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Articles of Interest

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CHAPTER REPORT

Collaboration Among Texas ComSoc Chapters and IEEE Section

by Fawzi Behmann, IEEE ComSoc Central Texas Chapter Chair, USA

On March 30, 2023, several chapters in the IEEE Central Texas Section led by Fawzi Behmann, chair of the Communications, Signal Processing and Consumer Technology joint chapter in organizing a special talk about "Space Communications, a Review" collaborated with Computer & EMBS joint chapter, Life Members group and Consulting Networks in promoting and hosting the talk in both San Marcos and Austin. The talk was delivered by Scott Atkinson, Treasurer, Life Lone Star Section, Chair, Life Members Affinity Group, IEEE Lone Star Section, and Chapter Treasurer: San Antonio Com/SP, Computer & TEMS. Mr. Atkinson retired from a career as a Communications Engineer and Project Manager. Now a full-time volunteer at IEEE providing presentations on Space Communications, major telescopes, and Home Automation. Resides in San Antonio with his wife and two daughters.

The talk covered NASA's reliable space communications and navigation (SCaN) networks as the backbone of all of NASA's space missions, providing the critical communications services for all earth, space science, and human space missions. This included all the telemetry, tracking, and commanding required by each spacecraft to transfer key data to the ground systems to manage space operations.

At San Marcos, the talk was held at Texas State University Ingram School of Engineering and was locally organized by Prof. Semih Aslan and was presented to students and faculty (11:30 am – 1:30 pm). Over 29 persons have registered and 20 attended. Students engaged in Dialog with Mr. Atkinson during and after the talk. Some of the students are currently engaged with Nasa in Senior Design projects and use the opportunity to ask specific questions about the communications mission in space.

At the end of the talk, Fawzi Behmann shared his experience, opportunities received and benefits he received of being a ComSoc member. He presented the special promotion being offered by ComSoc and IEEE for students. Students that were present at the talk have expressed interest to be members.

There was networking opportunity where Piazza and beverages were offered along with promotional items from ComSoc.

In the afternoon, both Fawzi and Scott travelled to Austin and had evening function at Asia & America Resource Center in Austin from 5:30 om to 8:00 pm. The evening session was a hybrid event started with networking with meal boxes and beverage followed introduction and talk by Mr. Atkinson. There were 28 persons registered for the talk, and a total of 18 that attended (12 in-person, 6 virtual).

In total, for both events, we had 57 registered in vTools and 38 in attendance.

At both events, Mr. Atkinson was presented with an appreciation certificate for his presentation

This event was a great example of collaboration among chapters within Central Texas Section.

Luis Basto, Kai Wong, Scott Atkinson, Fawzi Behmann.

Prof. Semih Aslan, Scott Atkinson, Fawzi Behmann.

Luis Basto, Kai Wong, Scott Atkinson, Fawzi Behmann.

CONFERENCE REPORT

Being Part of the IEEE Sections Congress 2023

by Kayoum Djedidi, IEEE ComSoc Tunisia Chapter

SC2023: A World of Insights and Connections

The anticipation was palpable as I embarked on a journey to the prestigious IEEE Sections Congress 2023. From August 11th to 13th, Ottawa, Canada, played host to this remarkable event that brought together passionate minds from around the globe to celebrate innovation, unity, and the power of collaboration. The Congress offered an array of enlightening sessions that expanded my horizons on a range of subjects. Engaging with thought leaders and industry experts, I delved into topics that resonated with my passion for technology and innovation. What struck me most was the unity that pervaded the atmosphere – a reminder that despite our diverse backgrounds, we all share the same goal of advancing technology for the betterment of society.

A highlight of the Congress was the chance to interact with esteemed IEEE ComSoc leaders. Engaging with figures like Dr. Shashank Gaur and Dr. Celia Desmond, former IEEE ComSoc president, was an enlightening experience. These interactions underscored the importance of ComSoc's impact in our region and the value of engaging graduate student members.

Encountering Mrs. Susan Brooks, the former ComSoc executive director, was an honor. Her warmth and appreciation for ComSoc's student volunteers showcased the society's dedication to nurturing the next generation of technology leaders.

Among the many memorable encounters was a conversation with Mr. José Roberto de Marca, Chair of the Governance Committee of IEEE Communications Society and former IEEE president. His inspiring words resonated deeply, emphasizing the role of the newer generation in shaping the future of technology. Despite the event's bustling atmosphere, I seized the opportunity to connect with Mr. Raed Abdulah, the ComSoc North America Region Board secretary. These interactions provided me with valuable insights into ComSoc initiatives and introduced me to a network of dedicated ComSoc volunteers.

While Dr. Ashutosh Dutta's schedule prevented a direct meeting, we connected later via LinkedIn and scheduled a discussion on various ComSoc initiatives, as he is the founding Co-Chair for the IEEE Future Networks Initiative that focuses on 5G.

This experience illuminated the expansive scale at which our society operates and the diversity of our members from regions, fields, and age groups. IEEE truly embodies a global family, a realization that empowers me to excel in my field, with unwavering support from fellow members.

A Bright Future Ahead

Throughout the Congress, diverse topics took center stage, ranging from groundbreaking technological advancements to strategies aimed at invigorating member engagement and fostering the growth of emerging professionals. As a dedicated student eager to carve a career within ComSoc's dynamic realm, these discussions resonated deeply, infusing me with a sense of purpose and enthusiasm. Among these discussions, one theme emerged as a focal point — the convergence of artificial intelligence (AI) and the Internet of Things (IoT) within communication systems. The discourse around AI-driven optimization and IoT's potential for unprecedented connectivity was captivating. As an engineering student in the field of IoT, the realization that AI and IoT are set to reshape communication networks profoundly excited me. Notably, the revelation of ComSoc's commitment to this through its Emerging Technologies Initiative, introduced to me during these discussions, indicates a promising avenue for innovation. Sharing this initiative with fellow members can undoubtedly ignite enthusiasm and engagement.

Shifting towards the student perspective, the dialogue addressed the unique needs of aspiring communication professionals within ComSoc's vibrant community. Exploring the challenges student members face — accessing crucial resources, securing mentorship, and guidance for a successful career — underscored ComSoc's dedication to nurturing the next generation of communication trailblazers. In response, discussions circled around pivotal initiatives bolstering student support. Notable concepts included comprehensive mentorship programs, pairing students with seasoned experts to exchange knowledge and cultivate career pathways. Student-centric technical webinars and workshops emerged as potent tools for bridging theoretical education and practical applications. Elevating ComSoc's commitment to student support will undoubtedly strengthen its capacity to attract and retain young talents. Offering accessible resources, networking platforms, and mentorship will empower students to navigate their careers with resilience.

Some promising potential initiatives emerged:

- The "ComSoc Student Hall of Fame" award, recognizing outstanding student contributions. This award could foster a culture of excellence within the ComSoc community.
- The "ComSoc Call for Student Initiatives" proposition garnered interest. This platform could empower students to propose projects aligned with the society's goals, fostering hands-on experience in project management, event organization, and technical innovation.
- Encouraging academic prowess and research emerged through "ComSoc Student Paper of the Year" and "ComSoc Project of the Year" notions.
- ComSoc meetup event featuring sessions and engaging activities to foster connections and share experiences.
- Thought-provoking discussions surrounded another collaboration with IEEE HTB and SIGHT, aiming to bring the "Internet for All" program closer to student members, and involving SB and section SIGHT groups, By pooling resources, ComSoc, HTB, and SIGHT could bridge the digital divide, fostering connectivity and empowerment, all while empowering students and YPs.

It's important to mention that Enthusiasm surrounding the ongoing ComSoc student competition was palpable. A suggestion of implementing such a program at the Student Branch or Section Chapter level resonated well, fostering local innovation, knowledge exchange, and camaraderie.

These insights from the IEEE Sections Congress 2023 underscore ComSoc's potential to redefine budding professionals' trajectories. By tailoring discussions, orchestrating skill-building events, and fostering intergenerational exchange, ComSoc can sculpt an ecosystem that empowers students to thrive. The potential for ComSoc to guide young professionals is tangible, and I'm excited to contribute actively to this vision. The

Myself with Dr. Celia Desmond, former IEEE ComSoc president, Mrs. Susan Brooks, the former ComSoc executive director, and Mrs. Julia Upton, the Maine Section Chair, during the SC23.

congress indeed shed light on the transformative path ahead, inspiring a shared commitment to enhancing IEEE's impact on the next generation of leaders.

SC23 was undoubtedly an exhilarating experience, where the booths, sessions, and activities were captivating. But what truly stood out was the incredible community – one that's welcoming, collaborative, and open to new ideas. At IEEE, every member's voice matters, making it a thriving ecosystem to nurture professional growth and innovation. I extend my heartfelt gratitude to the IEEE Communications Society for enabling me to attend the IEEE Sections Congress 2023. Their support not only enriched my experience but also continues to empower countless volunteers and members within IEEE to shape their careers.

Kayoum Djedidi <djedidikayoum@ieee.org>

CONFERENCE REPORT

Amateur Radio Tutorial and Experimentation

CITS 2023, Genoa, Italy

by Miroslav Skoric, IEEE Austria Section

The 2023 International Conference on Computer, Information and Telecommunication Systems (CITS 2023) was held at magnificent Aula Magna of the University of Genoa, Italy, from 10th to 12th July 2023. The international forum was supported by IEEE Communications Society, and was intended for scientists, engineers, and practitioners to present their latest research and development results in all areas of computer, information, and telecommunication systems. Topics of interest were divided in several tracks: Computer Systems, Information Technology, Web Technologies, Networking Systems, Telecommunications Systems, and Security Systems. The conference featured technical paper presentations, distinguished keynote speeches, and a tutorial. Having in mind that the event was organized during the peak of tourist season, CITS 2023 allowed remote (on-line) presentations for authors who were not able to arrive in Italy on time because of flight disruptions, visa issues, or similar reasons.

While planning the travel to Genoa, I considered a set of technical tests related to radio signal propagation in a coastal area. Thankfully to Italian radio amateurs Gian Leonardo Solazzi, IW2NKE and Carlo Paroldi, IK1QKU, I booked a hotel room with terrace, in order to make ad-hoc experiments with APRS (Amateur Packet Reporting System) and Winlink (global radio email system) during a 10-day stay in the city. For that purpose, an Alpha MIL 2.0 antenna was installed on a tripod, and guyed by Mastrant rope & carabiners to survive coastal winds. The rest of the equipment (SCS pactor & packet-radio controllers, RIGblaster sound-card interfaces, MFJ antenna tuner and power supply unit, YIC and BadElf GPS receivers, Radioddity and Retevis radios, etc) was in the apartment room. The experimentation was performed under the special amateur radio identifier ('callsign') II1CIT, celebrating the conference. It was also possible to activate nearby voice repeaters at Mount Fasce.

The 1.5-hour tutorial session, entitled "Advantage of Winlink Global Radio Email® infrastructure and APRS™ positioning tool from Italian coastal perspective" was delivered by Miroslav Skoric, from IEEE Austria Section. It was an opportunity to inform the conference audience with achievements in exploring Winlink radio email service, capable to workaround the shortage of commercial telephony networks and Internet services after natural disasters and similar emergency situations. The results of aforementioned local tests were compared with experimentation done earlier at other locations (E.g. Greece and Mauritius). It was concluded that both Winlink and APRS resources were more developed in some other areas of northern Italy, such as in Milan than it was in Genoa. Having in mind high maritime activities at Genoa port facilities and ever increasing tourist & commercial traffic over the sea, it might be imperative for local ham community to establish alternative communication options to be ready in case when it might be of vital importance.

The conference chair, Prof. Franco Davoli (first from left in the photo), recalls using ham radio topics in some of his early research papers. His two researcher colleagues joined him in the audience, and both of them were Italian licensed hams who co-authored those papers: Sandro Zappatore, IW1PTR, and Alberto Giordano, I1TD.

Miroslav Skoric, II1CIT, during his tutorial lecture on amateur radio topics. The Alpha MIL 2.0 HF antenna is displayed on the left.

From left to right: Prof. Franco Davoli, Sandro Zappatore IW1PTR, Miroslav Skoric II1CIT, Alberto Giordano I1TD.

Besides the amateur radio tutorial as part of the official program, CITS 2023 welcomed a technical display arranged the second conference day. It included several VHF and HF radio stations, an antenna tuner, GPS/GNSS receivers, various packet-radio and pactor modems, the vertical 'whip' antenna exposed in the conference room, as well as a plenty of ham radio literature.

Miroslav Skoric <skoric@ieee.org>

CHAPTER REPORT

Activities of the Xi'an ComSoc Chapter in 2023

by Rong Sun, Bin Song, and Jiandong Li, Xidian University, Xi'an, China

During the past year, the Xi'an ComSoc Chapter has actively organized multiple academic seminars covering topics related to 5G/6G technology, communication security, and machine learning for students and members. These seminars have been held both online and offline, attracting hundreds of participants.

In addition to the seminars, we cosponsored "The 2023 International Conference on Ubiquitous Communication (UCOM2023)." The conference was held from July 8th, 2023 to July 9th, 2023. Over 300 participants including almost 100 IEEE members and student members attended this conference. IEEE Fellow, Prof. ZHANG Ping from Beijing University of Posts and Telecommunications, gave the lecture named "Wisdom-Emergent Ubiquitous Systems." IET and IEEE Fellow, Prof. WANG Jiangzhou from the University of Kent, presented the report named "Network-Assisted Integrated Sensing and Communications for 6G." IEEE Fellow, Prof. Arumugam Nallanathan from Queen Mary University of London, shared his idea on "Federated Learning for Energy-limited Wireless Networks" research.

The UCOM2023 focused on the frontier science and technology in the field of information and communications. Twelve sub-forums were set up around the topics of "Communication Theory and Technology," "Machine learning and Optimization of Wireless systems," "Polymorphic intelligent Network technology and its application," "Machine learning and optimization of wireless systems," "Signal processing and image processing," and "Joint communication, perception and Computing in Next Generation Network." Face-to-face academic exchanges and discussions were effective in this conference.


Prof. Arumugam Nallanathan.


Prof. Wang Jiangzhou.


Prof. Zhang Ping.


The organizers

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Good afternoon, Steve from Alpha Antenna & Shoto from West Mountain Radio.

I wanted to share my latest antenna experiment using Alpha Antenna's 10–40-meter magnetic loop antenna and West Mountain Radio's Target Tuner. I have combined these two products and have created an automatic magnetic loop antenna.

The only modification made to the magnetic loop was installing the tuning capacitor into a similar but larger enclosure to accommodate the drive motor attached to the tuning capacitor. The motor is attached with an insulated plastic coupler using nylon to insulate the motor drive and circuitry from high voltage across the capacitor. The tuning capacitor has a built in 6:1 vernier that safely slips at the end of travel.

I added two additions to the target tuner, as follows. Instead of connecting the pulse count input to a reed switch and magnet, I designed a very simple opto-interrupter circuit using a slotted plastic wheel attached to the motor/capacitor shaft and not the vernier shaft of the capacitor, that drives a reed relay to provide counting pulses for the target tuner.

I derived power for this circuit from the motor power provided by the PWM output from the target tuner. The power from the motor is rectified by a bridge rectifier, filtered by a 470uf capacitor and reduced to 5 vdc using a 78L05 voltage regulator. The power draw from the circuit is very tiny and does not impede the operation of the motor.

I have included the schematic for the pulse counting circuit and detailed photos of everything. I used RG8X coax for the antenna, a 4-conductor cable for the motor drive and pulse count. I used a longer Cat 5 cable from the swr sensor box to the target tuner. I put clip on ferrite on all of the cables, probably more than I need.

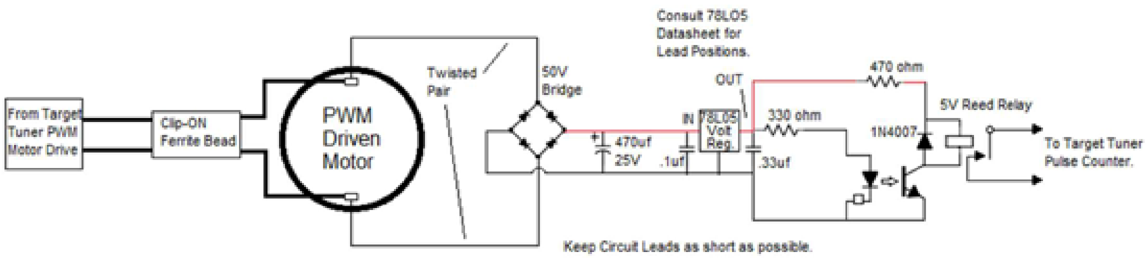
I have also included my test data; I did not do a swr test for 80 meters because I did not have time that day but I am sure it would work fine.

My experience with auto tuning, I would say overall it went well, I was able to tune through the phone bands. I started with the capacitor all the way meshed which would be near the 40-meter band. I played with the motor speed settings until I found the optimum settings that the target tuner could repeatedly tune to the lowest swr.

I would like to suggest a tweak to the software settings to look for the very narrow dip in swr from the tuning capacitor, stop instantly and very slowly go back and zero in on the lowest dip. Sometimes the tuner would miss the dip and just keep going. I have never used a screwdriver antenna; I can assume that the dip on a variable inductor is not a quick as the dip in the magnetic loop antenna.

Once I found the lowest swr points, I saved them in memory, the repeatability of the target tuner is excellent.

I hope that this data and photos might inspire a partnership between Alpha Antenna and West Mountain Radio to develop an auto-tune magnetic loop antenna.



Opto-Interrupter Circuit.

VSWR Test Data.

VSWR Test Data Sheet		Date: 9-8-24		F.M. Mode for Auto-Tuning		
				Power Level: 5 Watts		
80 Meters	LSB				Antenna Capacitor Tuning Range	
Phone	3.6 MHz	4.0 MHz	VSWR	Position	Min. Position	Max. Position
Center	3.8 MHz		N/A	N/A	0100	0220
40 Meters	LSB					
Phone	7.125 MHz	7.3 MHz	VSWR	Position		
Center	7.210 MHz		1.9:1	0110	Saved to Memory	
20 Meters	USB					
Phone	14.150 MHz	14.350 MHz	VSWR	Position		
Center	14.250 MHz		2.5:1	0164	Saved to Memory	
17 Meters	USB					
Phone	18.110 MHz	18.168 MHz	VSWR	Position		
Center	18.139 MHz		2.6:1	0178	Saved to Memory	
15 Meters	USB					
Phone	21.200 MHz	21.450 MHz	VSWR	Position		
Center	21.327.50 MHz		1.6:1	0186	Saved to Memory	
12 Meters	USB					
Phone	24.930 MHz	24.990 MHz	VSWR	Position		
Center	24.962.5 MHz		1,71:1	0204	Saved to Memory	

Yaesu FT-857D with Target attached to radio bracket, connected per instructions.
Note: I am sure I used more ferrites than necessary.

Red 4 pin connector set from Amazon, used for LED lights, nice gold-plated pins.

Alpha Loop showing cables separated from each other.

SWR sensor box, tied to a ground stake nearby, please pardon sloppy looking ground connection.

More snap-on ferrite at this end of the control cable. Used two short RG8X to small secondary loop because they were handy.

Motor/Capacitor Box detail photo.

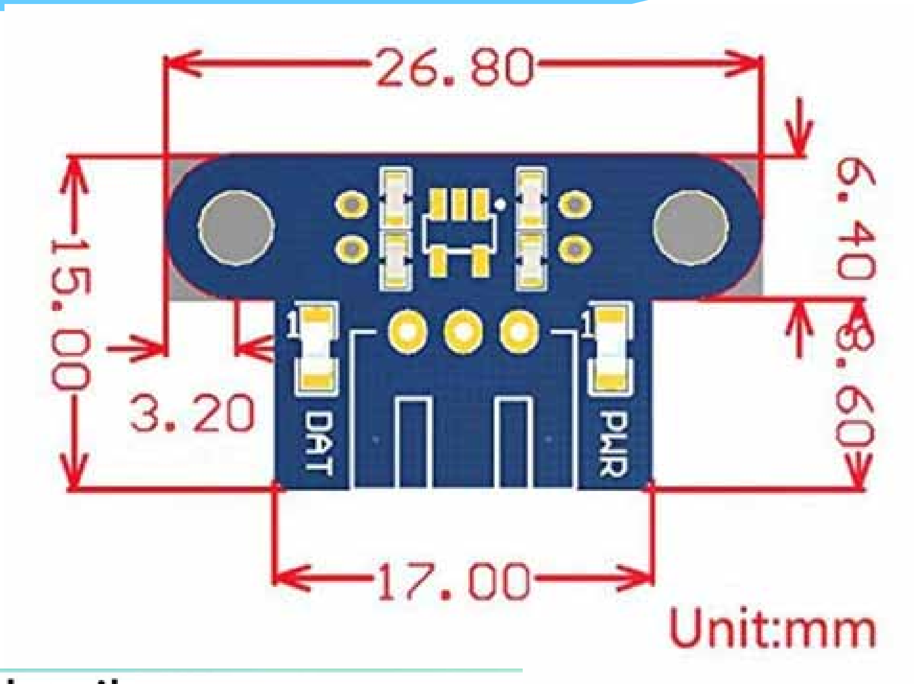
Inside view of Motor/Capacitor Box, note insulated motor coupler.

Opto-Interrupter layout Detail, Enclosure was closed to prevent light from interfering with pulse count.

4 pin connector detail with dust cap off. Enclosure is mounted on a sub-plate with four screws to cut down on the number of holes put in the box. Mast mount assembly bolted to plate with brackets.

Detail Photo of back on enclosure showing hardware. Selfie stick sections shown.

The following are photos of the Opto-Interrupter from Amazon that I used.



Product details

Top Highlights

Material	Copper
Brand	DAOKI
Voltage	5 Volts
Product Dimensions	1.06"W x 0.74"H
Manufacturer	DAOKI

- Infrared detection, eliminating the interferences of external stray light
- Schmitt trigger, stable wave form and signals
- Signal output indicator (while breaking the beam, outputs low level, the indicator lights up)
- Power: 3.3V to 5V
- Dimension: 26.8mm x 15mm x 18.7mm

Well, I hope this will inspire a partnership between Alpha Antenna and West Mountain Radio and a great product comes from it.

73's

Ron Colbert
AG5QE

BATTERY PACKS, CHARGING, AND CAPACITY TESTING

Photo Credit: Hanumant Singh / Woods Hole Oceanographic Institution.

By Kevin Hardy, Global Ocean Design LLC

An ocean lander has many strengths including flexibility of deployment location and tremendous seafloor persistence. Stored electrical power in batteries permit the untethered operation of seafloor instrumentation on ocean landers, activate the release of the descent weight, and power surface recovery beacons.

BATTERY BASICS

A cell generates electrical power through two galvanically active materials immersed in a conducting electrolyte. The galvanic difference between the cell anode and cathode is the potential and measured in volts. A battery is made from some number of cells in a series. The capacity of a battery is its ability to discharge current over a period of time, measured in amp-hours. A battery's energy, measured in watt-hours, is its capacity times its average potential. A battery pack is the assembly of batteries in series, to increase voltage, in parallel, to increase current capacity, or both.

There are two broad classes of batteries, primary and secondary. Primary cells can be used once, as the chemical process that produces the current is irreversible. Examples include alkaline and lithium cells. Secondary cells can be recharged by application of reverse current from a charger. The interior anode and cathode plates are refreshed in the process. The regeneration process is not perfect, and some material is lost in each discharge-recharge cycle. This limits the number of times the battery may be recharged, known as cycle life.

FACTORS EFFECTING CAPACITY

Batteries work on chemical reactions. The chemical reaction rates are largely driven by temperature. The colder temperatures of the deep sea will lower the capacity of most battery chemistries, some more than others.

Batteries are assigned a capacity rating based on some moderate Discharge Rate. If the actual rate exceeds that moderate discharge rate, the battery will be depleted faster due to increased internal resistance. Consult the manufacturer's datasheet for the discharge graphs.

Many batteries have a self-discharge rate, which means that even on the shelf under no load, the cell's reactants will slowly combine and reduce the amount of energy available. Rechargeable batteries may be put on trickle chargers to prevent this, as on a cabled-to-shore node, but untethered vehicle designers have to allow for this by adding additional capacity initially.

Some battery chemistries, principally Nickel-Cadmium (NiCd)

Reprinted with Permission from the March/April 2024 edition of Marine Technology Reporter www.marinetechnologynews.com

Figure 1

A self-righting vehicle design with buoyancy high and weight low, WHOI's SeaBED AUV captures the attention of a pair of curious Antarctic penguins as it is deployed from the British research vessel James Clark Ross. Vehicle designers allowed for temperature reduction of battery capacity.

and Nickel Metal Hydride (NiMH), have recharge memory effects. The condition describes the way these batteries gradually lose their maximum energy capacity if they are repeatedly recharged after only being partially discharged.

Increasing the ambient pressure on a battery capable of pressure compensation has no effect on the reaction rate as the solid or liquid materials are largely incompressible. Batteries in a metal case, including common alkaline cells, cannot be pressure compensated.

Physical Modifications to a battery, including means to pressure compensate the cells, can affect battery capacity.

COMMON BATTERIES IN MARINE APPLICATIONS

Certain chemistries have found wide use in the marine field for their availability, energy density, ease of handling, and cost. These include primary cells such as alkaline and lithium, and secondary cells including Nickel Metal Hydride, Nickel-Cadmium, Lead-acid, and recently lithium-ion and lithium-polymer. Each have advantages and disadvantages, and choosing one generally involves some measure of trade-off.

- **Battery Packs:** Soldering directly to batteries may damage the cell. Batteries can be purchased with spot welded nickel solder tabs that provide a ready way to join the cells into battery packs. Standard packs in rectangular geometries can be purchased from vendors such as Digikey. Numerous domestic manufacturers will assemble cells into custom battery packs. (Google "Custom battery pack manufacturers".) If you need to design your own, take a look at "Engineering Guidelines for Designing Battery Packs," at **PowerStream.com** (**www.powerstream.com/BPD.htm**).
- **Alkaline (alkaline-manganese dioxide):** These primary cells are available in the widest number of standard sizes, and are commonly available around the world. This is handy if you are in a remote port and need to cobble together a spare battery pack. Tip: Don't rely on spring-loaded battery holders for critical applications. Duracell reports that as the temperature drops to 0°C, alkaline cells loose about 1/3 of their capacity. As current drain increases, the temperature impact becomes more dramatic.
- **Lithium-iron (Li/Fe):** These primary cells from Energizer work as a replacement for alkaline batteries with a 1.5 V nominal voltage. Energizer Ultimate Lithium brand AA, AAA cells and 9v batteries employ this chemistry. These have 2.5 times higher capacity during high current discharge cycles than alkaline batteries, better storage life due to lower self-discharge, and more capacity at lower temperatures. The temperature effects on capacity only begin to show up after the cells pass below 0°C.
- **Lithium (Lithium-thionyl chloride, Li-SOCl2):** These primary cells have the highest energy density of all common cells, and the ability to deliver large amounts of current in a very short period of time. As a consequence of earlier misfortune, each cell is built with an internal fuse to protect it from being shorted and discharging rapidly with its attendant problems of outgassing and possible explosion. The metallic lithium, contained inside a thin stainless-steel cylinder, is extremely reactive with water.
- **Lithium-ion:** These secondary cells are not subject to memory effect, capable of moderately deep discharge, and much safer than primary lithium cells. They are used in applications requiring lightweight and high-power drains. They do require built-in protection against overcharging and over discharging. They have a relatively low self-discharge rate, about 6% per month. Li-Ion batteries are usually encased in a hard metal can to keep the electrodes wound tightly against the separator sheet, adding some weight and limiting the number of shapes and sizes.
- **Lithium Polymer (LiPo):** A lower cost version of the Lithium-ion battery. A LiPo battery uses a dry, thin electrolyte polymer separator sheet laminated between the anode and cathode plates in a construction called a "jellyroll". This method produces a thin cross section and wide range of flat shapes. LiPo batteries are considered safe for the trashcan and landfills once fully discharged, which manufacturers say can be done by dropping the pack into a bucket of saltwater.

Of special interest for marine applications, LiPo batteries are offered in a "pouch" design, with a soft, flat body. The pouch is vacuum-sealed, with all voids filled by a gelled electrolyte. Thus, there are no implodable spaces, and so are candidate cells for pressure-balanced, oil-filled (PBOF) assemblies. This author has personally tested pouch LiPos to 20,000 psi immersed in mineral oil inside a Ziplock™ bag, and not seen nor measured any

Figure 2

LiPo pouch cells have been tested in oil-filled bags to pressures of 20,000psi without damage. Their solid-state BMS protective circuitry can likewise be pressure tolerant.

Photo courtesy EHAO Manufacturing

performance degradation. The potential advantage to designers is two-fold: 1) battery packs carried on the outside of a pressure housing only subtract their water weight from the overall buoyancy, while carried inside, they subtract their air weight; and 2) it is easier to exchange batteries on a small ocean lander or AUV by unplugging the spent exterior battery packs and plugging in the replacement charged ones. (See Lander Lab #5, MTR, November/December 2022)

On March 26, 2012, James Cameron's DEEPSEA CHALLENGER submersible and ocean lander DOV MIKE demonstrated the practicality of this approach, diving the Challenger Deep in the Mariana Trench using PBOF, BMS-protected lithium polymer pouch batteries. The submersible's power could be configured to be as high as 96KWh, though it was typically between 76KWh and 84KWh on the 12 manned dives. These came from a maximum of 96 PBOF LiPo battery packs, divided into three buses. The sub could operate off a single bus in emergency mode. All power and control signals were passed through the Pressure Hull via four discrete penetrators in the penetrator plate at the upper pole of the Pressure Hull. The ocean lander used the batteries to power its LED lights and camera systems.

Shipping any kind of lithium battery can be a challenge, and IATA regs vary with the batteries inside or outside an instrument housing. Freight companies, including DHL, FedEx, and UPS, have specific guidelines available on their websites.

Lead-Acid: The venerable lead-acid battery comes in three variants: 1) wet-cell or flooded, 2) Absorbent Glass Mat (AGM), and 3) gel electrolyte cells. The latter two are known as valve regulated lead acid (VRLA), maintenance free designs. Lead-acids are temperature dependent, and their capacity may fall to as low as 60% of rated capacity as they approach 0°C depending on current drain. Lead acid batteries can provide substantially higher capacities when discharged at a rate lower than 1C.

Lead-acid wet-cells must remain upright or the electrolyte, a 35% sulphuric acid and 65% water solution, will spill. They can be exposed to high ambient pressure, and can be mounted outside the hull, as was done on the bathyscaph DSV Trieste in the early 1960's. If exposed to seawater, they must be pressure-compensated. Any compensation fluid must consider specific gravity, miscibility, and surface tension with respect to the electrolyte.

If sealed with a rubber diaphragm, the battery must be vented to manage gases formed during charging. (Myers, 1968) An innovative means of pressure compensation was shown by Frank Snodgrass, Scripps Institution of Oceanography, in 1968. His wet-cell automotive batteries were open to the sea at the top, filed to the cat eye indicator with electrolyte. A PVC riser tube extended each cell and was filled with an immiscible barrier fluid heavier than seawater (sg=1.026) and lighter than the battery electrolyte (sg=1.265). The original cell vent cap was screwed into the top of the riser pipe to vent the gases associated with charging. Wires were soldered to the lead (Pb) posts. The lead-acid battery was additionally used as an expendable ballast weight. Hence, the modified battery assembly was contained in a low-cost plywood box potted with hot tar. A pressure-compensated pull-apart connector allowed the simple disconnect of the electrical leads as the

Used with Permission, Earthship LLC.

Figure 3

James Cameron's DEEPSEA CHALLENGER rests on its back on the deck of the R/V Mermaid Sapphire, prior to its historic dive in March 2012 to the bottom of the Challenger Deep in the Mariana Trench. The sail is to the left, the keel is to the right. The starboard side PBOF LiPo battery packs are located behind a clear polycarbonate panel mid-body above the thrusters. A second identical set of batteries is located on the port side of the vehicle. Individual battery packs are held in separate pockets machined into the ISOFloat syntactic.

vehicle released from its ballast frame. (See Figure 4).

Absorbent Glass Mat (AGM) lead-acid batteries are constructed differently than the wet-cell battery. AGMs are considered a “Recombinant Gas Absorbed Electrolyte” battery. In AGM batteries, also called starved electrolyte batteries, there is a thin, ultra-fine fiberglass mat sandwiched between the plates of each cell that is saturated with battery acid to about 95% of what it can hold. This glass mat absorbs and immobilizes the acid while still keeping the acid available to the plates. The mat is slightly compressed between the plates when assembled in a frame. Because the plates and mats are packed fairly tightly, they are virtually immune to vibration. The remaining volume around the plates is air-filled, so that even if the case of the AGM battery is broken, no electrolyte will be spilled. It also makes the AGM battery lighter. Since the glass mat restrains the electrolyte, the AGM may be used in any orientation.

For an AGM battery to be adapted to a pressure-compensation system, thought must be given to the introduction of a compensating fluid other than electrolyte into the interior air-filled voids of the cells. The compensating fluid will have a dielectric strength, miscibility, and surface tension unlike the electrolyte. It is suspected that the compensating fluid preferentially wicks by capillary action into the glass mat, displacing the electrolyte. A reduction in battery capacity will follow as the opposing positive and negative plate areas are occluded by the intruding volume of compensating fluid. The terminal voltage will remain about the same, and charging will appear to proceed normally, but the adverse process reducing capacity will advance with succeeding charging cycles, presumably due to gas generation during recharge. A battery capacity test, described below with the West Mountain Radio CBA V, can be done to replicate this experiment yourself. (See Figure 7.)

- **Gel cell Sealed Lead-Acid (SLA)** batteries substitute a gel-type electrolyte for the liquid in basically a wet-cell lead acid battery. This permits it to be used in any position. They are operated at a lower potential to prevent gas generation, meaning they are never fully charged, resulting in the lowest energy density of all secondary batteries. They have low self-discharge rates, and no memory effects. They cannot be fast charged. They do have some promise of uncompromised function if pressure compensated, though this author has never tried that.
- **Nickel-Cadmium (NiCad)** batteries have a lower nominal cell voltage of 1.2v/cell. They can be recharged up to 2,000 cycles. Self-discharge rate is 20%/month. They have a reasonably high power-to-weight ratio. The discharge curve of a NiCad battery is flatter than other batteries. The NiCad battery can handle very high discharge rates, on the order of 15C, with no damage or loss of capacity.
- **Nickel Metal Hydride (NiMH)** batteries have high energy densities, self-discharge rate of up to 30%/month, and display some memory effects. Their max discharge rate is 5C. NiMH

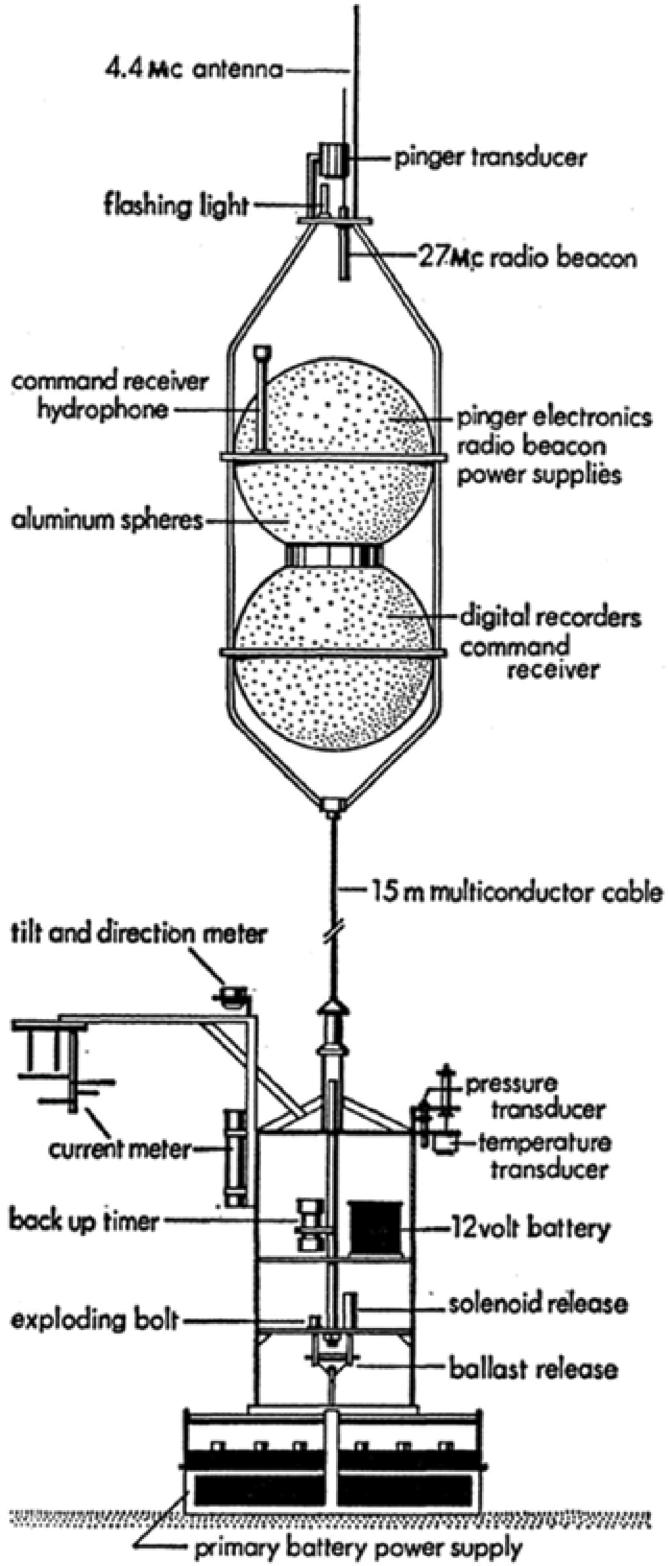


Photo Science, Vol 162, #3849, Oct 4, 1968

Figure 4

Scripps Institution of Oceanography’s Munk-Snodgrass deep sea tide capsule with expendable ballast frame and lead-acid batteries, 1968.

Photo courtesy of Clarios/AutoBatteries.com

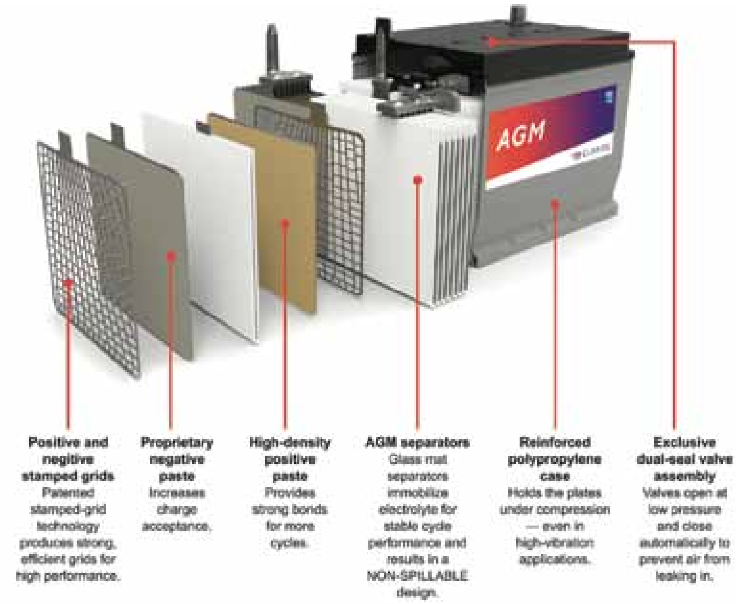


Figure 5

Exploded view of an AGM lead-acid battery.

Photo courtesy West Mountain Radio

Figure 6

The West Mountain Radio Computerized Battery Analyzer (CBA V) attaches to a laptop by a USB-B cable, and to a battery by Powerpole® Connectors.

cells are advantageous for high-current-drain applications, largely due to their lower internal resistance. NiMH can suffer longevity issues with deep discharge, but this may not be an issue if only a limited number of deployments are expected.

There is a low–self-discharge nickel–metal hydride battery (LSD NiMH). The LSD NiMH battery, known as Eneloop, is currently only available as AA and AAA.

CHARGING

Dependable performance and long battery life depend upon proper battery charging. Use a charger designed for the batteries you have. Universal smart chargers are pre-programmed for the correct charging profile for the different battery families. It just takes some user knowledge to set the charger for the right profile.

LiPo batteries can be ganged in parallel on a two-wire voltage bus, as was described in Lander Lab #5, "Lithium Polymer Batteries" (MTR, November/December 2022). Because each LiPo battery is regulated by its own BMS (Battery Management System) the batteries are individually balance charged and balance discharged on the same two-wire bus.

QUANTIFYING BATTERY CAPACITY

The best way to determine a battery's capacity is to measure its actual performance using a computer-controlled battery analyzer, such as the Computerized Battery Analyzer (CBA V), from West Mountain Radio (**https://www.westmountainradio.com/**). The CBA V can test any type or size of battery, any chemistry or number of cells, up to 57 volts, and up to 200 watts continuous. A 100v version is also available. The basic model is an affordable $189, while the Pro version is just $40 more.

The CBA measures the actual amount of energy stored in a battery, and reports that in units of amp-hours or watt-hours. The system graphically displays the voltage-versus-time on a single page using a constant current load. Displayed graphs may be saved and printed. Multiple test graphs of the same battery under different conditions, or multiple batteries under similar conditions, may be overlaid and compared. (See Figure 7.) Test result labels can be printed to put on the tested batteries.

The CBA's intuitive software is designed to protect both the CBA and the batteries being tested, providing automatic sensing of the battery cell count, a safety check of the test rate, and recommendation of a minimum safe discharge voltage.

This author has also used the CBA to check the function of a low-voltage cut-out (LVCO) to prevent over-discharge of a LiPo battery by setting the CBA cut-out voltage 0.50vdc lower than the rated LVCO minimum. The LVCO was confirmed to work as advertised.

Primary cells may be tested and used to predict performance of a larger battery pack. Once used, they are discarded.

Secondary cells or batteries may be tested then recharged.

Batteries intended for cold environments can be placed in a refrigerator or freezer and the leads brought out to the CBA V.

The CBA V can perform a Power Profile, useful for designers working with solar charging systems on buoys and unmanned surface vehicles (USV).

For very low currents, continuous or intermittent, the West Mountain Radio CBA HR (High Resolution) model is designed

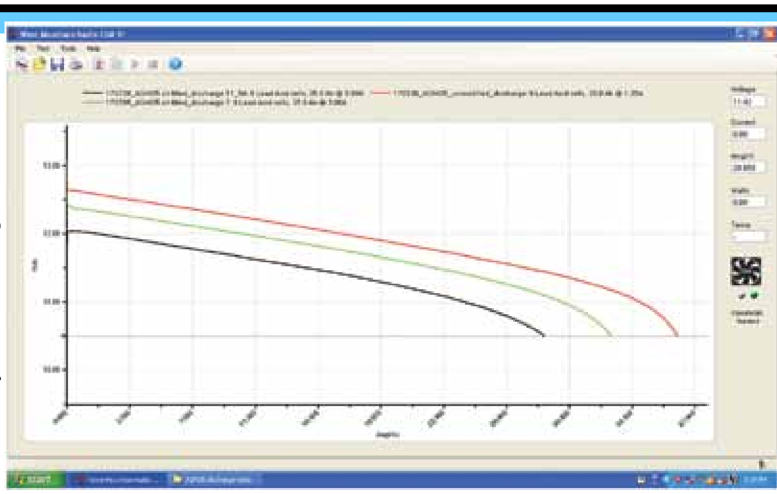


Photo courtesy Global Ocean Design

Figure 7

A 35Ah AGM lead-acid battery is tested using the West Mountain Radio CBA to show the effect of simply filling the battery voids with mineral oil as a compensating fluid. The CBA is programmed to cut-off at a voltage of 10.50v. The top line (red) shows the unmodified AGM battery capacity of 37Ah on its fourth discharge, exceeding the manufacturer's rating. It took 3 charge/recharge cycles of the new battery to rise to its maximum capacity measured on the fourth discharge. After the fifth discharge, the battery is recharged, the cell valves are removed, and the sixth discharge begun. Early in the sixth discharge cycle, the cells are filled to the top with mineral oil. Charge/recharge continues. The second line (green) shows the capacity on the thirteenth discharge, down to 33Ah. The third line (black) shows the capacity on the seventeenth discharge, further reduced to 29Ah. Starting voltages are all above 12v, while the energy capacity is progressively reduced. Max discharge rate is 1/7C.

to test any small battery from 0.7 to 10 volts at load currents of 1 mA to 1000 mA, (10 watt maximum), in increments of 1 mA.

CONCLUSION

Battery testing may be done by manufacturers for quality assurance or end-users to characterize batteries before selecting one for critical use.

Testing must replicate the expected field conditions, especially temperature and current drain.

Use your own data to drive your decision.

FURTHER READING

Landereans are encouraged to follow their curiosity into this hugely fascinating field. There are many good published references available from the library. On-line, a good place to start is Battery University at <**www.batteryuniversity.com**>.

FEEDBACK

Readers are encouraged to share their ocean lander experience, projects, inventions, and feedback by writing to Kevin Hardy @ **khardy@marinelink.com.**

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