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An Active Winch Control System for Ship-Induced Motion Isolation

Final Report

Kim D. Saunders

Oceanography Division
Ocean Science Directorate

Foreword

High-precision oceanographic measurements, especially those dealing with nonexpendable profiling instruments, are often difficult to make because of ship motions. In 1982, efforts to overcome this problem were undertaken and work on a motion compensation system started. Portability and low cost were primary design constraints.

This report covers the development of an active winch control system that should help solve the problem of motion isolation.

A handwritten signature in dark ink, appearing to read 'R. P. Onorati', is centered on the page. The signature is fluid and cursive, with a large, stylized initial 'R'.

R. P. Onorati, Captain, USN
Commanding Officer, NORDA

Executive summary

Many in situ measurements at sea are made using instruments tethered to a ship with an electromechanical cable. As the ship moves in response to the surface waves, the supporting cable transmits the motion to the instrument. This ship-induced motion is a source of error in the measurements and is a source of mechanical failure that has led to the loss of instruments.

To reduce the effect of ship-induced motion on an instrument package, an electrically controlled winch system was developed to provide motion compensation. An electrohydraulic winch is controlled by a micro-computer using a combination of open- and closed-loop control strategies.

The winch was tested during a cruise in the summer of 1984. The ship-induced motion was reduced by factors of 2-3. Further improvement is required and some means for achieving that improvement are proposed.

Acknowledgments

The author gratefully acknowledges the generous advice of Dr. A. W. Green. The testing of the winch could not have been accomplished as expeditiously as it was without the assistance of Dr. Henry Perkins, Bill Teague, Steve Sova, and Edward Mosevich. CAPT Kim Giaccardo, the officers, and the crew of the USNS BARTLETT gave invaluable assistance and advice. This project was funded under program element 61153N, Dr. Herb Eppert, program manager. The NORDA technical editing staff under Doug Johnston provided the support work in assembling this report. Their unfailing high levels of competence and personability contributed greatly to this report.

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An active winch control system for ship-induced motion isolation

1. Background

Most high-precision, nonexpendable oceanographic profiling instruments are directly tethered to a ship by an electromechanical cable. Ship motions, primarily roll and heave, cause the descent rates of such profilers to vary by up to several meters per second. The variations in descent rates cause significant errors in measurements of temperature, conductivity, and velocity (Gregg et al., 1982; Trump, 1983). These errors could be reduced if the profiler were uncoupled from the ship's motion.

Both passive and active systems have been used in the past. Kidera and Mack (1983) describe a passive pneumatic system designed and built at Johns Hopkins Applied Physics Laboratory. Gargett (1978) mentions a feedback-controlled winch built by the Defence Research Establishment (Canada) and used in 1972 and 1973 for towed temperature microstructure measurements.

In early 1982, it became apparent that to make high-quality, finescale measurements of velocity, temperature, and conductivity, a motion compensation system would have to be built. Portability and low cost were primary design constraints.

We first considered a passive system. A very compliant system was required for motion isolation. At the same time, the system had to support the loads of several thousand meters of electromechanical cable required for deep casts. Thus, the system had to be compliant at ship-roll frequencies and very stiff at cast-repetition frequencies. It did not appear that a low-cost passive system could be built with such a response.

The active system approach was taken. After considering both a hydraulically controlled active boom and an electrically controlled active winch, the active winch was chosen. It is interesting to note that Berteaux and Walden (1984) and Trump (1983) also came to the same conclusion at about the same time.

2. System design

The active winch motion isolation system consists of three parts: a suite of sensors to determine the system state and input variables, a controller, and an electrically controlled winch.

Open-loop control is achieved by adjusting the speed of the cable at the winch to balance the vertical motion of the ship at the point where the cable leaves the ship (the main block under normal circumstances). This velocity is estimated by integrating the output of an accelerometer mounted near the main block. This output is digitized by the control computer and the winch rotation rate is controlled by creating an analog voltage, which is sent to the control section of the winch.

The integration of the accelerometer output is performed by an analog circuit. Voltage offsets, which are partially removed by a long-term running mean in the control computer, are invariably introduced at this stage. Nevertheless, long-period fluctuations do occur and cannot be corrected unless the loop is closed.

Closed-loop control is obtained by comparing the observed pressure (P_{obs}) at the profiler with a desired pressure (the control variable, P_c). For a constant descent rate, $P_c = P_o + W*t$, where W is the descent rate in decibars per second, t is the time measured in seconds from the start of the cast, and P_o is the pressure at the start of the cast. The error signal, $e = P_c - P_{obs}$, is computed and the rotation rate of the winch is modified by a factor proportional to the error signal.

This control description is shown schematically in Figure 1, and the algorithm for the winch rate is given by:

$$R = K0 * (W + K1 * (V - V_{av}) + K2 * (P_c - P_{obs})),$$

where

- R = the winch rotation rate in Hz,
- $K0$ = a factor relating rotation rate to wire speed,
- W = desired descent rate,
- V = estimated ship velocity,
- V_{av} = running mean of V ,
- $K1$ = proportionality factor for open loop control,
- $K2$ = proportionality factor for closed loop control,
- P_c = desired pressure ($= P_o + W*t$),
- P_{obs} = observed pressure at the profiler.

The control design was implemented by hardware consisting of a Z-100 computer system with appropriate interfaces, which are described in more detail in the following sections.

The overall system configuration is shown in Figure 2 as a connection diagram.

3. Winch

An electrically controllable, seagoing winch capable of rapid response and of speeds and accelerations appropriate for expected ship motions was required for this system. The speeds and accelerations were chosen, based on observations from the Neil Brown Instrument Systems/NORDA Velocity Conductivity Depth Profiler (VTCD) accelerations and pressure records on earlier cruises. These specifications (Appendix A) were based on these data as well as specifications for an earlier winch procured by NAVOCEANO.

An open bid procurement for the winch was initiated in 1982. Three bids were returned. One bid was rejected as unresponsive (it did not meet the specifications). Of the other two, the lower cost bid was chosen. The contract was awarded to the SEA-MAC Marine Products Division of Harvey-Lynch, Inc., Houston, Texas. The contract price was \$45,482.

"The winch is powered by a 30 HP 460 VAC/3 Phase electric motor which is coupled to a closed loop hydraulic pump and charge pump assembly to operate a hydraulic motor which in turn is coupled through a multiple disc failsafe automatic brake and planetary gear reducer directly to the cable drum." (SEA-MAC, 1983).

Winch control is provided via a Sundstrand/Honeywell controller. The controller is designed to operate with a center deadband, which must be compensated for by the control computer. When the winch was delivered, a series of tests were made to determine the winch rotation rate as a function of the control voltage (Fig. 3). Several points were rerun during the at-sea tests, and no change from the original function was found.

4. Control section

A. Sensors

Accelerometer

The accelerometer was a Kistler Model 303G.5 servo accelerometer, which was salvaged from a vintage 1975 wave sensor package. The exact response of the accelerometer is not known, but the output appears reasonable in near-static situations.

Pressure sensor

The pressure sensor is part of the VTCD. This instrument was built by Neil Brown Instrument Systems, Inc. (NBIS), Cataumet, Massachusetts. The pressure sensor is a Paine Instruments, Inc., bonded strain gauge absolute pressure transducer. It has a range of 0-320 decibars, full scale, and the data are digitized in 12 bits. The least significant bit level is equivalent to 0.005 decibar. The accuracy

is quoted as 0.1% full scale (0.32 decibar), and the noise as less than 0.0015% full scale (resolution is quoted as 0.0015% full scale) (Neil Brown Instrument Systems, 1979).

The pressure is digitized by the profiler circuitry, converted to serial frequency shift key (FSK) code, and transmitted via the electromechanical cable to a deck unit on the ship. The deck unit demodulates the FSK code, converting it to serial and then to parallel digital code. The parallel digital code is transmitted to the controller via a general-purpose interface bus (GPIB or IEEE 488 bus). The computer interfaces to the bus via a GPIB/S100 bus interface.

B. Analog interface circuits

Buffer and offset amplifier

The accelerometer provides an output proportional to the sensed acceleration. The predominant acceleration sensed is gravity. Because we are interested only in variations from this mean, to remove it is advantageous. The circuit used for this purpose is shown in Figure 4. The signal is first attenuated by a factor of 1/2. An offset is added/subtracted, as appropriate, to bring the mean to zero volts. The signal is then amplified by a factor of 4 to double the original value without the mean due to g. The follower form of the amplifier used here also provides a high-impedance, low-capacitance buffer between the amplifier and the subsequent circuitry.

Integration filter

This circuit provides a voltage proportional to the instantaneous vertical velocity of the ship at the accelerometer. Because the offset circuit in the previous example cannot completely eliminate the mean output of the accelerometer, a differentiator/integrator filter is required. This circuit removes long-period variations in the signal by acting as a low-frequency differentiator while integrating the signal over the frequency bands of interest—in this case, the ship roll frequency band. The circuit is shown schematically in Figure 5. The capacitor between the amplifier output and the ground was required to damp very-high-frequency oscillations that were observed when the circuit was connected to the analog-to-digital interface.

Output buffer/power amplifier

To provide a buffer between the digital-to-analog board in the control computer and also to provide sufficient current to operate the Sundstrand controller on the winch, a power amplifier/buffer amplifier circuit was employed.

Figure 6 shows the schematic diagram for this circuit. Provision was made for either attenuation or amplification, but no attenuation was made, and unity gain was used.

C. Computer and digital interfaces

Z100 computer

The heart of the control circuitry is a Heath-Zenith Z100 microcomputer. This is a 16-bit machine based on the INTEL 8088 microprocessor. The system is configured with 392 K memory. The GPIB drivers were written in assembler language for the 8088, while the main control program was written in compiled BASIC and linked with the appropriate drivers. The control software is listed in Appendix B.

The Z100 communicates with other devices via an IEEE 696 bus (otherwise known as an S100 bus). All interfaces to the sensors and controllers must be S100 bus compatible.

GPIB/S100 bus interface

A National Instruments GPIB-696 interface board is used for communication with the profiler deck unit to obtain pressure data. This board is well documented, but does not come with software in useful form (some listings of drivers in assembly language are given, but they are incorrect). I revised the drivers, which are included in Appendix B.

Analog-to-digital/S100 bus interface

The output of the acceleration integration filter is passed to the computer via a DUAL Systems Corporation analog-to-digital converter, Model AIM-12. This is a 32-channel, 12-bit, -10V to $+10\text{V}$ A-D converter, S100 bus compatible. The conversion time is 25 microseconds (μsec) (typical).

Digital-to-analog/S100 bus interface

The control computer output is via a DUAL Systems Corporation digital-to-analog converter, Model AOM-12. This is a 4-channel, 12-bit -10V to $+10\text{V}$, D-A converter, S100 bus compatible. The conversion speed is about 5 μsec .

5. Test results

The active winch control system was first tested on Cruise 708-84 aboard the USNS BARTLETT as part of the Fine-scale Variability Experiment (FSV-84). The operation period was 1-19 August 1984. The operation area was the western North Atlantic in the vicinity of 30°N , 74°W .

The winch was located on the afterdeck, approximately on the center line of the ship. The electromechanical cable was lead aft to the main block, which was hung from the center of the "U" frame on the stern. Initially, the accelerometer was mounted on the block. Later, it was moved to a post on the stern.

To determine the best coefficients for the control algorithm, I first ran the system under open loop control. The test results are presented in Figure 7. The vertical axis is pressure in decibars, the horizontal axis is time in seconds. K1 is the open loop proportionality factor, as described in the control design section. The intent of this test (and all subsequent tests) was to hold the profiler at a constant depth. Under manual operation (no control, winch stopped) the profiler had vertical excursions of about 0.5-1 m. With the controller on and the K1 factor set at 0.25 the wave motion was greatly damped, but at the expense of a very long period oscillation (on the order of about 100 sec). The maximum amplitude at wave periods appears to be about 0.3 m, and typically much less. The long-term oscillations seem to be due to either the imperfect operation of the filter or to a side effect of the running mean (which had a length of about 100 sec). Other values of K1 were tested, but the best value was near 0.25. (It should be noted that this value will change whenever the input amplifier gain is changed, the offsets are changed, or the accelerometer gain is changed. All these values changed later in the cruise when the first accelerometer failed and the new one was installed on a post fixed to the stern.)

While the open loop approach is beneficial in reducing the package motion at wave periods, it also introduces serious long-term fluctuations. These long-period oscillations may be removed by closing the control loop. The next tests of the system were under closed loop control with open loop velocity compensation. The results of one of these tests (made after the accelerometer was changed and moved) are shown in Figure 8. As in Figure 7, the vertical axis is the pressure (in decibars) measured at the package and the horizontal axis is time in seconds. The first section of the plot illustrates the vertical excursions of the profiler under closed loop control. The large oscillations occurring before about 50 sec are due to the transient behavior of the startup phase of the control program (required to ensure smooth starting of the winch and to reduce the probability of the cable jumping the sheave). After about 350 sec of operation, the controller was stopped and the profiler returned manually to the original depth. The rest of the record was made with the winch stopped.

From this figure, we can see that the closed loop control gave a definite advantage over the no-control situation

By visual inspection, the controlled excursions appear to be about $\frac{1}{2}$ to $\frac{1}{3}$ those experienced when no control was exercised.

6. Development plans

The tests described were of the first version of the control system. The response of the system under closed loop control was good, but not as good as desired. Considerable improvement can and should still be made.

One of the possible sources of error is directly attributable to noise in the pressure signal. Occasionally, the pressure will appear to jump by as much as 0.3 decibars between samples, which is equivalent to a vertical speed of about 4.8 m/sec—clearly an erroneous reading. The effect on the winch control of such spurious points is severe and should be removed by the software. The algorithm for detecting and correcting spurious pressure data has not yet been incorporated into the control program.

Another source of error may be attributed to the effective sampling rate of the pressure. With the present setup, the system state was updated only at about 6-7 times per second. No smoothing filter was applied to the output, which may have led to jerky winch response.

I intend to improve the system response by increasing the effective speed of the processor by adding an INTEL 8087 arithmetic coprocessor to the system to handle the floating point operations and time critical fixed point operations. An analog pressure channel is planned for the VCTD deck units and direct analog-to-digital conversion will be used, rather than the more cumbersome (and slow) GPIB software. (This feature will also permit some prefiltering of the pressure signal, if required, to suppress the "wild" points.)

Also, better accelerometers will be used rather than using salvaged ones of unknown history and quality.

The accelerometer output will also be calibrated on a velocity test facility at NSTL, and the amplifiers and filters will be more precisely calibrated. An output filter stage will be added to the D-A converter to smooth the voltage to the winch. The winch itself will be serviced and adjusted for smoother operation.

Finally, if time and money permit, the actual winch response under load will be measured and incorporated into any modifications of the control model.

7. References

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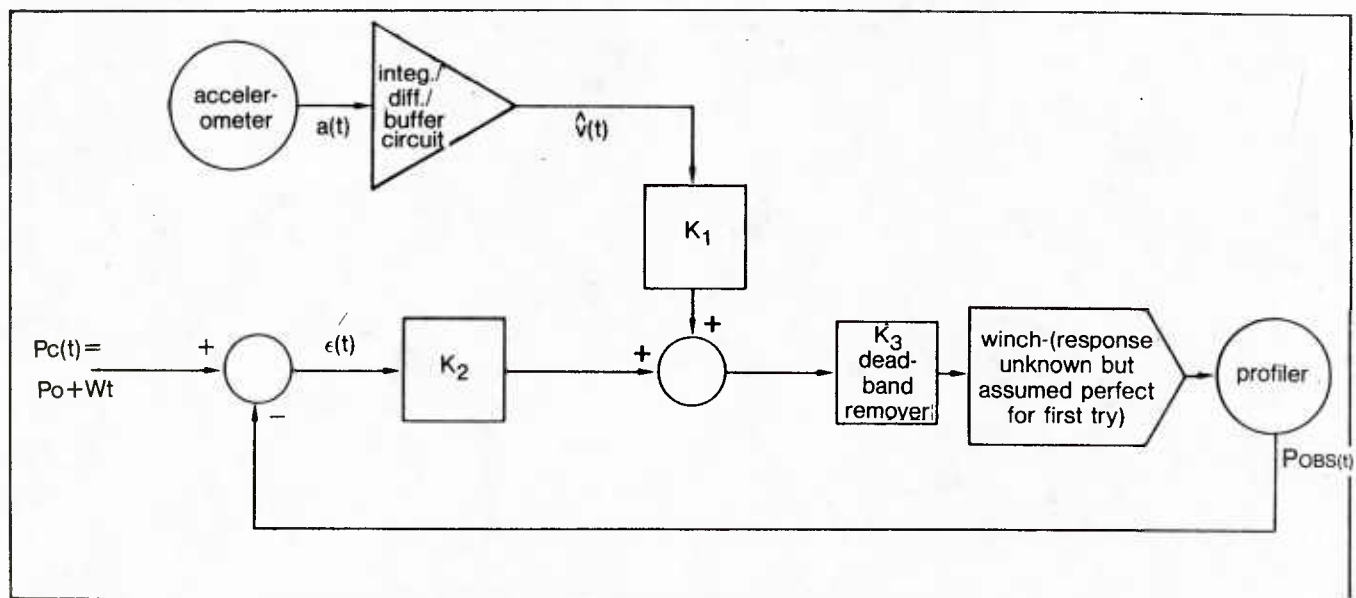


Figure 1. Schematic diagram for motion isolation winch control system.

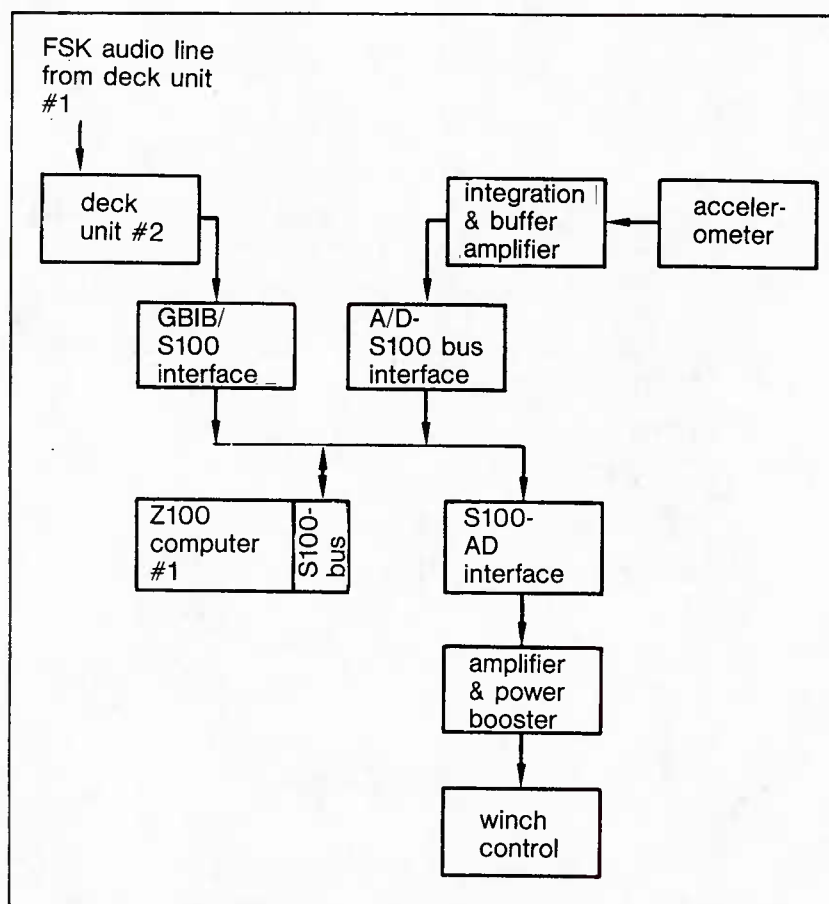


Figure 2. Schematic diagram for equipment connections in the winch control system.

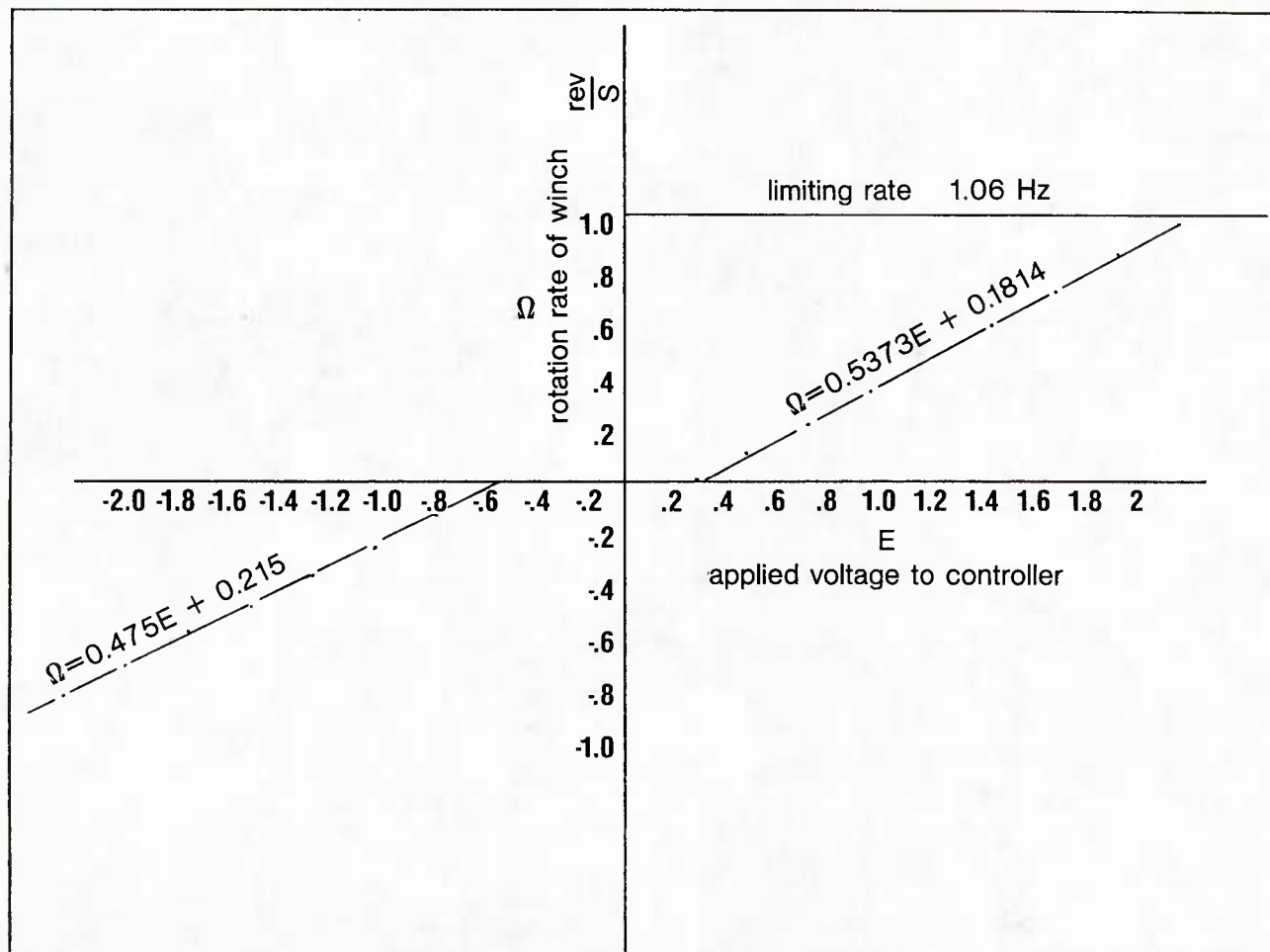


Figure 3. Winch drum rotation rate as a function of control voltage.

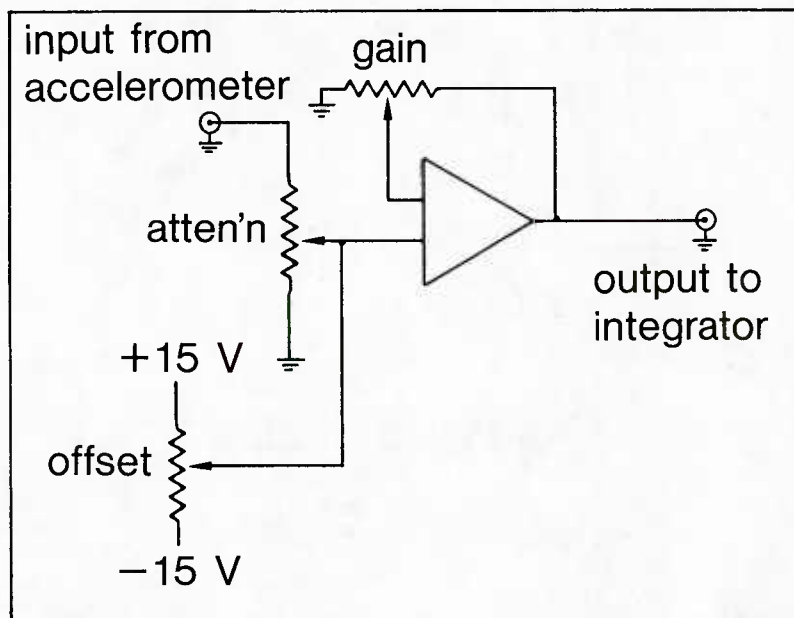


Figure 4. Schematic diagram of buffer/offset amplifier.

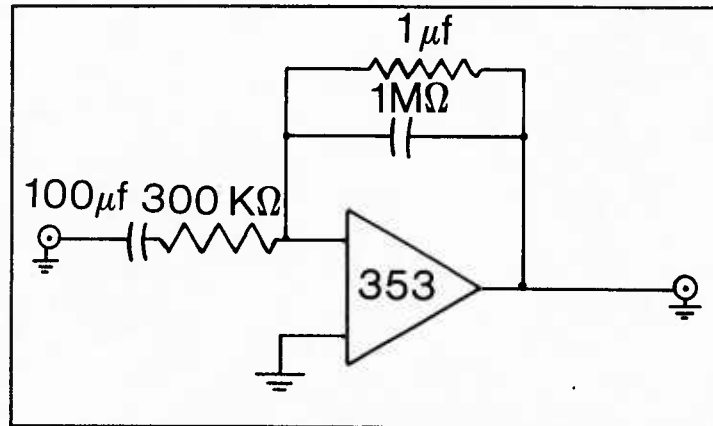


Figure 5. Schematic diagram of integration filter.

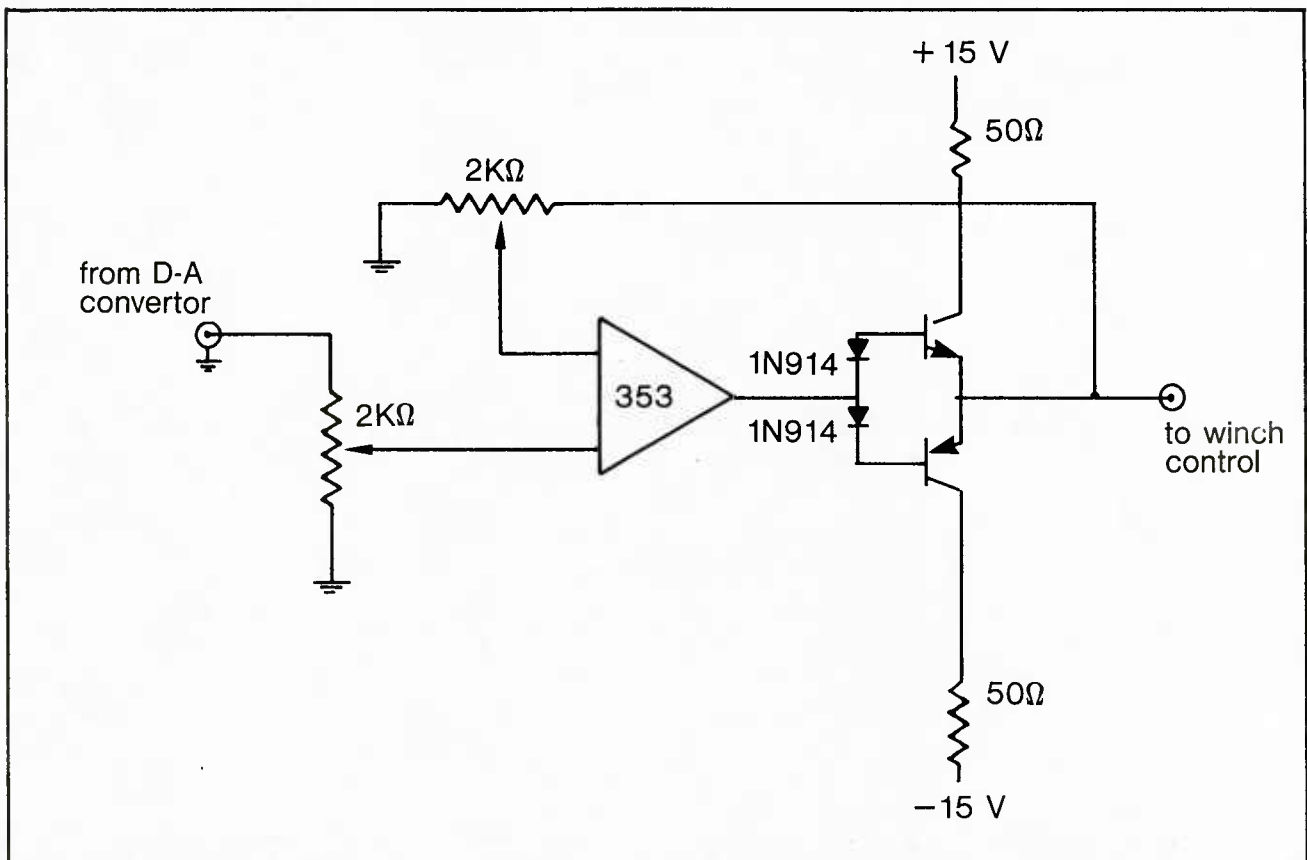


Figure 6. Schematic diagram of output buffer/power amplifier.

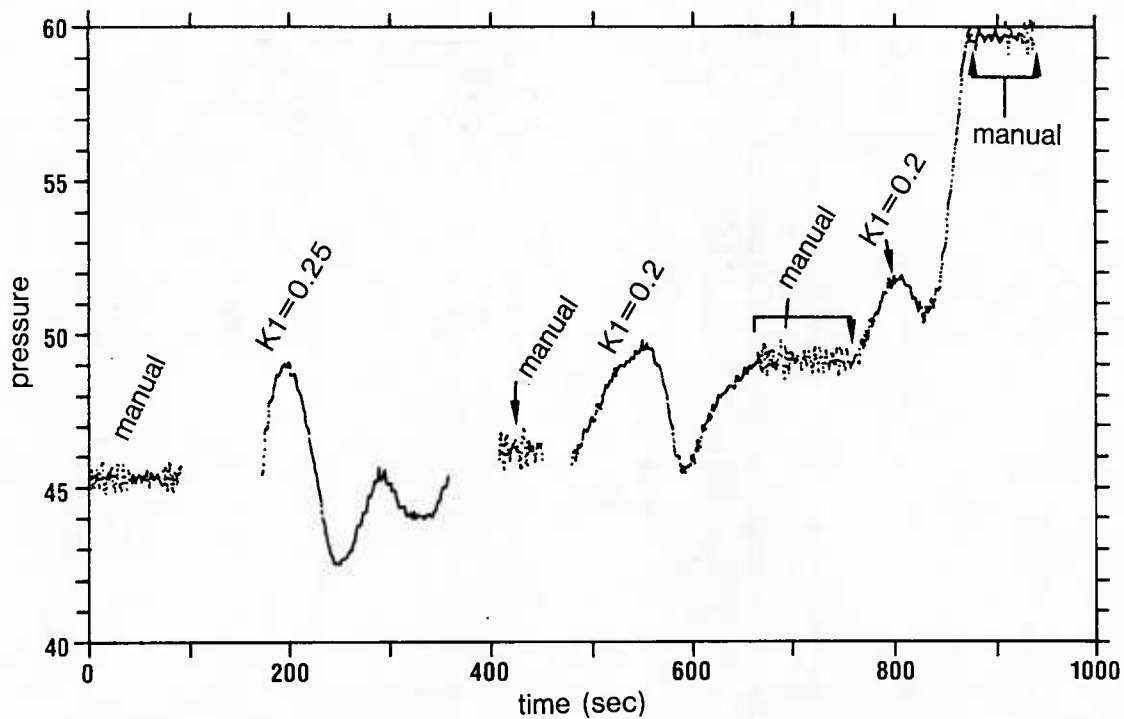


Figure 1. Example of an open loop test. Note the great attenuation of the ship-induced motion evidenced near the maxima and minima of the long-period oscillations. The oscillations are artifacts of the control process and imperfect filters.

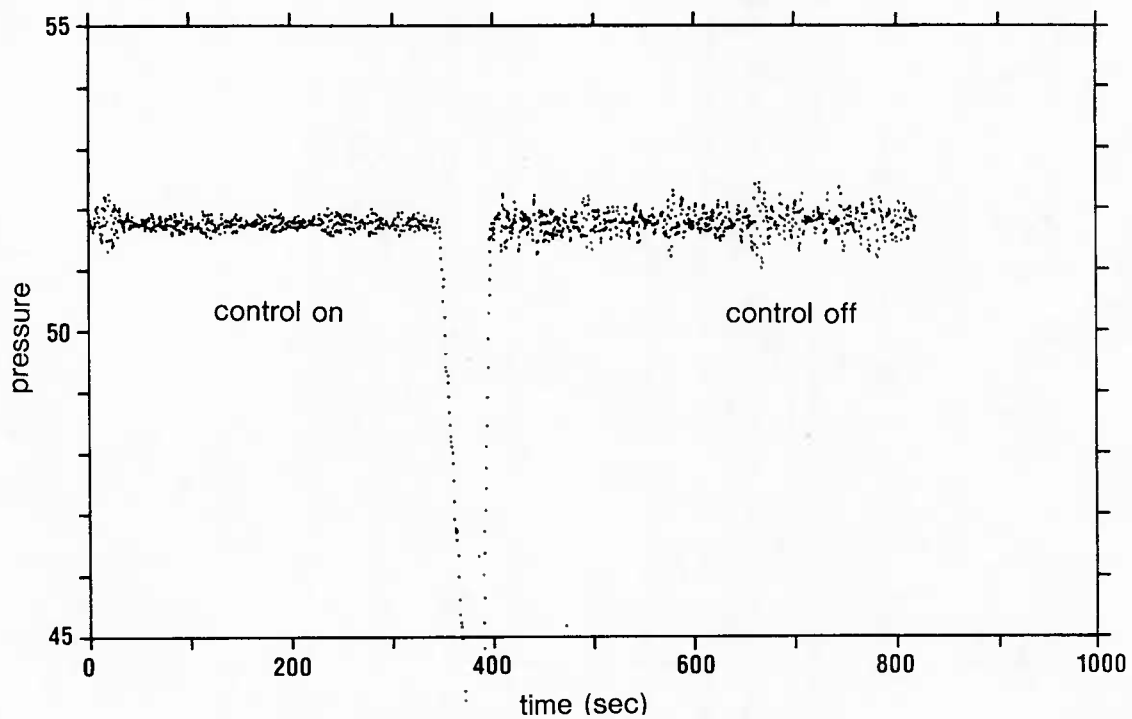


Figure 8. Comparison of closed loop control with no control. The rms amplitude of the profiler under closed loop control is about $\frac{1}{2}$ to $\frac{1}{3}$ that under no control.

Appendix A: Specifications for a variable speed oceanographic portable winch

1.0 SCOPE

1.1 Scope

This specification describes an electric or electrohydraulic winch specifically designed to deploy, cycle and recover a conductivity, temperature, depth (CTD) or a triaxial current profiler with CTD capability (VCTD) and having the capability of providing active compensation for ship motion. The winch speed and direction shall be remotely controlled by use of an analog voltage signal or a digital signal in IEEE 488 bus format.

2.0 APPLICABLE DOCUMENTS

2.1 Issues Of Documents

The following documents of the issue in effect on the date of invitation for bids or request for proposal form a part of this specification to the extent specified herein.

MILITARY STANDARDS

- MIL-STD-275 Printed Wiring for Electronic Equipment.
- MIL-STD-454 Standard General Requirements for Electronic Equipment.

(Copies of specifications and standards required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other Publications

The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on the date of invitation for bids or request for proposal shall apply.

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA Standards

(Application for copies should be addressed to the American Gear Manufacturers Association, 1330 Massachusetts Ave., N.W., Washington, D.C. 20005)

ANTI-FRICTION BEARING MANUFACTURERS ASSOCIATION (AFBMA)

AFBMA Standards

(Application for copies should be addressed to the Anti-friction Bearing Manufacturers Association, 2341 Jeff Davis Highway, Suite 1015, Century Building, Arlington, VA 22202).

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)

IEEE Standard 488-1978,

"IEEE Standard Digital Interface for Programmable Instrumentation"

(Application for copies should be addressed to the Institute of Electrical and Electronic Engineers, 345 East 47th Street, New York, NY.

NATIONAL BUREAU OF STANDARDS

Handbook H28 Screw-Thread Standards for Federal Services.

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402).

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3.0 REQUIREMENTS

3.1 General

3.1.1 Operational Location. - The winch shall be designed and constructed for installation of the weather deck of AGS or AGOR class ships which is unprotected from the marine environment. Design considerations shall be given to ensure that components do not become inoperative due to exposure to severe corrosive conditions and freezing temperatures.

3.1.2 Major Components. - The winch shall be electrically or electro-hydraulically driven and shall have the following minimum characteristics: electric motor, self-actuating brake, manual brake,

removable cable drum, slip-ring assembly, level wind device, line metering device, frame or bedplate, remote control unit, electrical cabling and connectors, protective fabric cover and all accessories necessary for independent operation as specified herein.

3.1.3 Power. - The winch shall operate solely on 440(+/- 40) VAC, 60(+/- 3) hertz, three phase, delta-connected ship's power. A main power switch and circuit breaker protection shall be provided.

3.1.4 Packaging. - All winch components except the controls shall be contained on a single support frame. A separate unit shall house the winch controls. This remote unit shall be connected to the winch via a single electrical cable.

3.1.5 Weight And Dimensions. - The total weight of the winch excluding the electromechanical oceanographic cable and the remote control unit shall not exceed 4000 pounds. The winch shall fit within a 6 foot square area and shall not exceed six feet in height. The remote control unit shall not exceed 50 pounds. It shall be designed for rack mounting on a standard 19 inch relay rack and shall not exceed 6 inches in height.

3.2 Operational Requirements

3.2.1 Manual Operation - The winch shall power hoist and lower the VCTD package in a manual control mode. The manual control system shall be separate from the remote control system and shall have the capability of overriding the remote control system. The manual control system shall include a control lever that will cause line payout when the lever is moved away from the operator and line retrieval when the lever is moved toward the operator. Upon release, the lever will automatically return to the neutral position. The operator shall have a positive indication, by feel, when the lever is in the neutral position. Line payout and retrieval speeds shall be linearly proportional to the control lever displacement from neutral. The manual control shall have a control switch to enable either manual or remote operation. Remote operation shall be initiated only by means of this switch. A safety interlock shall allow startup of the electric motor only when the control lever is in the neutral position and the manual/remote switch is in the manual mode.

3.2.2 Remote Operation - A remote control unit shall be provided which will allow control of the winch from a location other than the near vicinity of the winch. This unit shall accept as a control input, an analog signal between -15 and +15 VDC or a digital signal in IEEE 488 bus format. The direction and speed of payout or retrieval shall be controlled through this signal. If a digital signal is used, the speed must vary smoothly when the signal level changes.

3.3 Interface Requirements

The following information describes equipment and material owned by the government and does not form a part of this specification. This information is provided to aid the contractor in designing hardware that will properly interface with the existing system components.

3.3.1 Single Conductor Armored Cable. - The electro-mechanical sea cable that will be used with the winch is type 1-H-255 as manufactured by the Rochester Corporation, Culpepper, VA. This cable has the following mechanical properties:

Outside Diameter:	0.254 inch.
Breaking Strength:	5600 pounds.
Weight in air:	112 pounds/1000 feet.
Weight in sea water:	90 pounds/1000 feet.
Conductor:	20 AWG, 7 Strand.
Insulation:	0.040 inch polypropylene.
Inner armor:	18 strands, 0.0245 inch diameter.
Outer armor:	18 strands, 0.035 inch diameter.
Minimum Bend Radius:	7 inches.

3.4 Performance Requirements

3.4.1 Speed. - The winch shall be capable of raising and lowering the package at all speeds between -80 and +80 meters/minute. The speed shall be controlled by either an analog voltage signal between -15 and +15 volts, D.C. or a digital signal conforming to the IEEE 488 bus standard. The speed shall be controllable to within 0.5 centimeter/second. The speed of the winch shall be a linear function of the input signal to within 0.3% of full scale.

3.4.2 Acceleration. - The winch shall be capable, within the speed limitations given above, of providing up to at least 0.2 g acceleration of the VTCD package and wire at any layer and load, as herein specified.

3.4.3 Rated Load - The winch at mid-drum layer shall power hoist and lower a rated load of 1500 pounds. This load represents the static load of the VTCD instrument and the 1-H-255 sea cable as well as the dynamic load due to cable and instrument drag and inertial forces from the ship's motion. The winch shall payout and retrieve all loads up to and including the rated load at lines speeds from 0 to 80 meters per minute. It shall be capable of hoisting and lowering 150 percent of the rated load at no specific speed.

3.4.4 Duty. - The winch shall be capable of both intermittent operation and continuous operation up to 72 hours without overheating or component degradation beyond safe operating limits.

3.4.5 Environmental Conditions. - The winch will be exposed to a hostile marine environment that will include arctic and tropical conditions. It shall operate in accordance with this specification under the conditions described below. Performance shall not be degraded due to continuous exposure to this environment.

Ambient Temperature:	-20 F to 110 F
Vibration	: 1 g at 4 to 50 hertz
Inclination	: 30 degrees from horizontal in all directions.
Moisture	: drenchings from wind-driven spray and high seas; relative humidity 0-100%
Salt fog	: continuous exposure
Wind	: up to 40 knots

The winch remote control unit will be protected from saltwater drenchings and shall operate at temperatures between 0 F and 100 F. The vibration, inclination, salt fog and relative humidity requirements listed above shall apply to the remote control unit.

3.4.6 Reliability - The design life of the winch system shall be at least 10000 operating hours with normal preventative maintenance procedures. The winch shall operate for a minimum of 1000 hours between minor overhauls without adjustments or parts replacement.

3.4.7 Noise - The winch shall have an overall noise level no greater than 90 dbA at a distance of 5 feet from it in any horizontal direction and at a height of 5 feet above the winch/deck interface when operating at the loads and speeds specified above.

3.5 Component Requirements.

All components shall be designed such that the winch system shall meet the operational and performance requirements as described above.

3.5.1 Electric Motor - An electric motor shall be utilized as the system prime mover. It shall operate on 440 (+/- 40) VAC, 60 (+/- 3) hertz, three phase, delta connected ship's power. It shall be housed in a watertight enclosure and shall be cooled as necessary. The armature shaft shall be anti-friction bearing mounted. Readily accessible grease fittings shall be provided for lubrication of the bearings. A thermal protection device which senses winding overheating and shuts off the motor shall be included.

3.5.2 Hydraulic Components. - If electro-hydraulic drive is utilized, the components of the hydraulic system shall meet the following requirements.

3.5.2.1 Fluid Reservoir. - The hydraulic fluid reservoir shall be designed for easy maintenance. The tank bottom shall be sloped or dished with the drain at the lowest point to permit complete draining of all fluid. The drain shall be readily accessible and positioned to allow draining without spillage on the winch components or frame. One or more easily accessible covers shall be provided for cleaning and maintenance. The reservoir filler hole shall have a replaceable fine mesh screen filter to minimize fluid contamination during replenishment. A sight glass fluid level gage shall be provided to indicate normal, high or low fluid levels. The reservoir air breather shall be fitted with a replaceable filter capable of excluding the marine atmosphere. A baffle shall be included in the reservoir and shall separate the pump inlet line from returns lines such that the same fluid cannot recirculate continuously without significant mixing. To permit cold weather operation, an automatically controlled heater shall be provided that is capable of maintaining a minimum fluid temperature of 60 F when the ambient temperature is -20 F and the winch is exposed to 40 knot winds. A temperature gage that indicated fluid temperature shall be mounted on the reservoir in a highly visible location. This gage shall have a minimum range from -20F to

200 F and shall have an accuracy of at least 5 F. Under conditions of continuous duty and maximum ambient temperature, the fluid in the reservoir shall not exceed a temperature of 150 F. If necessary, an automatically activated heat exchanger system shall be provided to limit fluid temperature.

3.5.2.2 Pressure Gage. - A pressure gage shall be provided to indicate the hydraulic pump output pressure. The gage shall have a minimum accuracy of 5% of the rated operating pressure with a minimum resolution of 5% of the rated operating pressure. It shall indicate pressures from 0 to 125% of the rated operating pressure. The gage shall be readily visible from a standing position (when standing in back of the winch).

3.5.2.3 Relief Valve. - An adjustable relief valve shall be provided in the high pressure circuit to limit maximum system pressure. The relief valve shall have a volumetric capacity not less than the full displacement of the hydraulic pump.

3.5.2.4 Air Vents. - Air vents shall be provided at all points in the hydraulic system where air will tend to accumulate and may result in unsatisfactory operation. Disconnection of fluid lines is not an acceptable method of venting air.

3.5.2.5 Filter - A 10 micron full flow replaceable cartridge type filter shall be provided in an easily accessible location in the suction line between the reservoir and the hydraulic pump.

3.5.2.6 Fluid Connections. - All hydraulic lines and fittings shall conform to commercial hydraulic industry standards. A minimum safety factor of 8 shall be used in sizing pipe and tubing. All connections shall be leakproof under operating maximum pressure. Hydraulic system components shall have straight thread or flange connections with "O"-ring seals. Tapered pipe threads shall not be used except for pressure gage and drain line connections. Lines shall be properly supported with damping mounts to minimize loosening of connections due to shock and vibration. All fittings and tubing shall be of corrosion resistant material.

3.5.3 Self Actuating Brake - An electrically or hydraulically released, spring-setting brake shall be provided to stop the winch drum. The brake shall automatically release when the manual control lever is moved from the neutral position or when automatic cycling is initiated. The brake shall set automatically when the control lever is returned to the neutral position, when automatic cycling is stopped, when the system alarm sounds or when there is a loss of electrical or hydraulic power. In the remote control mode, the brake should not set and release during direction reversal. The brake shall be designed to stop a load of 2250 pounds at mid-drum layer when lowering at 80 meters/minute. Braking action shall be smooth and the drum shall come to a complete stop within 3 seconds of brake engagement. The design shall allow a static pull of 3000 pounds at mid-drum layer without slippage.

3.5.4 Manual Brake - The winch shall be provided with a manually applied brake that is separate and distinct from the self-actuating brake. The manual brake shall stop a load of 2250 pounds at mid-drum layer when lowering at 80 meters/minute and shall hold a static load of 3000 pounds without slippage at mid-drum layer. The hand wheel or lever used to set the manual brake shall be readily accessible and clear of the cable drum and level wind device to afford maximum safety to operating personnel.

3.5.5 Cable Drum - The winch drum shall have a capacity for 4000 meters of 1-H-255 cable. At least one inch of flange shall remain uncovered when this length of cable is fully wound on the drum. The drum core and flanges shall have sufficient strength to withstand forces (no permanent set) due to cable contraction and expansion caused by temperature changes or self-loading during deployment. The drum shall be easily removed and installed. It shall have provisions for bringing the cable end from the inner wrap to the slip ring assembly. A grooved drum may be used; however, provisions shall be made for easy removal of the grooves to permit use of the drum for other cable diameters.

3.5.6 Slip Ring Assembly - A slip ring assembly with a minimum of two circuits shall be used to provide electrical continuity between the 1-H-255 sea cable and the data terminal on the ship. It shall have the following characteristics:

Voltage rating:	200 VDC minimum
Current rating:	2 amps minimum
Resistance :	0.1 ohm maximum
Noise :	100 microvolts maximum at 2 to 18 KHz.

3.5.7 Level Wind Device. - A power operated level wind device capable of smoothly laying the 1-H-255 cable onto the drum shall be provided. It shall accomodate cable leads from 10 degrees below the horizontal to 30 degrees above. Additionally, it shall accept cable from 30 degrees to either side of a line perpendicular to the drum axis. Provisions shall be made to permit disengagement of the level wind power drive and allow manual spooling of the line. A means to easily adapt the level wind device to other cable cable diameters shall be provided.

3.5.8 Line Metering Device. - A means to measure the amount and rate of cable payout and retrieval shall be provided. The amount shall be measured to an accuracy of ± 10 meters or 1% of the amount out, whichever is greater. The rate shall be determined to better than ± 1 meter/min.

3.5.9 Frame. - A single frame or bedplate of welded construction shall support the winch components. Provisions shall be made to allow the frame to be bolted to the deck of AGS and AGOR class ships without special modifications or additions to the frame. Frame design shall avoid pockets where water can stand or collect. Lifting eyes shall be provided such that the winch can be easily and safely moved. Tie down points shall be provided for securing the protective fabric cover.

3.5.10 Gearing. - If gear drive is used (as opposed to direct motor drive) on the winch drum, the gearing shall be in accordance with the American Gear Manufacturers Association (AGMA) publications. Design consideration shall be given to loads and speeds in the selection of gear types and sizes. Gears which exhibit smooth, quiet operation, such as helical gears shall be used. All gearing shall be enclosed in an oil-tight case and lubricated by an oil bath. The case shall have a drain plug that will permit complete draining. A means to easily check the oil level shall be provided.

3.5.11 Bearings. - Ball or roller bearings shall be used on gear and drum shafts and on all accessory mechanisms that rotate continuously during winch operation. All bearing shall conform to Anit-Friction Bearing Manufacturers Association (AFBMA) standards. Loading, speed, lubrication, and service life shall be considered in the selection of bearing types and classes. Exposed bearings shall be sealed to exclude contaminants and salt spray and to retain lubricant. Corrosion resistant grease fittings shall be provided in easily accessible locations.

3.5.12 Manual Control Unit - The manual control unit shall contain such switches, readouts, controls, and electronic circuitry necessary for complete manual control of the winch. As a minimum, the following features shall be included:

(a) Winch on/off switch This shall start and stop the electric motor, provided the control lever is in neutral and the remote/manual switch is in the manual mode.

(b) Manual control lever This shall permit manual operation of the winch whenever the remote/manual switch is in the manual mode.

(c) Remote/manual switch This shall control whether the winch operates in a manual mode or is controlled by the remote control unit.

(d) Line out read-out This shall display, in meters, the total amount of cable payed out. Resolution shall be to the nearest meter. The display should be easily readable in daylight or night. A manual reset shall be provided to zero the readout.

(e) Line speed readout This shall display the rate of line payout or retrieval in meters per minute. An indication whether the cable is paying out or coming in shall be provided. Resolution shall be to the nearest meter per minute. The readout shall be easily readable in daylight or night.

(f) Audible alarm The remote control unit shall sound an audible alarm and shall cause the self actuating brake to engage whenever the cable speed is greater than 100 meters/minute.

3.5.13 Remote Control Unit - The remote control unit shall contain such switches, controls, electronics and connectors as necessary to permit remote operation of the winch when the remote/manual switch on the manual control unit is in the remote mode. The remote control unit must contain as a minimum, the following features:

(a) Control connector If the control be analog, this shall consist of a BNC RG58U female connector. If the control is to be digital in IEEE 488 bus format, the connector shall be the standard IEEE 488 bus female connector, compatible with a Hewlett-Packard model 10833A connector.

(b) Remote indicator This shall indicate whether the remote or the manual unit is enabled. Such indicator shall be easily visible in day or night conditions and shall be controlled solely by the manual control unit remote/manual switch.

(c) Manual operation switch This shall provide a means by which control may be switched from remote to manual operation from the remote unit. It shall not be capable of enabling remote operation once manual operation is selected. When control is

passed to the manual controller by means of this switch, the manual speed lever shall be automatically set to neutral, after which the manual control may be exercised.

3.5.14 Fasteners. - All threaded fasteners, including set screws, shall be locked to prevent loosening due to vibration. Externally located fasteners shall be of corrosion resistant material. Threads shall be unified fine or coarse (UNF) or (UNC) thread series in accordance with National Bureau of Standards Handbook H28.

3.5.15 Electrical Connections - Watertight, corrosion resistant electrical connectors shall be provided wherever exposure to a hostile environment may be possible. All other electrical connections shall be made inside watertight enclosures or junction boxes. Connections for major components shall be readily accessible and easily disconnected to facilitate maintenance and repair.

3.5.16 Electrical Cables. - A power cable and a control cable shall be supplied with the winch. Both cables shall be of rugged construction suitable for exposure to weather and the marine environment. The power cable shall be at least 200 feet in length. The control cable shall be at least 200 feet in length.

3.5.17 Elapsed Time Meter. - A meter which indicates cumulative winch operating time in hours and tenths of hours shall be provided and mounted in an accessible location on the winch.

3.5.18 Protective Cover. - A waterproof coated fabric cover shall be supplied with the winch. The fabric weight shall be not less than 15 ounces per square yard. The cover shall fit neatly over the winch and shall have some means for attachment to the winch frame. Points of high stress or excessive wear shall be reinforced.

3.6 Painting.

3.6.1 Ferrous Surfaces. - Before assembly, all ferrous surfaces not intended to be bright shall be cleaned by abrasive blasting to near white metal. One coat of Dimetecote 6 or Dimetecote 9 (manufactured by Ameron, Protective Coatings division, Brea, California) or an equivalent inorganic zinc rich primer shall be applied to the blasted areas. Dry film thickness shall be not less than 2.5 mils. After assembly, the exposed primed surfaces shall be coated with Amercoat 84 or Amercoat 383HHS (manufactured by Ameron) or an equivalent polyamide epoxy topcoat. This coating shall have a minimum dry film thickness of 4 mils.

3.6.2 Non-ferrous Surfaces - Before assembly, all non-ferrous surfaces shall be cleaned and lightly abraded. One coat of Amercoat 83 primer or equivalent shall be applied immediately to the abraded areas. Dry film thickness shall be not less than 2 mils. After assembly, a topcoat shall be applied as in the previous section.

3.7 Safety.

Safety for operating and maintenance personnel shall be a consideration in the design and construction of the winch. When the equipment is properly installed and grounded, there shall be no accessible way for personnel to receive an electrical shock due to an internal fault or short. External projections and sharp corners which may cause injury in rough seas shall be avoided or properly safeguarded. Guards shall be provided on moving parts that are potentially hazardous.

3.8 Maintainability

The winch shall be designed for ease of maintenance. Time required to service the winch and cost of replacement parts shall be kept to a minimum. If special tools are required, they shall be supplied with and attached to the winch. Routine preventative maintenance procedures shall be easily performed aboard ship.

3.9 Materials.

All materials used shall be in accordance with either commercial or Government specifications. Part shall be compatible with each other and with the environment for which they are intended.

3.10 Workmanship.

Electrical components shall exhibit workmanship in accordance with MIL-STD-454, Requirement 9. Printed wiring shall conform to MIL-STD-275. Conformal coating is required on printed wiring assemblies. Internal hookup wire shall be selected and identified in accordance with MIL-STD-454, requirement 20. Soldering shall meet the requirements specified in MIL-STD-454, requirement 5.

3.11 Documentation.

The following documents shall be prepared in the contractor's format:

(a) Mechanical Drawings. These shall include all assembly drawings and parts lists used in fabricating the winch. All components shall be identified by manufacturer's name and part number. If electro-hydraulic control is utilized, a hydraulic circuit shall be prepared.

(b) Electrical drawings. These shall consist of schematics and wiring diagrams which depict all electrical and electronic components and interconnections. Assembly drawings showing component locations and complete parts lists shall be prepared.

3.12 Operation And Maintenance Manual.

An operation and maintenance manual shall be prepared and shall contain the following information as a minimum:

- (a) Description of equipment
- (b) Operating instructions.
- (c) Maintenance program.
- (d) Trouble-shooting procedures.
- (e) Documentation list.
- (f) Manufacturers' specifications for major components.

3.13 Recommended Spare Parts List.

A listing of recommended spare parts shall be prepared and delivered.

3.14 Test Plan And Test Report.

A test plan describing test setups and procedures to be used in quality conformance testing shall be submitted to the Naval Ocean Research and Development Activity, Code 331 for approval prior to running any tests. Code 331 shall be notified at least two weeks prior to testing in order to have a representative present during the manufacturer's testing of the winch. A test report giving the results of these tests shall be submitted to code 331.

4.0 QUALITY CONTROL PROVISIONS

4.1 Responsibility For Inspection.

Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to assure supplies and services conform to prescribe requirements.

4.2 Quality Conformance Inspection.

4.2.1 Visual Inspection. - The winch shall be visually examined to determine compliance with the requirements of this specification. Any non-conformance shall be cause for rejection.

4.2.2 Tests. - The winch shall be tested as specified in 4.3.1 through 4.3.4 to determine compliance with this specification. Any performance failures or shortcomings shall be cause for rejection of the winch.

4.3 Test Methods.

4.3.1 No Load Test. - The winch shall be operated without load at maximum drum speed for 30 minutes in each direction of rotation. No abnormal heating (150 F) of bearings or operating parts shall occur.

4.3.2 Rated Load Test. -

4.3.2.1 Rated Load Test - Manual Operation. - In the manual mode of operation, the winch shall payout and retrieve the rated load for at least 10 meters in each direction at a rate of 80 meters/minute. The load shall be stopped and held for approximately 20 seconds at the end of each half cycle. Cycling shall continue for a period of 30 minutes. The load shall be continuous throughout the test. No abnormal heating of any part shall occur.

4.3.2.2 Rated Load Test - Remote Operation - In the remote mode of operation, the winch shall payout and retrieve the rated load in each direction for at least 5.95 feet. The winch shall be controlled by an appropriate controller (either digital, utilizing, for example, a Hewlett-Packard 9825A desk-top calculator or analog). The winch shall be cycled with a sinusoidal signal providing a speed amplitude of 80 meters per minute with an acceleration amplitude of 0.2 g (1.96 meters/sec/sec), minimum. Cycling shall continue for a period of 60 minutes. The load shall be continuous throughout the test. The speed of payout shall be a linear function of the input control signal to within 0.5 centimeters per second. No abnormal heating (150 F) of any part shall occur. After 60 minutes, the manual override switch on the remote control unit shall be switched to manual operation. The winch shall stop automatically and manual control shall be verified in both directions.

4.3.3 Overload Test. - The winch shall payout and retrieve 150 percent the rated load at no specified speed through a distance of at least 20 feet in each direction for five complete cycles. The load shall be stopped and held for approximately 20 seconds at the end of each half cycle. The load shall be continuous throughout the test.

4.3.4 Brake Test. - The self-actuating brake and the manual brake shall be individually tested to demonstrate their ability to stop and hold 150 percent of the rated load when paying out at 80 meters/minute. Each brake shall be subjected to a static pull of 200 percent of the rated load and shall demonstrate no slippage.

5.0 PACKAGING

5.1 Packaging Requirements

Preservation-packaging and packing shall protect the equipment against corrosion, deterioration, and damage during shipment. Shipping container design and marking shall comply with applicable regulations as determined by the mode of transportation

6.0 NOTES

6.1 Data Requirements.

The data specified below shall be delivered by the contractor in accordance with the Contract Data Requirements List (DD Form 1423).

<u>Paragraph</u>	<u>Data Requirements</u>
3.11	Drawings
3.12	Operation and maintenance manual
3.13	Recommended spare parts list
3.14	Test Plan
3.14	Test Report

Appendix B: Computer code for Z-100 winch control

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0000

PAGE .132
FUNC SEGMENT
ASSUME CS FUNC
PUBLIC CIC
PUBLIC INIT
PUBLIC CLBF
PUBLIC RCV
PUBLIC READGPB
PUBLIC DSEND
PUBLIC WRITEGPB
PUBLIC CSEND
PUBLIC CMD
PUBLIC IFC
PUBLIC PASS
PUBLIC GPIBTIME
INCLUDE MACLIB.ASM

```
C
C
C
C ; MACLIB - library of commonly used macro definitions
C
C SVC MACRO DOSF ; Supervisor (DOS function) call
C MOV AH,DOSF
C INT 21H
C ENDM
C
C RETF MACRO ; Return far instruction emulation
C LOCAL TEMP1
C TEMP1 PROC FAR
C RET
C TEMP1 ENDP
C ENDM
C
C PUSHALL MACRO ; Save all registers
C PUSH AX
C PUSH BX
C PUSH CX
C PUSH DX
C PUSH SI
C PUSH DI
C PUSH BP
C PUSH DS
C PUSH ES
C ENDM
C
C POPALL MACRO ; Restore all registers
C POP ES
C POP DS
C POP BP
C POP DI
C POP SI
C POP DX
C POP CX
C POP BX
C POP AX
C ENDM
C
C ERRNZ MACRO LABEL,ADDRESS ; Check current location
C IF ((%-OFFSET LABEL)-ADDRESS NE 0)
C #1: DW LABEL,ADDRESS
C ENDIF
C ENDM
C
C ERRZR MACRO LABEL,ADDRESS ; Error if zero
C IF ((%-OFFSET LABEL)-ADDRESS EQ 0)
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[illegible]

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134      = 0001
135      = 0030
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141      = 0020
142      = 0060
143      = 0080
144      = 00A0
145      = 00C0
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148
149
150
151      = 0000
152      = 0003
153      = 0006
154      = 0010
155      = 0011
156      = 0012
157      = 001A
158      = 0013
159      = 001B
160      = 001C
161      = 001E
162      = 0016
163      = 001F
164      = 0017
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170      = 0009
171      = 003F
172      = 005F
173
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175
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177
178      = 0000
179      = 0080
180      = 0000
181      = 0010
182
183
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185
186
187      0000 00
188      0001 0000
189      0003 0000
190      0005      64 [
191                      FF
192
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```

ADMIR BITS

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MODE1 EQU 01H ; ADDRESS MODE 1
TRM EQU 30H ; GPIB FCTS FOR T/R2 AND T/R3

```

AUXMR HIDDEN REGISTERS

```

ICR EQU 20H ; INTERNAL COUNTER REGISTER
PPR EQU 60H ; PARALLEL POLL REGISTER
AUXRA EQU 80H ; AUX REG A
AUXRB EQU 0A0H ; AUX REG B
AUXRE EQU 0C0H ; AUX REG E

```

AUXMR COMMANDS

```

IEPON EQU 0000 ; IMMEDIATE EXECUTE POWER ON
FH EQU 0030 ; FINISH ( RELEASE ) HANDSHAKE
SEOI EQU 0060 ; SEND END
GTS EQU 0200 ; GO TO STANDBY
TCA EQU 0210 ; TAKE CONTROL ASYNCHRONOUSLY
TCS EQU 0220 ; TAKE CONTROL SYNCHRONOUSLY
TCSE EQU 0320 ; TAKE CNTL SYNC. ON END
LTN EQU 0230 ; LISTEN
LTNC EQU 0330 ; LISTEN CONTINUOUSLY
LUN EQU 0340 ; UNLISTEN
SIFC EQU 0360 ; SET IFC
CIFC EQU 0260 ; CLEAR IFC
SREN EQU 0370 ; SET REN
CREN EQU 0270 ; CLEAR REN

```

GPIB COMMANDS

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TCT EQU 0110 ; TAKE CONTROL
UNL EQU 0770 ; UNIVERSAL UNLISTEN
UNT EQU 1370 ; UNIVERSAL UNTALK

```

USER SPECIFIED COMMANDS

```

SELO EQU 0 ; SELECT ADRO
SEL1 EQU 2000 ; SELECT ADRI
MA EQU 0 ; GPIB ADDRESS OF GPIB-696 = 0
SC EQU 0200 ; SYSTEM CONTROLLER

```

PROGRAM VARIABLES/BUFFERS

```

CIC DB 0 ; CIC FLAG
T1 DW 0 ; CX REGISTER FOR TIME
T2 DW 0 ; DX REGISTER FOR TIME
CMDBUF DB 100 DUP(0FFH) ; COMMAND BUFFER FOR INTRFC MSGS

```

```

194      0069 00      C
195      006A 00      C
196      006B      64 [  C
197                      FF  C
198                      ]  C
199                      C
200      00CF 0000      C
201      00D1 36      C
202      00D2 00      C
203      00D3 00      C
204      00D4 00      C
205                      C
206      00D5 0200 [  C
207                      00  C
208                      ]  C
209                      C
210                      C
211                      C
212                      C
213                      C
214                      C
215                      C
216                      C
217                      C
218                      C
219                      C
220                      C
221                      C
222                      C
223                      C
224                      C
225                      C
226                      C
227                      C
228                      C
229      02D5      C
230      02D5 B0 02      C
231      02D7 E6 45      C
232      02D9 E4 41      C
233      02DB E4 42      C
234      02DD E4 45      C
235      02DF B0 00      C
236      02E1 E6 43      C
237      02E3 E6 41      C
238      02E5 E6 42      C
239      02E7 B0 31      C
240      02E9 E6 44      C
241      02EB B0 00      C
242      02ED E6 46      C
243      02EF B0 E0      C
244      02F1 E6 44      C
245      02F3 B0 25      C
246      02F5 E6 45      C
247      02F7 B0 80      C
248      02F9 E6 45      C
249      02FB B0 A0      C
250      02FD E6 45      C
251      02FF B0 C0      C
252      0301 E6 45      C
253      0303 B0 70      C
254      0305 E6 45      C
255      0307 B0 00      C
256      0309 E6 45      C
257      030B CB      C

```

```

CMDCT DB 0 ; NUMBER OF COMMANDS TO BE SENT
COUNT DB 0 ; NUMBER OF CURRENT CMDS XFERED
DATBUF DB 100 DUP(0FFH) ; DATA BUFFER

```

```

DATCT DW 0 ; NUMBER OF DATA BYTES TO BE SENT
OLA DB 54 ; LISTEN ADDRESS PASSED TO WRITE
SRE DB 0 ; REN FLAG ( NOT 0 SETS REN )
TCTADR DB 0 ; TCT ADDRESS OF NEW ACTIVE CONTROLLER
VSEDI DB 0 ; SEDI FLAG ( NON 0 TO SEND END MSG
; WITH LAST DSEND BYTE )
DUMMY DB 512 DUP(00H) ; DUMMY SPACE

```

INCLUDE INITGPID.ASM

```

*****
*
*   INITIALIZE   -   INIT
*
*****

```

THE DETAILED COMMENTS FOR THIS CODE HAVE NOT
BEEN INCLUDED. THEY MAY BE FOUND IN THE LISTING
ON PAGES D-6 AND B-7 OF THE GPIB-696 REF. MANUAL

```

INIT PROC FAR
MOV AL, 020
OUT AUXMR, AL
IN AL, ISR1
IN AL, ISR2
IN AL, CPTR
MOV AL, 0
OUT SPMR, AL
OUT IMR1, AL
OUT IMR2, AL
MOV AL, MODE1+TRM
OUT ADMR, AL
MOV AL, MA+SELO
OUT ADR, AL
MOV AL, DT1+DL1+SEL1
OUT ADR, AL
MOV AL, ICR+5
OUT AUXMR, AL
MOV AL, AUXRA
OUT AUXMR, AL
MOV AL, AUXRB
OUT AUXMR, AL
MOV AL, AUXRE
OUT AUXMR, AL
MOV AL, 1600
OUT AUXMR, AL
MOV AL, IEPON
OUT AUXMR, AL
RET

```

```

258      030C      C  INIT      ENDP
259      C
260      C          INCLUDE CSENDGPI.ASM
261      C ;
262      C ;
263      C ; *****
264      C ; *
265      C ; *      COMMAND SEND      - CSEND
266      C ; *
267      C ; *****
268      C ;
269      C ;
270      C ;
271      C ;      COMMENTS HAVE BEEN LEFT OUT  THEY MAY BE FOUND
272      C ;      ON PAGE B-18 OF GPIB-696 MANUAL
273      C ;
274      C ;
275      030C      C  CSEND  PROC  FAR
276      030C  2E: C6 06 006A R 00  C      MOV      COUNT, 0
277      0312  2E: A0 006A R      C  CSEND4: MOV      AL, COUNT
278      0316  3A C3              C      CMP      AL, BL
279      0318  74 1B              C      JZ       CSEND3
280      031A  E4 42              C  CSEND1: IN       AL, ISR2
281      031C  24 0B              C      AND     AL, CO
282      031E  74 FA              C      JZ       CSEND1
283      0320  2E: FE 06 006A R  C      INC     COUNT
284      0325  2E: BA 04              C      MOV     AL, BYTE PTR CS:[SI]
285      0328  E6 40              C      OUT     CDOR, AL
286      032A  E4 41              C      IN      AL, ISR1
287      032C  24 04              C      AND     AL, ERR
288      032E  75 03              C      JNZ     CSEND2
289      0330  46                  C      INC     SI
290      0331  EB DF              C      JMP     CSEND4
291      0333  B3 FF              C  CSEND2: MOV     BL, 3770
292      0335  CB                  C  CSEND3: RET
293      0336                      C  CSEND  ENDP
294      C
295      C          INCLUDE CMDGPIB.ASM
296      C ;
297      C ;
298      C ; *****
299      C ; *
300      C ; *      COMMAND      -      CMD
301      C ; *
302      C ; *****
303      C ;
304      C ;
305      C ;
306      C ;
307      C ;      THE COMMENTS FOR THIS CODE MAY BE FOUND ON PAGES
308      C ;      B-19 OF THE GPIB-696 MANUAL.
309      C ;
310      C ;
311      C ;
312      0336      C  CMD      PROC  FAR
313      0336  B0 11              C      MOV     AL, TCA
314      0338  E6 45              C      OUT     AUXMR, AL
315      033A  BE 0005 R          C      MOV     SI, OFFSET CMDBUF
316      033D  2E: BA 1E 0069 R  C      MOV     BL, CMDCT
317      0342  9A 030C ---- R    C      CALL    CSEND
318      0347  CB                  C      RET
319      0348                      C  CMD  ENDP
320      C
321      C          INCLUDE IFCGP'B.ASM

```

```

322
323
324
325
326
327
328
329
330
331 0348
332 0348 B0 1E
333 034A E6 45
334 034C B9 012C
335 034F E2 FE
336 0351 B0 16
337 0353 E6 45
338 0355 CB
339 0356
340
341
342
343
344
345
346
347
348
349
350
351
352
353 0356 00
354 0357
355 0357 B0 10
356 0359 E6 45
357 035B B9 0000
358 035E 2E: C6 06 0356 R 00
359 0364 E4 41
360 0366 24 11
361 0368 75 0F
362
363 036A 2E: FE 06 0356 R
364 036F 2E: A0 0356 R
365 0373 3C 32
366 0375 74 1D
367 0377 EB EB
368 0379 2E: C6 06 0356 R 00
369 037F E4 40
370 0381 2E: B9 05
371 0384 47
372 0385 41
373 0386 3B D9
374 0388 75 DA
375 038A EB 08 90
376 038D E4 40
377 038F 2E: B8 05
378 0392 9B D9
379 0394 90
380 0395 CB
381 0396
382
383
384
385

```

```

C
C
C *****
C *
C * IFC
C *
C *****
C
C IFC PROC FAR
C MOV AL, SIFC
C OUT AUXMR, AL
C MOV CX, 300
C IFC1 LOOP IFC1
C MOV AL, CIFC
C OUT AUXMR, AL
C RET
C IFC ENDP
C
C INCLUDE RCVGPID.ASM
C
C ;
C ;
C ; *****
C ; *
C ; * RECEIVE -RCV
C ; *
C ; *****
C ;
C ;
C ; COMMENTS ON PAGES B-10 AND B-11 OF MANUAL
C ;
C ERRCNT DB 0
C RCV PROC FAR
C MOV AL, 200
C OUT AUXMR, AL
C MOV CX, 0
C MOV ERRCNT, 0
C RCV3: IN AL, ISR1
C AND AL, ENDRX+DATI
C JNZ NEXT
C IN AL, DIR
C INC ERRCNT
C MOV AL, ERRCNT
C CMP AL, 50
C JE RCV6
C JMP RCV3
C NEXT: MOV ERRCNT, 0
C IN AL, DIP
C MOV BYTE PTR CS:[DI], AL
C INC DI
C INC CX
C CMP BX, CX
C JNZ RCV3
C JMP RCV6
C RCV5: IN AL, DIR
C MOV BYTE PTR CS:[DI], AL
C MOV BX, CX
C RCV6: NOP
C RET
C RCV ENDP
C
C INCLUDE READGPID.ASM
C
C ;
C ;
C ;

```

```

386
387
388
389
390
391
392
393 0396
394 0396 FA
395 0397 B0 00
396 0399 E6 45
397 039B 9A 034B ---- R
398 03A0 B9 01F4
399 03A3 E2 FE
400 03A5 2E: A0 0005 R
401 03A9 2E: A2 0007 R
402 03AD B0 5F
403 03AF 2E: A2 0005 R
404 03B3 B0 3F
405 03B5 2E: A2 0006 R
406 03B9 B0 20
407 03BB 2E: A2 0008 R
408 03BF 2E: A0 0069 R
409 03C3 04 03
410 03C5 2E: A2 0069 R
411 03C9 9A 0336 ---- R
412 03CE B0 10
413 03D0 E6 45
414 03D2 2E: 8B 1E 00CF R
415 03D7 BF 006B R
416 03DA 9A 0357 ---- R
417 03DF B0 11
418 03E1 E6 45
419 03E3 FB
420 03E4 CB
421 03E5
422
423
424
425
426
427
428
429
430
431
432
433
434 03E5
435 03E5 8B CB
436 03E7 E4 41
437 03E9 24 06
438 03EB 74 FA
439 03ED 24 04
440 03EF 75 19
441 03F1 49
442 03F2 7C 19
443 03F4 75 0C
444 03F6 2E: 80 3E 00D4 R 00
445 03FC 74 04
446 03FE B0 06
447 0400 E6 45
448 0402 2E: BA 04
449 0405 E6 40

C ; *****
C ; *
C ; * READGPB
C ; *
C ; *****
C ;
C ;
C READGPB PROC FAR
C CLI
C MOV AL, 0
C OUT AUXMR, AL
C CALL IFC
C MOV CX, 500
C XLOOP: LOOP XLOOP
C MOV AL, CMDBUF
C MOV CMDBUF+2, AL
C MOV AL, UNT
C MOV CMDBUF, AL
C MOV AL, UNL
C MOV CMDBUF+1, AL
C MOV AL, 400
C MOV CMDBUF+3, AL
C MOV AL, CMDCT
C ADD AL, 3
C MOV CMDCT, AL
C CALL CMD
C MOV AL, GTS
C OUT AUXMR, AL
C MOV BX, DATCT
C MOV DI, OFFSET DATBUF
C CALL RCV
C MOV AL, TCA
C OUT AUXMR, AL
C STI
C RET
C READGPB ENDP
C
C INCLUDE DSENDGPI.ASM
C ;
C ; *****
C ; *
C ; * DATA SEND - DSEND
C ; *
C ; *****
C ;
C ;
C DSEND PROC FAR
C MOV CX, BX
C DSEND1: IN AL, ISR1
C AND AL, DO+ERR
C JZ DSEND1
C AND AL, ERR
C JNZ DSEND3
C DEC CX
C JL DSEND4
C JNZ DSEND2
C CMP VSE01, 0
C JZ DSEND2
C MOV AL, SEDI
C OUT AUXMR, AL
C DSEND2: MOV AL, BYTE PTR CS:[SI]
C OUT CDOR, AL

```

```

450      0407 46      C      INC      SI
451      0408 EB DD    C      JMP      DSEND1
452      040A BB FFFF  C      DSEND3: MOV     BX,177777Q
453      040D CB      C      DSEND4: RET
454      040E          C      DSEND  ENDP
455
456                      C      INCLUDE WRITEGPI.ASM
457
458
459                      C      ;
460                      C      ;
461                      C      ; *****
462                      C      ; *
463                      C      ; WRITEGPIB
464                      C      ; *
465                      C      ; *****
466
467      040E          C      WRITEGPIB  PROC    FAR
468      040E 2E: C6 06 0069 R 04  C      MOV     CMDCT,4
469      0414 2E: C6 06 0005 R 5F  C      MOV     CMDBUF,UNT
470      041A 2E: C6 06 0006 R 3F  C      MOV     CMDBUF+1,UNL
471      0420 2E: C6 06 0007 R 40  C      MOV     CMDBUF+2,MA+100Q
472      0426 2E: A0 00D1 R      C      MOV     AL,CLA
473      042A 2E: A2 000B R      C      MOV     CMDBUF+3,AL
474      0433 B0 10      C      CALL    CMD
475      0435 E6 45      C      MOV     AL,GTS
476      0437 2E: 8B 1E 00CF R    C      OUT     AUXMR,AL
477      043C BE 006B R      C      MOV     BX,DATCT
478      043F 9A 03E5 ---- R    C      MOV     SI, OFFSET DATBUF
479
480                      C      CALL    DSEND
481                      C      .WRITE1  IN      AL,ISR1
482                      C      .      AND     AL,DO
483                      C      .      JZ     WRITE1
484      0444 B0 11      C      MOV     AL,ICA
485      0446 E6 45      C      OUT     AUXMR,AL
486      0448 2E FE 0E 0069 R    C      DEC     CMDCT
487      044D 9A 0336 ---- R    C      CALL    CMD
488      0452 CB      C      RET
489      0453          C      WRITEGPIB  ENDP
490
491                      C      INCLUDE PASSGPIB.ASM
492
493                      C      ;
494                      C      ;
495                      C      ; *****
496                      C      ; *
497                      C      ; PASS - PASS ADDRESSES OF BUFFERS
498                      C      ; TO CALLING PROGRAM
499                      C      ; *
500                      C      ; *****
501
502                      C      CALLING SEQUENCE.
503
504                      C      CALL PASS(CIC,CMDBUF,CMDCT,DATBUF,DATCT,OLA,SRE,TCT,
505                      C      VSEOI)
506
507                      C      WHERE THE PARAMETER ADDRESSES ARE DEFINED AS 16 BIT
508                      C      WORDS AS FOLLOWS
509
510                      C      SYMBOL      DEFINITION
511
512                      C      -----
513                      C      CIC      CONTROLLER IN CHARGE FLAG

```



```

578      04AD E2 FA      C      LOOP      DBFZ
579      04AF 2E: C6 06 00D1 R 34 C      MOV      DLA, 52
580      04B5 2E: C6 06 006A R 00 C      MOV      COUNT, 0
581      04BB 2E: C6 06 0000 R 00 C      MOV      CIC , 0
582      04C1 2E: C6 06 0069 R 00 C      MOV      CMDCT, 0
583      04C7 2E: C7 06 00CF R 0000 C      MOV      DATCT, 0
584      04CE 2E: C6 06 00D2 R 00 C      MOV      SRE , 0
585      04D4 2E: C6 06 00D3 R 00 C      MOV      TCTADR, 0
586      04DA 2E: C6 06 00D4 R 00 C      MOV      VSED1 , 0
587      04E0 CB      C      RET
588      04E1      C      CLBF      ENDP
589      C
590      C      INCLUDE TIMEGP1B ASM
591      C ;
592      C ;
593      C ;
594      C ;      *
595      C ;      *      GPIBTIME      *
596      C ;      *
597      C ;      *
598      C ;
599      C ;
600      04E1      C      GPIBTIME      PROC      FAR
601      04E1 D4 2C      C      MOV      AH, 2CH
602      04E3 CD 21      C      INT      21H
603      04E5 2E: B9 0E 0001 R      C      MOV      T1, CX
604      04EA 2E: B9 16 0003 R      C      MOV      T2, DX
605      04EF CB      C      RET
606      04F0      C      GPIBTIME      ENDP
607      C
608      04F0      C      FUNC      ENDS
609      C      END      INIT

```

Macros.

Name	Length
FRRNZ	0002
ERRZR	0002
PDPALL	0003
PUSHALL	0003
RETF	0001
SVC	0001

Segments and groups:

Name	Size	align	combine	class
FUNC	04F0	PARA		NONE

Symbols:

N a m e	Type	Value	Attr
ADMR	Number	0044	
ADR	Number	0046	
ADRO	Number	0046	
ADR1	Number	0047	
ADSR	Number	0044	
AUXMR	Number	0045	
AUXRA	Number	0080	
AUXRB	Number	00A0	
AUXRE	Number	00C0	
BASE	Number	0040	
CDOR	Number	0040	
CIC	L BYTE	0000	FUNC Global
CIFC	Number	0016	
CLBF	F PROC	0497	FUNC Global Length =004A
CMD	F PROC	0336	FUNC Global Length =0012
CMDBUF	L BYTE	0005	FUNC Length =0064
CMDCT	L BYTE	0069	FUNC
CMDZ	L NEAR	049D	FUNC
CO	Number	0008	
COUNT	L BYTE	006A	FUNC
CPTR	Number	0045	
CREN	Number	0017	
CSEND	F PROC	030C	FUNC Global Length =002A
CSEND1	L NEAR	031A	FUNC
CSEND2	L NEAR	0333	FUNC
CSEND3	L NEAR	0335	FUNC
CSEND4	L NEAR	0312	FUNC
DATBUF	L BYTE	0068	FUNC Length =0064
DATCT	L WORD	00CF	FUNC
DAT1	Number	0001	
DBFZ	L NEAR	04A9	FUNC
DIR	Number	0040	
DL1	Number	0020	
DO	Number	0002	
DSEND	F PROC	03E5	FUNC Global Length =0029
DSEND1	L NEAR	03E7	FUNC
DSEND2	L NEAR	0402	FUNC
DSEND3	L NEAR	040A	FUNC
DSEND4	L NEAR	040D	FUNC
DT1	Number	0040	
DUMMY	L BYTE	00D5	FUNC Length =0200
ENDRX	Number	0010	
EOI	Number	0080	
EOSR	Number	0047	
ERR	Number	0004	
ERRCNT	L BYTE	0356	FUNC
FH	Number	0003	
GPBTIME	F PROC	04E1	FUNC Global Length =000F
GTS	Number	0010	
ICR	Number	0020	
IEPON	Number	0000	
IFC	F PROC	0348	FUNC Global Length =000E
IFC1	L NEAR	034F	FUNC
IMR1	Number	0041	
IMR2	Number	0042	
INIT	F PROC	02D5	FUNC Global Length =0037
ISR1	Number	0041	
ISR2	Number	0042	
LTN	Number	0013	
LTNC	Number	001B	

LUN.
 MA
 MODE1.
 NATN
 NEXT
 OLA.
 PASS
 PPR.
 RCV.
 RCV3
 RCV5
 RCV6
 READGPB
 SC
 SELO
 SEL1
 SEOI
 SIFC
 SPMR
 SPSR
 SRE.
 SREN
 T1
 T2
 TCA.
 TCS.
 TCSE
 TCT
 TCTADR
 TRM.
 UNL.
 UNT
 VSEOI
 WRITEGPB
 XLOOP

Warning Severe
 Errors Errors
 0 0

Number	001C		
Number	0000		
Number	0001		
Number	0040		
L NEAR	0379	FUNC	
L BYTE	00D1	FUNC	
F PROC	0453	FUNC	Global Length =0044
Number	0060		
F PROC	0357	FUNC	Global Length =003F
L NEAR	0364	FUNC	
L NEAR	038D	FUNC	
L NEAR	0394	FUNC	
F PROC	0396	FUNC	Global Length =004F
Number	0010		
Number	0000		
Number	0080		
Number	0006		
Number	001E		
Number	0043		
Number	0043		
L BYTE	00D2	FUNC	
Number	001F		
L WORD	0001	FUNC	
L WORD	0003	FUNC	
Number	0011		
Number	0012		
Number	001A		
Number	0009		
L BYTE	00B3	FUNC	
Number	0030		
Number	003F		
Number	005F		
L BYTE	00D4	FUNC	
F PROC	040E	FUNC	Global Length =0040
L NEAR	03A3	FUNC	

Symbol	Cross Reference	# is definition)			Cref-1											
ADMR		36#	174													
ADR		40#	176	178												
ADRO		39#														
ADR1		41#														
ADSR		35#	339													
AUXMR		38#	168	180	238	257	261	279	284	287	305	331	333	338	345	
		373	401	409												
AUXRA		86#														
AUXRB		87#														
AUXRE		88#														
BASE		26#	27	28	29	30	31	32	33	34	35	36	37	38	39	
		40	41	42												
CDOR		28#	209	375												
CIC		130#	280													
CIFC		105#	260													
CHD		10	236#	243	329	343	399	411								
CHDBUF		131#	239	320	321	323	325	394	395	396	398					
CHDCT		135#	240	326	328	342	393	410								
CO		57#	202													
COUNT		136#	200	204	207											
CPTR		37#														
CREN		107#														
CSEND		9	199#	217	241											
CSEND1		201#	203	214												
CSEND2		212	215#													
CSEND3		206	216#													
DATBUF		137#	335	403												
DATCT		141#	334	402												
DATI		48#	290													
DIR		27#	294	301												
DL1		65#	177													
DO		49#	363	406												
DSEND		7	360#	380	404											
DSEND1		362#	364	377												
DSEND2		369	371	374#												
DSEND3		366	378#													
DSEND4		368	379#													
DT1		64#	177													
ENDRX		51#	290	292												
EOI		63#														
EQSR		42#														
ERR		50#	211	363	365											
FH		95#	278													
FUNC		2#	3	415												
GTS		97#	332	400												
ICR		84#	179													
IEPON		94#	167													

Symbol Cross Reference

(* is definition)

Cref-2

IFC	11	255#	263			
IFC1	259#	259				
IMR1	30#	169				
IMR2	32#	170				
INIT	4	166#	182	416		
ISR1	29#	171	210	289	362	405
ISR2	31#	172	201			
LTN	101#	330				
LTNC	102#					
LUN	103#	344				
MA	123#	175	396			
MODE1	77#	173				
NATN	71#	340				
OLA	142#	397				
PPR	85#					
RCV	5	277#	307	336		
RCV1	282	296#				
RCV2	285	288#				
RCV3	287#	291	299			
RCV5	293	301#				
RCV6	300	304#				
READ	6	319#	347			
READ1	339#	341				
SC	124#					
SELO	121#	175				
SEL1	122#	177				
SEDI	96#	372				
SIFC	104#	256				
SPMR	34#					
SPSR	33#					
SRE	143#					
SREN	106#					
TCA	98#	237	408			
TCS	99#	337				
TCSE	100#					
TCT	113#					
TCTADR	144#					
TRM	78#	173				
UNL	114#	324	395			
UNT	115#	322	394			
VSEOI	145#	370				
WRITE	8	392#	413			
WRITE1	405#	407				

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