TIMING IS EVERYTHING - Basic Kart Ignition Explained

PART 2

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By John Copeland

Last month we began looking at the basic principles that make the ignition system on your engine work. You'll recall that we noted that when the magnets in the rotor or flywheel on the crankshaft rotate past the windings of wire in the coil, they induce a voltage in those windings. But that "potential" doesn't have enough voltage to jump the gap on the sparkplug. We have to "muscle it up" to about 5000 volts or so to be able to consistently ignite the compressed fuel/air mixture in the cylinder. That's where the secondary winding, with a lot more "turns" of wire comes in. Like a transformer, it boosts up the voltage to where we need it to get the job done.

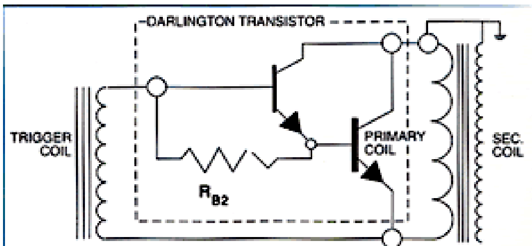


Figure 1 - Electrical schematic for the Darlington transistor

We also looked at the magneto ignition systems used in the Yamaha KT l00S engine, and took a rather general look at the Capacitive Discharge Ignition systems used on most of the Reed Valve 2 cycles today. The largest share of the 80cc and 125cc engines also use some variant of this CDI ignition. Now let's look at the venerable Briggs & Stratton and its "Magnetron" ignitions system. It seemed impossible to believe when Briggs told us we could yank out the points and condenser that had served us to well for years and plug that little box in their place. Well, not only does it work, but also it works better than the old points ever did. Here's how: The magnetron coil actually contains 3 separate coils of windings. In addition to the primary and secondary windings, there is a 3rd winding, called the "trigger" coil." When the leading edge of the magnets in the flywheel approach the coil, the magnetic field surrounding those magnets generates a small voltage (about 1 volt) that powers a solid-state switching device called a Darlington Transistor, turning the transistor "on." That "on" mode completes the circuit on the primary winding and a current of about 3 amps flows to ground on the crankcase (Figure 2). As the flywheel continues to rotate that current builds the magnetic field in the secondary winding.

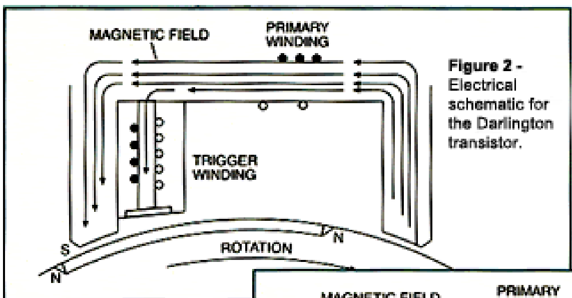
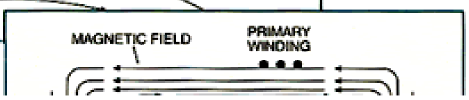


Figure 2 - Electrical schematic for the Darlington transistor.



When the trailing edge of the magnets in the spark plug gap. the flywheel reaches the trigger coil, a second small current is induced in the trigger coil and that current tells the transistor to "turn off", effectively breaking the circuit of the primary winding to ground (Figure 3). As we discussed last month, the sudden break causes the magnetic field to collapse. Since current

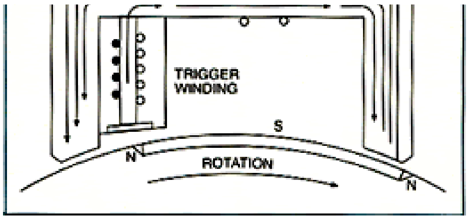


Figure 3 -
As the trailing edge of the magnets reaches the trigger coil that current tells the coil to "turn off", causing a "spike" allowing the voltage to jump.

(amperage) and voltage are inversely proportional, suddenly stopping the current flow causes the voltage to "spike" as it compensates. It's that spike that builds the voltage required in the secondary winding to jump the sparkplug gap and ignite the mixture. By the way, in the Magnetron coil, the primary winding has 74 turns of wire and the secondary has 4400. That's a 59.5:1 ratio and that helps insure that there's enough voltage to get the job done. All this, the initial current in the trigger coil, the buildup of potential, the second trigger coil pulse, and the collapsing field with the resulting voltage spike and spark, in on about 10 degrees of crank rotation. That means that at 6000 RPM the whole thing, start to finish, only takes about 0.00027 seconds. Pretty amazing.

This simple, but very effective, spark control system even advances the ignition timing, causing the plug to fire earlier (in degrees of crank rotation) as RPMs go up. You may recall from the part on of this series (NKN January,2000) that "the rate at which (the) potential develops determines its magnitude." In other words, the faster you spin the magnet on the flywheel past the windings in the coil, the greater the potential voltage that is developed. Since it only takes about 1.0 volts from the trigger coil to turn the Darlington transistor on (and off), the faster (in terms of crank rotation degrees) the potential builds to the required 1.0 volts, the earlier the induced current in the primary side of the coil will begin to build. And likewise, the earlier the second trigger coil potential reaches 1.0 volts, the earlier it will turn the transistor off and trigger the spark process. Take a look at Figure 3 to see how this advances the timing.
I know this sounds like a lot of engineering gobbledygook. But what it means to you as a racer is, the faster you turn the engine, the earlier the spark occurs in the rotation of the crank. "Advancing" the spark is something that engine tuners from karts to NASCAR have played with for years. Most big-car ignition systems have had built-in ignition advance for decades. In more recent years, old mechanical systems to change the timing in the distributor have been replaced with sophisticated electronic engine control systems. The Briggs "Magnetron" system does exactly that, cleanly, efficiently, and reliably.

There are only a few factors in the ignition system that the racer can adjust. Some are relatively simple and tuning with them is common practice. Others require sophisticated machining and fabrication work. Still others are just a matter of swapping components. In any case, you can make some changes that will have a dramatic effect on how your engine performs by working with the ignition system.

Let's begin by seeing what happens when we start fiddling with the Briggs.

Probably the most commonly used ignition-tuning tool on the Briggs & Stratton 4stroke is the offset flywheel key. Every kart shop carries them and the savvy Briggs racer carries a selection to adjust the engine to the track. Basically, these little machined pieces replace the stock Briggs 1/8" X 1/8" flywheel key. Although they are sometimes marked in thousandths of an inch offset, more commonly they are identified by degrees of offset. In other words, how many degrees of crank rotation do they move the flywheel from the stock position. Most engine builders building methanol-burning Stock-class engines usually send their engines out the door with 5 degrees or so of offset. That amount of advance provides a reasonably safe performance increase without too many headaches for the less experienced or adventurous tuner. Part of that improved performance comes from starting the combustion process itself earlier and thus performance comes from starting the combustion process itself earlier and thus optimizing the point at which the combustion chamber pressure reaches its peak. Another part comes from the fact that the methanol/air mixture burns somewhat more slowly than a gasoline/air mixture for which the engine was designed. So you gas-classers out there take note; 2 or 3 degrees is a better place for you to start.

One thing to be careful of, silly as it seems, is that you offset the key the correct direction. You want the sparkplug to fire earlier in the crank rotation, when the piston is farther down in the cylinder on its way up. That means that, when viewed from the flywheel side, with the starter or starter nut removed, along with the washer, the keyway slot in the flywheel should be closer to top-dead-center than the keyway slot in the crankshaft, as the keyway rotates up toward the coil (Figure 4).

Ok out there, l see you rolling your eyes. But 1 have seen engines come in with the flywheels offset the wrong way. And believe me, retarding the spark 5 degrees or so won't do anything to help your performance.

Anyway, what happens when you move up or down from that 5 degree starting point? Offsetting the flywheel even more helps the engine achieve more complete combustion at higher RPMs. Starting the fire earlier, you know. But more combustion time in the cylinder means more heat absorbed in the block and head too. You'll gain top end but you'll probably need a bigger jet to keep the heat below the 380?390 degree upper limit. If you've blocked off part of the air intake on the fan shroud you may want to open that back up a bit. Most tuners aren't afraid to go up to 7 or 8 degrees, but few venture beyond there.

Unfortunately, that top-end increase comes at the expense of low end. And on track where getting off the slow corners is the difference between winning and losing, that's a poor trade. In cases like that, an experienced tuner reduce the flywheel offset to 4 or even 3 degrees to improve low RPM performance. Since the fuel/air mixture always burns, more or less, at the same speed, if you need the engine to be at its best at lower RPMs too much advance can move the peak combustion pressure back so early in the crank rotation that it actually resists the momentum of the crank and flywheel and hurts performance. Of course, to get the optimal fuel mixture at these lower RPMs, and to help get the heat up into the desired range, you may need a smaller jet if yon reduce the offset in the ignition. Closing off some of those air intakes in the shroud may help get the heat up too.

There's only one problem with offsetting the flywheel key to get the timing where you want it. The folks at the Briggs factory took great pains to balance the flywheel/crankshaft/piston/rod combination for smoother running and better performance. Offsetting that key upsets all that carefully engineered balance, and that hurts performance. So are you shack having to choose one factor over another? Not necessarily.

Next month we'll look at how you can get the timing you want without giving up too much in the balance area. Then we'll conclude this look at ignition systems by examining what other adjustments and tuning features each system offers and what affect those adjustments can make. See you then.

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