

The Mark Ortiz Automotive

CHASSIS NEWSLETTER

PRESENTED FREE OF CHARGE
AS A SERVICE TO THE
MOTORSPORTS COMMUNITY
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WELCOME

Mark Ortiz Automotive is a chassis consulting service primarily serving oval track and road racers. This newsletter is a free service intended to benefit racers and enthusiasts by offering useful insights into chassis engineering and answers to questions. Readers may mail questions to: 155 Wankel Dr., Kannapolis, NC 28083-8200; submit questions by phone at 704-933-8876; or submit questions by e-mail to: markortiz@vnet.net. Readers are invited to subscribe to this newsletter by e-mail. Just e-mail me and request to be added to the list.

OPTIMIZING ENGINE-OVER-DRIVE-WHEELS LAYOUTS

My question concerns taking a front-wheel-drive car and giving it the response of a rear-wheel-drive car.

It seems that for large sedans the trend in the market today is to build rear-wheel-drive platforms. The ideal seems to be to emulate the handling characteristics of the BMW and Mercedes RWD sedans. This is becoming a big deal as first Chrysler, and now Hyundai and the Chinese (new Cherry V8 of 4.8 liters), are heading down the RWD path.

Recently GM put the Pontiac GXP into production with a 327 cid V8 driving the front wheels. It can cut a 13.8-second 1/4 mile and it's an automatic. It's faster than a standard Mustang! I discovered that the GXP was ready to produce ten years ago but GM couldn't afford to tool special parts for it then! Nor could they justify retooling the platform of the time in order to move the suspension hard points to more favorable locations. The recent new model introduction allowed the V8 option as they completely revised the platform for all model variants (Chev, Pontiac, Buick) and all engine options. It's an excellent car by all accounts (available only as a wrong-side-of-the-road model, so they can't export it – tsk tsk). [Questioner is in Australia.]

GM makes the point that front wheel drive is better in winter when traction is poor, for example in snow. Large parts of America (and many other countries) have difficult winters with snow and ice, so that's a valid argument.

This got me thinking about chassis response. I have a question about handling. Would it be possible to make a front-wheel-drive car behave like a RWD car (or feel like it had similar response) by applying some active rear wheel steer? I don't mean like Honda's mechanical system (where rear steer was a fixed function of front wheel steer regardless of speed, weight transfer, yaw rate, available traction, or chassis balance), but active. It wouldn't have to be much, perhaps just a degree or maybe even two at appropriate moments. What do you think?

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This question implicitly raises a larger question: how can we get the most from an engine-over-drive-wheels two-wheel-drive car? To answer this, we need to look at the advantages and disadvantages of the whole engine-over-drive-wheels idea.

But first, to answer the question, yes it certainly is possible to use active rear wheel steering to point the rear wheels out of the turn in response to inputs from a steering position sensor, a throttle position sensor, a yaw acceleration sensor, wheel speed sensors, and any other inputs we can get a control computer to read and process. This would provide a yaw increase, or car rotation, in response to throttle application, as when throttle steering a rear-drive car. Getting exact reproduction of rear-drive behavior would probably be impossible, but getting the car to point the tail out when the driver applies power would be possible.

One reason that it would not be possible to duplicate rear-drive behavior is that we would have different behavior at the front wheels. At best, we'd be simulating the behavior of a throttle-steerable all-wheel-drive car, rather than a rear-wheel-drive car.

Another problem is that steering the rear wheels is not the same as powering them. Powering the rear wheels does not simply produce a slip angle increase; the effects are somewhat more complex. Light application of power actually plants the rear end, with front drive or rear drive. With rear drive, as throttle application increases, sooner or later we reach a crossover point, at which the use of the rear tires' friction envelope for propulsion starts to erode their lateral force capability faster than the normal force increase increases the lateral force capability. Then the tail starts to point out. With modest static rear percentage, this crossover point occurs relatively early. In tail-heavy rear-drive cars, there is a substantial range of throttle application in which power actually makes the tail stick rather than slide.

So the question arises: what sort of rear-drive response would we be trying to mimick? Rear-drive cars aren't all alike in their response to power application.

Regarding the Pontiac referred to: actually, the current Grand Prix GXP is the second V8, FWD car to bear the GXP designation. The 2004-2005 Pontiac Bonneville GXP has an engine closely related to the Cadillac Northstar V8, which has been used in FWD layouts branded as Cadillacs for many years now. This is a 4,565cc (279 cubic inch) engine with 4 cams and 4 valves per cylinder.

The current platform, using the 327 cid LS4 engine, is shared with the Chevrolet Impala and Monte Carlo. It is the first use of a pushrod "small block" family engine in a transverse front-drive layout.

This is little remembered now, but GM's first FWD cars were big V8-engined designs. The first was the Olds Toronado, in 1966. That was a really big, heavy car. As I recall, it weighed close to 5,000 pounds. A Cadillac variant followed, which had engines as large as 500 cubic inches. These cars had longitudinal or "north-south" engine mounting.

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So putting large amounts of power through the front wheels can definitely be done. Power steering becomes a necessity, but power steering has become so commonplace, even on light cars with rear wheel drive, that we are generally not accepting an increase in cost or complexity if we include it.

With a transverse V8, the engine compartment packaging really gets tight. This makes it hard to find room for controls on either side of the car, to provide both left and right-hand-drive versions. It also becomes hard to find room for large-section structural rails beside the engine. The rails have to be narrowed to make room for the wheels to steer, and then the only way to make them adequately stiff is to make the walls thick, which adds weight. GM is using strut suspension, which helps some as the loads from the top of the struts can be fed into the cowl area. However, with struts and wide tires, the steering geometry doesn't work out very favorably. We have to accept either a large steering axis inclination, or a large scrub radius, or both.

Looking at the mechanics of putting ample power to the pavement, a FWD car doesn't look that much worse on dry pavement and street tires than a RWD, front-engined car. In fact, if both cars are relatively nose-heavy, the front-drive car may be better. For example, suppose both cars have a center of gravity 18 inches above the ground, and a wheelbase of 108 inches. At .50g forward acceleration, 1/12 of the car's weight, or about 8%, will transfer from the front to the rear.

If the front-drive car has 60% static front weight, it ends up with about 52% on the drive wheels. If the rear-drive car has 56% static front weight, it also ends up with about 52% on the drive wheels.

If the front-drive car has 62% static front weight and the rear-drive car has 58%, the front-drive car has 54% on the drive wheels at .50g, and the rear-drive one has 50%. That means the front-drive car will actually put power down better, assuming the coefficient of friction is such that the .50g figure is realistic. With 50% of the weight on the drive wheels dynamically, that would be a coefficient of friction around 1.00.

If we put slicks on the cars, things change. Assuming wheelspin still sets the limit, rear drive starts to look better, because more weight transfers rearward as the forward acceleration increases.

Conversely, if the surface is so slippery that it's a challenge to get the car moving at all, the front-drive car is clearly better. If the road slopes uphill, the front-drive car loses some of its advantage, but will generally still have an edge.

Note that we are comparing a fairly typical front-drive car to a decidedly nose-heavy rear-drive car. The more static rear percentage we have for the rear-drive car, the better rear drive looks.

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Readers who like Porsches and Corvairs will be quick to point out that there is no law of nature that says an engine-over-drive-wheels car has to be front-engined. Assuming we are ruling out all-wheel-drive for reasons of cost, complexity, and weight, we really should be considering three layouts: front engine/front drive; front engine/rear drive; and rear engine/rear drive.

From the standpoint of propulsion, the rear-engine configuration has clear advantages over the other two layouts. The drive wheels can have 60% or more of the static weight, and this percentage increases when accelerating forward or climbing hills. Under hard braking, the front and rear brakes share the workload. In straight-line limit braking, the front wheels will do around 60% of the work, as opposed to 70% for a front-engined car with 50% or a bit less static rear weight, or 75-80% for a typical front-drive car.

The rear-engine layout can also be throttle-steered without any added contrivances. It can often do without power steering if desired. There is lots of room for the controls, making left and right-hand-drive versions relatively simple to accommodate.

The biggest problem with the two engine-over-drive-wheels layouts is the difficulty of achieving balanced cornering with four equal sized tires. This was more of a problem when tires were less reliable than they are now. Until recently, it was fairly important to have a single spare tire that would fit any corner of the car. Now, most cars have compact spares that are only suitable for limp-home use and don't match any of the regular tires anyway.

With four equal-size tires, we can build a FWD car that understeers, or a front-engine RWD car with balanced handling, or a rear-engined car that oversteers. The first two options are clearly preferable from a safety standpoint.

However, if we are willing to entertain the use of bigger tires at the heavy end of the car, some interesting possibilities open up. If we are careful with the body shape so that we maximize aerodynamic stability, and if we use a longish wheelbase, we can have a rear-engined sedan that will out-handle any front-engined design, and outperform it in the snow. This approach would be well suited to a transverse V8 powertrain. The problem of finding room for structural rails would be greatly eased since the wheels wouldn't have to steer. The car would be, just barely, mid-engined.

There would be some drawbacks. There could be two trunks, as in some mid-engined sports cars, but fold-down rear seats with a pass-through from the rear trunk would not be an option. The rear seat passengers would be subjected to more engine noise. Building a station wagon version would be problematic. Still, such a car could probably find an enthusiastic following among buyers who need to carry multiple passengers, yet give priority to performance.

Alternatively, we can also have a FWD car with little understeer. To make the most of this approach, we would want to have the engine well forward for at least 65% static front weight, bigger tires in front than in back, and the rear wheels way at the back of the car, as in a Citroen

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DS21. This requires the designer and the buyer to cast aside accustomed notions of how a car should look, but it offers the promise of better handling and traction than existing two-wheel-drive cars, with a large, quiet, unobstructed passenger and luggage space in the rear.