

PREFACE

Ocean covers an area of about 140 million square miles or 362 million sq km. An estimated 50–80 % of all life on earth is found under the ocean surface and the oceans contain 99 % of the living space on the planet. Less than 10 % of that space has been explored by humans. The dark, cold environment called the deep sea constitutes 85 % of of the ocean's area and 90 % of its volume. The average depth of the ocean is 3,795 m. The average height of the land is 840 m. The oceans cover 71 % (and rising) of the Earth's surface and contain 97 % of the Earth water. Less than 1 % is fresh water, and 2–3 % is contained in glaciers and ice caps (and is decreasing). Oceans are the site of 90 % of all volcanic activity. Our oceans teem with life ranging from the blue whale, the biggest animal on Earth, to tiny microbes. But nobody knows exactly how many different species live in this environment. There is no data for around 20 % of the ocean's volume. It's a location whose details everyone is very much interested to know.

This book covers many topics encountered in the design and application of electronic instruments related to the ocean, both basic ideas and advanced technologies. It also covers requirements of ocean research.

Chapter 1 discusses oceanographic remote sensing, including applications, radar, radiometry, satellites, sonar, telemetry, laser and LIDAR, and research ideas. It also discusses the difference between satellite images

and maps, remote sensing and GIS, remote sensing and aerial photography, remote sensing and sonar. It also describes oceanography, synthetic aperture radar, NADIR radar, microwave radiometry, infrared radiometers, imaging radiometer, microwave measurement of ocean wind, wind and wave height measurements, mapping the ocean floor with single beam echo sounding, multi-beam bathymetry, sound as underwater navigation, echo-sounders, applications of telemetry, data collection in LIDAR, discrete-return LIDAR, waveform recording devices, and applications of LIDAR remote sensing.

Chapter 2 discusses sensors for ocean monitoring and their measuring parameters. Sometimes satellites are called sensors, as well as the sensors they carry. It discusses the sensors, scanners, weather sensing, SAR sensors, marine observation sensors (MOS), ocean color monitoring sensor (OCM) and micro-sensors for ocean acidification monitoring. It also discusses the measurement of ocean parameters, such as ocean color, sediment monitoring, surface currents, surface wind, wave height, wind speed, sea surface temperature, upwelling, sampling, wave energy, and ocean floor. It also describes spatial resolution, pixel size, scale, spectral/radiometric resolution, temporal resolution, sensor design, sensor selection, and research on ocean phenomena.

Chapter 3 discusses underwater acoustics, including the interaction of sound with the seafloor, sound wave features, transmission of data underwater, wave height, wave velocities, bubbles study, water depth, sea temperature, global climate change, ocean current measurement using sound, fish finding, study of Earth history, and surf zone measurement using sound. It describes locating and identifying fish, methods of underwater communication, measurement of ocean temperature using acoustic tomography, inverted echo-sounders, acoustic doppler current profilers, RAFOS floats, and reciprocal transmission.

Chapter 4 discusses underwater wireless communication, including acoustic waves and acoustic communication, optical waves and optical communication, underwater acoustic communication, underwater optical communications, underwater mobile communication, types of modulation, Internet, and GPS. It describes the underwater communication **environment and propagation mediums**, limitations of underwater acoustic communication, using laser as optical communication above water and underwater, protocol stack for the underwater laser sensor network, wireless laser communication system description, **instrumentation system devices**, **the MEMS approach**, benefits of smart optical systems

for underwater vehicles, systems and methods in underwater optical communication, frequency shift keying as applied to UAC, direct sequence spread spectrum (DSSS), multi-carrier modulation, multi-input multi-output techniques, Internet to ships using oceanographic tool (SeaNet), Internet access for voyagers, voice communication on ship, submarine communications cable, optical submarine cable repeaters, Antarctica, perfectly secure communication and environmental impact.

Chapter 5 discusses the wireless sensor network, oceanographic WSN, WSN architecture, WSN network topologies, WSN applications, and underwater network technology. It also discusses the wireless underwater acoustic sensor network, 2-dimensional underwater sensor network architecture, 3-dimensional underwater sensor network architecture, and sensor network architecture with AUV. It describes the difference between terrestrial WSNs and oceanographic WSNs, application areas of oceanographic WSN, general sensor node, sensing parameters of different sensors, challenges in oceanographic WSN, wireless communication technologies, oceanographic sensors protection, advanced buoy design, energy harvesting system design, system stability, reliability, wireless underwater sensor network, underwater sensing applications, underwater communication, physical layer, medium access control, resource sharing, the network layer, routing, transport, network services, sensing and application techniques, hardware platforms, test beds, simulators, models, the difference between underwater acoustic sensor networks and terrestrial networks, unique characteristics of underwater acoustic sensor networks, underwater acoustic sensor network architecture, network challenges for underwater acoustic sensor networks, and research challenges and opportunities in underwater WSN.

Chapter 6 deals with analog and digital images, EM spectrum, multi-layer images, spectral response patterns, multi-spectral images, multi-spectral remote sensing, superspectral images, hyperspectral images, hyperspectral remote sensing, sensor/platform systems, spatial resolution, pixel size, radiometric resolution, data volume, infrared remote sensing, black body radiation, microwave remote sensing, digital image processing and software for ocean color and algorithms. It describes image processing for the ocean, push broom scanning, interaction mechanisms, aerial photography, aerial videography, satellite-based scanning systems, interaction between microwaves and the Earth's surface, image preprocessing, image enhancement, image classification, and image transformation.

Chapter 7 discusses ocean energy as a renewable source of energy, wave energy, wave energy technologies, tidal power, ocean thermal energy conversion, ocean current energy, offshore wind energy, offshore wind energy technology, offshore solar energy, offshore solar energy technology and concentrating solar power technology. It also describes the operation of tidal barrages, ocean turbines, semi-submersible offshore wind turbines, offshore floating structures for mounting wind turbines, transmitting power ashore through subsea cables, and challenges in ocean power technologies.

Chapter 8 discusses the role of electronics in marine generator sets, marine instruments, wireless control stations, navigation equipment, autopilot systems, satellite phones, fire-fighting equipment, bubbler gauges, navigation instruments, AIS operation, electrical propulsion, and gas indicators. It also describes marine electronics, engine governors, timing considerations, fuel injection, marine instruments, salt assault, producing nautical charts, GPS-based instrument recovery, stray line buoys, weather monitoring systems, **routing and reporting**, integrated sail boat instruments, ship board level sensors, pressure-based level measurement, ultra sonic/microwave level sensors, capacitive level sensors, ship's bridge, controlling ship's speed and direction from the bridge, tracking ships using AIS, information transfer, boil-off for propulsion, TFDE propulsion layout, gas detection meters for ships, noncombustible gas indicators, and multi-gas analyzers.

Chapter 9 deals with instruments and their measured parameters, oceanographic instrumentation, Argo robots, measurements of hydrographic properties, measurement of dynamic properties, BIOMAPER, and many more instruments. It also discusses how to measure depth, temperature, salinity, oxygen, phosphate, silicate, nitrate, pH, water clarity, sound, current, waves and tides, seabed sampling, and bioluminescence. It describes research vessels, moorings, moored profilers, satellites, submersibles, towed vehicles, floats, and drifters, as well as reversing thermometers, CTDs, multiple water sample devices, thermosalinographs, remote sensors, current meters, wave measurements, tide gauges, shear probes, ferry box, glider, radar doppler current profiler (RDCP), X band radar, HF radar, satellite remote sensing, underwater nodes, zooplankton recorder, nucleic acid biosensor, sensors for pH and alkalinity, Air Sea Interaction METeorology (ASIMET), gravity corers, hydraulically damped gravity corers, marine magnetometers, ocean bottom seismometers, submersible incubation devices, deep ocean tsunami detection buoys, and oceanographic instruments.

Chapter 10 deals with the optical constituents of seawater, retrieval of oceanic constituents from ocean color measurements at sea level, ocean optics dip probe spectrometers, and interesting facts about ocean. It describes ocean optics, optical properties of the ocean, Inherent Optical Properties (IOP) variability, retrieval of oceanic constituents from ocean color measurements taken at top of atmosphere, the atmospheric correction problem, spectrometers, and ocean optics visible spectrophotometers.

The appendices present in-depth data about Indian satellites for ocean monitoring and acronyms used in the ocean electronics field. Almost every chapter can be read independently from the others; hence a flexible presentation of subjects can be realized. The consequence of this approach is that some of the details are repeated in different contexts, but this can only improve understanding. Furthermore, every chapter provides three levels of exercises for testing reader comprehension.

The authors would be glad to receive any suggestions for improving this textbook. Anyone requiring further information should contact the authors [email: srvijisiva@gmail.com]. The web links lead to relevant websites; appropriate material may be found in the web databases. S. R. Vijayalakshmi thanks the University Grants Commission, Government of India for the financial support in doing my postdoctoral research project work.

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