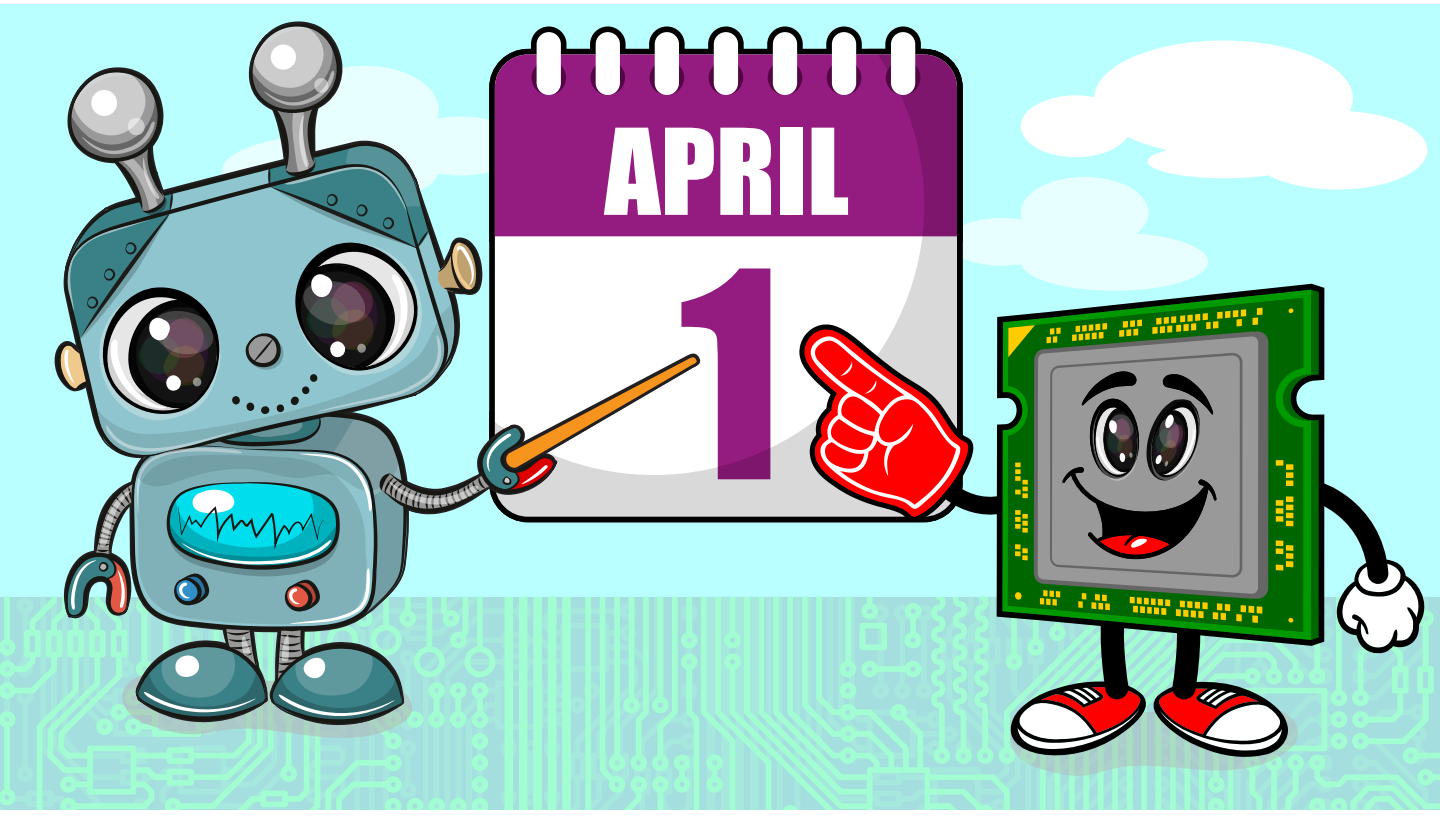

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Difficult Concepts Explained on April 1st

WILLIAM WONG

Senior Content Director

Endeavor Media

"Humor. It is a difficult concept. It is not logical."

Lt. Saavik, Star Trek II: The Wrath of Kahn (1982)

We are living in interesting but trying times. A tiny virus has challenged the entire world, and everyone is now working to cope with COVID-19. Thankfully, technologies like the internet, video conferencing, and collaboration software is making it possible for many to continue to work and interact with others.

April 1st, aka April Fools' Day, has been celebrated for centuries. Its origins remain a mystery as do many new technologies. Tales have been twisted to entertain and bring levity as spring emerges.

So, while you may not believe in the "No-Win Scenario," you might believe in some of the technical tales we have collected here. They are from the best authors around, who will be bringing you news and insight about real world products and technologies—on April 2nd.

LEE GOLDBERG, Contributing Editor/Power, Electronic Design

Is a Tesla Diesel-Powered Cybertruck in the Works?

Repeated sightings of a Tesla Cybertruck filling up at truck stops seem to confirm persistent rumors of the company's first petroleum-powered vehicle. Observers still can't explain however, why the truck seems to have a second fuel port, apparently reserved for liquid oxygen.

Repeated sightings of an odd-looking Tesla Cybertruck at various truck stops in and around Fremont, Calif. appear to confirm long-standing rumors that the unthinkable has occurred: The planet's leading manufacturer of electric vehicles will be powering at least one of its models with an internal combustion engine (ICE).

While corporate spokespeople refused comment on the matter, several formal employees confirmed that an advanced ICE technology project had been underway for more than two years. The information they shared, and the Cybertruck's appearances at truck stops, confirmed suspicions that the Tesla power plant was some sort of high-performance diesel engine.

Electronic Design has obtained a series of PowerPoint slides leaked from Tesla headquarters that fill in a few other details about the counter-intuitive business strategy behind this unique vehicle. The idea of offering an ICE power plant was first conceived of as a stopgap measure about three years ago, when it wasn't clear whether Tesla's then-nascent Gigafactory

Tesla refuses to confirm or deny its involvement with what appears to be a prototype of a Cybertruck equipped with a 400+ horsepower racing-derived diesel engine. (Credit: MGM)

Repeated sightings of the prototype outside Tesla's Fremont facility and at local truck stops provided the first clues that there might be an ICE-powered vehicle in the works. (Credit: MGM)

Taken at a NASA test facility on Groom Lake, Nev., this photo shows the prototype of the ICE Cybertruck being prepared for a test run to verify the operational parameters of the production vehicle's Overthruster mode. (Credit: MGM)

would be able to manufacture enough batteries to meet the growing demand for its vehicles.

Although the ICE-powered truck was conceived as a way to maintain growing sales in the face of battery manufacturing shortfalls, it was also meant to serve as a "gateway drug" to bring hard-core gasoline users to the Tesla brand. Around that time, Tesla's marketing team had identified a market segment (roughly 40% of American drivers) who said that they would continue to purchase petroleum-powered vehicles until, as one focus group participant put it, "they pry the gas nozzle from my cold, dead fingers."

Most people who were surveyed attributed their aversion to EVs to an extreme form of range anxiety. Still, nearly 10% shunned electric cars and other so-called sustainable technologies because they believed them to be part of a large, shadowy conspiracy.

To help counter any lingering perceptions that Tesla makes "sissified" vehicles, the ICE power plant is derived from Audi's A15 TDI motor, a 5.5-liter turbocharged V10 racing diesel[1] capable of producing over 600 horsepower. Since weight is less of an issue for the truck, its engine block and other components were strengthened to allow it to perform reliably under the day-to-day rigors of commuting, grocery runs, and hauling loads of gravel and manure. Even without its turbochargers (eliminated to keep costs down), the Tesla diesel is reported to produce nearly 400 horsepower, and that's before activating either of the vehicle's "alternate fuel modes." More about these shortly.

Eliminating the Cybertruck's 1200-lb. battery assembly lightens the vehicle considerably, and it creates an extremely large space for a fuel tank. Range anxiety will be a thing of the past with enough fuel aboard for 1,200-1,800 miles of driving, depending on the type of driving you're doing, and the type of fuel you're using.

The Tesla diesel was designed to run cheerfully on the low-sulfur dino-juice available at any truck stop, but it delivers maximum performance when sipping RP-1, a highly refined type of kerosene, used to power many rockets, including Space-X's Falcon 9. The rocket fuel, which Tesla says will be available for sale at all Super Charger stations beginning Q3 of this year, burns much cleaner, allows the diesel to rev higher, and produce 20% more power.

For those who feel that 475hp is still insufficient, there's Sea Level Supercharging (SLSC). This $25,000 option allocates a portion of the battery bay's space to a vacuum-insulated cryogenic tank, which is used to store liquid oxygen (LOX) (also

This image, smuggled out from a NASA test facility on Groom Lake, Nev., shows a glimpse of the first successful run of the Overthruster at full power. Note: This demonstration was performed by a professional driver, on a closed course, using a highly-modified vehicle—do not attempt this at home. (Credit: MGM)

available at most Super Charger stations).

When SLSC mode is activated, the tank's precision heater system produces a controlled boil-off of pure oxygen, which is fed to the normally aspirated engine's intake. Sensors adjust the fuel injectors to deliver enough fuel to burn efficiently in the oxygen-enriched atmosphere, enabling the un-boosted engine to deliver the equivalent performance of a turbocharged power plant running at 2,000-2,200 bar.

The on-board LOX supply also enables Tesla to offer an exclusive "Overthruster Mode" for the ICE Cybertruck. For $450,000, Tesla will install one of its Kestrel rocket engines on the truck, along with propellant plumbing and a retractable protective engine shroud, and replace the driver and co-pilot's seats with a pair of acceleration couches. The Kestrel, a much smaller predecessor to the company's Falcon engine, also burns LOX/RP-1 and produces 6,900 pounds of thrust. It was retired from production nearly a decade ago, but several dozen of the engines were recently discovered in a storage facility.

Tesla CEO Elon Musk is rumored to be reserving an Overthruster-equipped model for himself and making plans to have it modified it to support catapult launches off of a surplus aircraft carrier he's trying to acquire (*see "Insider Reveals New Disruptive Manufacturing Strategy, Denies Rumors of Orbiting Second Tesla Roadster" for details*).

Information about the ICE truck's 0 to 60 performance for its normal or SLSC mode are unavailable at this time. Tesla has no plans to document the 0 to 60 time for the truck's Overthruster mode, but the company will include its 0 to Mach 1 performance in the owner's manual once NASA authorizes release of the test data.

Reference

1. Why Diesels Rule the Le Mans Raceway - https://www.popularmechanics.com/cars/a5865/le-mans-diesel-winners/

ANDY TURUDIC, Special Correspondent, Electronic Design

Tesla Insider Reveals New Disruptive Manufacturing Strategy, Denies Rumors of Orbiting Second Tesla Roadster

Elon Musk's ocean-going manufacturing strategy takes "offshoring" to new extremes. Does that make him a modern-day pirate, or is he just looking for a new way to put a Tesla Roadster into orbit?

An anonymous source within Tesla (allegedly a VP) has confirmed the persistent rumors that the company is moving forward with a highly ambitious and unconventional plan for expanding its battery manufacturing capacity. If successful, the project has the potential to end the bottleneck that's threatened to prevent the company from meeting the explosive demand for its cars and trucks. The highly placed Tesla insider said, in order to avoid any further delays to his plan for world domination, Tesla CEO Elon Musk, has ordered the creation of a floating battery-manufacturing complex that incorporates its own lithium mining operations.

Tesla's dilemma is not unique. In these early days of the electric-vehicle (EV) boom, every auto manufacturer has had difficulty sourcing enough lithium batteries. Some, like General Motors, have inked priority supplier agreements where they "pull" as many batteries as they need from LG Chem for production of the Chevy Bolt EV, leaving the likes of Volkswagen, Hyundai, and others to pick up whatever excess cell production is available. This has caused vehicles like the Kona to be limited in supply and Volkswagen to slide the introduction of its ID3 EV to a point in time where LG's manufacturing capacity expansion can pace their needs.

Gigafactories and Mines

Tesla' partnership with Panasonic that resulted in the original "Gigafactory" concept has helped keep those shortages at bay—at least for the short term. The first GigaFactory, located near Reno, Nev., is a massive operation, where raw materials, cells, modules, and battery packs (and, according to locals, assemblies for an undisclosed secret project) are made under the same roof.

Tesla expanded its vertical integration strategy to include assembly of the vehicles themselves in Shanghai's Gigafactory 3, Berlin's Gigafactory 4, and a yet-to-be-selected Cybertruck & Semi Gigafactory 5 that Elon Musk has tweeted will be

Tesla has acquired three mothballed freighters from the Navy's Reserve Fleet and converted them into a floating, vertically integrated production facility for its lithium batteries. (Credit: By Earthpig - Own work, CC BY-SA 3.0, *https://commons.wikimedia.org/w/index.php?curid=15900615)*

An aerial view of the Puget Sound Naval Shipyard and Intermediate Maintenance Facility in Bremerton, Wash. (USA), on November 24, 2012. Visible are the following ships (top to bottom): aircraft carrier USS Independence (CV-62); USS Kitty Hawk (CV-63); USS Constellation (CV-64); amphibious transport dock ship USS Dubuque (LPD-8); USS Ranger (CV-61); three Oliver Hazard Perry-class frigates; an (active) Lewis and Clark-class dry cargo ship; a Seawolf-class submarine. (Credit: Jelson25 - Own work)

somewhere in the U.S. Midwest. According to this story's primary source, Gigafactory 5 will also be the first high-capacity facility for manufacturing dry-cell battery packs based on the technology it acquired in its purchase of Maxwell technology. This corroborates the observations of several industry observers who say that the new batteries are essential for giving the Semi and the pickup an acceptable range when they are heavily loaded.

Although Tesla's manufacturing initiative solves one problem, it puts an even greater strain on the raw materials supply chain it needs to make several billions of 21700 cells required annually. It's been previously rumored that Musk has been trying to solve this problem by partnering directly with one or more lithium mining operations.

While accompanying Musk on a tour of one of those lithium mines, our source reports to have heard Musk remark that there might be a better way to obtain the vital element. Upon being told that the lithium deposits being mined were not veined minerals, but rather deposits from ancient inland seabeds that once covered North America and China, he began to quietly investigate mining the ocean itself.

Reimagining SpaceX

Under the guise of being in port for "rework," Musk ordered the refit of SpaceX's fairing-recovery ships, GO Ms Tree and GO Ms Chief, with lithium nodule mining equipment, beginning with the modification of their catcher arms (basically pieces of pipe). For the past several months, the ships would use launches for cover as they'd sail to loitering positions to catch SpaceX rocket fairings, all the while mining lithium nodules from the ocean bottom. Happy with the results, Musk ordered GO Ms Tree to the West Coast, with the cover story that it needed to be near SpaceX's Hawthorne headquarters.

According to the Tesla source, Musk used his SpaceX military connections to exchange a Falcon Heavy mission for the mothballed Navy vessels Cape Breton, Cape Blanco, and the Borda, which had been anchored in the Suisun Bay Reserve Fleet storage facility, near Benicia, Calif. These vessels are presently being retrofitted by Tesla and Maxwell engineers to produce lithium batteries, modules, and packs.

According to the source, the fleet would be anchored in international waters off the coast of San Francisco, where ocean-mined lithium nodules would be offloaded from GO Ms Tree and GO Ms Chief to the Cape Blanco, which is being

refitted as a lithium refinery. The refined ore (now 99.314% pure lithium) would then be transferred for cell production to the Cape Breton. From there, modules and battery packs would be assembled on the Cape Borda, with finished goods being moved by barge to the Port of Oakland to offload and clear U.S. Customs and, subsequently, by Tesla Semi to Tesla's Fremont car plant.

COVID-19 Concerns

Electronic Design's source also said that as an unexpected bonus, the engineers, technicians, and workers involved with the offshore commissioning of the refinery and manufacturing ships over the past couple of months had been isolated from the mainland and weren't exposed to the coronavirus. As such, they've been able to ramp up the three-ship "Mini-Gigafactory" to pilot production levels over the past month without fear of the COVID-19 virus.

To prevent infection, any new production employees and engineers are being "airlocked" for 14 days prior to boarding the ships. To ensure no interruptions in production, this procedure is expected to remain in place well beyond the 18 months its expected for a COVID-19 vaccine to become available. The Tesla insider said, at the time this is being written, that the first ocean-lithium-based batteries are scheduled for delivery to Tesla's Fremont plant on April 1st, 2020.

Keeping Things Afloat

Musk is also rumored to be looking to barter several Falcon missions for a retired aircraft carrier (ideally with its nuclear power reactor fully operational) from the Puget Sound Naval Shipyard's Reserve Fleet, or elsewhere. The converted carrier would serve as a floating factory for Model 3 and Model Y vehicles. A PowerPoint slide leaked from another source illustrated how the carrier's crew quarters could be used to house and feed the workforce, while the ship's integrated aircraft elevators would be used to transfer parts and finished vehicles between levels of the multi-deck manufacturing operation.

If the deal goes through, the decommissioned carrier will be anchored with its three support ships in international waters to form Gigafactory 6, escaping California and federal taxes completely, as well as dodging "red tape" with, as Musk terms them, "silly things" like OSHA regulations, minimum wage laws, and corporate governance requirements.

Unconfirmed reports of a project to launch a Tesla Roadster into low Earth orbit using the carrier's catapult system are likely to be simply rumors.

LOU FRENZEL, Contributing Editor

This Battery Breakthrough Changes Everything

It's "like having an ordinary DieHard or Interstate battery in your shirt pocket." Most EEs say it's about time.

Battery technology has lagged all other electrical and electronic developments for decades. Some have actually said we're not much further along from the development of the long-lived lead-acid battery that's been around since its invention in 1859. The reason for its long life is that very few new batteries have been able to deliver that kind of power in a reasonably sized package.

The biggest recent development was the lithium-ion battery with its excellent power per size-weight rating, which has gradually been replacing many others in portable gear like smartphones. It's also slated to be the prime power source in our future vehicles, the EVs, and self-drivers. But now with this recent announcement, that could change.

At their press conference last week, the Battery Advanced Development Inc. announced its breakthrough battery technology. The new battery uses an unusual combination of chemicals for the electrodes and the electrolyte, an elixir they would not divulge. Unlike some of the new batteries that require special rare chemicals, this battery uses a stew of ingredients that are all readily available from existing resources.

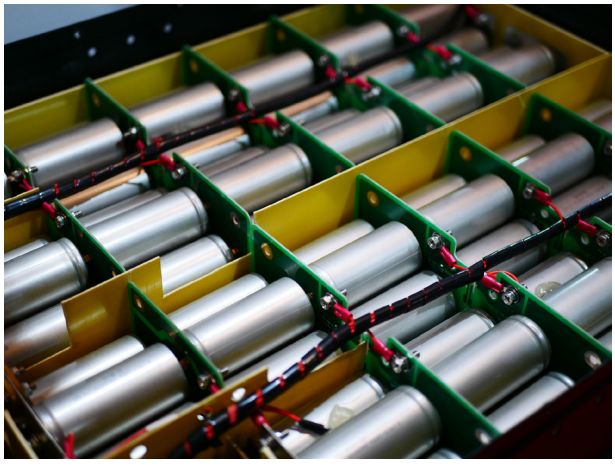
With patents pending, the company is working toward producing a signature product. Now that the chemistry is out of the way, the next step is the engineering and manufacturing to mass-produce some versions of the product profitably.

A Peek at the New Battery

The company hasn't decided on a physical form factor yet, but apparently it will be possible to produce standard sizes like D, C, AA, and AAA cells. And it doesn't have to be as large as the typical car battery.

At the press conference, they showed a prototype about the size of a deck of cards. It has impressive specifications. The nominal output voltage is 13 V, which kind of makes one wonder what chemical cocktail they're using. Cell voltage is 4.3 V and three are required to make the 13-V battery.

But that's not the real eye-opener. This battery can supply as much current as a car battery. One of the demos at the press conference involved starting a car with just the new miniature battery. Like having an ordinary DieHard or Interstate battery in your shirt pocket. Impressive. Maybe unbelievable is a better word to describe it.



The Good News and the Bad News

This new battery really is a major development. It will change some things, but not others. In my assessment, there will be some positive outcomes but with some conditions. For starters, this is a primary battery—not a secondary battery—so it's not rechargeable. When they're used up, you need to get a new one. You will have to replace them probably at high cost, initially at least.

Instead of recharging your electric vehicle overnight, you simply open the car hood and replace the batteries like you would change the AA cells in flashlight. This is good news for the battery company, as a constant supply will be needed. Time to buy stock in Battery Advanced Development?

At the press conference, the CEO introduced the company's development team, literally three heavily bearded guys working for a couple of years in an uninsulated cinderblock building in Oklahoma. All three were close college buds, two

chemists and one EE. No names were given. They are part of a subsidiary research organization called Advanced Science Systems. I wanted to ask how they arrived at the chemical combination that produced the breakthrough, but they took no questions.

The other bad news is that a whole boatload of dead batteries will need to be disposed. There was no discussion of this; maybe an environmental crisis in the making.

But look on the positive side. Batteries like this will make electric vehicles practical at last. And perhaps, they will lead to applications like replacing solar-powered homes with battery power. Or minimizing the need for wind power. Based upon a good battery life, you could run your whole home from a few of these batteries and some inverters. You just have to keep a stock of these replacement batteries on hand as they will eventually fail.

Imagine yourself on a driving trip in Nebraska. While driving on I80 near Cheyenne, Wyo., your EV dies. You get out your spare battery and replace it. It's not as big or heavy as your spare tire. Your EV requires the near 800-V level to run the motor and other things. Be careful as you plug in that new hot 800-V dc supply.

What Do You Think?

Yes, this is a significant battery breakthrough, but with reservations. Are the downsides less than the upsides? And forget about charging, it's not an option. Keep a spare battery in your EV at all times. Thankfully it will be small. While other EV users will be waiting in line at the only charging station in Nebraska, you will be hours ahead on your way to Wyoming.

The founders of the company and its subsidiary concluded the press conference with a summary of the VC interest. Will a one-million-square-foot battery factory in the desert of Utah become a reality? Is it time to invest or not? If you were a VC, would you?

Look for our follow-up articles as we are closely tracking the progress of this development. If we can get a representative battery, we will run some tests to see where this bizarre new battery fits into the battery spectrum. Stay tuned.

LOU FRENZEL, Contributing Editor

You Can Now Achieve Zero-Bandwidth Modulation

Perhaps Shannon and Hartley were wrong after all? Let's look at the math.

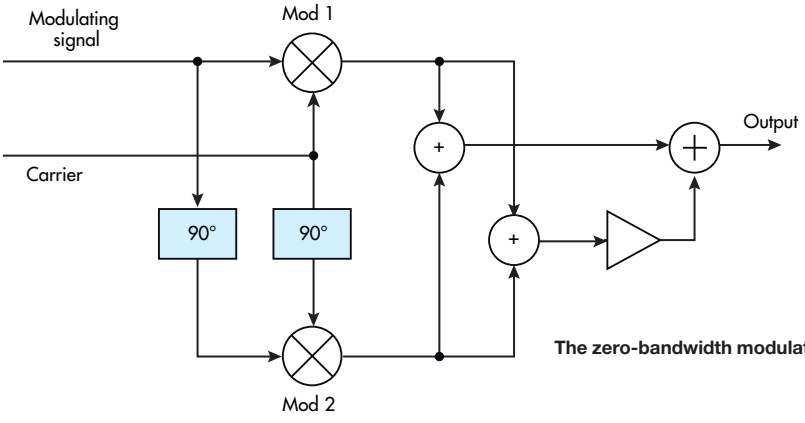
The curse of the communications engineer has always been getting maximum data rate through the narrowest channel. In broadband applications, modulation provides the carrier, but in all cases, the resulting sidebands eat up the bandwidth. Now a recent discovery lets you achieve your data objective with zero bandwidth.

Hidden from discovery in plain view for decades, this method has some engineers wondering if all that they ever knew about spectral efficiency is wrong. You can prove this recent discovery by going through the math yourself. All you really need to remember are some basic trigonometric identities:

$\sin A \sin B = 0.5[\cos (A - B) - \cos (A + B)]$
$\cos A \cos B = 0.5[\cos (A - B) + \cos (A + B)]$
$\sin A \cos B = 0.5[\sin (A - B) + \sin (A + B)]$

Write the math through the modulation circuit in the figure and voilà…

The primary signals are:



The zero-bandwidth modulator.

Carrier = $V_c \sin 2\pi f_c t = A$
Modulating signal = $V_m \sin 2\pi f_m t = B$

Balanced modulator 1 produces the product of these two signals:
$(V_m \sin 2\pi f_m t)\ (V_c \sin 2\pi f_c t)$ or $\sin A \sin B$
Applying one of the common trigonometric identities:
$\sin A \sin B = 0.5[\cos (A - B) - \cos (A + B)]$

Note that these are the sum, and difference signals are the upper and lower sidebands.

The carrier and modulating signal are then shifted by 90 degrees, producing cosine waves that are multiplied in balanced modulator 2 producing:
$\cos A \cos B$
Applying another common trigonometric identity
$\cos A \cos B = 0.5[\cos (A - B) + \cos (A + B)]$

Now, summing the outputs of modulators 1 and 2 we get:
$0.5[\cos (A - B) - \cos (A + B)] + 0.5[\cos (A - B) + \cos (A + B)]$
$\cos (A - B)$

Now, following the remaining processes, you will recognize the result immediately.

Proof at last that you can achieve the elusive zero-bandwidth condition.

The technique isn't unique, so anyone is free to use it.