of interference resulting from the demodulation process. Components R6 and D1 at pin 15 of the relevant IC limit the size of the sandcastle pulse to a level which is acceptable for IC1.

The output signals from IC1 are fed to the baseband delay line simulator, IC2. This IC adds the information pertaining to the received TV line to that of the previous line, which has been delayed exactly 64 μs. Hence this IC is suitable for PAL as well as SECAM, although a gain of 0 dB is stated for the SECAM standard, and 6 dB for the PAL standard. That is because both colour difference signals are present in a PAL signal, resulting in a doubled output level after addition. With IC2, too, the level of the sandcastle pulse is limited. In this case, with the aid of R5a/R5b.

The sandcastle pulse required for IC1 and IC2 is supplied by IC9. For proper operation of the SECAM decoder, the sandcastle pulse should contain vertical as well as horizontal blanking information. Consequently, an IC is used which is specially designed for this purpose, the TDA2579B. Again, this IC was also used in the PIP processor. Here, however, a practical problem has to be overcome: the horizontal blanking calls for a flyback pulse. In a TV set, the flyback pulse is supplied by the deflection system, and that is an element which is not present in the decoder. To solve the problem, the horizontal output of IC5 (pin 11) is connected directly to the flyback input (pin 12). An RC network, R2 - R14 - C58, determines the exact length of the horizontal blanking in the sandcastle pulse, and R24 in particular determines the proper timing of the horizontal blanking.

**Level shifting**

In practice, the voltage levels of video signals are often on the low side. Add to that the fact that the converter's output buffer introduces some loss, and you will see the need to 'boost' the input voltages to the PAL encoder at least a little. The gain is accomplished by inserting two small amplifiers, IC3a and IC3b, between delay line IC2 and the PAL encoder. The same function is performed by IC4 for the Y signal. The bandwidth of the opamps used here, the AD847 and its 'dual' counterpart the AD827, ensure that there is no corruption whatsoever of the signals. Incidentally, IC4 has to supply 6 dB of additional gain to compensate for the attenuation of the delay line. Because the exact gain may vary a little, it is adjustable (within a small range) with preset P9. The 4.4-MHz trap at the input of IC4, R41 - C78, is already suppressing a large part of the colour information contained in the SECAM signal, before this is applied to the PAL decoder as a Y signal. The function of delay line DL1 is to compensate the propagation delays of the colour difference signals incurred in IC1 and IC2. A type DL330 delay line is used because a delay of 330 μs was found to be the optimum value. However, when we started to use standard RGB signals, it was found that the CVBS signal supplied by IC9 was only 60% of its nominal value. If problems occur because of this signal reduction, the solution is to increase the value of R9 to 120 Ω.

**Final station: PAL**

Although the TDA8501 PAL encoder used here can be used, in principle, as an NTSC decoder, this option is not used in the basic version of our converter. A fixed PAL setting is created by voltage divider R46 - R47. The most important reason to skip the NTSC option is that the colour information is modulated on a 4.43 MHz carrier in the PAL system, and that the SECAM decoder uses that very same frequency as a reference. That allows double use of a single oscillator. For NTSC television, a 3.579 MHz crystal would be required, which, in turn, would call for an extra oscillator.

Speaking of oscillators, the one built around IC5 supplies the reference signal for decoder IC1 (via IC8) as well as the carrier for IC4 (via IC6). Although the oscillator has a simple layout, it is important to observe the crystal's exact frequency as well as its CLOAD value of 20 pF. Jumper JP3 allows an external carrier signal to be used for IC5. Such a signal may be connected via R9, and the option is primarily intended for a complex circuit which locks the line frequency to the carrier. In that case, the carrier frequency should be 4.433361875 MHz exactly. The filtered video signal is available at connector K7 to enable an external oscillator to be synchronized to the video signal.

Returning to the PAL decoder, it is seen that the multiplex switch control input (pin 2) is connected to the fast blanking terminal on K7 via jumper JP5. Consequently, switching transistor T3 provides a simple way of making the converter process RGB signals only. All you have to do is interconnect the two PCB terminals marked 'RGB'.

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**ELEKTOR ELECTRONICS JANUARY 1996**

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**Fig. 1. The architecture of the converter is obviously based on the blocks marked 'SECAM decoder' and 'PAL encoder'. The nice thing about the circuit is that it will do more than 'just' converting SECAM into PAL.**
Pin 16 of IC9 supplies the encoded PAL/CVBS signal. In addition to this, the TDA8501 also provides separate Y and C outputs. These are bonded out via buffers T3 and T4 and a mini-DIN socket. This S-VHS socket should, however, be considered as a kind of ‘bonus’ for test purposes etc., because the quality of the output signal is rather poor for lack of proper filtering and clipping. Moreover, the signal contains a measurable residue of the SECAM colour information. By contrast, the CVBS signal is pretty clean, mainly because of a notch filter, L2-C43, which affords excellent suppression of the SECAM carriers.

IC7 is described by the manufacturer as a ‘video switch’. Here, it actually functions as a combined video switch/buffer/amplifier. The IC has two outputs: one ‘ordinary’ (pin 2) and one switched video output (pin 6). The former supplies a buffered copy of the PAL/CVBS signal applied to pin 3: this output signal is fed out via K9, for which a cinch or BNC socket may be used. The signal at the other output of IC7 (pin 6) depends on the switching level applied to pin 5. When a low level is applied, pin 6 is connected through to the PAL/CVBS signal at pin 3. A high level causes the video (or CVBS) signal arriving via K1 to be switched through (amplified) from pin 8 to pin 6. This is done to enable the incoming video signal from a VCR in ‘play’ mode to be fed directly to K2. In case a SECAM signal arrives, that can be displayed in colour on the TV set, via the PIP processor.

**Different modes**

After the conversion from SECAM to PAL (mode 1), the translation from RGB into PAL (mode 2) is probably the most frequently used feature of the converter. In support of this second mode, jumper JP1 allows the fast blanking signal from K1 to be interrupted, and to set the PAL encoder permanently to RGB via the ‘multiplex switch control input’ (pin 2). Obviously, the RGB source connected to K1 should then supply the sync pulses (via pin 20). Both mode 1 and mode 2 require jumpers JP4, JP5 and JP6 to be set to position ‘A’.

As already mentioned, mode 3 enables the PIP unit to be used in combination with ‘older’ TV sets without...
RGB and fast blanking input lines on the SCART socket. This is accomplished by setting jumpers JP4, JP5, and JP6 to position 'B'. Evidently, the TV set should receive back its own sound, and that is why the audio input signals are connected directly to the output audio contacts of K2. By the way, the extra (cinch) audio sockets, K2 and K3, are always connected to the audio output signals of K2.

A few more remarks about mode 3. In this application (for PAL), the PIP processor supplies the input signals for the converter. As already mentioned, the synchronization of the inset picture requires the CVBS signal to be fed back from the TV set to the PIP processor. Hence, the circuit diagram shows pin 20 of K2 as connected to pin 19 of K1. But that is not all. Strictly speaking, this signal should be modulated again so that the inset picture and the main picture can be joined via the fast blanking feature of the PAL encoder. If the main picture is to be shown in colour, then an external PAL decoder is required, which may be hooked up to the converter via connector K6. All signals needed for that purpose are available on K6, including the 12-V supply voltage.

Finally, it should be mentioned that a fourth mode is feasible. Those of you who use a PAL TV set to watch SECAM satellite TV stations not only have the possibility to convert a SECAM signal into PAL and use it as the parent (main) picture (JP4 in position 'A'), but in addition may feed the TV's own PAL signal back to the TV, through the PIP unit (as an RGB signal), and employ it as an inset picture. Both the parent and the inset picture then appear in colour! As regards sound, a choice is available between 'parent picture' sound and 'inset picture' sound. This selection is made with the aid of JP5 and JP6. The only condition for being able to use all these features is that the TV set must be able to fully process the PAL signals that arrive via its SCART socket (in many cases, that can only be achieved via the antenna input).

Construction and power supply

The double-sided printed circuit board for the project is shown in Fig. 3. This board is available through the Readers Services (see page 70). Construction is straightforward, and mostly a matter of locating the component on the component overlay, soldering and cutting wires. All essential connectors (in most cases, only K1, K2 and K4 will be used) may be fitted straight on to the board. Only K6, K7 and K8 are connected externally with short wires to the respective solder pins. For the audio outputs belonging with the S-VHS option, K4 and K5, both solder pins and cinch sockets are available on the board. The pins and the sockets are not interconnected, so may have to establish the links yourself with the aid of two short lengths of screened cable.

Among the passive parts are eight inductors. Six of these, L3 through L8, are ready-made miniature chokes. L1 and L2 however are home-made, adjustable inductors, built from type 7F1S assemblies from Neosid. Making these inductors is not difficult because there are no taps or secondary windings. L1 should have a value of about 60 µH, and L2, 86 µH. These values are achieved by winding 70.5 and 84.5 turns of 0.1-mm dia. enamelled copper wire on the formers, respectively. Be sure to solder the wire ends to the right base pins, if necessary look...
at the component overlay.

Although it did not seem to be strictly necessary on the prototype, screening may be fitted around the oscillator section on the board. This section (IC2 and surrounding parts) is bordered by five holes intended for solder pins which serve to hold pieces of tin-plate in place. If you want, you may also fit a cover on the screening. If you do, remember to drill a small hole so that the fixing hole of the PCB remains accessible. The mains transformer may be cut off without problems. No special tools or equipment are required at this point, although a plastic trimming tool may be useful to set K10. Once the board has been built up and checked, the mains transformer may be connected to K10, and the converter may be taken into use. If you do not envisage using the optional S-VHS connection, that section of the board may be cut off without problems.

Adjustment

Once the board has been built up and checked, the mains transformer may be connected to K10, and the converter may be taken into use. No special tools or equipment are required at this point, although a plastic trimming tool may be useful to set L1 and L2.

Start by setting the jumpers to the positions which correspond to the standard mode of the converter. So: JP1 and JP2 closed. JP3 in position T and JP4 in position 'A'. Do not interconnect the PCB pins marked RGB! Turn preset P1 about 36 clockwise, and

If you do not envisage using the optional S-VHS connection, that section of the board may be cut off without problems.

**Components List**

<table>
<thead>
<tr>
<th>Resistors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 - R8, R63, R71 = 750Ω</td>
</tr>
<tr>
<td>R9, R20, R6, R162 = 4kΩ</td>
</tr>
<tr>
<td>R7, R38, R50 = 5kΩ</td>
</tr>
<tr>
<td>R8, R11, R70 = 8kΩ</td>
</tr>
<tr>
<td>R9, R2 = 150Ω</td>
</tr>
<tr>
<td>R10, R33, R35, R57 = 10kΩ</td>
</tr>
<tr>
<td>R12, R13 = 10Ω</td>
</tr>
<tr>
<td>R14, R15, R36, R49 = 100Ω</td>
</tr>
<tr>
<td>R16, R18 = 2kΩ 1%</td>
</tr>
<tr>
<td>R17, R19 = 22Ω 1%</td>
</tr>
<tr>
<td>R20 = 1kΩ</td>
</tr>
<tr>
<td>R21 = 47Ω</td>
</tr>
<tr>
<td>R23 = 560Ω</td>
</tr>
<tr>
<td>R24, R26 = 1kΩ 1%</td>
</tr>
<tr>
<td>R25 = 147Ω 1%</td>
</tr>
<tr>
<td>R27 = 140Ω 1%</td>
</tr>
<tr>
<td>R28, R32, R34, R37 = 1Ω</td>
</tr>
<tr>
<td>R29 = 12Ω</td>
</tr>
<tr>
<td>R30 = 82Ω</td>
</tr>
<tr>
<td>R31 = 120Ω</td>
</tr>
<tr>
<td>R32 = 22Ω</td>
</tr>
<tr>
<td>R40 = 180Ω</td>
</tr>
<tr>
<td>R41 = 47Ω</td>
</tr>
<tr>
<td>R42 = 47kΩ</td>
</tr>
<tr>
<td>R43 = 150pF</td>
</tr>
<tr>
<td>R44 = 220μF, 5mm</td>
</tr>
<tr>
<td>R45 = 47pF</td>
</tr>
<tr>
<td>R46 = 22kΩ</td>
</tr>
<tr>
<td>R47 = 2M22</td>
</tr>
<tr>
<td>R48 = 47kΩ</td>
</tr>
<tr>
<td>R49 = 27kΩ</td>
</tr>
<tr>
<td>R50 = 100Ω</td>
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<tr>
<td>R51 = 1kΩ</td>
</tr>
<tr>
<td>R52, R55, R59 = 1kΩ</td>
</tr>
<tr>
<td>R53, R56, R60 = 68Ω</td>
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<tr>
<td>R54, R66, R58 = 2M22</td>
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<tr>
<td>R55 = 2kΩ</td>
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<tr>
<td>R56 = 33kΩ</td>
</tr>
<tr>
<td>R57 = 10Ω 5W</td>
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<tr>
<td>R58 = 120Ω</td>
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<td>R59 = 120Ω</td>
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<tr>
<td>R60 = 3kΩ</td>
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<tr>
<td>R61 = 10kΩ preset</td>
</tr>
<tr>
<td>R62 = 50Ω preset</td>
</tr>
<tr>
<td>R63 = 100kΩ preset</td>
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<table>
<thead>
<tr>
<th>Capacitors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 = 100nF, raster 7.5mm</td>
</tr>
<tr>
<td>C2 = 220nF, raster 7.5mm</td>
</tr>
<tr>
<td>C3 = 100pF</td>
</tr>
<tr>
<td>C4, C19, C45, C46 = 47μF 25V radial</td>
</tr>
<tr>
<td>C5 = 22μF ceramic</td>
</tr>
<tr>
<td>C6, C7 = 1nF ceramic</td>
</tr>
<tr>
<td>C8, C10, C24 = 22μF 40V radial</td>
</tr>
<tr>
<td>C9, C11 = 10nF ceramic</td>
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<td>C12, C13, C14, C16, C20, C32, C44, C47</td>
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<tr>
<td>C48, C50, C52, C54, C56, C66, C67, C70</td>
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<tr>
<td>C71 = 100nF ceramic</td>
</tr>
<tr>
<td>C15, C49, C51 = 1μF 63V radial</td>
</tr>
<tr>
<td>C17, C59 = 22μF</td>
</tr>
<tr>
<td>C21 = 330nF, 5mm</td>
</tr>
<tr>
<td>C22 = 150pF</td>
</tr>
<tr>
<td>C23 = 2μF 63V radial</td>
</tr>
<tr>
<td>C25 = 6μF 35V tantalum</td>
</tr>
<tr>
<td>C26 = 47μF, 5mm</td>
</tr>
<tr>
<td>C27, C28, C30 = 100nF, 5mm</td>
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<tr>
<td>C29, C78 = 2nF, 5mm</td>
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<tr>
<td>C30, C34, C77 = 1000pF 16V</td>
</tr>
<tr>
<td>C31 = 1000pF 25V radial</td>
</tr>
<tr>
<td>C32, C39, C74, C77 = 47μF ceramic</td>
</tr>
<tr>
<td>C40, C42 = 220μF, 5mm</td>
</tr>
<tr>
<td>C43 = 15pF</td>
</tr>
<tr>
<td>C45, C57 = 220μF 10V radial</td>
</tr>
<tr>
<td>C58 = 10μF trimmer</td>
</tr>
<tr>
<td>C60 = 27pF</td>
</tr>
<tr>
<td>C61, C63 = 4μF</td>
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<tr>
<td>C62 = 10μF</td>
</tr>
<tr>
<td>C64 = 47μF</td>
</tr>
<tr>
<td>C65, C69 = 10μF 63V radial</td>
</tr>
<tr>
<td>C66, C69 = 10μF 63V radial</td>
</tr>
<tr>
<td>C72 = 100μF 25V</td>
</tr>
<tr>
<td>C68, C73 = 1000μF 16V</td>
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<table>
<thead>
<tr>
<th>Inductors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 = 0.06μH @ 70.5kHz, turns 0.02mm a.w on 7F1S (Nobelsid)</td>
</tr>
<tr>
<td>L2 = 0.06μH @ 84.5kHz, turns 0.02mm a.w on 7F1S (Neosid)</td>
</tr>
<tr>
<td>L3, L4, L6, L8 = 47μH choke</td>
</tr>
<tr>
<td>L5, L7 = 22μH choke</td>
</tr>
<tr>
<td>L68, C73 = 1000μF 16V</td>
</tr>
<tr>
<td>L1 = 0.06μH 70.5kHz, turns 0.02mm a.w. on 7F1S (Nobelsid)</td>
</tr>
<tr>
<td>L2 = 0.06μH 84.5kHz, turns 0.02mm a.w. on 7F1S (Neosid)</td>
</tr>
<tr>
<td>L3, L4, L6, L8 = 47μH choke</td>
</tr>
<tr>
<td>L5, L7 = 22μH choke</td>
</tr>
<tr>
<td>L68, C73 = 1000μF 16V</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Semiconductors:</th>
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</thead>
<tbody>
<tr>
<td>D1 = 6V Zener, TO-5 2V</td>
</tr>
<tr>
<td>D2 = 6V Zener, TO-5 2V</td>
</tr>
<tr>
<td>D3 = 1N4148</td>
</tr>
<tr>
<td>D4, D6 = 1N4002</td>
</tr>
<tr>
<td>D5 = low current LED</td>
</tr>
<tr>
<td>T1 = BSC47C</td>
</tr>
<tr>
<td>T2 = BC327</td>
</tr>
<tr>
<td>T3, T4, T5 = BC337</td>
</tr>
<tr>
<td>IC1 = TDA8095 (Philips)</td>
</tr>
<tr>
<td>IC2 = TDA8466 (Philips)</td>
</tr>
<tr>
<td>IC3 = AD827 (Analog Devices)</td>
</tr>
<tr>
<td>IC4 = AD847 (Analog Devices)</td>
</tr>
<tr>
<td>IC5 = TDA2579B (Philips)</td>
</tr>
<tr>
<td>IC6 = TDA8501 (Philips)</td>
</tr>
<tr>
<td>IC7 = TDA8501 (Philips)</td>
</tr>
<tr>
<td>IC8 = 74HC04</td>
</tr>
<tr>
<td>IC9 = 7405</td>
</tr>
<tr>
<td>IC10 = 74F12</td>
</tr>
</tbody>
</table>

**Miscellaneous:**

| JP1, JP2 = 2-pin PCB header with jumper |
| JP3, JP6 = 3-pin PCB header with jumper |
| K1, K2 = SCART socket, PCB mount |
| K3 = 4-way mini-DIN socket, PCB mount (5VHS) |
| K4, K5 = cinch socket, PCB mount, e.g. T-709C (Monacor 'Monarch') |
| K6 = cinch socket, chassis mount (SVHS) |
| K7, K8 = see text |
| K9 = 10-way boxheader |
| K10 = 2-way PCB terminal block, raster 5mm |
| X1 = crystal, 4.333MHz, Cload = 20pF |
| DL1 = DL330 (Philips) |
| DL2 = DL470 (Philips) |

Printed circuit board, order code 95078-2 (see pages 48, 50).
SECAM: THE FRENCH WAY

SECAM stands for "séquentielle à mémoire" which indicates that this TV system is sequential and based on signal storage. As with the PAL system, the underlying principle of SECAM is that the colour information never changes drastically from one picture line to another. Furthermore, the human visual perception system is not 'annoyed' by a slightly decreased ability to resolve colour vertically. This gave the designers of the SECAM TV system the idea to transmit colour difference signals (which represent all colour information) in successive lines, rather than simultaneously. Consequently, the signal of one line has to be stored in a delay line for a period of 64 μs. After the delay, the output signal supplied by the delay line is combined with the signal of the next line. Figure A presents a simplified block diagram of a SECAM encoder. The associated decoder is shown in Fig. B.

In the encoder, each of the two colour difference signals, B - Y and R - Y, is fed to an FM modulator. Next, the output signals of the two modulators are alternately connected through to a summing circuit. This switching is controlled by the line frequency. The summing circuit then adds the black-and-white signal. The carriers used to convey the composite signal are locked on to the line frequency. Noise suppression is improved by using different carrier frequencies for the two colour difference signals. Apart from two FM demodulators, the decoder also contains a switching circuit and a delay line. In this way, the FM demodulators alternately receive a current carrier and one which has been delayed. To prevent distortion of the output signal, the reference frequencies of the demodulators have to be very stable. In the present decoder, the actual decoding operation differs a little from that illustrated in Fig. B. Although the principle remains the same, the present design has a delay line for each colour difference signal, and lacks a switch.

Obviously, there is a lot more to say about the SECAM TV system but unfortunately that is beyond the scope of this article.

![Figure A](image1.png)

![Figure B](image2.png)

P2, P3 and trimmer C58 to about the centre of their travel. Turn the cores in L1 and L2 so that their tops just protrude from the formers. In most cases, this adjustment will be fine, and no further action is necessary.

Next, connect a SECAM signal to K1, and a PAL TV to K2. Use fully wired SCART cables for both connections.

Switch on the converter, and turn P1 until the picture synchronization is optimum. By turning the preset, try to find the extremes which still give a synchronized picture, and then set the preset exactly between these extremes. Next, adjust trimmer C58 for the best possible picture quality, preferably using a plastic trimming tool. Then try to find the settings on P3 and P5 which give the best possible picture quality. In most cases, these adjustments will be uncritical. For the ideal setting of gain adjustment P3, you may also measure the output video signal at pin 19 of K2. The measured level should be 1 Vpp into 75 Ω.

Finally, there are L1 and L2 which may require fine adjusting. These inductors serve to suppress residual levels of the SECAM signal, and should be adjusted for minimum interference in the output picture. Owners of an oscilloscope may adjust the cores for maximum suppression of both carriers.

Fitting the converter board into a case is left to your own ingenuity. Do consider, however, that the converter, based on its function, may be fitted into the same enclosure as the PIP processor!
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TRIANGULAR WAVEFORM GENERATOR
AS ANALOGUE-TO-DIGITAL CONVERTER

Design by M. Brüggenwirth

A triangular waveform generator can be converted into a very precise analogue-to-digital converter with the aid of a single resistor. This converter may be configured for a variety of applications.

The basic setup of an analogue function generator is shown in Fig. 1. It is an integrator followed by a Schmitt trigger comparator, whose output is fed back to the input of the integrator. As long as the output signal is high, the capacitor is being charged; when the comparator changes state, the capacitor is being discharged. In this way, a triangular voltage ensues at the integrator output, and a rectangular one at the comparator output. Integrated circuit function generators, be it the old standby XR2206 or the modern MAX038, operate on the same principle. Often, a waveshaper is added to the comparator to derive a virtually undistorted sinusoidal signal. This is, however, not needed in the present design.

If, in Fig. 1, the output signal of the comparator is symmetrical with respect to earth, it is a square wave. If, however, an additional voltage is applied across R at the integrator input, the comparator output is a rectangular wave of different frequency. The duty factor of this signal depends on $U_R$.

Charging and discharging
The inverting input of the operational amplifier forms a virtual earth, so that a current $I = U_b/R$ flows through resistor R. The state of the comparator output (high or low) determines the direction of flow of the current. A current $I_n = U_n/R$ flows through resistor $R_n$, so that capacitor $C$ is charged or discharged linearly with a current $I_C = I + I_n$.

Up to time $t_1$ in Fig. 2, the voltage at the integrator is positive waveform peak, $U_{SO}$. Then, the output of the comparator changes state (goes high). A current $I = I + I_n$ flows into the capacitor, and the output voltage of the integrator falls linearly until $t_2$ is reached, when the potential at the integrator is negative peak $U_{SN}$. The comparator again changes state, that is, becomes negative for a time $T_1$. If during that time the level of $I$ is higher than that of $I_n$, that is, $I$ becomes positive, the integrator output rises until time $t_3$ is reached, whereupon the process repeats itself.

Circuit description.
A practical circuit is, of course, not as straightforward as just described. For example, the basic circuit was powered by a symmetrical supply, whereas the circuit in Fig. 3 has a single 5-V supply.

Reference voltage $V_C$ at pin 5 of IC2, which is derived from an internal potential divider, is buffered by IC1a and applied to the non-inverting input of integrator IC1b. With a supply voltage $U_b = 5$ V, the reference voltage is typically $3.3$ V ($2/3U_b$), but may be quite different.

Since the output of IC1a is capacitively loaded by the input source, a compensating network $R_1 - C_2$ is essential.

The peak positive and negative voltages of the comparator are:

$U_{SO} = 2/3U_b$

and

$U_{SN} = 1/3U_b$ (CV plus $R - $pin 2)

The potential across $C_1$ fluctuates between these values.

The timer output is not applied directly to the integrator, but via $T_1$.

The current through $R_2$ is

$I_{R2} = (5 - 3.3)/3 \times 10^{-3} = 45 \mu A$.

As long as the output of IC2 is low, $T_1$ is cut off and $C_1$ is charged with a current of 45 $\mu A$.

When the output of IC2 goes high, $T_1$ conducts and connects the output to earth. The current through $R_2 - P_1$ to earth is then

$I_{R3} = 3.3/(R_2 + P_1) = 90$ $\mu A$.

Half this current derives from the power line, the other half is the dis-
charge current of \( C_1 \). Thus, provided \( P_1 \) is set correctly, the charging and discharge times of \( C_1 \) are equal. The consequent output is a square wave signal (but, of course, only if no input voltage is applied across \( R_1 \). This means that the level of the supply voltage, the level of the reference voltage, the potential across the capacitor, the value of \( C_1 \), and the charging and discharge resistors, provided these are all constant, have no effect on the duty factor, which is determined solely by the input voltage.

### Some design formulas

The integrator capacitance, \( C \), is defined as

\[
C = \frac{Q}{U} = \frac{\Delta U}{U}
\]

where \( \Delta U \) is determined by the two peak values of the comparator: the capacitor is charged \( (T_A) \) and discharged \( (T_D) \) in the time interval \( \Delta t \).

\[
C = \frac{(I + I_{in}) T_A}{U_b / 3}
\]

Equalizing these two quotations and solving for \( I_{in} \) gives

\[
\frac{(I + I_{in}) T_E}{-U_b / 3} = \frac{(I + I_{in}) T_A}{U_b / 3}
\]

Substituting these equations gives

\[
U_{in} = \frac{R_1}{3R_2} \cdot U_b \cdot \frac{T_E - T_A}{T_E + T_A}
\]

Unlike the duty factor, the period (and thus the frequency) of the output signal depends on the peak values of the output voltage, the supply voltage and the value of \( C_1 \).

\[
f = \frac{3f}{2CU_b} \left[ 1 - \left( \frac{I_{in}}{I} \right)^2 \right]
\]

To avoid large frequency fluctuations, the right-hand term should not exceed about 0.25.

\[
U_{in} \cdot \frac{3R_2}{R_1} \leq 0.5
\]

To obtain an accuracy of eight bits, the write frequency, \( f_{CPU} \), of the computer must be at least a factor 2^8 higher than the converter frequency, \( f_{in} \). This allows the value of \( C_1 \) to be determined:

\[
C_1 > \frac{2^8}{f_{CPU} \cdot R_2}
\]

The value of \( R_1 \) must be chosen such that the input signal can vary within the desired limits.

### Software with three routines

The necessary software consists of one compute and two count routines—see Fig. 4—taking no more than a few blocks in a language like BASIC. The counting loops should be sampled about 4000 times (depending on the values of \( R_2 \) and \( C_1 \)) in any measurement period. If the software is too slow, or too fast, the value of \( C_1 \) must be altered accordingly. This changes the measurement period (normally about 200 ms), but it avoids rounding off errors in the computation.

The program must, of course, not be interrupted during the counting loops. Unless an additional card with real-time timers is used, the PC is normally not able to drive the program.

After the converter has been connected to the PC, \( P_1 \) must be adjusted to give exactly 0 V at the open-circuit output. Apply a known voltage, \( U_{in} \), to the input and turn \( P_1 \) until 0 V is obtained. The preset is not required if the software provides scaling of the indicated values. In this case, \( R_3 \) must be 39 k\( \Omega \).

Fig. 3. The circuit of the analogue-to-digital converter comprises two op amps and a timer.

Fig. 4. Flow diagram of a control program of the converter.
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<table>
<thead>
<tr>
<th></th>
<th>8951</th>
<th>8952</th>
<th>1051</th>
<th>2051</th>
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<tr>
<td>FLASH code ROM</td>
<td>4K</td>
<td>8K</td>
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<td>32</td>
<td>15</td>
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</tr>
<tr>
<td>Timer/Counter (16 bit)</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
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<tr>
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<td>YES</td>
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<td>Interrupt Sources</td>
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<td>5</td>
</tr>
<tr>
<td>Pins (DIL/PLCC)</td>
<td>40/44</td>
<td>40/44</td>
<td>20</td>
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<tr>
<td>Special features</td>
<td>Timer 2</td>
<td>Comparator</td>
<td>Comparator</td>
<td></td>
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<tr>
<td>Price (1-24) DIL part</td>
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<td>£16-95</td>
<td>£4-70</td>
<td>£5-85</td>
</tr>
</tbody>
</table>

*Offer includes one AT89C1051, one AT89C2051 and one IC extractor tool.
Offer valid until 31st December 1995 when ordered direct through Equinox Technologies.
All prices shown exclude VAT & VAT plus any bank charges for overseas customers and remain valid until 31st December 1995. All items subject to availability.

For further information on our full range of development systems for the ATMEL microcontroller range, please contact John Marriott at Equinox Technologies.

---

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RESOURCE
Component sourcing & Technical reference
September 1995 version

RESOURCE is a CD-ROM database designed as a tool for specifying and sourcing electronic components, operating under Microsoft Windows™.

According to the makers: "RESOURCE provides the ability to source technical data across the fields of active and passive components, together with supplier listings and current prices within seconds. Product features include the ability to search on approved parts and/or preferred suppliers, search on limited component specification, build shopping
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WANTED. Circuit diagrams of 10W-stereo FM transmitters and relevant information. Please phone Matthew on 01243 252 942. Will pay small amount.

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Another Windows application.

Searching for components is sometimes rather tedious, because it is impossible to just key in a component name or number. You first have to select from a number of columns, such as resistor, capacitor, IC, and so on. After that comes another menu from which you have to make a second selection, such as ceramic capacitor, electrolytic capacitor, and so on. This means that you have to understand the subject matter and know what you are doing. Looking in the wrong file leads nowhere.

We were not able to search successfully with incomplete names: even a space in a name or search area yielded 'not found'. Searching according to specification has to be done meticulously: even the slightest error results in 'not found'.

As stated earlier, the database is not (yet?) complete: a number of areas have not been finalized.

Owing to its cost, the database cannot be said to be suitable for other than professional engineers and businesses. It is sold on an annual subscription basis with updates every four months at £395 per year.

A demonstration disk is available on floppy and can be obtained by phoning Sue Dawson on 01327 311353. N N Eleven, 11 Warwick Street, Daventry, Northants NN11 4AJ
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Top of the range hi-fi apparatus is now termed 'high-end equipment' and the name is a good indication of the prices charged for it. For those who can not, or will not, pay these prices, there is another solution offered in this book: build your own (at considerable cost savings). But this book is aimed not only at this sector of the market, but also at the many enthusiasts who want to be able to experiment and make their own modifications to their 'high-end' equipment.

Build your own High-end Audio Equipment contains construction projects for solid-state and valve preamplifiers and power amplifiers, active cross-over filters, an active subwoofer, a mono/stereo compressor and a headphone amplifier.

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Price £ 14.95

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Whether it is nostalgia, interest in the technical parameters, the appeal of a gleaming amplifier chassis with softly glowing valves, respect for the technical know-how of an earlier generation, or perhaps the firm conviction that the sound of a valve amplifier can not be bettered, it is a fact that valves are not only still very much in demand, but are gaining popularity in audio circles. It is particularly gratifying that many of the younger generation admire valve amplifiers. Perhaps this is due to the popularity of the electric guitar.

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THE LIBERATED SOFTWARE MARKET

The liberalization of the British telecommunications market did not just allow new companies, such as Mercury and Energis, to compete with BT for customers. Another result is that, because today's customers are receptive to new ideas, companies have grown up to develop new and innovative products which were unimaginable just a few years ago.

To strengthen this sector, and to help UK companies compete effectively, a joint initiative called Telecoms 2000 has been set up by the UK Department of Trade and Industry (DTI) and the trade association Federation of the Electronics Industry (FEI) in collaboration with BT, Cable & Wireless, Ericsson, GPT, Motorola and Nortel. The aim of the initiative is to encourage a UK-based network of small supplier companies who can deliver world class products and services. In particular, this applies to software, which is a particularly strong area within the UK telecoms industry.

User software

A very fruitful area is in user software which, by improving access to a service, boosts usage and thus has a multiplier effect on the size of its potential marketplace. For example, the off-line readers (OLRs) developed by Ashmount Research Ltd (ARL) have been instrumental in making CIX easier and cheaper to use.

Compulink Information eXchange (CIX - pronounced kicks)1 was set up in 1985 as the UK's first public-access on-line e-mail and conferencing service. It allowed both private individuals and companies to send local and world-wide e-mail as well as set up both private and public discussion groups known as conferences. They are extensively used for product support and information distribution.

In the early days of systems such as CIX, users would dial in from their computer via modems and give the appropriate commands to request the system to download any waiting messages and then type in their replies or new messages directly. Being connected to the remote computer while carrying out these actions (in countries with high telephone charges) resulted in fairly high - some thought 'horrendous' - system and telephone usage charges.

New messages

An OLR allows a user to write new messages (both private and for conference 'discussion') and read existing replies off-line without being connected to the remote system. The, when the user dials in, the OLR automates all the necessary activities and is typically 40 times faster than when on-line manually to carry out the same activities.

ARL was founded in 1990 to provide the corporate communications market with an OLR offering conferencing, e-mail, file transfer and information retrieval. It was not long before the appeal of the product also took it into the leisure or single-user sector of the market.

The company has been a pioneer in developing OLR or Navigator software that works with a variety of host commercial systems and was the first organization in the world providing unified integrated interfaces to multiple host systems. Today, it offers both standalone and network products to access CompuServe, Delphi, CIX, BIX and others.

In September 1995, Ashmount Research2 launched a new generation of its software to supersede its WigWam and PowWow range to take a new direction in product strategy. From then, all products are known as Virtual Access, a name which is felt to truly describe the nature of the product.

Information transfer

Although the product still gives the user the ability to work off-line, it offers much, much more in the way of information transfer and management and will also include extensive Internet functionality.

Internet is also the raison d'être of Turnpike Ltd3. It was established by Locomotive Software Group Ltd, which has been producing low-cost software for the past seven years to address the need for easy-to-use, cost-effective electronic messaging software for both major Internet suppliers, small businesses and home users.

Chris Hall, Turnpike's managing director, explains: "As users of the Internet, we quickly discovered that there was little or no software which was simple to use and offered all the basic Internet functions for the dial-up user. So, we decided to develop our own. People don't need to be computer experts to use Turnpike. It's designed to be easy to use and straightforward to install. Most popular modems and access providers are supported."

Basic functions

Turnpike, which was launched in May 1995, offers all the basic Internet functions: Mail, News, FTP, Finger and Ping. There is also a built-in Winsock to provide access to other Internet functions such as WWW (the World Wide Web) with registered users being offered a copy of a Web browser.
The aim of the designers of Turnpike has been to produce a package which meets the needs of businessmen wishing to make use of the Internet without the computer or software getting in the way. While Turnpike is a new company formed to take advantage of an emergent market, Wordcraft International Ltd (WIL) was formed in 1978 when the first version of the Wordcraft word processing package for the Commodore PET range of microcomputers was written. Since then, it has become a major force in fax software.

Now, its LaserFAX is the market leader in the fax machines’ FC-connectivity market world-wide. Furthermore, its computer fax protocol CFP has been submitted to the ITU (International Telecommunications Union) for consideration as an international standard.

Close relationships
Mike Lake, WIL’s managing director, points out that the company has developed very close relationships with fax machine manufacturers in many countries around the world. A number of these are, or will be, bundling WIL software with their equipment. Furthermore, in the new market for multifunctional digital machines – printer, scanner, copier, manual fax and computer fax – a wide variety of manufacturers world-wide already feature WIL’s software.

However, hardware and software can come together. Psion, makers of the Series 3a, which is the world’s number one selling palmtop, has developed Psion SMS Link, which it is selling as a cable and software bundle to enable 3a users to hook up to a Nokia 2110 digital phone or Orange phone to make use of the SMS (Short Message Service). This is intended as a corporate product for vertical applications and will be used as a development kit for value-added resellers.

Not only will this provide an opportunity for even smaller companies to move into communications software applications, it will enable applications to be developed to meet specific user needs. And, after all, this is the requirement because telecommunications is a means to an end and not the end itself.

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1 CIX Ltd, London House, The Square, Llanravist, Gwynned, Wales, United Kingdom LL26 0LD. Tel: +44 (0)1492 641 961. Fax: +44 (0)1492 641 538.
2 Ashmount Research Ltd, 26 Baker Street, London, United Kingdom W1M 1DF. Tel: +44 (0)171 935 7712. Fax: +44 (0)171 935 7713.
3 Turnpike Ltd, Dorking Business Park, Dorking, Surrey, United Kingdom RH4 1HN. Tel: +44 (0)1306 747 747. Fax +44 (0)1306 747 749.
4 Wordcraft International Ltd, Kelmscott House, Vernon Street, Derby, United Kingdom DE1 1FR. Tel: +44 (0)1332 371 428. Fax: +44 (0)1332 295 525.
5 Psion PLC, Alexander House, 85 Frampton Street, London, United Kingdom NW8 8NQ. Tel: +44 (0)171 262 5580. Fax: +44 (0)171 236 7341.
Recent additions to the catalogue are products from blue-chip companies such as Brother, IBM Lexmark, Samsung, and Black & Decker. Several new product sections have been added to this year’s catalogue, including opto-electronics, PCB prototyping, surface mount, motor control and data comms/networking.

The catalogue now contains 53 sections, including switches, tools, and remote controls. Every one of the sections has been tailored to meet the demand of the ever-changing market. To assist customers, each product is accompanied by a brief description and colour photograph.

CPC is dedicated to service the industrial and commercial user, but its catalogue and service are becoming increasingly popular with other market sectors, such as education.

Another aspect of the CPC operation is that customers need not waste time looking for the part number they require. By simply ringing CPC’s Partfinder Service, operators will access the vast and constantly expanding database of 750,000 products to find the parts you need. The highly trained staff, backed by the latest technology, handle 3500 calls and 3000 orders a day and four new fax lines are being installed to help cope with demand. Not only this, but CPC ensures that language is no barrier to their potential customers. Qualified personnel in the Export Department are able to deal with orders and enquiries in German, French and Spanish.

On the day the 1996 catalogue was published, CPC opened a new 2800 m² extension to its warehouse at Preston. The company is currently drawing up plans for a high-bay warehouse to join this extension by the end of 1997.

Available free of charge, CPC’s 1996 catalogue is offered to all account holders; new accounts can be opened simply by ringing one of the many telephone sales operators.

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Equinox Technologies has recently launched a low-cost programmer to support the Atmel range of FLASH-8051 microcontrollers. The ‘Atmel Micro Pro’ can program both the 40-pin 8951/8952, the new 20-pin 1051/2051 micros and most serial EXTRAS from Atmel. To meet popular demand, the Intel and Philips 87C51/52 generic parts are now also supported.

The ‘Micro Pro’ is different from most low-cost programmers in that it is based around Field Programmable Gate Array (FPGA) technology rather than using a microcontroller. Every time a device is to be programmed, the digital circuitry required for programming the target device is downloaded from the PC into the FPGA. This allows the hardware to be customized to suit each device, giving faster programming times and future device support without the need for expensive adapters.

The new AT89C2051 from Atmel is an 8051 in a 20-pin package. The 2 kByte on-chip reprogrammable flash ROM can be erased, programmed and verified in under five seconds with no need for a UV eraser (guaranteed 1000+ reprogramming cycles). The device features 128 bytes of RAM, 15 I/O lines capable of direct LED drive, two 16-bit counter/timers and five interrupt sources. The standard 8051 serial interface has also been included, together with an analogue comparator useful for A/D conversions.

The ‘Micro Pro’ has recently gained official programming approval from the Atmel Corporation for programming their complete range of FLASH microcontrollers. To celebrate the association, Equinox are offering an Atmel Micro Pro programming system, together with a free Atmel AT89C1051 and a free AT89C2051 microcontroller, data sheets, PSU, parallel cable and an IC extractor tool for only £99. excl. VAT and P&P. The offer ends on 31 December 1995. For further details call John Marriott on +44 1204 491 110. See also advertisement on p. 39.
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CPC. Faraday Drive, Fulwood, Preston, Lancashire.
Slash PIC16/17 Development Time

Microchip's new MPLAB Integrated Development Environment software gives PIC16/17 microcontroller developers the flexibility to edit, compile and emulate from a single user interface. The sophisticated MPLAB software is now available as part of Microchip's PICMASTER Universal Development System.

MPLAB includes a project manager and program text editor, a user-configurable toolbar containing four predefined toolsets and a status bar which communicates editing and debugging information. A dynamic error capability allows rapid application development with a simple click on any error listing, returning the user to the source code for quick editing.

Integrated development tools have long since been available for workstation and high-end PC-based developers. MPLAB offers the same flexibility to 8-bit microcontroller developers. Operating under a Microsoft Windows environment, the PICMASTER development system also includes an emulator control pod, target specific emulator probe, PROMATE device programmer, PC host interface card, demonstration hardware and software.

Existing PICMASTER users can integrate the MPLAB software into their systems at no cost by downloading the new productivity tool from Microchip's Bulletin Board System (BBS). Users can connect to the Microchip BBS through the CompuServe communications network.

Arizona Microchip Technology Ltd., Unit 6, The Courtyard, Meadowbank, Furlong Road, Bourne End, Bucks SL8 5AJ. Tel. (01628) 851077, fax (01628) 850259.

Simpler Access to IDT Product Info: WWW and CD-ROM

Integrated Device Technology Inc. (IDT) has set up a number of new methods to access product and company information, including data sheets for IDT's complete range of products. A free CD-ROM, designed for use on Macintosh, Windows, DOS and SUN Unix systems, is now available. It uses the Adobe Acrobat portable document format reader to display and print pages of information from the many sources that IDT has brought together onto this one medium. Macintosh and Windows users can use hyperlinks to move easily between documents.

Information on the CD-ROM includes data on RISC processors, multiprotocol and FIFO memories, and high-speed logic and interfacing devices, plus product selector guides, application notes, quality reports, and background information on the company.

For those users who are on-line, almost all of the same information is provided via IDT's home page on the World Wide Web (http://www.idt.com). The advantage of this system is that the information is always the most up-to-date available, with pages being updated daily. Information can also be retrieved using anonymous ftp using ftp.idt.com/docs/docid.ext. All documents on the ftp server are in Adobe Acrobat format. On-line users can also contact IDT's European sales operation by sending e-mail to eurosales@idt.com.

Anyone who is not on-line but who needs information immediately, can use IDT's fax server. This Fax-on-Demand service offers all the same information as the CD-ROM, except manuals, which are too long to be practical to send. Fax-on-Demand can be accessed by calling +1-408-492-8341 and following simple directions.

Integrated Device Technology, Europe, Prime House, Barnett Wood Lane, Leatherhead, Surrey KT22 7DG. Tel. (01372) 367334, fax (01372) 378851.

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Last month we published the design that won the International First Prize, a Tekscope THS720.

This month we continue the success story of our International Circuit Design Competition (July/August 1995) with a 16-page supplement which contains a selection of prize winning designs submitted to the German (G), Dutch (NL), French (F) and English (UK) language editions of Elektor magazine. It is our intention to publish in random order the Top-3 winning designs from each language edition, giving a total of 12 circuits, in two installments of 6 pages each.

Designs are published 'as is', i.e., with only minor editorial corrections to the text. Please note that none of the published circuits have been tested by ourselves.

---

**EIGHT-BIT LOGIC ANALYSER**

**For PC Parallel Port**

An 8-bit 50-MHz on PC parallel port Logic Analyser for home application is always a useful tool for small digital projects, especially in field uP applications. Eight bits with two triggers, 512 bytes and a maximum sample rate of 50 MHz are good specifications for hobby users. Low power and portability are also important if you want to use this tool with a laptop computer on the road. Optionally, you may use one 6-bit flash A/D converter at the input and so obtain a combination of one analogue and two digital inputs.

By Jankijewic Ninoslav, el. ing.

My first idea was to make a logic analyser with a very small number of components, and as simple as possible. I had one sample of a CMOS FIFO from IDT (Integrated Device Technology, Inc.) type IDT72210 in a 28-pins 300-mil plastic DIP case. Important features for this project are: a 512x8 bit memory array structure, 15-ns read/write-cycle time (66-MHz clock), and dual ports for input and output data. I decided to use this chip (with 25 ns cycle time) for my application.

To tackle another problem, the triggering and time base, I selected a PAL from Altera, type EP910. The time base is built from a 2-5-10 dual decade counter 74HC390 which produces three output frequencies: 20 MHz, 8 MHz and 4 MHz.

In the block diagram, Fig 1, the signal from the XTAL oscillator (40 MHz) goes to the decade counter and a selector which switches the programmable clock or the maximum clock from the XTAL generator. Programmable clock is selected with four bits named A, B, C and D. With these four bits the desired sampling rate is selected as shown in Table 1. A programmable counter contained in the PAL can divide one of three input frequencies by 1, 10, 100 or 1000.

The trigger section is also based on a PAL, and uses two direct signals from input ch0 and ch1. With four bits E0, E1, E2 and T1 we can select the trigger edge polarity. Table 2 gives an overview of these settings.

Register 1 (CD4094) is used to set all eight bits and select the mode of operation for the Logic Analyser. To read data from FIFO memory, a MUX (74HC157) is used with a control input (1 for low/high) to select and read four low or four high bits of data.

The procedure to start...
scanning the digital input, read data and display it on the PC screen is:

1. Reset FIFO signal, RES=0, and reset FIFO read function. RD,OE=1. At the same time the trigger flipflop will be reset.
2. Set trigger and time base bits (Tables 1 and 2).
3. Reset FIFO signal, RES=1.
5. Enable read FIFO function, RD=1.
6. Read all 512 bytes of data (Q0/Q7) in three steps:
   a) output one read clock RCL:
   b) read low data (4 bits from MUX): 
   c) read high data (4 bits from MUX).
7. Display data on PC display and go to step 1.

The first three steps may be controlled and programmed in BASIC (I used Power Basic). For the remaining steps (4 through 7) it is best to use assembler for fast data updating.

**Hardware**

The power supply may be an external unregulated 9-V DC source. The board contains a standard 7805 regulator for a clean 5-V supply rail. Supply current is about 250 mA at 40-MHz sampling rate. A 40-MHz XTO and a buffer 74ACT04 are used for the clock source.

Frequency selection outside of the PAL is achieved with a three-state buffer (74HC125) which is also used for the trigger gate. Digital input signals are buffered by a standard 74HC541 and then passed.
to two octal D-type flipflops 74HC574 which are clocked at the same clock and opposite phase. When the main trigger occurs, the FIFO input receives a one-clock delayed signal which occurs one clock before the trigger action.

The printed board is a single-sided home-made product with seven jumpers at the top side and one jumper (j4) at the bottom side. If you use double-sided board it is recommended to use the top side for a ground plane. There are no direct connections between the computer and critical components like the FIFO and the PAL. To separate signals like Read Enable, FIFO Reset, Read Clock and FIFO Full Flag from the computer a darlington transistor array type ULN2003 is used. Each collector has a load resistor of 3kΩ (R2). There are no critical parts except the blank PAL which must be programmed with a special PAL programmer. A PAL from INTEL series EPLD type 85C090-20 may also be

![Circuit diagram of the Logic Analyser](image)

![PCB copper track layout and component mounting plan](image)
### Table 3. Components list

<table>
<thead>
<tr>
<th>LPT1 pin</th>
<th>signal</th>
<th>part address</th>
<th>function</th>
<th>name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>STROBE</td>
<td>out 37A bit 0</td>
<td>read clock for FIFO</td>
<td>RCL</td>
</tr>
<tr>
<td>2</td>
<td>DATA0</td>
<td>out 37B bit 0</td>
<td>strobe for Register 1</td>
<td>STR</td>
</tr>
<tr>
<td>3</td>
<td>DATA1</td>
<td>out 37B bit 1</td>
<td>Data for Register 1</td>
<td>DOUT</td>
</tr>
<tr>
<td>4</td>
<td>DATA2</td>
<td>out 37B bit 2</td>
<td>clock for Register 1</td>
<td>CL</td>
</tr>
<tr>
<td>5-8</td>
<td>DATA3-6</td>
<td>out 37B bit 3-6</td>
<td>not used</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>DATA?</td>
<td>out 37C bit 7</td>
<td>select L/H data</td>
<td>LOW/HIGH</td>
</tr>
<tr>
<td>10</td>
<td>ACK</td>
<td>in 37D bit 6</td>
<td>data input bit 3/7</td>
<td>03/07</td>
</tr>
<tr>
<td>11</td>
<td>BUSY</td>
<td>in 37D bit 7</td>
<td>data input bit 2/6</td>
<td>02/06</td>
</tr>
<tr>
<td>12</td>
<td>PE</td>
<td>in 37D bit 8</td>
<td>data input bit 1/5</td>
<td>01/05</td>
</tr>
<tr>
<td>13</td>
<td>SEL</td>
<td>in 37D bit 9</td>
<td>data input bit 0/4</td>
<td>00/04</td>
</tr>
<tr>
<td>14</td>
<td>AFO</td>
<td>out 37E bit 1</td>
<td>reset FIFO</td>
<td>FF</td>
</tr>
<tr>
<td>15</td>
<td>ERR</td>
<td>in 37F bit 3</td>
<td>read FIFO Full flag</td>
<td>RO-DE</td>
</tr>
<tr>
<td>16</td>
<td>INIT</td>
<td>out 37A bit 2</td>
<td>read enable for FIFO</td>
<td>not used</td>
</tr>
<tr>
<td>17</td>
<td>SLC</td>
<td>out 37A bit 3</td>
<td>ground</td>
<td>GND</td>
</tr>
<tr>
<td>18-25</td>
<td>GND</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Software**

Before I started to write a driver in assembler, all hardware test were performed in Power Basic. The test program was based on the information contained in Table 3. The final software is divided in two parts. The main program, written in BASIC, sets all modes for the Logic Analyzer. The assembly code driver is linked with the BASIC program, and is used for fast reading of the FIFO buffer, and displaying data on the screen.

**A LOW COST WIND GENERATOR BATTERY CHARGER**

Small wind powered generators are useful devices for people dependent on battery power, such as caravaners and yachtsmen. Commercial products are expensive. The smallest models cost over £250. A generator giving up to 30 watts output can be made using a permanent magnet radiator fan motor, obtainable from a car breaker, costing about £5, a DC-DC converter, described here, costing less than £15, and an 800-mm diameter wooden propeller described by Mr. Piggott in Ref. 1.

**Design by C. John Dakin**

The DC-DC converter is necessary because the voltage output of the motor when used as a generator is much less than 12 V, the commonest battery voltage.

As shown by the circuit diagram in Fig. 2, the converter uses an inductor, L1, and a power MOSFET switch, T2. Each time T2 switches off, the current which has built up in L1 during the 180 μs T1 was on, is steered into the battery, B1, by D2. The current in L1 is sensed by R1, a 10-mΩ resistor, and two voltage comparators, IC1b and IC1c. When the input voltage, $V_i$, is 3 V, IC1b detects when the current rises to 10.4 A, and IC1c detects when it falls to 0.9 A. Both current levels are defined by the voltages from R1, R3 and R4, and are proportional to $V_i$. The converter looks like a resistor, $R_m$, of 0.57 Ω to the generator. The outputs of IC1b and IC1c set and reset respectively the bistable formed by the two NAND gates IC2b and IC2c. The set

![Fig. 1a. Typical 12V car radiator fan motor power output power.](image-url)
pulse is via a third NAND gate IC2a, the second input to which is held high by IC1a, a third voltage comparator, as long as \( V_i \) is more than 2 V. Setting the bistable switches T1 on and the collector falls from +12 V to 0 V. T1's output drives the six inverters of IC3. IC3 drives the gate of T2, which has an input capacitance of 2 nF. from 0 V to +12 V in 2 μs.

When \( V_i \) is rising from 0 V to 2 V, IC1a's output stays low as pin 6 is above pin 7. IC1b's and IC1c's outputs stay high as there is no current through R11. The bistable is forced to the reset state by R5 and R6 holding pin 9 of IC2b low. When \( V_i \) reaches 2 V, the output of IC1a goes high, the bistable is set and the first operating cycle starts. Whenever \( V_i \) is less than 2 V, T1, IC3, C5 and D2 draw only leakage current from the +12 V rail.

The inductor in the circuit consists of 16 turns of 2-mm dia. enameled copper wire wound on an ETD39 Ferroxcube core. A 0.6-mm air gap is put in the magnetic circuit of the core using pieces of cardboard or other non-magnetic material. Each end of the winding is connected to two pins of the former. See the PCB layout for the correct pins.

ZD1, a BZY93C16, 16-V, 20-W zener, should be fitted if B1 may be disconnected at any time. ZD1 will then limit the peak voltage at the drain of T2 to 17 V. ZD1 requires a suitable heatsink.

Figure 1a shows the power output of a typical car fan motor when used as a generator. The output is maximum with a load of about 0.4 Ω. This equals the output resistance of the generator, \( R_g \). Because the converter losses increase as \( R_m \) decreases, \( R_m \) is set higher

![Fig. 1b. Power output of the combined generator and converter against wind speed.](image)

**Fig. 2. Circuit diagram of the wind-powered battery charger.**

ELEKTOR ELECTRONICS JANUARY 1996
than $R_g$ for the best efficiency of the combined generator and converter. The resistance of the connecting cable between the generator and the converter must be kept as low as possible.

(950307-1)

References:
1. Scrapyard Windmill Realities — Building Windmills with Recycled Parts by Hugh Piggott. Published by The Centre for Alternative Technology, Machynlleth, Powys, Wales SY20 9AZ. Telephone: (01654) 702400.

**COMPONENTS LIST**

- **Resistors:**
  - R1a-g 10kΩ SIL array
  - R2 3kΩ
  - R3 330Ω
  - R4 680Ω
  - R5 1kΩ
  - R6 220Ω SIL array
  - R7 3MΩ
  - R8a-g 10kΩ (Farnell 148-724)
  - R9 6fΩ (all single resistors metal film)

- **Capacitors:**
  - C1 10μF 16V
  - C2, C3, C4 0.01μF
  - C5 1μF 50V

- **Inductor:**
  - L1 3CB core, former
  - Cliff, ec wire 14SWG (2mm). Maplin order codes: JR81C, JR82D, JR83E, 9L16S.

- **Semiconductors:**
  - T1 BC547
  - T2 BUZ11
  - D1 1N4148
  - D2 RYW80-150
  - IC1 LM339
  - IC2 HC202
  - IC3 HCF048
  - ZD1 62Y83C16

---

![Design of an 800-mm propeller suitable for a typical fan motor. The reader is recommended to read Mr. Piggott's excellent paper, Ref. 1, for full details of propeller design and construction.](image1)

![PCB layout for the battery charger.](image2)
REMOTE MONITOR FOR CENTRAL HEATING SYSTEMS

WITH SECURITY ALARM

This circuit allows the proper functioning of different elements of a fuel burning central heating (CH) system to be monitored. An alphanumerical display is used at a convenient location to display useful data, while a buzzer sounds when a problem occurs with the CH system (burner switched to protection).

Design by Bernard Leclerc

In many houses, the central heating boiler/burner is mounted in the attic, or in another place which is not easily accessible. In case of a breakdown, or lack of fuel, you will not notice that there is a problem until the temperature starts to drop appreciably. The CH system monitor presented here uses a minimum of connections, yet enables you to check the current state of the heating system at any time.

The circuit is fitted in a discrete, but easily accessible, location within the normally inhabited space in the house. It will indicate the proper functioning of the various sub-units of the boiler, and will sound an audible alarm (by means of a buzzer) whenever a fault occurs (burner switched to safety mode).

The display indicates whether the CH system operates in standby-mode (overnight, or when no heating is required), or when the accelerator pump is on. It also indicates whether the burner is on, or waiting for cold return water (i.e., having a temperature below the desired temperature), in which case it will switch on again. Each safety action which has to do with burner is immediately signalled by the display and a buzzer, by means of a pulsed sound.

The circuit may be modified to suit other applications, for instance, as regards the alphanumerical characters which appear on the display (edit the microcontroller ROM contents), or as regards the voltage levels at the inputs.

Hardware

Because the circuit can work from a.c. as well as d.c. voltage sources, there are few constraints as regards the power supply of the circuit. You may use either a mains transformer or a suitably rated mains adaptor. All inputs are electrically isolated by means of opto-isolators, of which the internal LEDs are powered via a resistor and a capacitor, which is discharged by a diode. The logic information supplied by the opto-isolators consists of active low levels, which are read by the con-

---

Fig. 1. The circuit of the central heating system monitor is considerably simplified by a microcontroller. Here, a Motorola 68705P3 is used.

Translations: security = safety; bruleur = burner; accéteur = accelerator.
COMPONENTS LIST

Resistors:
- R1 = 8-way SIL array 22 kΩ
- R2 = 8-way SIL array 10 kΩ
- R3, R4, R5 = 15 kΩ 1W
- R6 = 12 kΩ
- Ra[1] = 1 kΩ preset

Capacitors:
- C1 = 1 μF 63V
- C2, C3 = 47 μF
- C4 = 1000 μF
- C5 = 1000 μF 63 V
- C6-C8 = 100 μF 400 V

Semiconductors:
- D1 = 1N4148
- D2 = bridge rectifier
- D3, D4, D5 = 1N4001
- Q1 = 2N2222
- Opt2, Opt2b, Opt3 = 4N25
- U1 = 68705P3 (programmed)*
- U2 = LM7805

Miscellaneous:
- Y1 = quartz crystal 1 MHz
- B1 = buzzer

* Programming files for this project available on disk; see page 70.

trol software.

The alarm output occupies one line of the other half of port B, split into inputs/outputs, and drives a transistor which supplies the required current for the buzzer. The other ports are programmed to output mode, and deliver the LC display signals: eight-bit data (Data, port A); data/command selection (port C); and data strobe (port C).

The contrast of the LCD module is adjusted by a preset (the multturn cermet is not obligatory). The system clock is derived from a quartz crystal, Y1. Although the clock will also function if the crystal is replaced by a resistor or a wire link, the timing accuracy will drop unless you modify the MOR in software. The reset pulse is supplied automatically by capacitor C1 when the system is switched on. Diode D1 enables any voltage higher than the supply voltage to be shunted away into the power supply.

Printed circuit board

The circuit board is single-sided. It has only seven wire
The connection is made on the terminal strip of the controller. Where the terminals at the far left should be connected to the points marked with the letters A, B, C, D, E, or F, and the two remaining terminals at the far right are connected to the remote monitoring equipment in parallel. The connection is further made by a suitably rated multicore cable.

The software starts by allocating the ports and their direction (I or O). Next, the memories are configured, and the ports are cleared. Then follows the display initialisation and the transmission of the first message. Next, routines are executed which define the permissible setup times of the various signals. Then comes an input line scanning operation in order of priority, followed by a five times over verification of the logic state which should be different from the 0 V belonging to the non-used half-cycle in the sinusoidal wave at the inputs. Return to the loop if nothing is detected, or jump to the relevant subroutine for the message to be written. The subroutine completed, always return to the main program (input reading), except for the audible alarm subroutine, which forms an endless loop.

Next comes the ‘version’ message, and then the copyright notice. At value 8784, there is the programming byte of the chip: the MOR, followed by the rest of the control program.

Connections
The connection is made on the terminal strip of the control panel, where the three ‘signals’ required for the monitor are tapped and sent to the remote monitoring unit by a suitably rated multicore cable.

The two screw terminals at the far right are connected to the supply voltage (between 6 and 15 V a.c. or d.c. at about 10 VA). The input voltage may be supplied by a transformer fitted inside the case, a mains adaptor, or it may be supplied by the boiler’s internal power supply.

The two terminals at the far left should be connected to the panel strip in parallel with the barrier motor.

The two remaining terminals are connected to the same panel, to the points marked ‘fault’, ‘error’ or similar.
DESIGN COMPETITION WINNERS

For reasons of security (risk of shunting, or return currents via other terminals), it is best not to use a common wire. Instead, use two wires for each signal to be fed to the remote monitor.

Options

Obviously it is possible to modify the display messages using a simple editor; that is the reason which prompted me to equip various subroutines with this property.

The input voltages may be adapted to suit another application, simply by shorting out C6 and C8 if direct voltages are applied, or by changing resistors R3, R4 and R5 to limit the input current to 15 mA.

The Competition version of the circuit contains less than 30 components. For my own use, I made a version which is slightly more complex: it has four inputs and a watchdog. The fourth input is connected to the ignition transformer. These additions bring the number of parts to 38, which is more than allowed by the Competition rules.

SIMPLE STEPPER MOTOR CONTROLLER

The main feature of the circuit is that it is very easy to construct. In addition, it has a very low price and is based on easily obtainable components. Suitable motors can be salvaged, for example, from old 5.25" floppy disk drives. The other components in my project may be found in just about any junk box. By contrast, special controller chips are often not so easy to obtain or are pretty costly.

Design by Sami Karhulahti

So this simple controller is the answer to this problem. The prototype circuit was used to control a small mirror attached to a motor spindle in a light effect unit.

The heart of the stepper motor controller is a GAL 16V8 chip, which contains the 8-state counter and combinational logic required to control the driver transistors. A timer chip (555) is required only to generate clock pulses and is not required if the controller is connected, for example, to a computer's I/O port. This is why the circuit can be adapted to many purposes where simple and cheap stepper motor controllers are needed.

The stepping speed can be adjusted by means of potentiometer P1 and changing the value of C1, while the direction of rotation or full/half step mode can be selected by small DIP switches S1 and S2. When S3 (ENA) is set to low, every output 05-08 goes low so that the driver transistors all switch to their off state. The internal state counter can also be reset by pulling up the RES line with switch S4. In full-step mode, the motor torque is about 2 times higher than in half-step mode, though in the half-step mode the step resolution is two times better.

The step sequence can be reversed by setting the DIR-input high.

The binary output table

Fig. 1. Circuit diagram of the simple stepper motor controller.

Conclusion

Although the application of the circuit is neither dedicated nor restricted, the monitor is relatively inexpensive, based on easily found components, and easy to build. (950308)
The circuit may be powered from a suitable 7-24 volt mains adaptor. Because the controller itself draws negligible current, the current consumption of the whole circuit depends mainly on the motor type selected.

**COMPONENTS LIST**

- **Resistors:**
  - R2 = 1kΩ 0.25W
  - R3-6 = 470Ω 0.25W
  - R7-10 = 1kΩ 0.25W

- **Capacitors:**
  - C1, C3 = 10μF 10V electrolytic cap.
  - C2 = 1μF 50V electrolytic cap.

- **Semiconductors:**
  - IC1 = GAL16V8, programmed (step2.jed)
  - IC2 = CA555
  - IC3 = 7805
  - Q1-4 = BC337
  - PT4 = 1N4007

- **Miscellaneous:**
  - S1-4 = 4-way DIP switch block
  - M = unipolar stepper motor 7-24V

*Programming files for this project available on disk, see page 70.*

---

### RES = L, ENA = H, DIR = L

is given in a separate box.

---

**ELEKTOR ELECTRONICS JANUARY 1996**
It is generally known that young children soon develop a habit of watching TV far too long. Although most parents would like to see them reading books or playing quietly, youngsters will spend hours on end in front of the telly if nothing is done about it.

Design by Robert Lacoste

The simple circuit presented here provides an original solution to the above educational problem. It allows you to 'give' a certain amount of TV viewing time to each youngster, who is free, in principle, to use up this time as he or she sees fit. After a short learning phase, you will notice (hopefully) that the children are developing much more intelligent viewing habits. Of course, the Telly-Guard may be used for any other application where electronic time allotment is required.

The principle
Each little rascal has a personal 'key' which 'contains' a certain number of time units. To be able to use the TV set, all he or she has to do is insert the key in a special reader, which then switches on the TV. The remaining time is indicated by an LED scale. When the end of the scale is reached, the time is up, and the TV is switched off without warning. You, the responsible parent, have a 'master key' which enables the user keys to be 'charged' with a certain number of time units. This master key also allows the rightful owner to watch as much TV as he/she likes!

Circuit description
The circuit diagram is very simple indeed, and based on an inexpensive microcontroller, the Motorola MC68705P3. The entire circuit contains only 30 components, including the reader/controller and one key.

A clean 5-V supply voltage is supplied by a voltage regulator consisting of T1, D1 and U1. The TV is switched on and off via a relay, K1, which is controlled via transistor T2. The use of a relay ensures a complete electrical isolation of the circuit from the mains.

The unit is operated by three push-buttons, SW1, SW2 and SW3. Four jumpers, JP1-JP4, allow different modes of operation to be selected, depending on how you would like the unit to function (see below under 'Practical use'). The 'remaining time' indicator is formed by an array of ten LEDs (D4). Don't worry, the meaning of the LED bar is easily learned and understood by children.

The unit has two more LEDs. D5 indicates the on/off status of the TV set.
while D3 lights when a key is inserted into the reader. In order to limit the number of input/output lines used for the LEDs, they are multiplexed under software control.

To limit the cost of the project, each key contains just one 'classic' EEPROM, a 93C06 256x16 bit type, and two passive parts.

**Construction**

The printed circuit board designed for the Telly-Guard is single-sided and has only one wire link. It consists of two sections, which should be fitted at an angle of 90°. The larger sub-board holds the main circuit and a hidden button, SW3. The smaller board contains front-panel elements SW1, SW2 and the LEDs. The construction with the two sub-boards allows the circuit to be fitted into a case with almost no wiring.

Start by fitting the wire link, the IC sockets, and then all other parts. Then connect the two boards via a few pieces of solid wire. Use a few drops of glue or epoxy potting compound to fix the boards in the case.

The construction of the personal keys requires some dexterity. The components that make up a key (U3, R1, C6) are soldered 'in the air' inside a 5-way DIN plug. Although this construction

---

**COMPONENTS LIST**

- **Resistors:**
  - R1, R2, R3 = 10kΩ
  - R4 = 8-way DIL resistor array, 220Ω
  - R5 = 8-way SIL resistor array, 47kΩ
  - R6 = 1kΩ

- **Capacitors:**
  - C1 = 220µF 16V
  - C2 = 100µF 10V
  - C3 = 10µF 10V
  - C4 = 1µF 10V
  - C5 = 27pF
  - C6 = 6µF, 10V (tantalum)

- **Semiconductors:**
  - T1, T2 = 2N2907
  - T3 = 6N170
  - D1 = bridge 1A 50V
  - D2 = 1N4002
  - D3 = LED 5mm orange
  - D4 = 10-LED bar, red
  - D5 = LED, 5mm, green
  - U1 = LM7805
  - U2 = 6870SP (programmed)*
  - U3 = NM93C06

- **Miscellaneous:**
  - TR1 = mains transformer 9V 5VA
  - X1 = quartz crystal 4MHz.
  - K1 = relay 9V 5A, 1 make contact, 350-V rated.
  - SW1, SW2, SW3 = PCB mount push button.
  - F1 = fuse 5 A.
  - P1 = 5-way DIN socket, 45°, PCB mount.
  - P2 = 5-way DIN socket, 45°.
  - JP1-JP4 = 2.54mm pitch jumper.

* Programming files for this project available on disk, see page 70.
is not difficult, it does require accuracy and a little patience. Pay attention to proper isolation between the parts and the metal screening of the plug (which is connected to +5 V).

As with all mains-powered circuits, precautions should be taken to ensure electrical safety. In particular, the circuit must be earthed, so that it remains safe if the transformer or the relay breaks down. This precaution should always be observed, unless you are dealing with a double-insulated device, which is difficult to produce by a hobbyist. Here, the earthing is achieved by connecting the +5 V line to the earth pin of the mains plug. Although the mains voltage is only present at some points at the mains voltage is only present at some points at the mains, you should always pull the mains plug before doing any work on the circuit.

Practical use

Fix jumpers JP1, JP2 and JP3 before you switch on the circuit. These jumpers set the length of a time unit. The total number of time units which can be charged is ten. The available options are shown in a separate box.

Jumper JP4, if fitted, gives a 'magnifying' effect during the last time unit. When the available time has dropped to one tenth of the total time, the LED scale is 'magnified' by ten and the display starts to flash. This function is disabled when JP4 is not fitted. Your choice!

The circuit is adjustment-free. After taking it up for the first time, you should start by making the 'master key'. This done by inserting a blank key and then pressing the 'hidden' push-button, SW3. A user key is made as follows: insert a blank key, press SW3, and then SW1 (down). This produces a fully charged user key. If you leave this key inserted in the reader, the system starts to count down the time units until the load is switched off.

To charge a user key, first insert the master key (D3 lights), remove it, and then the user key. Next, adjust the number of push-buttons SW1 and SW2. Other keys are charged in the same way. The reader switches to normal mode automatically if there is no push-button activity within 10 seconds.

Although the construction and use of the Telly-Guard is explained for the benefit of most of you, getting children to accept the principle of limited TV viewing time may present some fierce problems initially.

Note: the software mentioned on this floppy disk is available on page 70.
This design answers the widespread interest in applications involving smartcards. Chip-type telephone cards and credit cards catch the fancy of many. Those of you thinking of fraud at this point need not read any further, because that is not possible with this design. The circuit is, however, suitable for many other interesting applications, so don't throw away those expired telephone cards!

Design by P.H. Baars

One application of the smartcard reader could be access protection to a program you have written yourself. This means that any user has to insert an authorized smartcard before he or she is allowed to use the program. Similarly, access checking and logging is within easy reach. Only a handful of parts are needed for experiments at home. The present design allows, for instance, telephone chipcards to be read. The information read from such cards consists of the serial number, production date/month, and the remaining value.

The circuit diagram is so simple that a description is really superfluous. An external power supply is not needed because the supply voltage is stolen from the parallel port. Diodes D1 through D4 serve to prevent short-circuits between the databits. Databit 0 controls the green LED, databit 1 the red LED, and the yellow LED is connected to the power supply. The other databits are connected directly to the smartcard. The voltage is stabilized to some extent by electrolytic capacitor C1.

The smartcard connections Clock and Reset are inputs, while Data is an output. The smartcard reader unit has a small internal switch which checks if a card is inserted. This switch is also connected to the Centronics port.

Having built the small board, you may check if it works with the aid of the test program (test.exe). If this test is passed, try 'cardtest.exe', which reads and decodes the ATR string.
The program is relatively simple. There are various routines for the basic functions (LED on/off, clock high/low, etc.). The main program first checks if a card is inserted ('switch'). If so, data are read using the ATR (see Ref. 1) and checked. If this information is okay, it is converted into legible text.

The routine 'my_card' contains the registration number of one of my own telephone cards. The number may be replaced with your own number. The green LED will light when this number matches that on the card. If the numbers are different, the red LED lights.

The program is only intended as a starting point for further experiments. You can make it as intelligent and attractive as you like.

(960310)

COMPONENTS LIST:
R1, R2, R3 = 1kΩ 5%
D1-D4 = 1N4148
C1 = 10μF 16V radial
LED1 = 3mm dia., yellow
LED2 = 3mm dia., red
LED3 = 3mm dia., green
Con1 = Centronics socket, PCB mount, angled pins.

Note: the software mentioned in this article is available on floppy disk, see page 70.

Reference:
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There is a plethora of component testers on the market. Most of these are far too expensive for the average hobbyist or small business. The cost of the present tester is low enough to present no problems to a small budget. It does, however, require an oscilloscope.

Components may be divided into passive and active types. Active ones comprise, for instance, transistors, diodes, opamps. Resistors, capacitors, and inductors, to name but a few, are passive types. The tester is particularly suitable for testing passive components. As far as diodes and transistors are concerned, it can check the p-n junction; for more detailed tests, special test gear is needed.

The technology used is simple: a sinusoidal voltage is applied to the component to be tested (c.o.t.) and the consequent current flowing through the c.o.t. is measured. The applied voltage and resulting current are applied to the x-y terminals of an oscilloscope (voltage to x, current to y), which gives a good indication of the state of the c.o.t. In ideal resistors, voltage and current are in phase; in ideal capacitors and inductors, they are shifted 90° with respect to one another. The more the c.o.t. differs from the ideal, the more the phase relationship between voltage and current will differ from the ideal values.

**Circuit description**

The block diagram of the tester is shown in Fig. 1. The test voltage, provided by a discrete sine wave generator, is buffered by an amplifier and then applied to the c.o.t. via test resistor Rm. The voltage drop across the c.o.t. is buffered by a second stage, after which it is applied to the x-input of the oscilloscope.

When testing electronic components, it is not always necessary to gather detailed data on all the properties of a component. Often, gleaning a few facts yields enough information. The tester described quickly gives the user a good idea of various properties of a component on the screen of an oscilloscope.

From an idea by R. Veltkamp
The output potential of IC₂ is applied to the non-inverting input of op amp IC₃b, while the output signal of IC₃a (which corresponds to the voltage at the other terminal of the selected resistor) is applied to the inverting input.

The power supply for the tester is straightforward. The voltages at the secondaries of the mains transformer are converted into a symmetrical direct voltage of ±20 V. Regulators IC₄ and IC₅ provide a stable direct voltage of ±15 V. "Mains on" is indicated by D₁₀.

Construction

The tester can be built quickly and without undue difficulties on the printed-circuit board in Fig. 3. Before any assembly work is done, however, the power supply section must be cut off the mother board.

With component values as specified, IC₄ and IC₅ do not need a heat sink, but IC₂ does.

Set the required number of positions of S₂ (6) and S₃ (4) with the stop ring provided with these switches before fitting the switches on to the board.

When the board has been finished, check all soldering carefully and make sure that there are no short-circuits on the tracks. For the time being, set P₁ to the centre of its travel.

A possible front panel layout is shown in Fig. 4.

Fit the mother board behind the front panel with the aid of four 50 mm long M₃ screws, nuts and washers, and 40 mm long spacers. This gives sufficient space to fit the on/off switch. Mount the BNC sockets for the x- and y-outputs at the back of the enclosure. Fit the spring-loaded terminals for connecting the e.o.t. at the front panel. It is advisable to use a mains entry with integral fuse holder.

Calibration

Connect an oscilloscope to K₁, set switch S₂ to position 10 V and adjust P₁ to obtain an output of 10 V (peak) on the scope. The tester is then ready for operational use.

Parts list

Resistors:
R₁, R₆ = 715 Ω, 1%
R₂, R₇ = 7.15 kΩ, 1%
R₃, R₄ = 71.5 kΩ, 1%
R₅

Capacitors:
C₁, C₄

Diodes:
D₁, D₂, D₃, D₄

Transistors:
T₁, T₂

Integrated circuits:
IC₁ = TL081
IC₂ = TL082
IC₃ - TL082
IC₄ = 7815
IC₅ = 7815

Other components:
R₁₀, R₁₁, R₁₂, R₁₃
C₁₀, C₁₁, C₁₂, C₁₃
D₁₀, D₁₁
IC₆ - 1N4148
IC₇ - 1N4148
IC₈ - 1N4148
IC₉ - 1N4148

Fig. 2. The circuit uses easily obtainable components.
### Component Tester

**Fig. 3.** Printed-circuit board for the passive-component tester.

**Fig. 4.** Suggested front panel for the passive-component tester.

#### Resistors:
- R1, R5 = 715 kΩ, 1%
- R9 = 4.22 kΩ, 1%
- R10, R21-R31 = 10.0 kΩ, 1%
- R11 = 10 kΩ
- R12, R13 = 1 MΩ
- R14 = 4.02 kΩ, 1%
- R15 = 8.06 kΩ, 1%
- R16 = 20.0 kΩ, 1%
- R17 = 40.2 kΩ, 1%
- R18 = 80.6 kΩ, 1%
- R19 = 200 kΩ, 1%
- R20 = 1 kΩ
- R21 = 8.2 kΩ
- R22 = 100 kΩ, 1%
- R26, R27, R29 = 100 kΩ
- R33 = 3.3 kΩ
- P1 = 25 kΩ preset

#### Capacitors:
- C1, C4 = 22 nF, 5%, metallized polypropylene
- C2, C3, C9-C12, C15, C16 = 100 nF, high-stability
- C5 = 1 µF, metallized polypropylene
- C6 = 100 nF, metallized polypropylene
- C7 = 10 nF, metallized polypropylene
- C8 = 1 nF, metallized polypropylene
- C13, C14, C17, C18 = 1000 µF, 25 V, radial

#### Semiconductors:
- D1-D5 = 1N4148
- D6-D8 = 1N4001
- D10 = LED, red, high efficiency
- T1 = BF256A

#### Integrated Circuits:
- IC1 = TL081
- IC2 = L165V
- IC3 = TL082
- IC4 = 7815
- IC5 = 7915

#### Miscellaneous:
- K1, K2 = BNC socket
- K3 = 2-way terminal strip, pitch 7.5 mm
- S1 = rotary switch, 3-pole, 4-position
- S2, S3 = rotary switch, 1-pole, 12-position (see text)
- S4 = mains on/off switch
- T1 = mains transformer, two second...
Measuring with Lissajous figures

The measurement technology used depends on Lissajous figures. These are plane curves formed by the composition of two sinusoidal waveforms in perpendicular directions, that is, they form a coordinate x-y system. In such a system, the displacement of a point is determined by the vector sum of the x and y values.

Figure A1 shows how such a figure is obtained. Here, P is the pixel projected on to the screen of an oscilloscope by the electron beam; M1 is the vertical (y) deflection and M2 is the horizontal (x) deflection.

In the component tester, the frequencies at which the vector rotates in the circles are identical, since they are derived from the same signal. The diameter of the circles is a measure of the peak levels of the signals.

In Fig. A1 it is assumed that the phases of the two signals are identical, which is the case when the component on test is a pure resistance. The resultant of the two functions is a diagonal line. Since the voltage is represented by the x-axis and the current by the y-axis, the value of the resistance is calculated by summing the x- and y-values.

When the test signal is applied to a pure capacitance or pure inductance, there is a phase shift of 90°. The sinusoidal voltage is coordinated with a sinusoidal current that is +90° out of phase w.r.t. the voltage in the case of a pure inductance and -90° in case of a pure capacitance. In these cases, the cartesian equations are:

\[ x = a \sin (\omega t) \]
\[ y = b \cos (\omega t) \]

The resultant is:

\[ x^2 + y^2 = R^2. \]

Since

\[ \sin^2 (\omega t) + \cos^2 (\omega t) = 1, \]

this may be written as:

\[ (a \sin (\omega t))^2/a^2 + (b \cos (\omega t))^2/b^2 = 1, \]

from which may be derived:

\[ x^2/a^2 + y^2/b^2 = 1. \]

This corresponds to an ellipse. When \( a = b \), that is, when the impedance is a pure reactance, the ellipse becomes a circle.

The ellipse is composed of:

\[ x (\omega t) = U_1 \sin (\omega t) \]
and
\[ y (\omega t) = U_2 \sin (\omega t + \phi), \]

where \( \phi \) is the phase shift, whose value is determined by

\[ \sin^{-1} (U_{\text{max}}/U_{\text{max}}), \]

where \( U_{\text{max}} \) is the intersection of the ellipse with the y-axis.

Figure A2 shows an example of an ellipse and indicates at which two points the measured values are found. Impedance \( Z \) of the c.o.t. is determined simply by dividing the peak values of the two voltages (y into x) that are applied to the oscilloscope:

\[ Z = U_1/U_2 \]

where \( S \) is the transfer factor of the current sensor in A/V.

Both the reactance and resistance can be derived from the impedance. For instance, in case of a series network of a resistor and a non-ideal inductance:

\[ R_s = \frac{Z \cos \phi}{S} \]

and

\[ X_s = \frac{Z \sin \phi}{S}. \]

In case of a parallel network of a resistor and a non-ideal capacitor:

\[ R = \frac{Z \cos \phi}{S} \]

and

\[ X = \frac{Z \sin \phi}{S}. \]

The value of the inductor or capacitor is calculated from the computed value of the reactance:

\[ C = \frac{1}{2\pi f X} \]

and

\[ L = \frac{X}{2\pi f}. \]

To determine whether the c.o.t. is a capacitance or an inductance, the oscilloscope must be set to the time base position. If \( U_2 \) lags \( U_1 \), the c.o.t. is a capacitor; if it leads, the c.o.t. is an inductor.

daries. 15 V, 4.5 VA each (for instance, Velleman 215005OM from Maplin)

F1 = fuseholder (preferably integral in mains entry) with 50 mA slow fuse
1 off heat sink for IC2, 20 K W-1, for instance, Fischer FK222/SA-220
Figures talk ...

In this box, a number of measurement results on standard components are given. The curves on your oscilloscope should be roughly in accord with the figures shown here. Note, however, that their shape depends on the oscilloscope settings.

Figure B1 pertains to a 10 nF capacitor. The settings were: \( f = 10 \text{ kHz} \); \( U = 10 \text{ V} \); \( i = 1 \text{ mA} \text{ V}^{-1} \).

Figure B2 refers to a 2.2 mH inductor. The settings were: \( f = 1 \text{ kHz} \); \( U = 5 \text{ V} \); \( i = 20 \text{ mA} \text{ V}^{-1} \). The measurement shows that the inductor has a series resistance of about 32 \( \Omega \), resulting in a phase shift of around 22°.

Figure B3 relates to a 4.0 kΩ resistor. Settings were \( f = 1 \text{ kHz} \); \( U = 10 \text{ V} \); \( i = 1 \text{ mA} \text{ V}^{-1} \).

Figure B4 pertains to a 1N4148 diode. The settings were: \( f = 1 \text{ kHz} \); \( U = 10 \text{ V} \); \( i = 20 \text{ mA} \text{ V}^{-1} \).

Figure B5 refers to a zener diode (8.2 V, 500 mW). The settings were: \( f = 1 \text{ kHz} \); \( U = 10 \text{ V} \); \( i = 0.0 \text{ mA} \text{ V}^{-1} \).

Fig. 5. The finished prototype board of the passive-component tester.
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In addition to dynamic nets force vectors and density histograms, ULTIboard's Direct Recconnect instantly displays the shortest possible connections. Automatic Gate- & Pin Swap with full Backannotation guarantee the best. ULTIboard understands the different soldering techniques that apply to SMT. Flip your SMD to the other side of the board and ULTIboard automatically applies the pad definitions for either wave or reflow soldering.

The ULTIroute GXR Ripup & Retry Autorouter is able to remove connections that cause a block and automatically reroutes the removed connections. The user can define the Autorouter parameters.

ULTIboard's acknowledged powerful interactive features, Reroute-While-Move and Trace-shoving under REAL-TIME DRC guarantee flawless designs in the shortest time. But for non critical traces you can use our second Autorouter which blends in with your manually routed traces to allow you to route per net, component or window.

From concept to artwork in 1 day
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