# Ipso Facto

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A PUBLICATION OF THE ASSOCIATION OF THE COMPUTER-CHIP EXPERIMENTERS (ACE) 1981



No Man is fit to be entrusted with control of the "Present", who is ignorant of the "Past", and no People who are indifferent to their "Past" need Hope to Make Their "Future" Great.

Ancient "Inuit" saying

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Results of ELECTION OF OFFICERS for ACE INC. which was held at the April 8th, 1986 Meeting at Room 123, Sheridan College.

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THE SUBJECT WHO IS TRULY LOYAL TO THE CHIEF MAGISTRATE WILL NEITHER ADVISE NOR SUBMIT TO ARBITRARY MEASURES -- JUNIUS.

## EDITORIAL

This is the last issue of the 1985-86 year#. The "Mail Box" is empty, indicating your interest.

When sufficient material becomes available we will produce further IPSOS. We have real "Bargoons" on boards etc - see the Club Communique.

With the unbelievable advancement of technology in the last six months and finally, an inkling on the Horizon of a Universal computer language - perhaps it is time to reflect on just where we are going and what is actually happening around us.

Publication delays have been caused by

a) lack of material

b) editorial staffing, which was beyond our control

May the "FORCE" be with you.

John B. Morris

President

(VE3FOR)

# ISSUE NO. 6 OF 1985-1986 YEAR.

CONTRA MUNDRUM

## SONAR

- Michael B. Smith, 1 Cranleigh Crt, Islington, Ontario, M9A 3Y2

In old movies and science fiction stories, a robot was traditionally an evil power crazy machine bent on spreading chaos throughout our planet. In reality, however, robots simply follow a program, simple or complex, and make its decisions based on its observations of the world about it. Thus, when a team of three robot enthusiasts got together last September and decided to dwell into the field of robotics, our primary problem was exactly this - how does a robot go about "seeing" the world around it?

Many ideas were brought forth after our initial discussions; ranging from the ideas of mechanical feelers (short range and clumsy), UV light beams (short range, dependent on ambient light conditions, only could detect presence of object, not range) to sonar (long range, independent on environment). This last idea was the one we finally agreed to explore. However, with all its apparent advantages over the other ideas, it did have one major disadvantage - it was the most complex to implement.

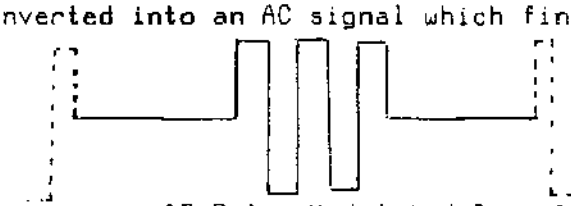
### BASIC THEORY

Sonar is actually an application of the every day phenomena called an echo. A sound wave, emitted from a transducer (vocal cords, or speaker), is transmitted through the air until it hits an object. At this point some of the wave is reflected back to the source. This reflected sound wave is then detected by another transducer (ear, or microphone) and the "echo" is heard. Due to the fact that sound travels relatively slow in air, the time required for the wave to be emitted and then for the echo to be "heard" is not very difficult to determine with some simple electronics. Then, knowing the speed of sound in air (343 m/s) one can determine the distance to the object by multiplying the time (in seconds) for the echo to arrive by the speed and then dividing the answer by two (the wave travelled twice the required distance, to the object and then back). This will yield the actual distance from the source to object in meters.

### BASIC IMPLEMENTATION

To produce the source for the sonar, two clocks were used. One clock was chosen to be a 555 timer producing a frequency from one to two hertz. The actual frequency does not matter, as long as it is very low. This signal is called the pulse frequency. The pulse frequency governs how often the sonar sends a signal at the object (or equivalently shouts at the cliff). This frequency has to be very low to allow one signal to die out before the next one is sent. The actual frequency that the sonar sends out at the object is called the modulation frequency. The actual frequency that one uses is entirely based on the type of transducers that are available to you. In our design we used a 32768 Hz crystal (standard time base frequency) because the transducers which we used had a peak efficiency at this frequency and because this frequency is inaudible to the human ear. This 32768 Hz signal was modulated onto the 555's signal using a 4016 bilateral switch. Then using a series of inverters, the pulse modulated signal was converted into an AC signal which finally went to the transducers.

Pulse Modulated Signal



AC Pulse Modulated Signal

Concurrently with the transmission of the leading edge of the sonar pulses, many other things occur throughout the circuitry. This leading edge is a universal reset for essentially all the sub-systems. The counter circuitry (to measure the time required to "hear the echo") and the noise lock-out circuitry (more on this later) are reset. At the trailing edge of the sonar pulses the counter starts counting at the rate of the modulation frequency (32768 Hz). This however is not mandatory, any frequency can be used - this was used just to eliminate a third crystal or a clock divider circuit. At this time, the detection circuit starts to "listen". During the reset period, any incoming signals are ignored by part of the lock-out circuitry. However, once the reset is over, the circuitry waits to "hear" the first received pulse (the leading edge of the echo). The lock-out circuitry also ignores this pulse, but it does send the second pulse further on. This first pulse is ignored due to the fact that there was some inherent switching noise in our first design, and no detection was possible because the first pulse was always a garbage pulse. This second pulse then goes to the 1852 I/O port and acts like a clock pulse. The 1852 latches the count from the 4024 timer into its internal latch and proceeds to inform the host computer that data is available. It is important to note that the 4024 timer is free running - it is continually counting (except during reset) and at the critical moment, data is trapped from it. The number stored in the 1852 is then directly related to time for the echo to be received. Knowing the counting frequency, the actual time for the echo can then be calculated by the host computer, and thus the distance can be determined.

## THE OPERATIONAL AMPLIFIERS

Being a strictly digital person, the design of the amplifier circuitry proved to be a formidable undertaking. The design specifications for this sub-system were quite horrendous for my inexperienced knowledge. By experimenting with the transducers that we were using, we determined that at the closest possible distance between the transmitting and receiving transducers, the voltage on the receiver side was approximately 2.2 VAC. However at a distance of 10 metres, this dwindled down to about 1 mV. Thus the circuit had to be able to accept a voltage input of anywhere from 1mV to 2200 mV and boost that up to 5 V (for the digital circuitry later) without distortion or induced noise. Furthermore, the circuitry would also have to filter out any incoming signal that did not originated from the transmitter, i.e. any signal that does not have a 32768 Hz frequency. Actually though, this problem did not arise due to the nature of the transducers. Their frequency response dropped off very rapidly on both sides of the 32768 Hz peak, thus essentially any unwanted signal was already filtered out before it got to the amplifier. If the transducers that you choose to use do not have this intrinsic quality, a filter stage (either a band-pass or low-frequency rejection) will have to be added. The operational amplifiers (LM 301) were chosen because they have a good high frequency response. With the addition of the external high frequency capacitors (30 pF is close enough to the actual value required in the specifications) and the potentiometers, the amplifier section is almost complete. The tuning of the pots is probably the most difficult part of the implementation, for one has to tune the op-amps over the 1 mV to 2200 mV range without causing one stage to saturate. Finally, after the third LM 301 the signal has a voltage of about 2.5 - 3.5 VAC. Modulated onto this is about 1 VAC p.p. of noise. Thus for the final stage, a standard transistor amplifier is used. This not only boosts the the signal up to the required 5 volts, but it also gets rid of the noise (the transistor has to be setup for saturation and cutoff on the 2.5 VAC received signal to accomplish this) and changes the AC signal to a DC one. Thus the op-amp circuitry finally sends out a CLEAN, noise free, TTL level signal of the incoming wave.

LOCK-OUT CIRCUITRY

The first stage of the lock-out circuitry that the incoming signal encounters is two divide by two D-flip flops. This combination divides the incoming frequency by four, thus the first incoming pulse is not allowed to pass beyond this stage.

The second incoming pulse is then sent to set an R/S flip flop. This flip flop had been previously reset by the 555's 1 Hz pulse. Thus the flip flop is reset for the duration of the travel of the transmitted wave. The state of this flip flop is monitored by an LED (no this is not a Hollywood style computer, this light is actually useful!). When this LED is blinking, it indicates that the flip flop is being set and reset repeatedly. Thus there is an incoming signal. If the light stays on, the flip flop is staying in reset state, and thus there is no incoming signal. This could indicate that either there is a fault somewhere in the op-amp stage or the previous reset circuitry, or that the echo is too faint to be amplified up to TTL level. In either case, somehow the host computer should know that the sonar is not receiving any data. Thus if no signal is received during the time in which the system is "listening" the leading edge of the 555 is used to latch data into the 1852 instead of a sonar received pulse. At the same time as this, a high level is put onto the MSB of the 1852. Thus the host computer when it reads the 1852 will see that the MSB is high and thus realize that either the object was out of range of detection or there is a problem with the receiving circuitry. (When the computer receives good data from the sonar, the MSB is set low.)

PROBLEMS

Besides the problem of tuning the op-amp's pots, the only problem with this circuit is in the last stage of the lock-out circuitry. Because the 555 timer is not only used to clock in the fact that no data has been received and to reset the circuitry at the same time, not all set-up and hold times are met. Thus time delay chips or extraneous chips have to be added in the time delay circuitry to make up for this.

BITS AND PIECES OF A ROBOT

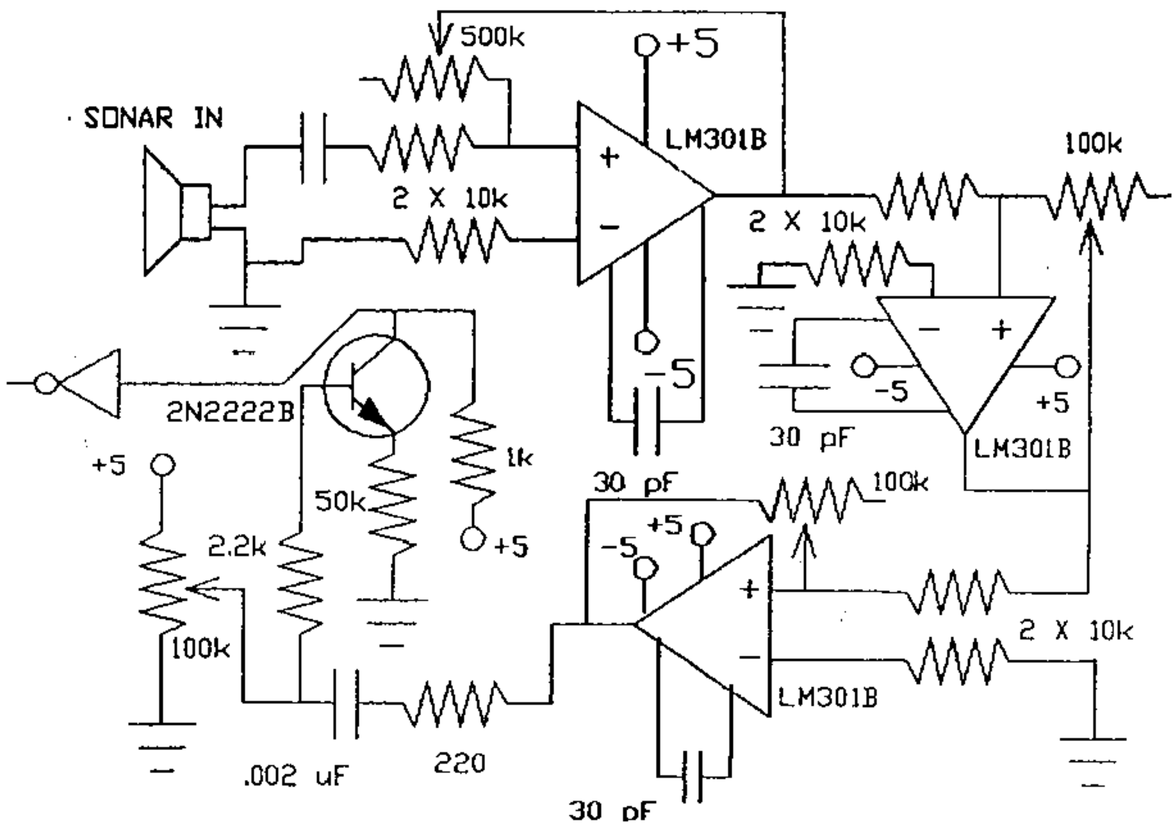
To actually make a working robot (which was the ultimate goal of our team) does not just entail creating a simple sonar range detector. Besides a basic computer to run the whole thing, lots of I/O is required. Other I/O included a 40 column LCD display, a keyboard, two stepper motors for the main drive unit, touch sensors, various internal monitoring sensors (primarily battery voltage levels and I/O status and failure), and a sonar aiming circuit.

The drive stepper motors were controlled by a digital frequency generator (with a consistent 50% duty cycle - we didn't want the motors to be jerky). In addition to this, a simple circuit was used to allow the motors to go in both directions and to distribute the stepping frequency into a four phase high current output for the motors. The sonar aiming circuit allowed the sonar to look around the robot, essentially a robotic neck. This circuit accepted an 8 bit number ~~and~~ then controlled a stepper motor to rotate to a position corresponding to the number. Thus the robot was give 360° of vision.

Designing this robot took many late nights over a cup of coffee and an oscilloscope. Though the basic theory behind the sonar, the stepper motors, and other systems is not exceedingly complex, its implementation at one o'clock in the morning is. If anyone does decide to play with a sonar system, or stepper motors, or other robotics, please let me know about your inevitable failures and the hopeful success.

THE DRAWINGS FOR THIS ARTICLE WERE DONE ON AN IBM PC XT USING AUTOCAD.

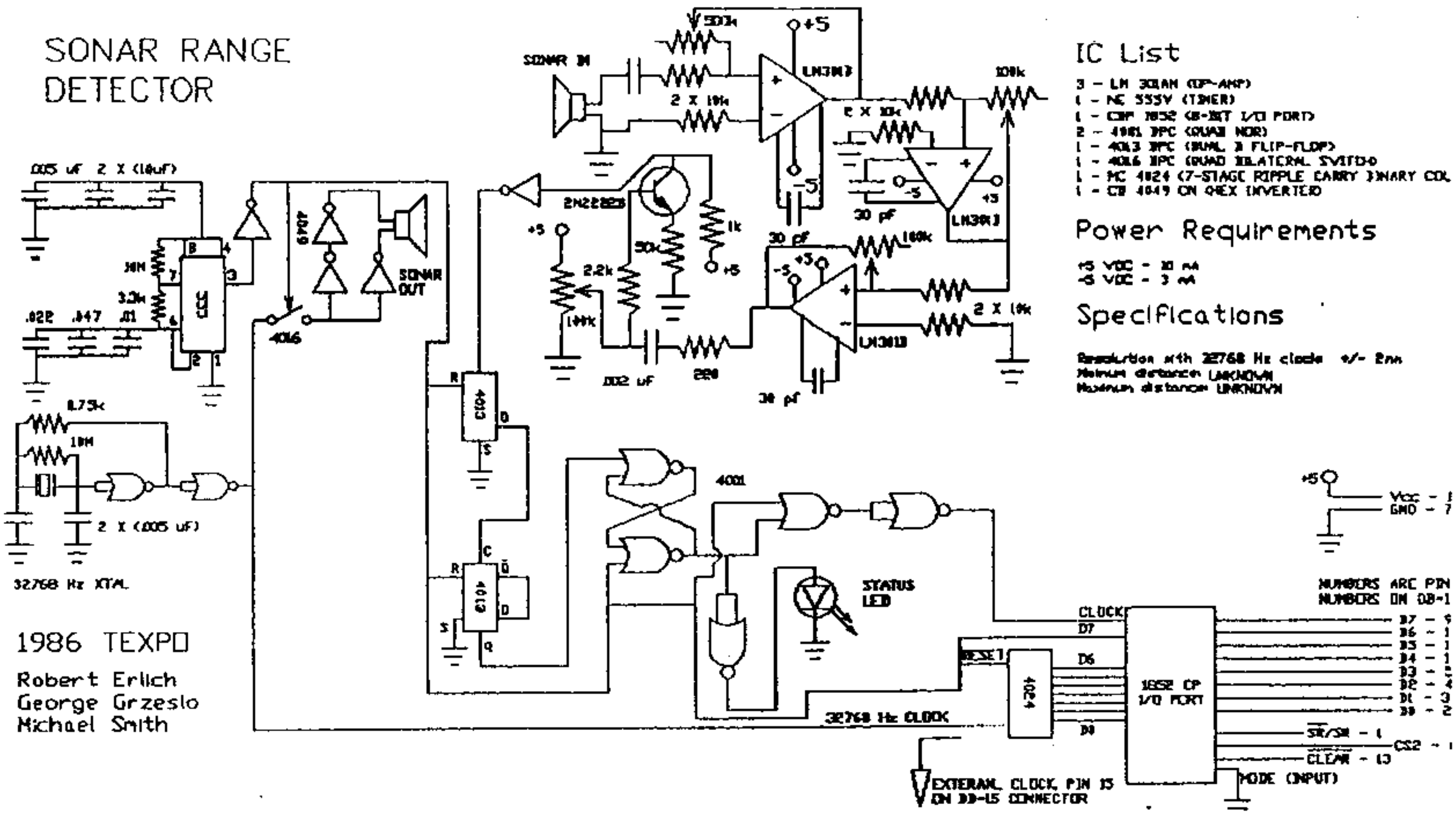
SONAR RANGE DETECTOR




986 TEXPO

ICHAEL SMITH
obert Erlich
eorge Grzeslo

# SONAR RANGE DETECTOR




## IC List

3 - LM 301AN (OP-AMP)
1 - NE 555V (TIMER)
1 - CDP 1852 (8-BIT I/O PORT)
2 - 4001 BPC (QUAD NOR)
1 - 4013 BPC (DUAL D FLIP-FLOP)
1 - 4016 BPC (QUAD BILATERAL SWITCH)
1 - MC 4024 (7-STAGE RIPPLE CARRY BINARY COU
1 - CD 4049 CN (HEX INVERTER)

## Power Requirements

+5 VDC - 10 mA
-5 VDC - 3 mA

## Specifications

Resolution with 32768 Hz clock +/- 2mm
Minimum distance UNKNOWN
Maximum distance UNKNOWN

1986 TEXPO


Robert Erlich
George Grzeslo
Michael Smith

## CLUB COMMUNIQUE

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