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SCOPING OUT

by JOHN RIST

YOU'VE PROBABLY SEEN "hot," "new" and "trick" written about so many R/C racing products that the words have lost their meaning, but Tekin's new TSC 411P really is hot, new and "trick"! This small, light, racing speed controller comes with heat sinks, a screwdriver, an instruction book, tie-wraps, filter capacitors, mounting tape and decals, and it features:

- seven Megafet transistors: six for forward and one for brake
- monster wire to handle a large current
- high-frequency, linear-current motor drive
- regenerating battery recharge
- electronic BEC bypass switching
- multi-layer printed-circuit board and surface-mount components

Several words on this list might be unfamiliar to you. As the article progresses, I'll try to explain them and point out their advantages, but first, let's determine whether this Tekin product is a winner or a "dog." Specification claims are cheap unless you can back them up!

To check out a controller, I first remove the case. I was very curious to see whether the TSC 411P really had a "multi-layer printed-circuit board covered with surface-mount components." A few words of caution: I don't recommend that you open an electronic speed controller unless you've had experience working with miniature electronics.

The TSC 411P is an incredible example of miniature electronics—the type that's usually found only in computers and satellites!—and it does, indeed, have a multi-layer printed-circuit (pc) board. This type of board is made by bonding multiple layers of pc boards under high pressure and temperature, and then connecting all the inner layers to the outer layers by drilling and plating a pattern of holes.

The process is expensive, but it provides two big advantages: first, interconnecting circuits can be placed in the inner layers, so the components can be placed closer together. (That's why the TSC 411P is so small.) Second, it can handle large currents. Multiple layers of etch under each FET greatly reduce the resistance of the printed circuit between the FETs.

The heart of the TSC 411P is a 24-pin, custom, surface-mount, large-scale integrated chip. All that's printed on the top is "LSI Logic" (the chip manufacturer's name), "Tekin", a custom part number, a date code and "VER A". Tekin must have paid LSI a lot to produce a very complex, compact, custom chip for its TSC 411P. There was probably a prototype chip, and the production version is identified as "VER A."

This controller makes extensive use of surface-mount components—another space-age innovation. The legs of the parts are bent outward so that they run parallel to (and lie flat on) the surface of the pc board and therefore can be lap-soldered to the matching etch. (Usually, a part's legs are at right angles to the board.) Surface-mount parts provide an obvious advantage: because their legs don't pass through holes in the board, parts can be mounted on both sides.

All this high-tech construction is exciting to engineers, but hammer-handed throttle-jammers are more interested in whether this baby is a new hot trick, or will just run hot and burn up. To find out, I headed to the "Scoping Out" lab to see how the real numbers compare to Tekin's advertised claims.

LAB TESTS

First, I reviewed the supplied instruction sheet, and I had only one complaint. The TSC 411 comes in two versions: the "S," which isn't scheduled for release until spring '91, has four large wires to connect the battery and motor; the "P" has only three. One installation drawing shows both setups. If you don't read the words that go with the picture, you could easily be confused by the number of wires.

The version I tested has three wires—red, black and blue. To set up this controller properly, connect the red wire to the positive (+) side of the battery, the black wire to the negative (-) side of the battery, and the blue wire to the negative

THE "SCOPING OUT" LAB

John Rist's lab consists of:

- an oscilloscope
- a digital voltmeter
- a resistor load bank
- a 6V 30-amp electricity supply
- a Pit Stop Radio servo/speed controller tester.

The oscilloscope is used to monitor the controller's output and to guarantee that it's fully on.

The digital voltmeter takes all the voltage-drop readings and verifies the reading on the current meter.

The resistor load bank consists of 40, 12-ohm, 5-watt power resistors, which can be switched on and off one at a time to vary the load between .6 amps and 20 amps.

In series with the resistors is a 25-amp Simpson current meter and a 1-percent .01-ohm resistor. By measuring the voltage drop across this resistor, the current-meter's reading can be double-checked. Of course, the lab power supply provides the test current.

(-) side of the motor. This leaves the positive (+) side of the motor without a connection. Use a separate piece of monster wire (supplied with the TSC 411P) to connect the positive (+) side of the motor to the positive (+) side of the battery.

The only other strange item was the torque-control pot. This is a current-limiting feature that can be used to restrict acceleration on slippery tracks. For my lab tests, I left this control on its maximum setting.

When testing a speed controller, I always take two voltage-drop measurements: with full-length wires (to determine the resistance of the controller "as supplied"), and at the 2-inch point on the wires (to provide a standard measurement for use in comparing controllers).

With the TSC 411P hooked up and 12 amps flowing, I measured a .08V drop across the controller. This gives a calculated resistance of .0066 ohm. The second measurement—taken at the 2-inch wire point—yielded a .06V drop, or a calculated resistance of .005 ohm.

These readings revealed two interesting points. The TSC 411P has a 2-inch-point voltage drop that's as low as any 7-FET controller I've ever measured, and the difference between the end-to-end and the 2-inch measurements was almost unmeasurable. I'm sure this is because the TSC 411P has true monster-wire leads and there were no connectors in the end-to-end test. As I've said many times, good connectors and monster wire are the cheapest "trick" parts you can buy.

Next, I ran my "let-it-cook" test. I jacked the test current up to 18 amps. Although I did install the heat sink, I didn't provide any cooling air. I let the controller cook for 15 minutes and then felt the heat sink and the controller. They were warm, but not overly hot, considering it was 95 degrees (in the shade!) the day I was testing this controller.

You should always use the heat sinks when running the new speed controllers with automatic thermal shutdown, because most have only one thermal-sensing FET. When this FET gets too hot, it clamps the control signal to ground, shutting off all the FETs. If one of the non-thermal-sensing FETs overheats, the heat sink transfers the heat to the Tempfet so that it can do its job and protect the other FETs. Although the 411P has an electronic device that monitors the temperature of the FETs more accurately than a single Mosfet, it still requires the use of the heat sink.

My final lab test was the "dead-short," in which I check whether the thermal shutdown circuit works. I lay the dead short across the speed controller, and the ammeter read 41 amps. The TSC 411P took this abuse for 3.5 minutes and went into thermal shutdown. After a 1-minute "cool down," it was able to supply full power again. The lab tests over, it was time for fun!

TEKIN TSC 411P

DIMENSIONS:

Height	0.75 inch
Width	1.6 inches
Length	1.4 inches
Weight (with wires)	1.5 ounces

TUNING:

Access to Controls	Good
Ease of Adjustment	Fair

PRICE:

Suggested Retail	$170
Warranty	120 days

ELECTRICAL:
(Manufacturer's Specs)

Max. Voltage	13.75 volts
Min. Voltage	5 volts
Max. Current	1050 amps
Continuous Current	Not listed
Resistance	0.0025 ohm

TEST PARAMETERS:

Voltage	6 volts
Current	12 amps
Voltage Drop to end of wires	0.08 volt
Voltage Drop, 2-inch point	0.06 volt
Resistance to end of wires*	0.0066 ohm
Resistance, 2-inch point*	0.005 ohm
BEC Output, 6-cell battery	5.50 volts

*Calculated Resistance = Voltage Drop / Current

COMMENTS:
The TSC 411P speed controller is a totally new weapon in Tekin's arsenal. This small, but *hot*, performer uses space-age technology such as multi-layer printed-circuit boards and custom surface-mount components. Tekin's new high-speed switching FETs have three major advantages: they provide smooth power at low speeds; they eliminate much of the arcing that destroys armatures; and they provide regenerating battery recharging. If you're looking for the "king" of 7-FET racing speed controllers, "test-drive" the TSC 411P.

ROAD TESTS

I put the TSC 411P in my Turbo Ultima, which I was getting ready for an off-road, dirt-track race. With a handful of charged 6-cell packs, a stock motor and some very tall gearing, I headed to the track for some test runs.

The TSC 411P was *very* smooth—especially at low speeds. A quick check of my lab-test notes revealed that the TSC 411P switches 40 to 50 times faster than a normal speed controller. If your motor is turning at 6,000rpm, the armature rotates at 100 turns per second. Most speed controllers switch at a rate of 60 cycles per second. At this slow speed, "juice" is fed to the motor less than once per revolution, and this causes gear-grinding vibration.

A slow switching rate causes another problem: the magnetic field in the motor has time to collapse completely between pulses. This creates a large "back voltage," which causes the armature to arc and spark. The TSC 411P seems to switch at a 2,700-cycle-per-second rate, while the braking side switches at 5,400 cycles per second! This faster rate provides much smoother power transfer and braking, and this protects the gears and greatly reduces armature arcing and sparking.

The TSC 411P's low "on" resistance was evident in the car's blinding acceleration and hot top speeds. Braking was adequate. (The car needed it to get around a 350-degree turn on the back side of the track!)

A running-time test conducted by racers at my local track revealed that the TSC

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411P provides runs that are 20 to 30 seconds longer when geared to dump at around 4 minutes. The Tekin instruction book gives two reasons for the longer running times. First, the batteries are recharged when the brakes are applied. When the trigger is released, a speeding car pushes the motor, which then acts as a generator and produces a large voltage that's capable of recharging the battery. As well as I can figure, a diode is built into each of the six forward FETs. These diodes provide a path back to the battery and permit the motor (which is now acting as the generator) to put some charge back into it.

Second, motor current is regenerated while you're driving. I spoke with the engineers at Tekin, who provided this explanation of regeneration: when you run at less than full throttle, the speed controller switches on and off at a high rate (2,700 cycles per second). When the controller is on, battery current flows through the motor and causes it to turn. When the controller is off, the motor acts as a generator.

In a normal speed controller, this generator action is harmful, because it produces a high-voltage spike that causes arcing, which burns the armature. In the TSC 411P, the "off" time is very short because of the high-speed switching. This short "off" time allows less of the magnetic field to collapse and produces less arcing. The second innovation is that there's another set of diodes in the FETs, and they allow the current to keep flowing in the motor.

In my lab, I compared the battery and motor currents at half throttle. With 10 amps of current flowing into the motor, only 5.6 amps flowed out of the battery. The higher motor current can be accounted for when you realize that it's the sum of the battery current (5.6 amps) that flows when the FETs are on and the motor back-voltage current (caused by the motor acting as a generator) that flows when the FETs are off.

You don't really get a two-for-one boost, because the motor-generated current doesn't provide any push to the wheels. It does, however, control the collapse of the magnetic field in the motor. When the FETs switch back on, it takes less time for the battery to get the field back up to full strength. Here lies the battery savings: because it takes less time to get the magnetic field back up to full strength, a lower throttle setting provides enough power to run at a given speed.

I adjusted the torque-control pot from its wide-open position to its minimum setting, and the car ran as if the battery were about to dump. It had no zip at all! With a range of "blinding acceleration" to "no zip," you should be able to find a setting that works for any track.

My son Joe and I entered the big off-road race at the local track, and we easily came in 1st in all the heat races. A bad start in the A-Main left us in last place, but because of the TSC 411P's "driveability," Joe was able to "reel in" all but one of the cars! Score a big 2nd-place finish in the A-Main for the TSC 411P on its first time out!

There you have it! Tekin's TSC 411P is the most technically advanced high-performance speed controller that I've tested in a long time. Its smallness and lightness made it a snap to install, and its performance rivals that of any premium-grade 7-FET speed controller. You'll notice the smoothness and precise control provided by the high-speed switching the first time you squeeze the trigger!

So that you don't think I've been bribed by Tekin, I *did* find a small problem. The three-wire setup leaves a gaping hole in the case where the fourth wire exits on other models. Tekin provides plugs to seal the adjustment holes, but it ignores the hole left by the missing wire! Nevertheless, if you're looking for a big step up in performance that comes in a small package, check out the all-new TSC 411P.

**Here's the address of the company featured in this article:*
Tekin Electronics, *970 Calle Negocio, San Clemente, CA 92672.* ■

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1st

ROAR OFF-ROAD NATIONALS
2WD Stock 1st

NEVADA STATE CHAMPIONSHIPS
4WD Modified 1st

FOUR CELL NATIONALS
1/12th Modified 1st

OFF-ROAD WINTER NATIONALS
4WD Modified 1st

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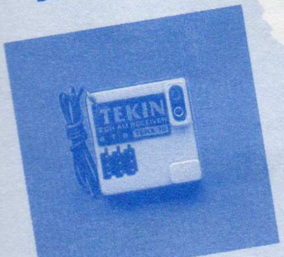

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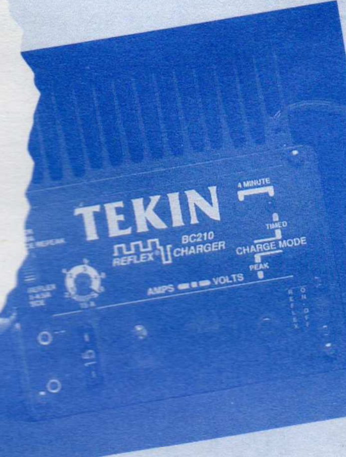

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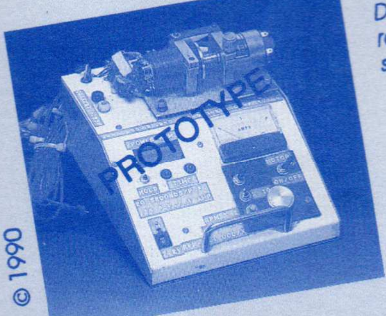

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