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A NEW ECHO-SOUNDER SYSTEM

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INTRODUCTION

Simrad has a long tradition in manufacturing acoustic instruments for fisheries research. Today the three main instruments for sea-going fisheries research vessels are:

EK 400   A general purpose scientific sounder with a powerful transmitter and an accurate receiver with both 20 log r and 40 log r TVG. EK 400 was introduced in 1980.

QD   Digital Echo-Integrator for abundance estimation in connection with EK 400. QD was also introduced in 1980.

ES 400   A split-beam echo sounder for target strength measurements. ES 400 was introduced in 1985.

Simrad has now developed a new echo-sounder EK 500 which contains the functions of all three instruments:

-    high performance echo-sounder transmitter and receiver
-    echo-integration
-    split-beam target strength measurements

It was decided early in the development process to take advantage of the state of art in electronics, and make a completely new design rather than utilizing existing circuits in the mentioned products. EK 500 represents a new generation.

A SELECTION OF FREQUENCIES

The EK 500 echo-sounder will be available at 38 kHz and 120 kHz with split-beam transducers and transceivers. In addition there will be single-beam transducers and transceivers at 12, 18, 27, 38, 49, 120 and 200 kHz. The cabinet for transceiver and processor has room for three transceivers, and has connections for three transducers.
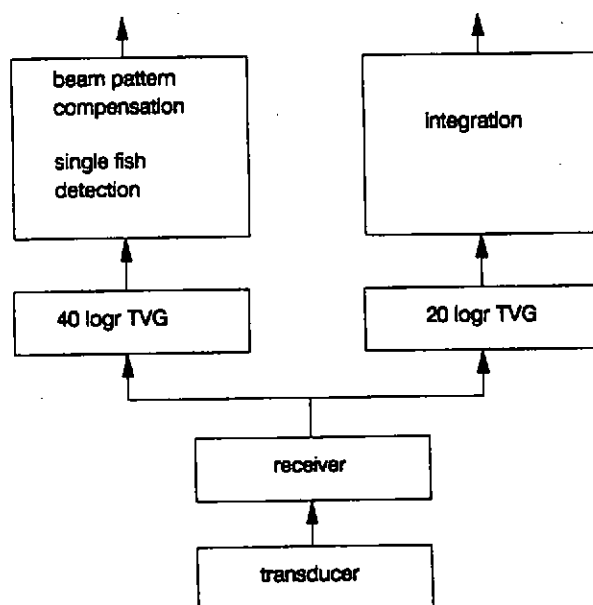
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SIMULTANEOUS ECHO-INTEGRATION AND TARGET STRENGTH MEASUREMENT

Abundance estimation with a calibrated echo-sounder and an echo-integrator is today a well established procedure. The echo sum derived from the integrator gives figures for the volume back scattering strength which then has to be converted to total fish weight or number of fish. If the target strength of the fish is known in addition to the volume back scattering strength this leads directly to the number of fish.

In a mixed population with different fish sizes the target strength distribution is used for splitting the integrated echo sum onto different fish sizes.

The new EK 500 has simultaneous echo-integration and target strength measurement by means of two software modules working in parallel. The two modules utilize exactly the same digitized echo signal as input.

Simplified diagram of signal path

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The echo-integration is based upon the echo signals from the
20 log r TVG, and is performed in a number of depth layers.
The operator specifies up to ten main layers, each of which
may be further divided in a maximum of 50 sub layers. The main
layers can be set without restrictions. They may be pelagic or
bottom-locked. Individual echo thresholds may be applied. They
may overlap or even be identical. This is useful for applying
different echo thresholds to the same depth interval and
thereby obtain integration on different parts in a biomass:
fish, plankton, noise. Within one main layer the sub layers
are equidistant and have equal threshold. The integrated
values are accumulated during one log interval. The operator
specifies the log interval. The minimum log interval is 0.1
nautical mile. The output value from the echo integration is
either

S_V, volume back scattering strength in dB (per cubic metre)
or s_A, area back scattering coefficient, as a linear value
(per square nautical mile)

selected by the operator.

A rising line in the echogram shows how the echo-integration
in a main layer accumulates. This is a feature which is
useful for judging the contributions to the integrated sum
from different objects, e.g. schools and single fish. A con-
centrated school causes a steep rise in the line, and this
increment tells the contribution from the school.

The target strength of the fish is calculated from the echo
signals through the 40 log r TVG, and with removal of the
transducer beam pattern according to the split-beam method.
The fish must be resolved as a single fish. EK 500 has a new
single fish detector to classify the echoes as either single
fish or multiple fish. This single fish detector looks at the
length of the echo and the stability in the angle measurement.
The length criterion is well known from previous echo-
sounders: A single fish gives a short echo, approximately
equal to the transmitter pulse. If two or more fishes are
present at different depth, but within the same pulse length,
the echo will be elongated. The angle criterion is an advanced
feature offered by the split-beam technique: Longitudinal
angle and transverse angle to the target is measured. A single
fish produces stable angle information. If two or more fish
are present in different directions, but within the same pulse
length, the angle information will be unstable.

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At the end of a log interval the target strength distribution in each of the main layers are calculated, with the target strength classified in 1.5 dB groups. There are 24 groups, covering a range of 36 dB.

COLOUR MONITOR AND COLOUR PRINTERS

The echogram is displayed on a colour monitor with standard RGB input. Additional slave monitors may be connected.

The user can manually control the system with a joystick on the display unit. A menu on the screen explains how to control the system. The menu is displayed on the left hand side of the screen and may be removed when not in use, thus leaving the entire screen for echogram and data presentation. The system can also be remotely controlled through Ethernet or serial line.

The transmitter ping interval is set by the operator, and is thereafter kept constant. This ensures that the horizontal scale on the recordings is a true time scale. The depth range displayed on the screen is set by the operator, independent of the ping interval, but of course within the limits set by the speed of sound in water. He is free to watch a range from the sea surface, or a phased down range of any size. This feature enables the operator to expand a small depth interval over the entire screen and study details in the echo traces. The range setting on the screen does not affect the echo recordings on the colour printers and it does not affect the data output stream to host computer or data logging systems.

A bar chart of the TS distribution can be displayed on the screen.

For permanent recording two colour printers are part of the system. The two printers are connected to two independent outputs on the transceiver/processor unit, so that the two printers can record different echograms, for instance a 20 log r echogram on one printer and a 40 log r echogram on the other printer. Another opportunity is to record two different ranges, e.g. 0 - 250 m on one printer and 250 - 500 m on the other printer. The range setting on the printers does not affect the range on the colour display and it does not affect the data output stream to host computer or data logging systems.

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Together with the 20 log r echogram on the colour printer a
table of the integrated s_A values is presented each log
interval.

Together with the 40 log r echogram on the colour printer a
bar chart of the target strength distribution is presented
after each log interval, as well as tables for the distribu-
tions.

Colour display

Colour printers

EK500

Transceiver and

processor

Transducers

EK 500 units
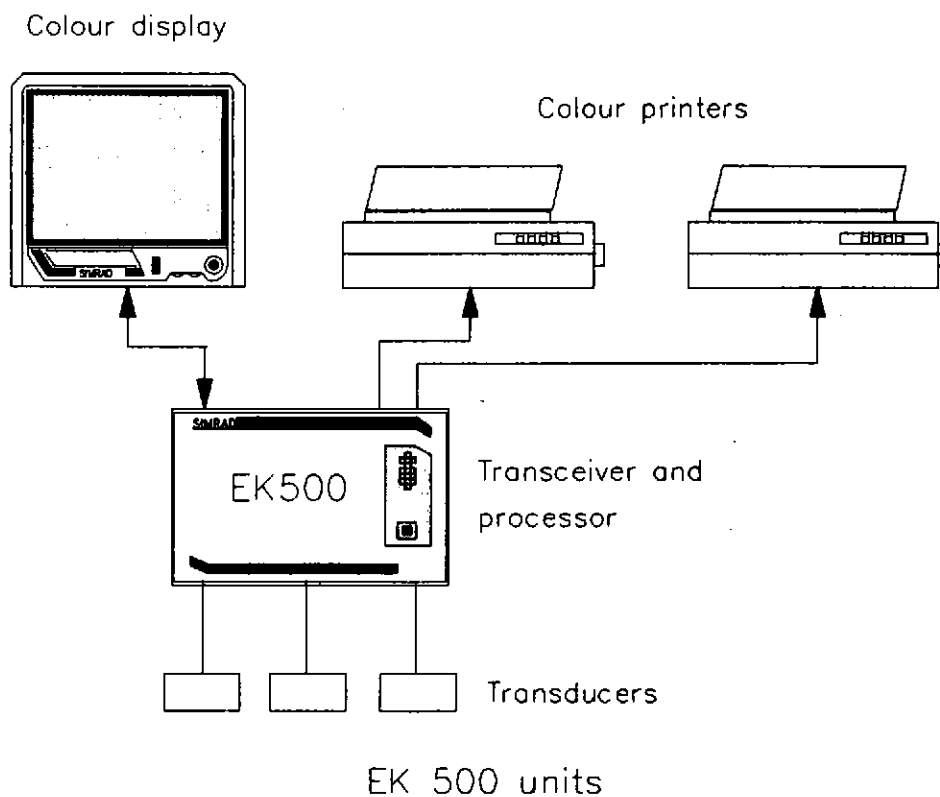
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SPEED LOG

EK 500 has interface for connection to a speed log:
-     one pulse per nautical mile
-     200 pulses per nautical mile
The operator has the possibility of manual setting of the vessel speed.

SERIAL INTERFACES

The system is equipped with four RS 232 serial lines for connection to :

-     host computer
-     remote VDU terminal
-     navigation receiver
-     trawl depth data

LAN INTERFACE

The system is also equipped with a Local Area Network interface of the Ethernet type for efficient high speed interfacing to standard computers (VAX, SUN, HP, IBM PC etc.) used for remote control, data logging and postprocessing. Communication via the Ethernet port is based on the TCP/IP protocol, a de facto standard which is included in the operating system of virtually all UNIX computers and is available for most other common operating systems. The TCP/IP/Ethernet standard is a popular LAN standard within office, engineering and university environments, and allows multiple computer-to-computer connections to coexist on the cable simultaneously by timesharing. We foresee that Local Area Networks of this type will be common onboard research vessels in the near future, and the EK 500 thus will match these systems.
The Ethernet 50 ohm coax cable allows large amounts of sample data, half processed integration data and final data to be transferred to a host computer.

PARALLEL OUTPUT

An 8 bit parallel output supplies data for each echo sample throughout the whole echo sounder range: echo amplitude, target strength, longitudinal angle and transverse angle.

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A NEW RECEIVER FRONT END WITH LARGE DYNAMIC RANGE

Starting the development of the new scientific sounder a number of limitations of existing receiver frontend designs were identified. Measurement accuracy could not be further improved using traditional TVG controlled amplifiers due to their limited gain linearity and stability. Furthermore, echo integration of the plankton versus schools of fish represents a dynamic range in echo level which exceeds the instantaneous dynamic range of digitized signal in existing equipment. A totally new receiver frontend was therefore designed in order to improve these properties. The new frontend includes no TVG but rather implements an instantaneous dynamic input range from -160 to 0 dB re 1 W, which corresponds to the background noise under quiet conditions and the maximum bottom echo signal in very shallow water. Thus the frontend merely functions as a power meter digitizing all input levels in one range with an amplitude accuracy of a fraction of a dB.

UNLIMITED TVG RANGE

The new echo-sounder implements the TVG function in software as part of the power budget algorithms, and ''compensation for transmission loss '' would have been a more appropriate term. The physical transmission loss is continuous and does not have any start or stop depth, and also the TVG is here implemented as a continuous function without start or stop, assuring that the measured target strength is always correct whatever the depth of the target.
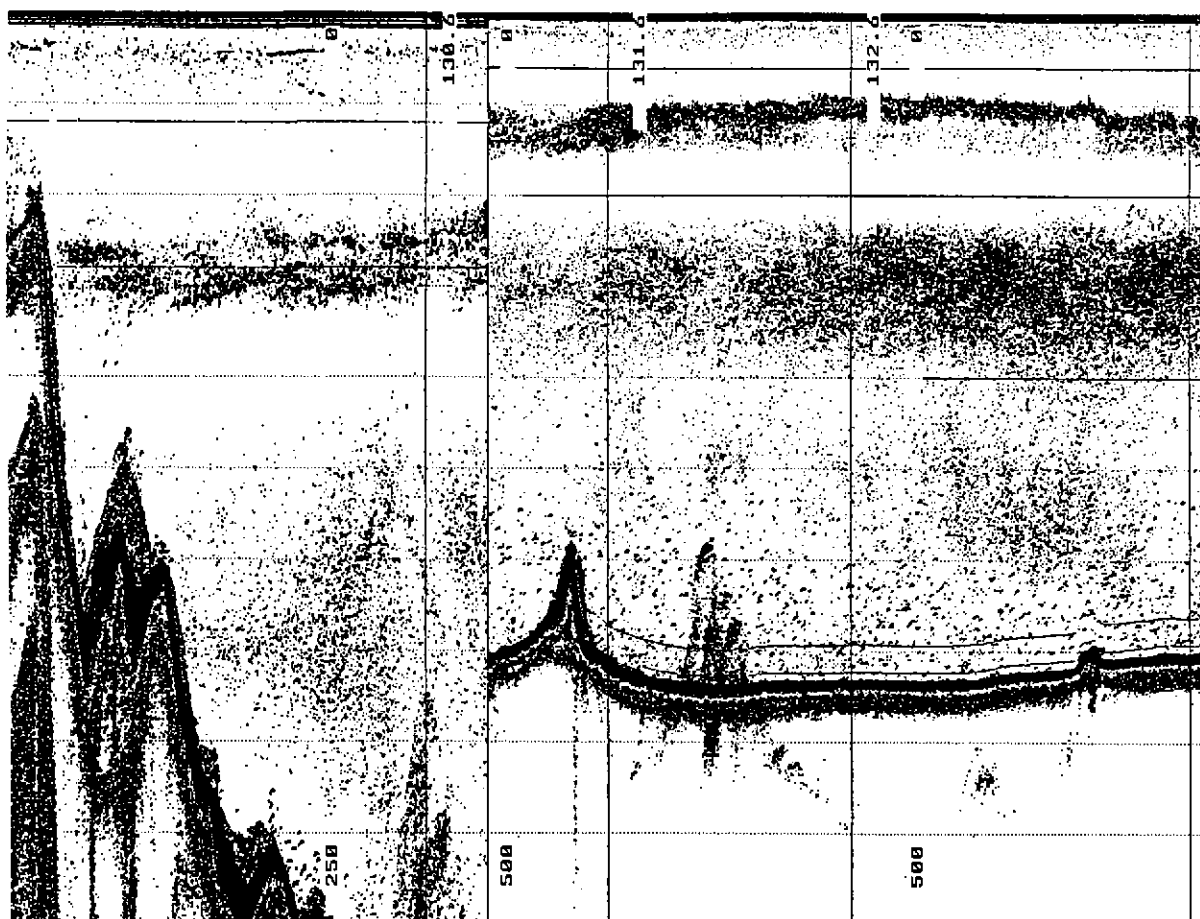
HIGH SPEED PROCESSOR

All signal processing tasks are performed by a dedicated micro processor board containing CPU and mathematics coprocessor (10 MHz 80286+80287). A standard real time operating system is used due to the complexity of the software. The internal representation of physical quantities is either a 16 bit dB format or standard floating point format. The dynamic range of algorithms and calculations is therefore virtually unlimited. Since the echo-integrator is no longer a separate unit all settings are easily taken care of so that echo-integration data, target strength distribution and echogram presentation will always be consistent.

TEST

A prototype of the new echo-sounder system has been tested at sea this winter on board Simrads own vessel, and the first model is now being evaluated in cooperation with The Institute of Marine Research, Bergen on board the research vessel G.O.Sars. The specifications decribed in this paper may change slightly as results from these tests are evaluated. The system will be commercially available in mid-1989.

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Layer Setting	Sa/Thick
1 P -100/ 30 70	97174 36.5
2	
3	
4	
5	
6	
7	
8	
9	
10	

Layer Setting	Sa/Thi
1 P -100/ 30 100	200 70.
2	
3	
4	
5	
6	
7	
8	
9	
10 B -100/ 5.0 20.0	52: 15.

EK 500 recording from G. O. Sars in Storfjord, Norway,
Dec. 1988.
The upper biomass layer is mainly krill, and the layer
below is blue whiting.