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TITLE

THE DEFENCE RESEARCH ESTABLISHMENT PACIFIC \(DREP/AT\) SIDE-SCAN SONAR SYSTEM INTERFACING

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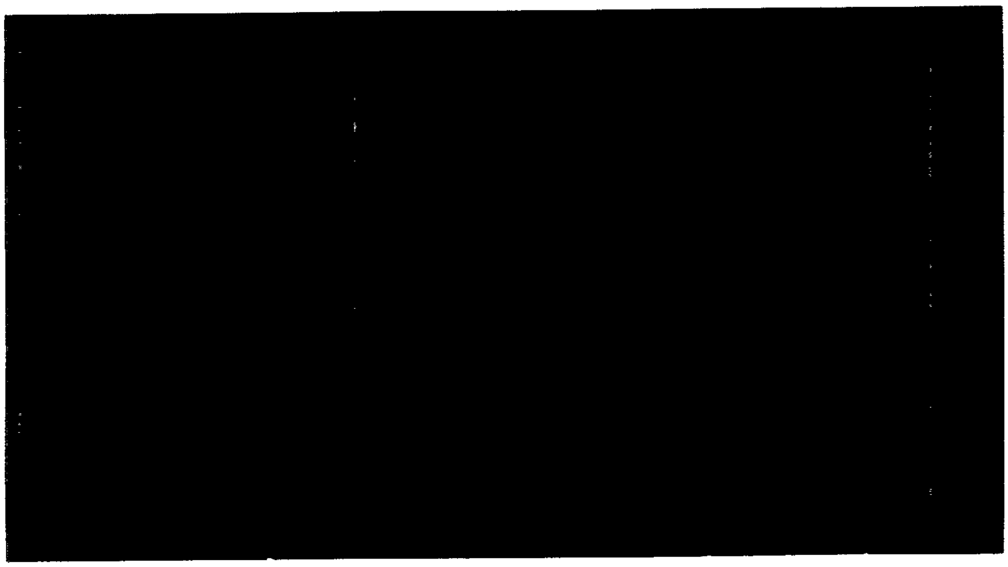

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DREP Technical Memorandum 94-155

The Defence Research Establishment Pacific (DREP/AT) Side-Scan Sonar System Interfacing

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Approved By:

Chief DREP

Research and Development Branch
Department of National Defence

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Abstract

This document describes the interfacing requirements for the Defence Research Establishment Pacific, Applied Technology Section (DREP/AT) Side-Scan Sonar system, for both the autonomous-underwater-vehicle and towed operations.

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INTRODUCTION

The DREP/AT sonar system can be viewed as a black box requiring power and producing baseband sonar signals ready for recording. It can be operated in a towed body, or in an self-powered autonomous underwater vehicle (AUV). All external connections are made through an Impulse XSM-BCR-16 connector. The only other connections are for the Klein side-scan transducer arrays through four one-pin high-voltage connectors and cables. There are various mechanical switches in the system for controlling range and signal compression, which can be adjusted manually (with the system removed from the pressure case and the covers off).

This paper describes the power requirements of the system, the signals produced, the available internal switch settings, and the physical size, weight, and mounting of the DREP/AT sonar system.

Figures 1 and 2 show reproductions of photographs of the DREP/AT sonar system electronics removed from the pressure case. Figure 3 shows the shielded transducer-array housings. Figures 4 and 5 show photographs of the exterior of the DREP/AT towed body, and the ARCS[1] vehicle respectively, and Figure 6 shows an inside view of the flooded fiberglass-section of the ARCS with the DREP/AT sonar system installed.

WARNING--HIGH VOLTAGES

Pulses of several thousand volts are transmitted from the one-pin connectors on the front of the system through the high-voltage cables to the sonar transducer arrays during normal operation. Extreme care must be taken during operation to ensure no human contact with these voltages. 750 VDC is present on the backplane during normal

[1] ARCS means Autonomous Remotely-Controlled Submersible, a specific commercial vehicle; AUV (autonomous underwater vehicle) is a generic term. UUV (unmanned underwater vehicle) is another generic term used for these vehicles.

operation, even with the transmitter trigger switched off. Care must be taken when the electronics is removed from the pressure case to ensure that no one comes near this dangerous potential. This is a prototype system and intended for use only by qualified personnel.

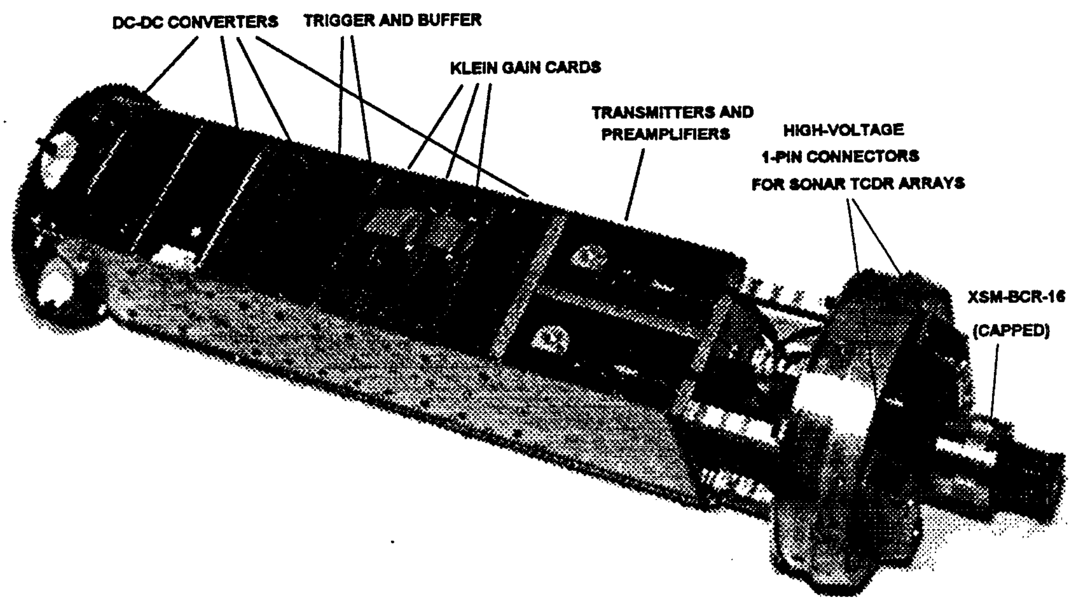

Figure 1: DREP/AT 1994 Sonar-System Chassis, Top
(covers removed)

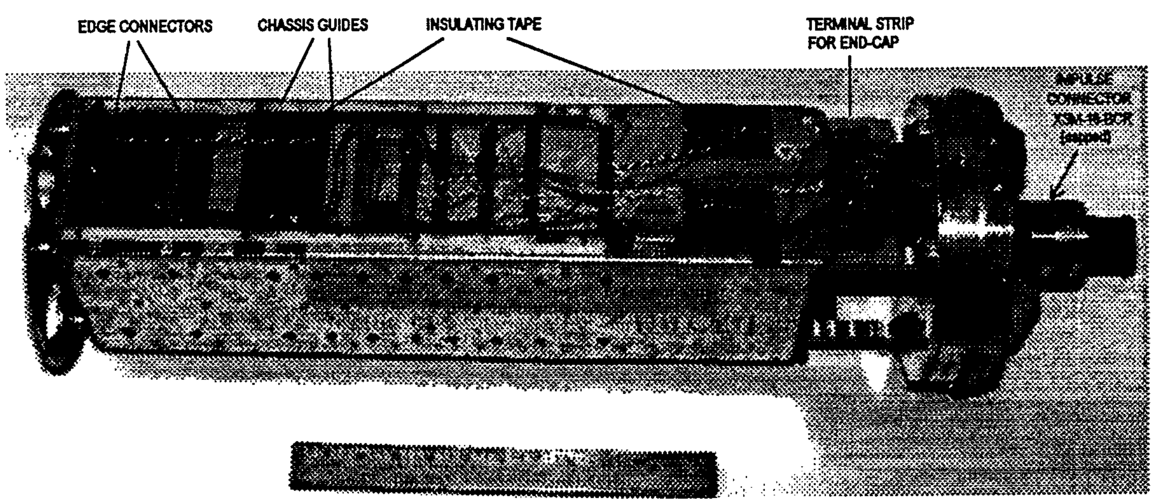

Figure 2: DREP/AT 1994 Sonar-System Chassis, Backplane

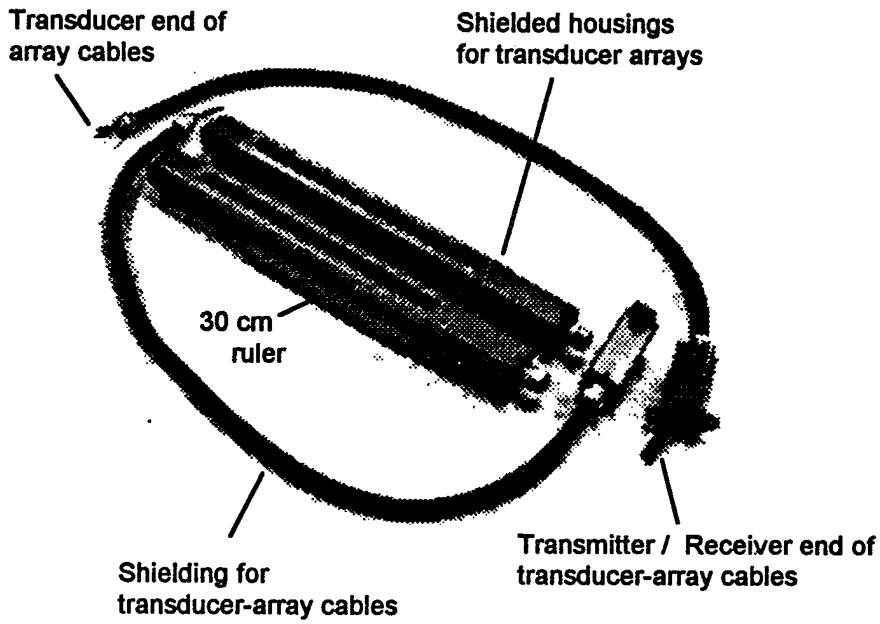

Figure 3: Shielded Transducer-Array Housings and Cables.

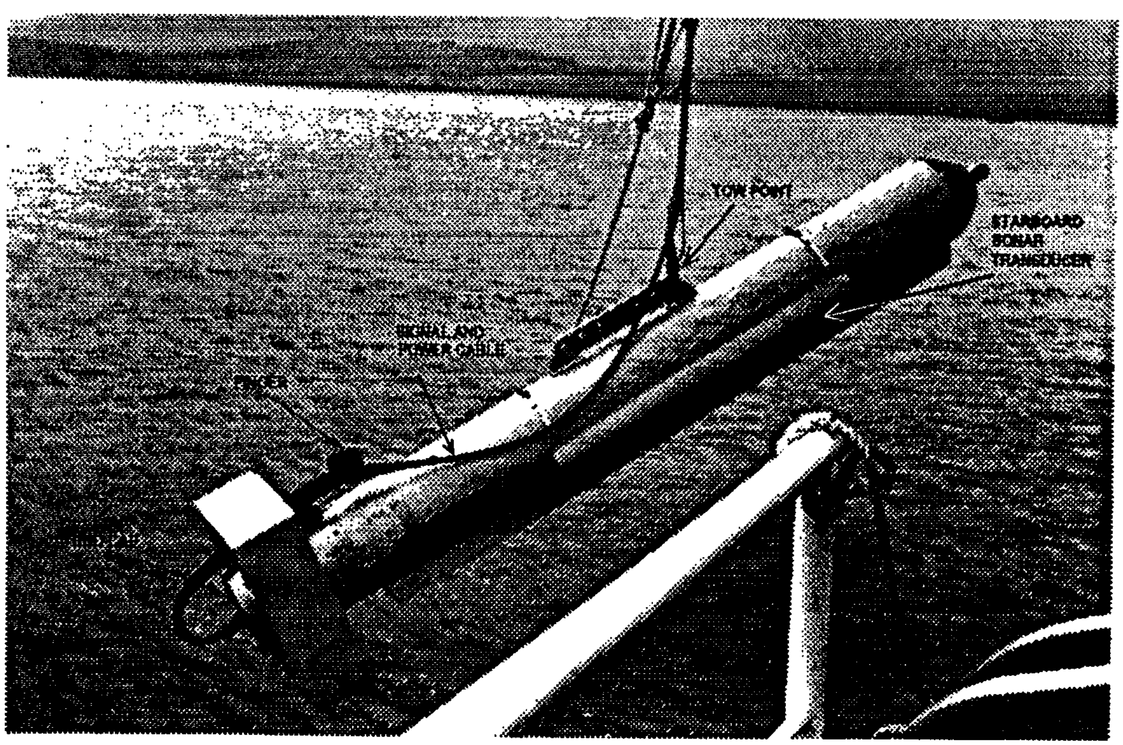

Figure 4: Exterior View of the DREP Towed Body

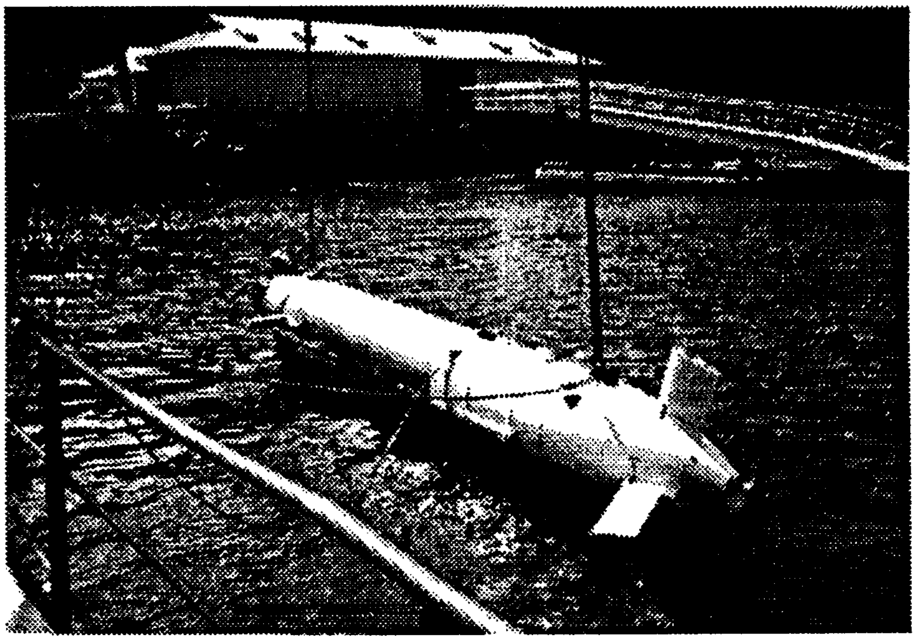

Figure 5: The ARCS

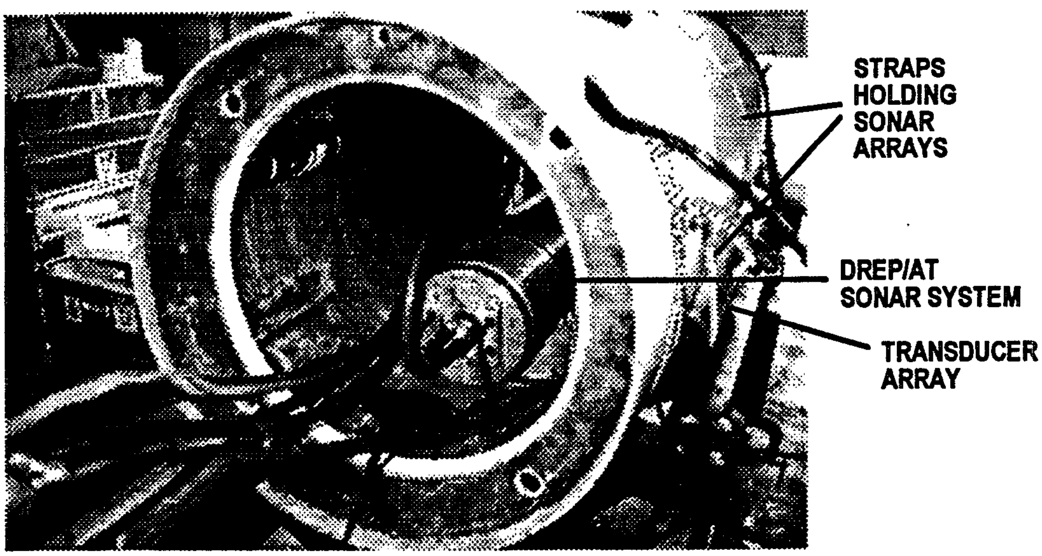

Figure 6: Installation of the DREP/AT Sonar System in the ARCS

WEIGHT AND DIMENSIONS

The pressure case for the AUV configuration is 21.6 cm outer diameter, 70.7 cm long, plus an extra 2.6 cm for the end cap. The connectors require another 15 cm, plus a large turning radius for the flexible steel tubing which is currently being used to electrically shield the sonar array cables from external noise sources. The 350 kHz electronics and pressure case weighs 31 kg in air and 4.4 kg in water.

The arrays are 48.3 cm long, 3.1 cm wide and 4 cm deep, and weigh 1.5 kg each in air and 0.9 kg each in water. The shielding for the arrays and their cables are 73 $\times$ 8 $\times$ 7 cm^3, with 155 cm cables, and weigh 4.85 kg per array in air. The volume and weight in water has not been determined. Note that the shielding for the arrays is not needed in the towed configuration.

The total weight in air of the 350 kHz system is 44 kg (100 lb.). The weight in water is about 11 kg (25 lb.).

In the towed configuration a much longer pressure case (towed body) is used. While this is heavier in air, it is mostly empty, and so is positively buoyant with a strong nose-up attitude in water. (The electronics goes into the tail end, as shown in Figure 4.) Both weights and floatation material must be used to balance the system. The total weights in air and water have not been calculated.

POWER

In the towed configuration the system requires an external 300 VDC supply (100 mA) (to minimize power loss with long towcables). This voltage is converted internally to 28 VDC using the board shown in Figure 7 in the last slot in the DREP/AT sonar system. In the AUV configuration the system requires a 28 VDC (1 A) external supply and the 300 volt converter board is replaced with a jumper circuit board (not shown) that shorts the input-power lines to the 28VDC lines.

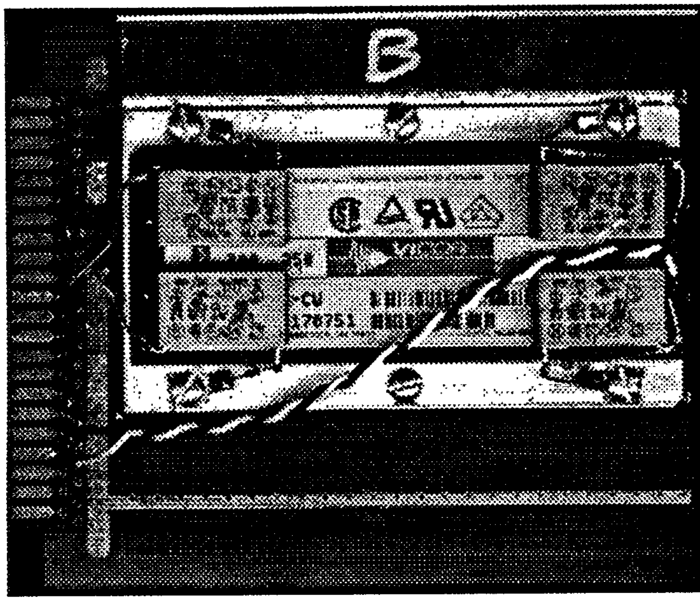

Figure 7: 300 VDC to 28 VDC Power Converter Card

SHIELDING

Extensive shielding has been added because the autonomous vehicle which was to be the platform from which this sonar system would be tested, the ARCS, is extremely electromagnetically noisy. The DREP/AT sonar has steel shielding around each power supply and every electronic card, and around the transducers and their cables.

Attention has been given, also, to the mounting of the transducer arrays, which are extremely sensitive to vibration. Rubber mounts are placed inside the shielded housings to absorb vibration energy.

TRANSDUCER MOUNTING

The Klein beam-compensation software expects the transducer arrays to be mounted to point at an angle of 15 degrees below horizontal. The arrays pick up considerable energy from the first return from the ocean surface at this angle, but changing the angle adversely affects the compensation for beam-strength variations which is applied by the software.

The shielding for the transducer arrays is not needed in the towed configuration; it is required only if the arrays are near strong sources of electromagnetic radiation, such as unshielded switching power supplies. The shielded housings are designed to be strapped easily onto the outside of the hull using standard aircraft cargo tie-downs. For the towed configuration there are cylindrical housings made to hold the transducers and strap onto a cylindrical towed body with band clamps.

CONNECTOR WIRING

The main connector on the front of the system is a 16-pin Impulse XSM-BCR-16 bulkhead connector. The mating (cable) Impulse connector is 'XSM-CCP-16 with locking sleeve.' DREP has a cable with the XSM-CCP-16 connector on the water-proof end (the end which connects to the DREP/AT sonar system), an ISE (International Submarine Engineering) 1-inch penetrator (for penetrating a pressure hull), and on the dry end of the cable, a $10 \times 12 \times 9$ cm^3 break-out box with coaxial connections for the signal lines and a terminal strip for power input, and both for trigger input or output. The dry end is 3 meters long, and the wet end is 1.5 meters long. A second underwater cable of the same type, 1.9 meters long, with an XSM-CCP-16 connector on one end, and an Impulse VMK-8-FSFIB connector with a K-FLS-P locking ring on the other, is also available. The mating 8-pin bulkhead connector is Impulse VSK-8-BCL. There is a third cable, also of the same type, 32 meters (100 feet) long. This cable is terminated with a 14-pin Cannon connector that connects to a rack-mountable break-out box. The break-out box has BNC connectors and banana jacks for signal and power connection to the cable. Table 1 shows the cable wiring and the wiring of the 16-pin bulkhead connector on the DREP/AT sonar system. The pin configuration of the cable connector is shown in Figure 8.

Table 1: Main Connector Wiring

XSM-16 PIN	ARMOURED CABLE	CABLE-BREAK-OUT-BOX NAME	USE	VMK-8-FSFIB pin
1	Black coax center	TRIGGERS	trigger	3
2	Black coax shield		trigger return	none
3	Blue coax center	COMMAND DN		
4	Blue coax shield			
5	Green coax center	DATA UP	Port sonar signal	7
6	Green coax shield		Port ss return	6
7	White coax center	972 LINK	Stbd sonar signal	5
8	White coax shield		Stbd ss return	4
9	Orange	"300-" top jack	supply common	2
10	Red	"300-" bottom jack	supply common	2
11	Yellow	"300+" top jack	+28V supply	1
12	Brown	"300+" bottom jack	+28V supply	1
13				
14				
15	Shield		chassis/ocean	8

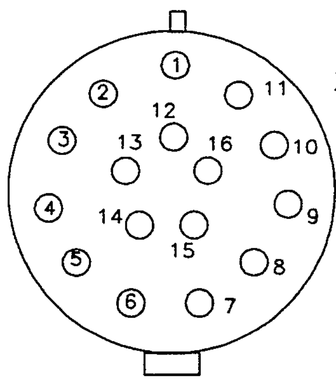

Figure 8: XSM-CCP-16 Cable Connector--face view
(to mate with DREP/AT Sonar bulkhead connector (XSM-BCR-16))

TRIGGER CARD

The standard trigger card, whose schematic is shown in Figure 9, generates the system triggers; it allows the range (swath width) to be set by dip-switches, and the high-voltage transducer triggers to be turned off while the rest of the system is triggered. (Note that the 750 VDC power supply is still on and this high-voltage is still present on the backplane.) This ability to turn the transmitter trigger off is useful for noise tests and for safety during various tests; also it may be harmful to the transducers if they are run in air for a long time. Figure 10 shows a picture of this trigger card.

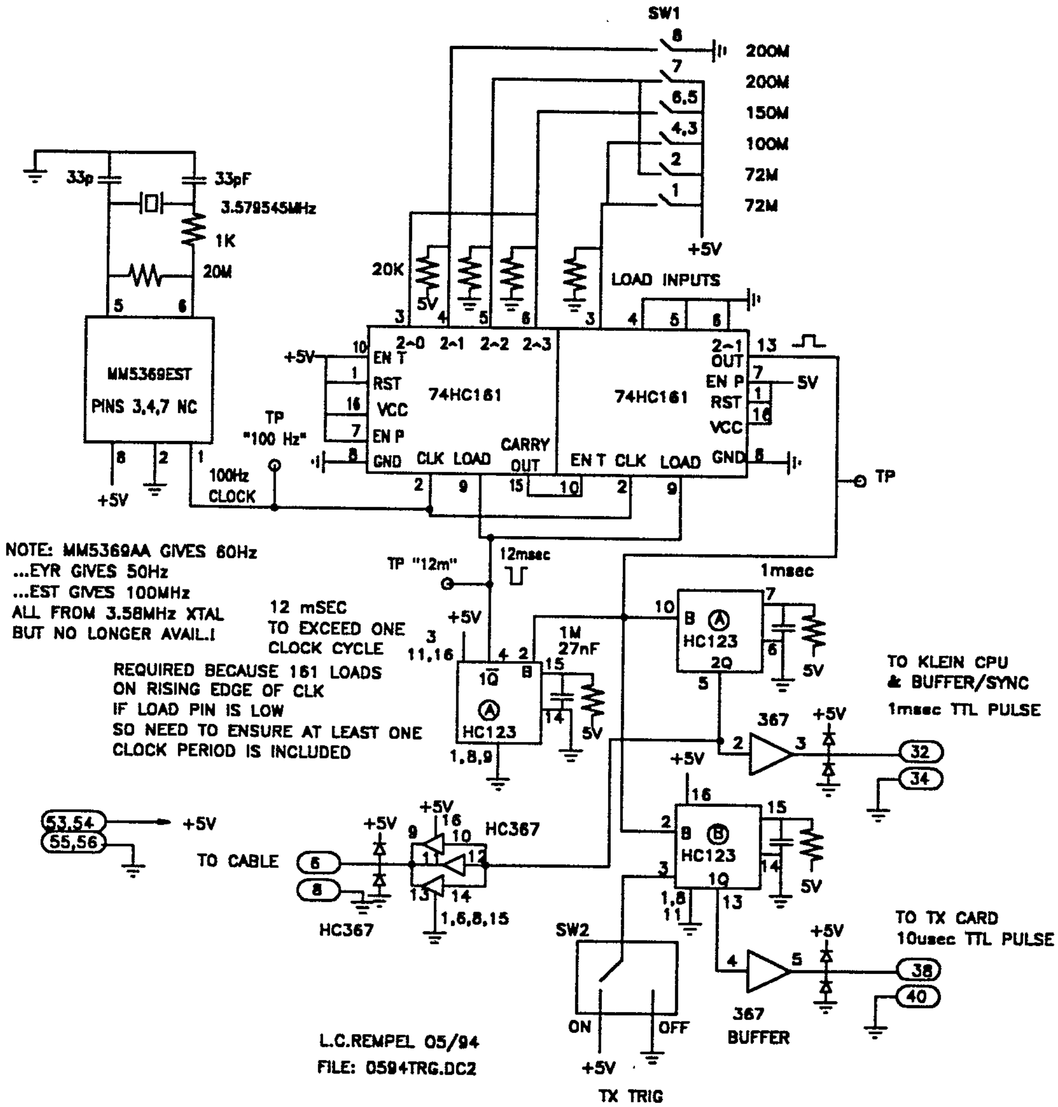

Figure 9: Schematic of Trigger Generator Circuit

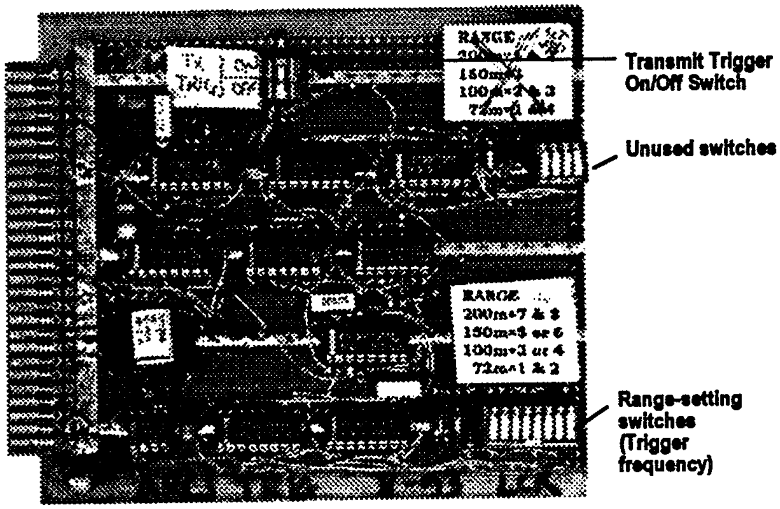

Figure 10: Trigger-Generator Circuit Board

An alternate trigger card is available which accepts external, positive-going TTL-level or RS-232-level trigger pulses and uses these to produce all required system triggers. This external-trigger interface circuit also allows the transmitter trigger to be turned off separately. Its schematic is shown in Figure 11, and a picture of the card is shown in Figure 12.

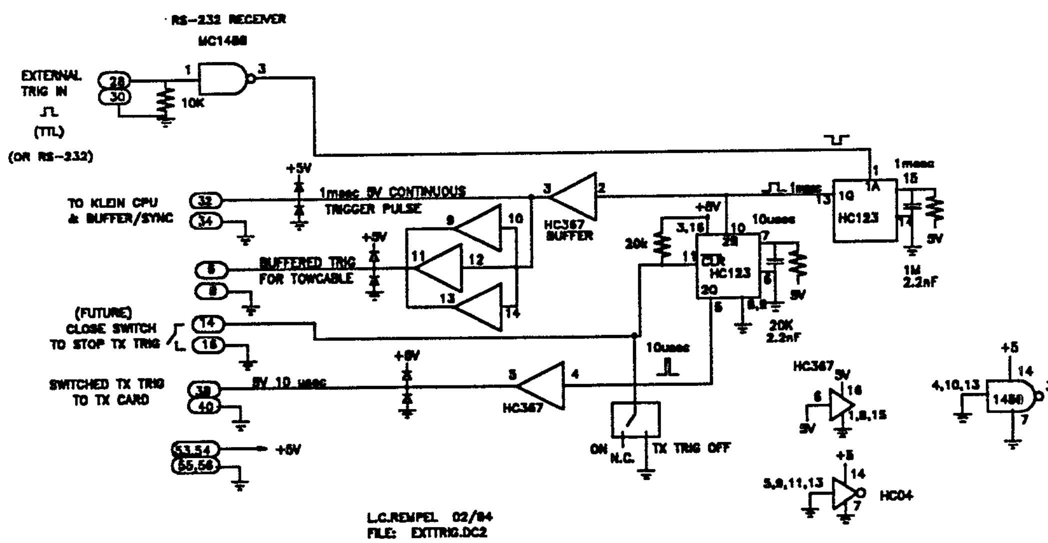

Figure 11: Schematic of the External-Trigger Interface Circuit

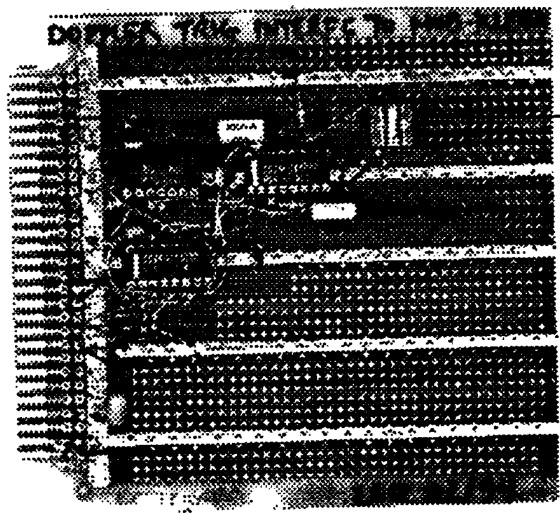

Figure 12: External-Trigger Interface Circuit Board

SYNCHRONIZATION

Synchronization (trigger) pulses are imposed on the rectified, baseband, sonar signals. They are one-millisecond, negative-going, rectangular pulses (between -2 and -5V) replacing the transmit pulse. A positive-going, one millisecond, synchronization pulse (the trigger pulse) is available at the XSM-16 connector (from either trigger card).

SIGNAL CONDITIONING

Figure 13 shows an image of the Klein TVG card edges showing the control switches. Only one of each type is shown, but the Klein TVG system actually uses one AUTO-CPU card to control two AUTO-TVG cards; one AUTO-TVG card processes port sonar signals and the other starboard sonar signals. These Klein 595 signal-conditioning cards allow various compression curves to be applied to the sonar data for optimizing the applied gain-versus-time function. The choice of gain-compression curve is selectable through the card-edge switches. An "automatic gain-choosing mode" (RETURN=0) is available but this does not work well in the DREP/AT sonar system because the electronics of the system differs considerably from the Klein sonar system from which these cards were extracted. Switch settings of RETURN=F, OFFSET=8, ALTITUDE=13, ATTEN=7, are optimal for DREP operations at 13 meters altitude, in the Esquimalt area, for a 75 meter range. For 100 meter range operation, a slightly lower offset (OFFSET=7) will probably produce the best overall results. The ALTITUDE switch should be set as closely as possible to the altitude at which the transducers are to be operated. This altitude affects the beam-compensation applied to the sonar signals. Operating at a different altitude than the one set on the ALTITUDE switch results in dark and light bands on the sonar record.

Table 2 shows the gains produced by the TVG cards at various settings. (There is also other amplification by an unspecified fixed amount on the cards.)

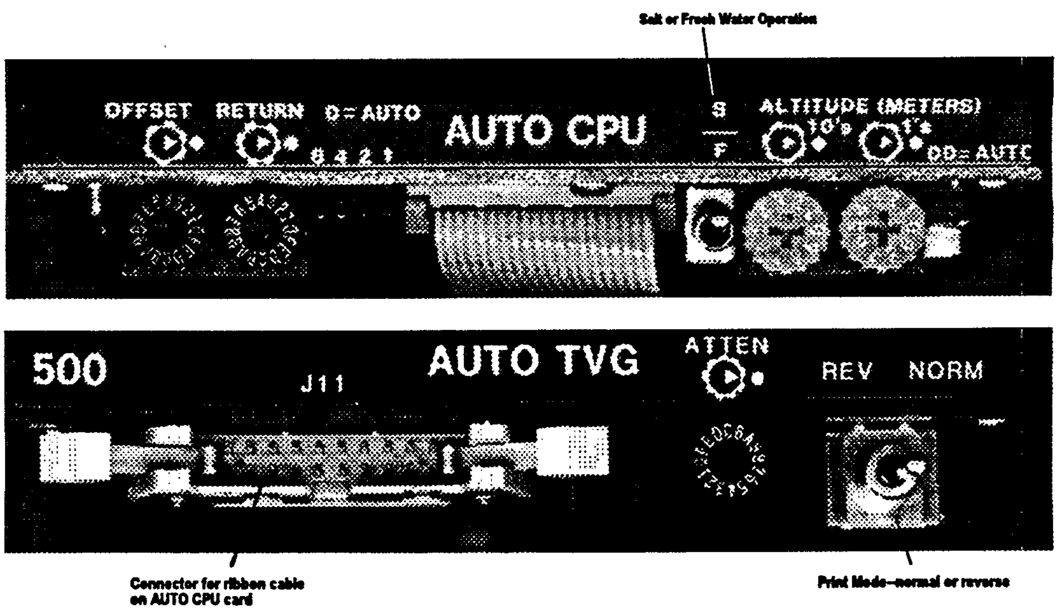

Figure 13: Klein-TVG-Cards' Switches

Table 2: Table of Klein-TVG-Cards' Switch Values

RETURN setting	OFFSET setting	Gain (dB)	ATTEN setting	Gain (dB)
0=auto	0	-45	0	-21
1=highest gains	1	-42	1	-18
2	2	-39	2	-15
3	3	-36	3	-12
4	4	-33	4	-9
5	5	-30	5	-6
6	6	-27	6	-3
7	7	-24	7	0
8	8	-21	8	3
9	9	-18	9	6
A	A	-15	A	9
B	B	-12	B	12
C	C	-9	C	15
D	D	-6	D	18
E	E	-3	E	21
F=lowest gains	F	0	F	24

The RETURN switch selects a basic gain-compression curve to be applied to the sonar signals. The OFFSET switch adds a time-invariant gain to each signal. The OFFSET gain affects the shape of the curve only if the curve saturates the available digital headroom of the TVG circuits, because this added gain influences how soon the maximum available gain is reached. Thereafter no further gain is available so the curve flattens out. The ATTEN switches also apply fixed gains to the system. These, however, can be applied independently to each channel, allowing transducer-strength imbalance to be corrected. The ATTEN gains may also affect the gain curve if the system saturates the available analogue headroom of the electronics. Analogue saturation is to be avoided, however, because it causes signal information to be lost. Digital saturation is less serious. The settings chosen at DREP, indicated above, select curves which do not reach digital saturation until the stated range. This gives the maximum overall slope to the gain curves.

OUTPUT SIGNALS

The baseband signals are available at the XSM-BCR-16 connector as two buffered channels of 0-19 kHz analogue signals within a range of -5 volts (synchronization pulse) to +15 volts. These can be transmitted up a long cable if necessary, and recorded directly. If the signals are transmitted up a long cable, it is best to receive the signals with an impedance-matched differential-input amplifier before printing or recording, to properly deal with the different ground levels at the two ends of the cable. Figure 14 shows the circuit of such an amplifier.

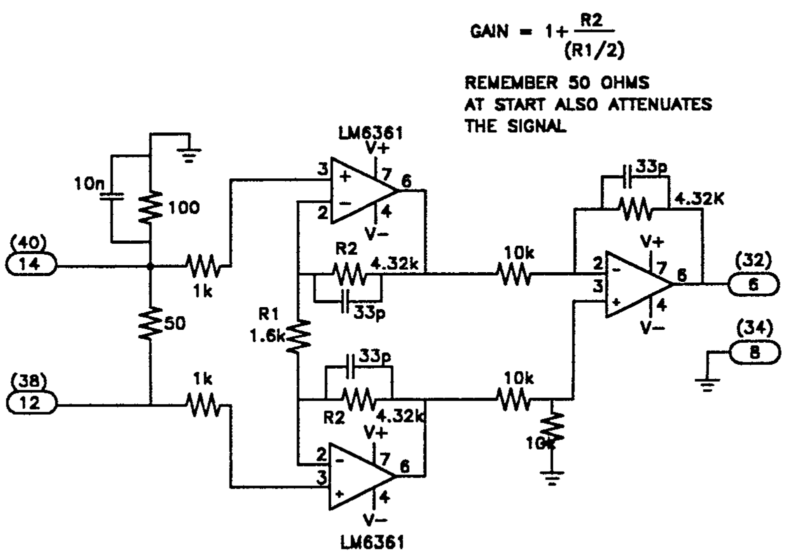

Figure 14: Wide-Bandwidth Differential Receiver

RECORDING SYSTEM

A Teac RD-135T DAT (Digital Audio Tape) Recorder (306 × 100 × 280 mm^3, 6 kg) is used with the DREP sonar system to record the baseband sonar signals. Signals enter the recorder through standard BNC coaxial cable connectors on the front-panel. Figure 15 shows a picture of the front panel of the Teac recorder. The recorder is operated in 2 channel mode at 1-times tape speed, but if a separate synchronizing channel or a navigation-data channel is required, it can be operated in 4 channel mode at 2-times tape speed with the same bandwidth of 20 kHz per channel (48 ksamples/sec). Table 3 gives more details of the specifications.

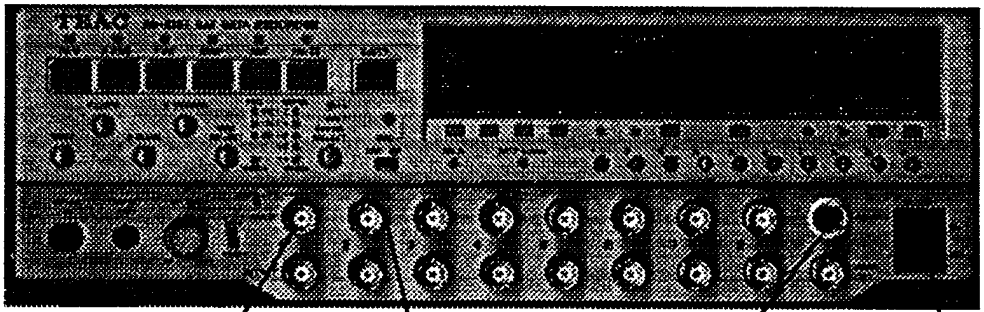

Figure 15: Teac RD-135T Recorder Front Panel

Table 3: Teac RD-135T Recorder Specifications[2]

Tape Speed	x1 (8.15 mm/s)			x2 (16.3 mm/s)	
Number of data channels	2	4	8	4	8
Sampling Rate	48 kHz	24 kHz	12 kHz	48 kHz	24 kHz
Recording and reproducing frequency	dc to 20 kHz	dc to 10 kHz	dc to 5 kHz	dc to 20 kHz	dc to 10 kHz
Input voltage: ±0.5 Vp, ±2Vp, ±5 Vp, ±20 Vp max.					
Input impedance: 100 kohms unbalanced (nominal)					
Input filters: both analogue filter and a 64-fold over-sampling digital filter are used.					
Output voltage: ±2 Vp to ±5 Vp (load resistance 100 kohms or more)					
Output impedance: 75 ohms (nominal)					

A power-supply interface for the Teac recorder (21 × 12 × 6 cm^3, 754 g) has been constructed which allows the recorder to be powered by a 28 VDC supply[3] that might be switched off to conserve power in an AUV. The schematic is shown in

[2]Taken from p. 36 of the Teac RD-125T/RD-135T DAT Data Recorder Instruction Manual, Teac Corporation P/N 10111419-00B.

[3] The recorder uses 1.1 A in steady-state operation, but draws more at start-up. To enable proper operation the interface circuit provides a large capacitor which is charged by the power supply (through an inductor and resistor) before the recorder is turned on. The supply, therefore, must be able to supply a larger current temporarily without shutting itself down. The Vicor VI-2NL-CV 48V to 28V, 150W dc-dc converter, for instance, works well. (This particular converter also accepts a wide range of input voltages (36 through 76 VDC) which is desirable for a nominally 60 VDC battery-powered AUV system.)

Figure 16. This power supply interface must both replace the front-panel on/off switch, connecting to the internal circuit board where the front-panel switch normally connects, and connect to the DC-power connector at the back of the recorder. The interface is housed in an aluminum chassis with a terminal strip for power connection, and cables for connection to the Teac recorder.

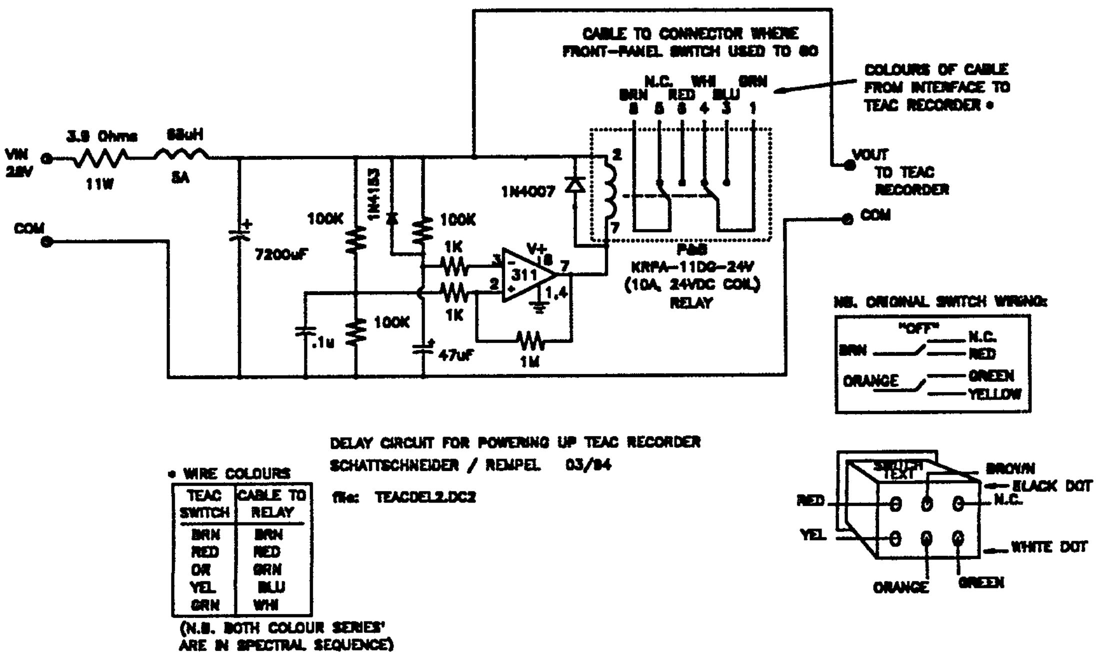

Figure 16: Teac-Recorder Remote-Power Interface Circuit

A remote-control interface for the Teac recorder, housed in a 21 × 12 × 6 cm³ chassis (750 g), has been constructed to allow the Teac recorder to be controlled by a single TTL-level signal, to conserve tape on an AUV. A TTL high level at the terminal-strip "REC/STOP" input to the interface tells the TEAC recorder to start (and continue) recording, a low level tells the recorder to stop recording. The interface requires a clean, fast-rise-time control signal. The remote-control interface is powered directly by the Teac recorder and connects through the remote-control-input connector on the front of the Teac recorder. The interface circuit uses the circuit from the Teac ER-40 Remote

Control Unit, and the circuit of Figure 17. The schematic of the ER-40 is in the ER-40 Maintenance Manual P/N 10111339-00.

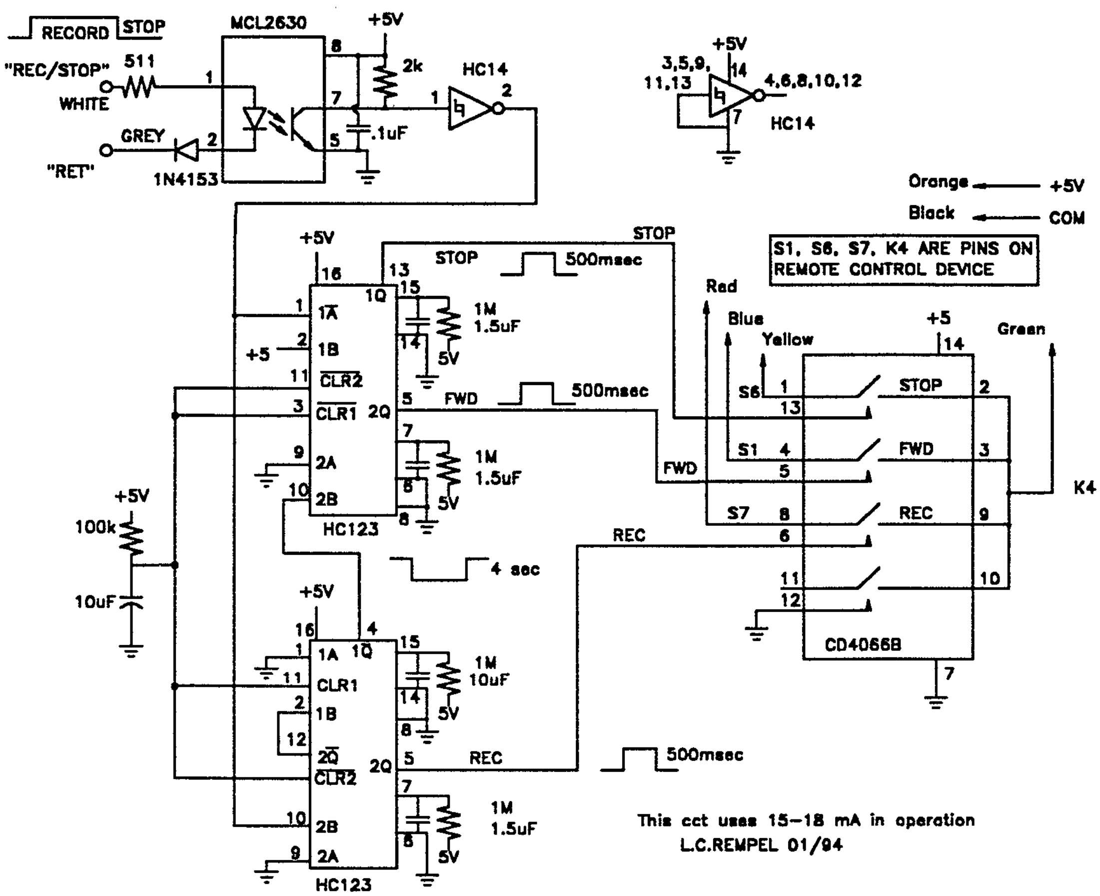

Figure 17: Teac-Recorder Remote-Control Interface Circuit

FURTHER INFORMATION

For further information contact George Schattschneider at Defence Research Establishment Pacific, FMO CFB Esquimalt, Building 199D, Victoria B.C. Canada V0S-1B0. Telephone (604) 363-2869, Fax (604) 363-2856.

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