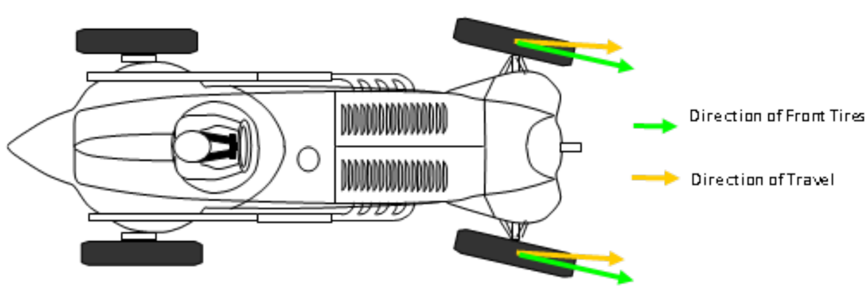
Front Wheel Driving

In vintage racing, if a driver says that his or her car has front-wheel-drive we can be forgiven for picturing a Mini. There are others, of course; Deutsch-Bonnet, SAAB and DKW come quickly to mind, but VRG-eligible front-wheel-drive (FWD) cars were also produced by Alfa-Romeo, Lancia, Citroen, Peugeot, Renault and many others. Even Ginetta's North American importer had a prototype FWD G4 built using SAAB components. It never went into production, but it demonstrates that the automobile industry, driven largely by the success of the Mini, was heading toward FWD as early as the 60s. As VRG's eligibility cut-off year changes - it changed recently - we're likely to see more and more FWD cars. At the suggestion of our newly crowned President, Mini driver Mack McCormack, we've decided to address the task of driving FWD vehicles. While some of the information contained herein is only of marginal interest to road racers, we've included it in the interest of being more or less exhaustive on the subject.

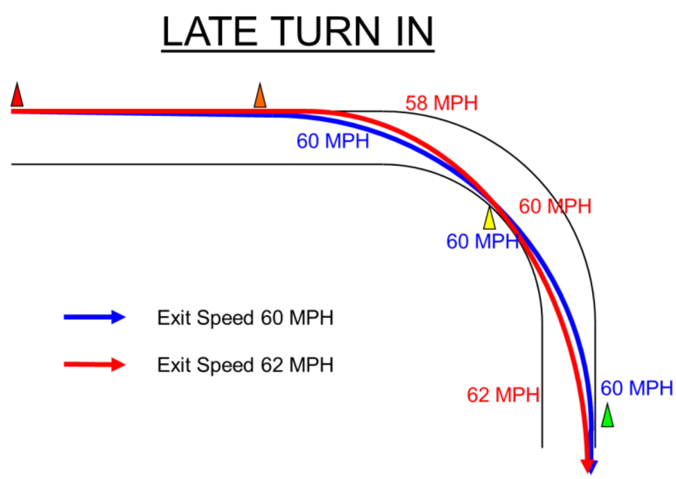
VRG President Mack McCormack in Turn 6 at PIRC

Since the very dawn of the automobile FWD cars have competed in racing events, including some very prestigious racing events such as the Vanderbilt Cup, the Indianapolis 500 and the French Grand Prix. But the laws of physics dictated very early on that when only two wheels are driving a road racing car – a car that is called upon to accelerate frequently on a surface with decent grip - the rear wheels are the best choice. One of the things that we dwell on in our Driving Schools is the fact that when a tire is more heavily loaded it can provide more grip. When we stomp on the gas pedal the drive wheels take off but the mass of the vehicle, most of which is sprung, wants to stay put, resulting in significant longitudinal load transfer to the rear… like standing on a rug that's pulled out from under you. As engine power and tire technology advanced, cars accelerated more quickly and the front tires became increasingly unloaded and less able to deliver that power to the ground. This is why purpose-built racing cars are RWD, and it's also why drivers of FWD race cars need to be very sensitive to understeer.



Understeer is a condition where the front tires aren't turning the car as much as the steering input has asked them to. It can be mild, meaning the front tires are simply generating larger slip angles than the rear tires, or it can be so extreme that the steering is at full lock yet the car is traveling nearly straight. Correcting understeer is very easy, but most drivers fail to recognize understeer in the first place. When they turn the steering wheel and the car doesn't respond adequately, they decide to turn the steering wheel even more, thus increasing already excessive slip angles and worsening the problem. Unfortunately, this Fight or Flight response usually trumps reason and skill. We know that the drivers who do this detect understeer because they keep adding more steering, but they don't recognize it for what it is. If they did, they wouldn't add the extra steering but instead would ease off the gas to load the front tires and then would wait for them to regain grip. This is a big hurdle… most drivers find it very difficult to just do *nothing*, but this is what understeer correction often requires. The second method of correcting understeer applies only when the driver has added too much steering, or has begun to accelerate and the resultant load transfer has caused the front tires to generate excessive slip angles. In this case, instead of easing off the gas we might first try reducing our steering input. When we do this the front tire slip angles are put back into their optimum range and the car will actually turn better. It's counter-intuitive – that straightening the steering wheel will help the car turn – but it often works and it's an option that is far less detrimental to lap times than lifting off the gas. Like a NASCAR driver on a super speedway, saw at the wheel a little and find the sweet spot in the tire's grip.

In addition to developing acute sensitivity to understeer, FWD drivers may also use later turn-in and apex points to compensate for their platform's major shortcoming, but to take advantage of this their cars need to turn well into corners. FWD cars as a rule tend to do this anyway due to their naturally front-biased weight distribution. It's when the time comes to put the power down that they start to have issues. At the apex the front tires are pretty busy trying to keep the car turning through the corner, and now we're going to ask them to accelerate the car as well; the result is often a very aggressive form of understeer. To combat this we can tune FWD cars to have inherent oversteer, by toeing out the rear tires and/or stiffening the rear sway bars. What we call sway bars are really anti-roll bars, because they plant their feet on the suspension components and push back against the body as it tries to roll during cornering. The stiffer the sway bar the more it pushes back. If we have a stiffer sway bar in the rear, the tires it's pushing against via the suspension component will be more heavily burdened than the tires being pushed against by the softer front sway bar, and as a result the rear tires will reach their limit and start to slide first. This may make the car almost too easy to rotate on corner entry, but because less steering input is required to turn the car throughout the rest of the corner the front tires can take more throttle input. With this in mind, we can alter our line to favor a later turn-in, which increases the radius we're driving on as we exit the corner and further reduces the steering demands on the front tires. This is the same line that many ground-pounders use because they, like FWD cars, have trouble putting the power down.



While on the subject of putting the power down, and before diving into more advanced FWD driving techniques, we're going to address the phenomenon known as torque-steer, even though there really isn't a lot we can do about it in our vintage racers. Torque-steer occurs in FWD vehicles when one front tire is accelerating the car more than the other front tire. We've all experienced how a bumpy braking zone can unsettle a car, making it twitchy… well, torque-steer is the same thing in reverse. If we're launching in a straight line, torque-steer is usually the result of the difference in the lengths of the stub-axles coming out of the transaxle. The longer axle will have a greater modus of elasticity and will therefore begin delivering power after the shorter axle. If the shorter axle is on the left side, the car will tend to pull to the right. If we're accelerating at the limit – generating a percentage of slip in the front tires – slight variations in the road surface can change the loading on each tire, change their relative grip and create torque-steer. Lastly, there's Ackermann steering geometry. Ackermann geometry is a combination of steering link/arm lengths and angles that allow the inside tire to turn more sharply than the outside tire, thus compensating for the tighter radius the inside tire must travel on. Ackermann geometries are very good, but almost never perfect, and as the influence of each front tire fluctuates so will the direction of steering.

So, we've resigned ourselves to living with torque-steer, we've tuned our FWD car to be fairly "loose" handling and we're using driving lines that reduce steering demands and improve our ability to accelerate out of corners. The latter two strategies will suffice for 99% of the driving we'll do on road courses. To help us better understand what we can do in the remaining 1%, let's rewind a bit. We mentioned that purpose-built race cars became exclusively RWD fairly early on. The manufacturing and cost advantages of FWD were significant, however, so the platform continued to evolve in production cars. By the 1950s FWD cars were relatively rare in road racing, but in rallying, particularly in the hands of Scandinavian drivers and most particularly those of Erik Carlsson, FWD began to dominate. Carlsson is credited with creating the driving technique known as Left Foot Braking (LFB), which he used to coax his under-powered SAABs to many significant rally wins. The technique remains to this day a crucial tool in any rally driver's toolbox, regardless of engine power, and judicious use of the technique has its place in road racing as well.

Carlsson winning '62 Monte Carlo Rally - www.caranddriver.com

We may use our left foot on the brake to scrub small amounts of speed, or to make it easier to brace ourselves in left-handers requiring mid-corner braking, but the true LFB technique is used entering and travelling through corners to help keep the car pointing through the corner. As we enter the corner we keep applying throttle with our right foot – how much depends on several factors – while with our left foot we apply pressure to the brake. By using brake and throttle at the same time, the power of the engine effectively cancels a proportionate amount of braking pressure on the drive wheels. Taking brake bias into account, let's say that under threshold braking at *n* MPH the front brakes resist the rotation of the front wheels with a force equal to 700 ft. lbs of torque and the rears do so with a force equal to 300 ft. lbs of toque (I pulled these numbers out of my… out of a hat). Under normal circumstances this would provide the proper amount of braking pressure to keep each pair of tires at threshold level (on the verge of locking up). Now, let's use the LFB technique at *n* RPM… we add 50 bhp worth of throttle and throw 50 ft. lbs of driving torque into the drive wheels. If your car has FWD, you've just reduced the amount of braking torque on the front wheels to 650 ft. lbs (50 ft. lbs below their limit), while the rear wheels remain at their limit of 300 ft. lbs. If we now increase our brake pressure by, say, 25 ft. lbs, the front tires are still below their limit at 675 ft. lbs, but the rear tires have exceeded their limit by 25 ft. lbs. The rear tires will lock up. If we're in a corner, the rear end will step out and the car will point further into the corner. Those who are very talented with the LFB technique will

LFB Foot Position – www.motorsportuniversity.com

Corner entry rotation initiated by the LFB technique - car-leisure.blogspot.com balance the brake and throttle with such finesse that they won't lock the rear tires, but instead will burden them enough to create larger slip angles than those of the front tires. This is the crucial skill when using the LFB technique, because a locked and sliding tire produces only about 70% as much cornering grip as a tire that is still spinning but generating large slip angles.

Just for fun, let's do the same thing with our Formula Ford. Skipping ahead to the next to last step, our 50 ft. lbs of engine torque puts the rear tires that much below their limit, while the front tires stay at their limit. When we increase our braking pressure by 25 ft. lbs the front tires lock and the car starts going straight, which is inconvenient in a corner. All Wheel Drive (AWD) cars with an open (unlocked) center differential are even more exciting because the majority of engine torque can go arbitrarily to either the front or the rear tires, like driving a box of chocolates. A friend once loaned me a BMW 325ix to rally-cross. During practice I rotated the car into a corner with trail-braking, counter-steered, added throttle and drifted through the corner very nicely. On the next lap I rotated the car into the same corner, counter-steered, added throttle and drove into the snow bank. On the first lap the engine torque had gone to the rear tires; on the next lap it went to the front tires. The LFB technique might have been a good remedy for this, in a Simon Says kind way, but it wasn't my car so I parked it.

Should we use the LFB technique in our FWD road racer? Maybe… in very tight hairpin corners. But we have to keep in mind that it's very hard on brakes, and all the more so on pavement because the tires have so much grip. I occasionally teach Navy SEALs, many of whom have attended pro rally schools. In the programs I'm involved with we put them in the kind of vehicles they would most likely end up driving in their various endeavors, meaning a somewhat clapped-out Jetta or Camry. The first thing they notice is that they have to push like hell on the brake pedal to get the car to rotate. This is because power brakes rely on the vacuum of the motor. If our right foot is pressing down on the throttle, there's no vacuum and hence no power brakes. The next thing they notice is that after about 5 minutes they have almost no brakes at all. This is because the LFB technique is so demanding on the brakes that stock brake pads will glaze over in about 5 minutes. If you want to use the LFB technique in your FWD race car, be sure you have the biggest and best possible brakes and pads, and scoop as much air as possible onto them… and have a cinder block handy to scuff the glaze off your brake pads after every session.

And there's always the E-Brake. You can do what I did when I owned a '66 Mini Cooper S back in the 80s… use duct tape to keep the little button on the E-Brake pressed in. This was very helpful in Bryar's Turn 8, but I never used it anywhere else. If you've ever watched in-car footage from modern rally cars you may have noticed that their E-Brake levers resemble ski poles mounted directly adjacent to the steering wheel. I suspect Tivvy and Ralph would frown on this. Further, these ski poles are connected to *hydraulic* master cylinders and E-Brakes. In other words, in a rally car what we would call an E-Brake is really a secondary, fully capable braking system that functions only on the rear wheels. I'm fairly certain that you won't make it off your trailer if you show up at a VRG event with one of these.

So, should we use the LFB technique and cleverly hide a hydraulic E-Brake in our vintage racing car? No. The advantages gained by these strategies in 1% of the corners we see is not so overwhelming that it will be significant, and if you're doing it 1% of the time you won't get enough practice to be any good at it anyway. Both LFB and yanking on the E-Brake will easily pitch the car sideways unless done just right, and sliding sideways scrubs way too much speed, so if you're unpracticed and not very good at it the chances of realizing a benefit from using either technique are very slim. Lastly, because of the level of grip provided by asphalt, conventional braking alone should be enough to rotate a properly set up FWD car. If you want to derive a benefit from rally techniques on a road course, convince your competitors to start using them.

Whatever the techniques employed, a properly prepared FWD car can be very quick and a lot of fun to drive, but perhaps more than RWD they require fairly strong car control skills to be driven quickly. And this is particularly true on corner entry, where a properly set up FWD car will be looser than its RWD counterpart. If you own a FWD car, gradually dial in oversteer until you think you've dialed in a bit too much, then leave it there and learn to drive it. With time, you may meet with Erik Carlsson's approval.