Photography: Bob Carpenter Words: Bob Carpenter

SHIFTING INTO OVERDRIVE

An Inside Look Into What May Be the Most Significant Automatic Transmission Controller to Hit the Market

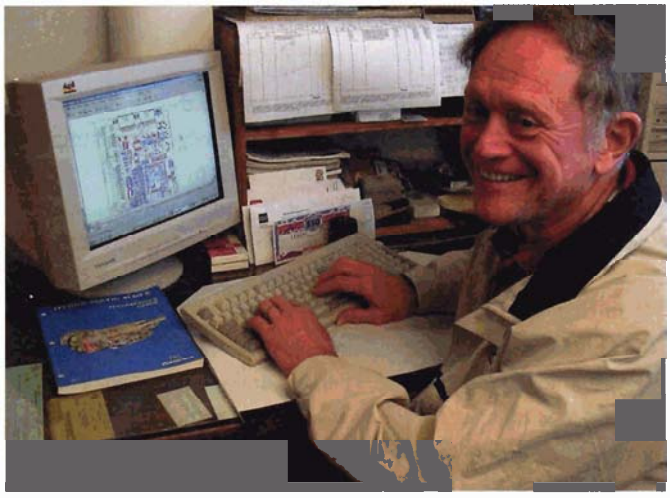
Mike Hoy owns Torrance Transmission and always wanted to come up with a computer to control electronic transmissions. With his two partners at HGM, they have succeeded possibly beyond their lofty goals.

In case you've been on a cloud somewhere, electronic overdrive lockup electronic transmissions are a hot item. Call it any way you see it—demand for increased fuel economy or enhanced driveability—but there's a demand for electronically controlled automatic transmissions with more forward speeds and an electronically controlled torque converter clutch lockup. Interestingly, HGM Automotive Electronics, the developer of the CompuShift electronic transmission controller, identified this long before all the buzz and has treated the street rodding community to just such a device ever since.

There's a black magic to the electronics end of what we do, so we thought the more we could learn about the CompuShift controller, the better our appreciation would be. Consider the following: Not only does the CompuShift operate the automatic shifting and shift points of an electronic transmission, it also coordinates the electronic torque converter clutch lockup, and it doesn't require a PC laptop to program it. And you can shift automatically or manually up and down using a set of pushbuttons, all the while taking advantage of the electronic transmission advantages.

You would be correct in assuming that all this requires a high degree of advanced technology, not the least of which is making the CompuShift compatible with a list of electronically controlled transmissions: GM's 4L80E, 4L85E, 4L60E, 4L65E, 4T80E and Ford's AODE, 4R70W, E40D (to 1995) and 4R100. Ideally, the controller is factory pre-programmed with shift and pressure tables, proprietary shift algorithms and built-in diagnostics, and no programming is required. Simple adjustments and calibration are available with screwdriver adjustment and/or pushbuttons. For advanced control and setup, there is the optional display. All of the high-impact electronic protection you would expect in such a dependent field unit is incorporated, along with a non-volatile memory for storage of calibration and programming and high-density multi-layer surface mount printed circuit boards. For that high-performance look, the new kits come in a finned aluminum housing.

Naturally, the controller is shift point and pressure adjustable, and it includes a self-calibrating TPS (throttle position sensor). Where fitment is applicable, the new AccuLink carburetor TPS is included, which replaces the cable-actuated throttle position sensor. Shift sequencing is automatic, controlled by the shift lever, vehicle speed and throttle position, and can be manually controlled by the shift lever. Shift adjusting is done with a simple screw adjustment or by display. While the automatic shift control is based on throttle position and heuristic algorithm, the torque converter clutch (lock and unlock) is based on throttle



With a background in satellite communications, Hap Caldwell knew that a collaborative effort of three individuals with different skills could make the dream happen. The crew used Protel to design the software.

position, vehicle speed and gear selection. Vehicle-speed lockup is user adjustable, and unlocking is based on throttle position. The user-adjustable lockup is based on transmission gear, and available operating modes are never third and fourth gears or fourth gear only.

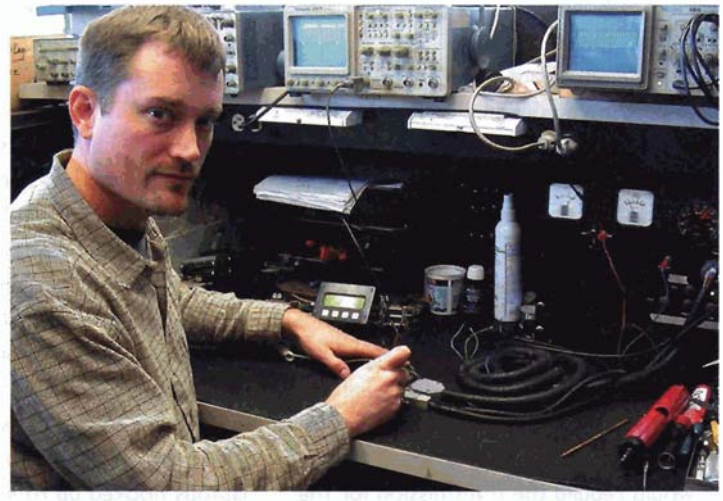
When you think of the simple use of all this programmable power, it's understood that this product was simply not dreamed up and created in someone's garage; it was a collaborative effort among three richly talented individuals. We had the opportunity to sit with them to better understand what makes this unique product work and why it was designed the way it was. We were fascinated with what we learned and thought you would be, too. This is their story.

Mike Hoy has been a transmission man for many years and owns Torrance Transmission in California. He's been a street rodder for as long as he can remember and has built a number of impressive cars over the years. As the then-new electronic overdrive transmissions came on the scene, Hoy became intrigued by the possibilities of using them in street rods, but there was no way to electronically control them without the complete computer and harness from a new car. So he bought one of the heavily advertised units available and found it practically useless. He felt the GM 4L60E and 4L80E transmissions were superior to what most street rodders were presently using, but there had to be a way to electronically control them if they were to make sense for rodders.

In those days, most street rodders were using the Turbo Hydro 350 and 400, which were plenty strong enough for most applications, but they were limited to three-speeds. This limitation left a compromise regarding gear selection and the fine balance of great launch capability without running super-high revs at cruise. The answer was to use an already available overdrive transmission, and the most popular at the time was the TH700R4 with a lockup torque converter.

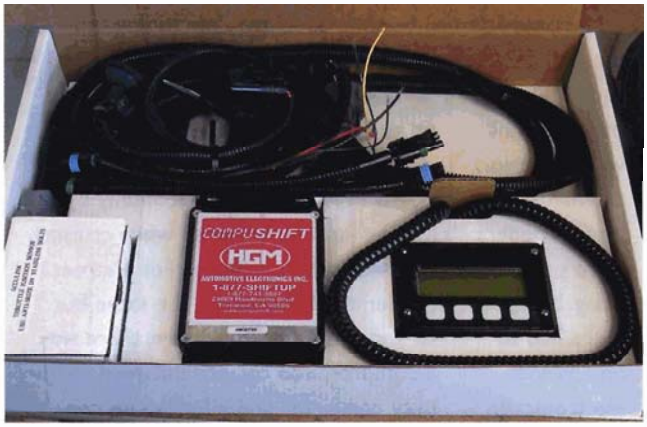
The 700R4 was designed during the time GM was desperately trying to increase fuel mileage due to government regulations. GM needed overdrive and torque converter lockup, which it managed in a number of different ways. Some guys running 700s don't even use the lockup capability because there's no convenient way to accomplish lockup; there are no internal transmission "smarts" to accomplish this. GM actually ran that control feature off of a separate controller that sometimes came off the engine.

The original intention for GM (and other OEs) was to get good cruising mileage. If they could get 2 percentage points in improved fuel economy by locking up the converter while cruising, that would be significant. For a street rodder, the benefits are the same but far more difficult to achieve; there was a compromised balance between a slippery converter and a locked-up converter with little or no slip at speed. This challenge has not changed over the years. You want a good launching converter using a lower gear ratio but with the proper control for top-end converter lockup. When you run a non-lockup converter with a loose torque multiplication, you are basically slipping the converter—the higher the stall, the more it slips—and that creates a lot of heat. Even with the addition of add-on transmission oil coolers, premature transmission failure will generally result.



Guy Caldwell designed the software to run the CompuShift, along with many other high-tech responsibilities.

Hap Caldwell met Mike Hoy innocently enough. "When I was ready to put a Turbo Hydro 400 in my El Camino, I came in to see Mike at Torrance Transmission because he had rebuilt a transmission in an old Cadillac for me. I asked him about building a special TH400. He said, 'Bring the car in.' I said, 'No, I want to put it in myself.' He said, 'I don't do that. I've got to be



Here's a CompuShift boxed and ready to ship out. This is considerably smaller than the original prototypes.

able to drive the car and test it and so on.' Then we got to talking. He asked me what I did for a living. I said I design exotic circuitry for communications satellites," says Caldwell, who has been a consultant for the past 23 years for Hughes/Boeing and has won awards and patents for his work.

"Seemingly out of nowhere, Mike said, 'Can you design a computer that would run a transmission?' My answer was, 'No, but with the help of my son, I could.' I do the analog stuff, and he does the digital stuff. Guy Caldwell works for Motorola and designs electronics systems and has been involved in fingerprint recognition technology, signal processing and much more," Caldwell says. Recognizing the perfect blend of skills between the two, Hoy decided he would rebuild the transmission for the elder Caldwell and continue to grill him on the possibility of developing his idea of a transmission controller. That was 1994.

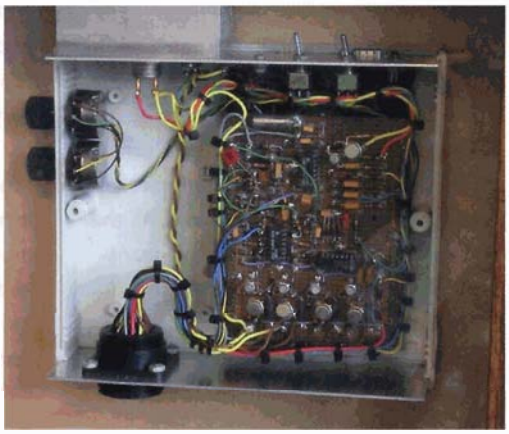
They are both the best at what they do, "So we agreed to have a meeting," Hoy says. They discussed what Mike had in mind and what he thought the device needed to do. Mike had wanted to do this since the electronic transmissions were introduced (the 4L60E and the 4L80E) back in the '80s. Hap told us that he tested another unit that was available at the time, "But it just didn't work, no matter what I did. The car would go through the gears with no control, no driveability, no adjustability and was not user friendly. The product was heavily advertised at the time, but it didn't work," Caldwell says.

"So then we talked about doing it. The first thing I wanted to do was an analog version, but Guy wanted to use a processor." There's a lot of signal processing you have to do. We each agreed to put in a third of the cost to develop the product," Caldwell says. Guy and Hap would do the development, and Mike would sell it. Guy Caldwell began studying the GM manuals to see how they do their shift tables, what their algorithms looked like, how they compensate for temperature, and then he read as much as he could about how they were doing the controls electronically. "The books tell you a lot of what, but not about how or why. They are diagnostic from the standpoint of someone trying to debug a transmission, but that's a far cry from telling you, 'This is how you control one of these and here's why,' " Guy said.

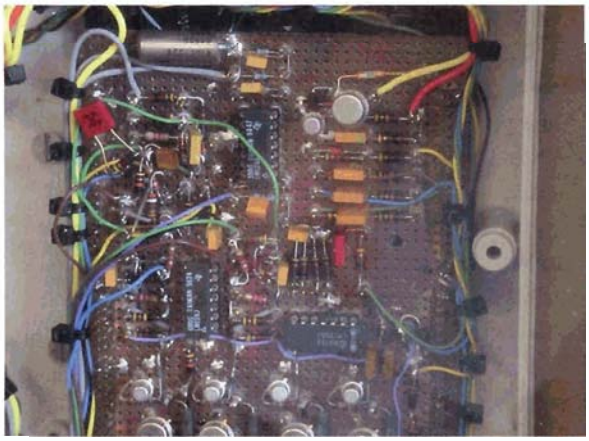
This led to hundreds of hours in stock GM vehicles with scanners and laptops hooked up to look at everything that was going on inside the transmission. "It turns out we didn't use any of their [GM] techniques," Guy said. "We pulse-width modulate because that is the way to control the pressure regulators. But the manner in which we decided to control the pressure and so on is different than GM and gives us better response and actually has some advantages."

Hap and Guy were responsible for developing the controller side of the equation, and Mike handled the support and marketing. The development process took more than three long years, thinking out the problems before they even bought the emulation pod, which is a sample of a computer processor and the software to control it. It also allows you to write software. The breadboard was built with hand wiring and pushpins. Guy took the GM solenoids that Mike supplied and characterized them one by one. Then he designed a wiring loom. Six or eight more months passed, and during that time Hap designed the signal processing, how to condition the signals coming from the transmission and how to drive the solenoids. Guy was doing all of the digital logic about how to control it.

There is very fast 8-nanosecond memory on board, so the layout and routing is critical because the timing getting to the memory has to be very precise or you'll lose the information. There are six layers on the board, which you can think of as a six-story house. You've got to run the electrical, the plumbing, air conditioning and so on, and it all has to match from one floor to the next. We're talking hundreds and hundreds of hours here. They made five prototypes and hand-loaded two of them. They worked right off the bat, so with the usual list of modifications, they went into production. What's interesting is that it's not at all unusual to make several prototypes and have them not work at all. And if you had to



The original prototype was put behind glass in a display case as a reminder of all the hard work that it took to produce.



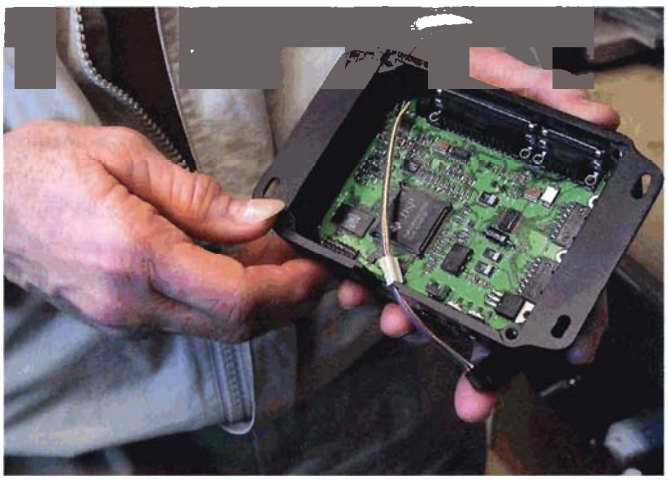
A lot of hand work went into the prototypes.

go out and hire all of the development work that was required here, the investment would be staggering, and that doesn't take into account the number of prototypes it could have required to accomplish the objectives. Then you have the expense of getting a programmer to design the software. The process can be mind-boggling.

It's almost comical to look back on how the trio went about their creation. The day they brought the first prototype to Hoy, they carried it in a big shoebox. The box was full of electronics created to prove the concept, but when they showed up and showed it to Hoy, he was skeptical and complained that the box was way too big. The Caldwells knew that the production units would be considerably smaller than the prototype, so they ignored the complaint and hooked up the apparatus to Mike's truck. The unit worked almost perfectly right out of the "box," and Mike couldn't stop grinning. Its early success was no doubt due to the attention to detail the trio paid each step along the way. It's also interesting that the unit spent months on end at Guy's house shifting a group of solenoids (which would normally be in the transmission) before they were willing to bring it to Hoy's shop for testing.

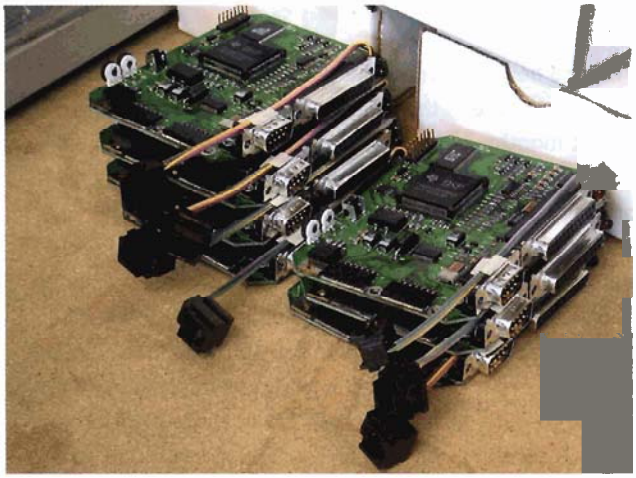
Once they understood what they had and the testing had gone better than expected, the next step was to take it from shoebox to a sellable product. That took another two years. They not only had to minimize the packaging, but they also refined how the product operated in the vehicle. They spent months riding with oscilloscopes, laptops and other instrumentation. Their rolling laboratory helped them decide on their philosophies of torque converter lockup. Significant questions were addressed and proven. When they did their temperature compensation, Hap said, "We watched the oil temperature by looking at the thermister (a temp sensing device in the transmission), and we used that info to compensate for the shift behavior as the oil temperature changed." If the car had some kind of hiccup or did anything funny, they would pull over and analyze it. "We had one problem, for example, where it was hunting for the right time to lock up the torque converter." Hap said, "I'll fix that problem, I'll make it vote 15 times before it can lock up." So he wrote a piece of software that looks at all the parameters (driveshaft speed, throttle opening, and more) and then votes 15 times before it locks up. That solved the problem. And so every step of the way, they addressed one question after another until everything seemed perfect. Then Hoy started adding other parameters and questioned, "What if a guy ran a different torque converter or other settings that are not stock?" So they tested and resolved the CompuShift for every conceivable alternative.

One critical aspect going in was Guy's decision to not use a laptop as a controller. The average street rodder may not be a computer guy, so a simple controller was designed with a screen that says "shift speed higher," and you push a button to make the shift speed higher. "We put ourselves in the position of the typical customer," Guy says. "These transmissions are out of production vehicles, but a street rodder is not interested in the same things. The factory is concerned with fuel economy, comfort, durability, comfortable shift feel and such. These are our issues, too, but not always. The street rodder wants to feel the shift a little bit, wants some adjustability and wants it to do what he wants it to do as opposed to what GM wants it to do. GM knows every aspect of a particular vehicle, and they might build a million of them, so they set their parameters and forget it. We've learned from manuals and from various vehicles that every car they build has a slightly different program running the transmission. They have the luxury of knowing what engine, what rearend gear, what tire size, vehicle weight and more. We make ours adjustable for every situation and simple to use, so [anyone] can buy it and do it without being a genius or studying shift tables," he says.



The newest box construction utilizes heat-sink capabilities and protects the board.

"There's a support issue that comes along with a developing a product like this," Guy continues, "which is probably (from a mind-share standpoint) our biggest cost. We're always thinking about [what happens] after the product



A stock of boards is waiting to be tested before being assembled in the boxes. Production has nearly doubled every year since the CompuShift hit the market.

gets into [someone's] hands. How do you give him enough rope to do what he wants but not so much that he can get into trouble? When you look at what is on the market, the offerings are at one extreme or the other and are either so simple they offer very little adjustability, or they have to be tuned with a laptop. I've got nothing against using a laptop, but the average guy can get into trouble and even ruin a transmission. We don't want a customer calling who has a problem with Windows or his Mac thinking he has a problem with the unit. The lessor of two evils is to make a display available that plugs in. Then you can make adjustments with simple prompts." And to further that point, for those of us who don't want the optional display, you can make simple adjustments with the two provided pots.

"The widespread availability of the 700R4 is our biggest battle," Hoy says. "They sell for $1,195. But here's the thing...When you get that 700R4 installed and adjusted correctly, and it doesn't work just right, how much labor can you get into trying and get it to work the way you want? Also, most people we've found who have been using 700R4 transmissions don't know how bad they've had it. I just did a '57 Chevy Nomad, a high-end car, and the guy came in because he hated the car. He said the car drove terribly. It had a 700R4 in it, so we simply took out the 700R4 and put in a 4L60E (which is the same transmission mechanically, but is computer-controlled) with the CompuShift. The guy loves the car, and now he's my best friend. He's called me 50 times to tell me, 'This car drives nice. I like it. It's driveable. I didn't know how wrong it was.'"

The trio doesn't wish to disrespect anyone who sells 700R4 transmissions. "Our dealers sell them, too," Hoy says. "We just want to make the point that the electronic trans is far better." It's obviously a more complicated transmission. "The 700 has been out of production for many, many years, and GM built so many of them I don't think they'll ever run out of them," he says. "But if you look at any new modern-technology street rod, it has to have an electronic transmission to go with the rest of the car."

But it's not just 700s. Here's another typical scenario from Hoy. "We have a customer with a Pontiac GTO with a 502. The car has a Turbo 400 transmission with a high-stall torque converter with a Gear Vendors overdrive. Here's the problem with that particular scenario on this car where an electronic transmission immediately fixes the problem. With the big motors, you don't have to open the throttle very far to get the car to go. Well, the Turbo 400 looks at the manifold vacuum, which with a closed throttle stays high. So the transmission says, 'The throttle's not open,' so you're in third gear by the time you cross the intersection. Now you're in third gear with a 2,500-3,000 stall converter. It won't vacuum downshift correctly, so now you're driving around with this transmission that feels like a '55 Dynaflow, and you've got no performance. Again, you step on the throttle hard, and the vacuum stays high and just goes boom, boom, boom, and it's in high gear. On that Pontiac, we pulled out the 400, put in a 4L80E and the guy fell in love with the car all over again," Hoy says.

We asked if it's a good idea to run an electronic transmission and a Gear Vendors overdrive together. Hoy says, "With an electronic overdrive transmission in a street rod, it's really not necessary unless you want to split gears. I'll tell you one application where the Gear Vendors is really cool to use, though—when you're towing and the overdrive in the electronic transmission is not as strong as the overdrive in the Gear Vendors unit. Some of the OEs even have stickers saying, 'Don't tow in overdrive.' What you do is shut off the overdrive (in the trans), run it in third gear in direct drive and turn on the Gear Vendors overdrive for heavy-duty towing."

With the simplicity of the unit, Guy Caldwell thought there was one glaring problem remaining—the throttle position sensor. With some transmissions you have to be very careful with the links and cables, and it's a pain to get just right. With the AccuShift TPS, you hook it up, stroke the throttle one time and it's calibrated, even with fuel-injected cars. That kind of simplicity takes a lot of research and sweat equity, but it's what these guys do. They just happened to come together with a combination of the right skills among them. And they've been moving forward ever since, smoothly and without slippage, all the while doubling and tripling the number of units now in use. SRB

Product Profile

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