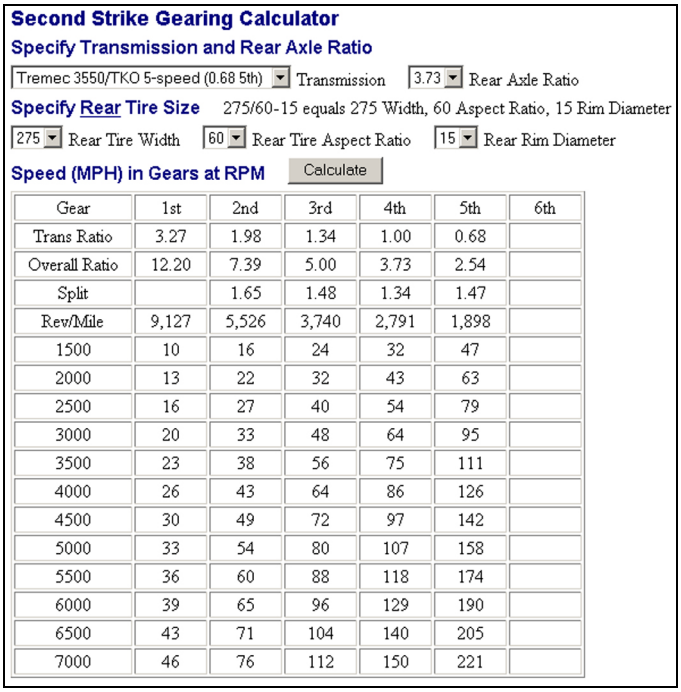
Second Strike Gearing Calculator

The Second Strike Gearing Calculator



Gear	1st	2nd	3rd	4th	5th	6th
Trans Ratio	3.27	1.98	1.34	1.00	0.68	
Overall Ratio	12.20	7.39	5.00	3.73	2.54	
Split		1.65	1.48	1.34	1.47	
Rev/Mile	9,127	5,526	3,740	2,791	1,898	
1500	10	16	24	32	47	
2000	13	22	32	43	63	
2500	16	27	40	54	79	
3000	20	33	48	64	95	
3500	23	38	56	75	111	
4000	26	43	64	86	126	
4500	30	49	72	97	142	
5000	33	54	80	107	158	
5500	36	60	88	118	174	
6000	39	65	96	129	190	
6500	43	71	104	140	205	
7000	46	76	112	150	221	

To assist owners in evaluating transmission, rear end ratio, and tire combinations, an interactive gearing calculator has been added to the Second Strike web site (www.SecondStrike.com).

The calculator is designed to help you analyze contemplated changes and get it right before committing your hard earned bucks. Changing the transmission, rear end, or rim size is not for the faint of heart or thin of wallet.

Input Section

The Gearing Calculator supports the most commonly used transmissions, rear ends and tire sizes used for the Superformance Mk III, Coupe, and GT.

Transmission

Transmission	Mk III	Coupe	GT
Tremec 3550/TKO 5-speed (0.68 5th)	Yes	Yes	
Tremec 3550/TKO 5-speed (0.82 5th)	Yes	Yes	
Tremec TKO-500 5-speed (0.68 5th)	Yes	Yes	
Tremec TKO-600 5-speed (0.82 5th)	Yes	Yes	
Tremec TKO-600 5-speed (0.64 5th)	Yes	Yes	
Tremec T-56 6-speed (Mustang SVT)	Yes	Yes	
T-56 6 speed (Viper)	Yes	Yes	
Ford Toploader 4-speed (close ratio)	Yes		
Ford Toploader 4-speed (wide ratio)	Yes		
RBT 5-speed (transaxle)			Yes

Rear Axle Ratio

Rear Axle Ratio	Ford 8.8 Mk III	BTR Coupe Mk III	RBT GT
3.08	Yes		
3.27	Yes		
3.46		Yes	
3.55	Yes		
3.73	Yes		
3.77			Yes
3.91		Yes	
4.10	Yes		
4.30	Yes		
4.56	Yes		

The Ford 8.8 IRS (independent rear suspension) rear end is used in MK III's prior to chassis number 2068. The BTR is used in the Mk III from chassis 2068 on.

Tire Size

	Mk III	Coupe	GT
Common Tire Sizes	275/60-15 295/50-15 335/35-17	285/50-18 295/45-18 315/35-18	275/60-15 295/50-15

The "standard" tire size is shown first. Other commonly used sizes are also shown.

275/60-15 is a 275 width, 60 aspect ratio, and 15" rim diameter. Width is in millimeters. The aspect ratio is the ratio of the tire section height to section width expressed as a percent. Rim size is in inches.

Output Section

Trans Ratio

Trans Ratio shows the transmission ratios for the selected transmission.

Overall Ratio

Overall Ratio is the transmission ratio times the rear end ratio.

The terms "tall" and "short" are sometimes applied to gearing. Short gearing is a high numerical ratio that winds up quickly, i.e. in a short time. Tall gearing is numerically low and covers a lot of ground with each rev, i.e. long-legged or tall.

Split

Split is the ratio of the previous gear to this gear, a ratio of ratios if you will. For the transmission to "feel right", the split should be the same or drop evenly from one gear to the next. If the split drops from gear to gear then goes back up as with the standard Tremec 3550 ratios, you will notice a "gap" when you shift. The standard Tremec is really a 4-speed with a tall overdrive 5th gear for cruising.

The split is a good measure of gear spacing. For a split of 1.31, the engine speed will go up 31% if you downshift, say from 3500 rpm to 4500 rpm. The tighter (smaller) the split, the less the engine speed changes when you shift. The split requirement is determined by the width of the power band. Engines with very narrow power bands need tight splits to keep the engine operating in the power band. Tight splits mean more gears to cover the same speed range and more gears means more time lost shifting. Engines with broad power bands work well with wider splits.

For the types of engines we are looking at, a "close ratio" transmission will have an average split in the 1.30 range. A "wide ratio" transmission will have an average split in the 1.40 to 1.50 range.

In some gearboxes the splits are all the same. This purely geometric arrangement provides the same rpm change in every gear when you shift. So the optimum shift point is the same for each gear.

In some gearboxes, the splits decrease rather uniformly. In this case, the gears get tighter as you go up. This has a very natural feel to it and is the most common gearbox design. However, the optimum shift point will be different for each gear.

In some cases, the split jumps up on the top ratio. This indicates an overdrive gear for highway cruising. The increase in the split is usually easily detected as a bog when shifting into top gear.

Rev/Mile

Rev/Mile is the engine revolutions per mile, which is the same as engine rpm at 60 mph. It is the best comparison figure for overall gearing since it includes transmission ratio, rear end ratio, and tire size.

The following observations are for a light car with a large powerful engine. Different observations would apply to other type vehicles.

The rev/mile in first gear is a good measure of how easy the car is to launch and drive in traffic. If the rev/mile in first is much below 7000, the car will require noticeable clutch slippage to get under way in traffic and when driving in slow traffic. First gear for this combination is too tall for comfortable dual-purpose use. A rev/mile in first of 7500 is workable if the engine is tractable. A rev/mile in first in the 8000 to 9000 range is easy to start and drive in traffic. A rev/mile over 9000 will seem too short. First gear will not be a useful performance gear. Traction will be a problem. You won't stay in first very long before it is time to shift.

The rev/mile in top gear is a good measure of how comfortably the car will cruise on the highway. If it is too low, the engine will run roughly or buck at cruising speeds. If it is too high, the engine speed will be wearing on both the engine and the passengers. A rev/mile in top gear of 1500 is possible for a tractable high performance engine, typically with an electronic engine management system. For high performance carbureted engines, something in the 1800 to 2000 range is a better target.

Speed in Gears at RPM

Speed in Gears at RPM. Following Revs/Mile is a chart of speed in each gear in 500 rpm increments.

This section will show you how slow you can go in each gear at a given engine speed, say 1500 or 2000 rpm. This is a good measure of drivability. Consider the following example for a Mk III with a TKO II transmission, 3.08 rear end and 275/60-15 tires.

Gear	1st	2nd	3rd	4th	5th
1500	12	20	29	39	48
2000	16	26	39	52	63

If the minimum drivable rpm is 2000 rpm, then a 25 mph speed limit requires 1st gear, 35 requires 2nd, 45 requires 3rd, and 55 requires 4th. Tuning the engine for a minimum drivable rpm of 1500 rpm means that 25 requires 2nd, 35 requires 3rd, 45 requires 4th, and 55 requires 5th. Improving drivability allows cruising in one taller gear at each speed limit.

This section will also show you how fast you can go in the gears. Considering the same example:

Gear	1st	2nd	3rd	4th	5th
6000	48	79	117	156	190
6500	52	85	126	169	206

With this gearing, the car will easily exceed 150 mph in 4th gear. Above 150 mph, aerodynamic stability is an issue for any blunt car, so it is a reasonable upper limit even on the track for safety reasons. Any gearing that will get you to 150 in 4th means that 5th is no longer needed as performance gear and will be used for highway cruising only.

Gearing

In this sense, "gearing" is anything that affects the relationship between engine speed and car speed. This includes the transmission ratios, the rear end ratio, and the tire size. From a performance perspective, the primary objective is to keep the engine operating in the power band from rest all the way to the maximum speed.

For a street machine or a dual-purpose road/track machine, there are typically other objectives as well. For example, the

car should cruise comfortably at minimum engine speed on the highway. This reduces noise, engine wear, and fuel consumption, and improves cruising comfort and pleasure. In addition, the car should be able to get underway and manage slow traffic without excessive clutch slippage.

In the early years, the 351 cubic Windsor was the most popular engine and the "standard" gearing (Tremec 3550 and 3.73 rear end) was the right choice for many owners. However, with the large displacement engines, it is easy to overpower the tires in first and frequently second gear with the standard gearing. The ever present big blocks and the growing popularity of large displacement small blocks have caused a number of new and existing owners to revisit the standard gearing.

Selecting the proper gearing is part engineering (running the numbers) and part experience (seat of the pants). For running the numbers, I have over the years analyzed the gear ratios in virtually every high performance manual transmission produced in the USA and have a pretty good feel for what the designer was trying to accomplish. I also have developed a rather sophisticated performance simulator that I use to evaluate alternatives. For seat of the pants, I have driven a fair number of cars over the years with 4-speeds, 5-speeds, and 6-speeds, and a number of rear end ratios. Even better, I have the Olthoff's track and customer car experiences to draw on.

Ford Toploader 4-Speed and 3.55

The Ford Toploader Close Ratio with a 3.55 rear end ratio illustrated in the chart below was a standard combination for the original 427 Cobra. It is representative of "period correct" gearing. The data shown is for the close ratio version of the Ford Toploader. The splits are close and decrease only slightly. This is basically a geometric gearbox.

The rev/mile in first is just above 6000. Based on actual driving experience with a 427/Toploader combination, it requires a good bit of clutch slippage to get underway and when driving in slow traffic. First gear for this combination is too tall for comfortable street or dual-purpose use.

Gear	1st	2nd	3rd	4th
Trans Ratio	2.32	1.69	1.29	1
Overall Ratio	8.24	6	4.58	3.55
Split		1.37	1.31	1.29
Rev/Mile	6,163	4,489	3,427	2,656
1500	15	20	26	34
2000	19	27	35	45
2500	24	33	44	56
3000	29	40	53	68
3500	34	47	61	79
4000	39	53	70	90
4500	44	60	79	102
5000	49	67	88	113
5500	54	74	96	124
6000	58	80	105	136
6500	63	87	114	147

The rev/mile in fourth is over 2600. Again, experience indicates that this is a bit high for highway cruising and will be taxing on long trips at highway speeds. Fourth gear is too short.

So what is the point of gearing combination with a tall first and short fourth? It works well for road courses where you only launch once and the top speeds are limited by layout. The close ratios do help the driver find the right gear for each corner on the course. However, they were not always the hot ticket for the street or even for drag racing.

One of the more successful drag racers in the 1960s, I believe it was Hayden Proffit, discovered that big engines with broad power bands lost time shifting extra gears. He went back to a 3-speed and kicked some 4-speed b***. He was diggin' while they were rowin' the gearbox.

Tremec 3550 5-Speed and 3.73

The Tremec 3550 and its big brother the TKO share the same relatively wide ratios. The splits drop progressively through 4th gear then jump up again in 5th. This jump is typical for overdrive gears. It can easily be detected when running through the gears as a bog when shifting into fifth. Like its baby brother, the T-5 used in Mustangs, the Tremec 3550 ratios are designed as a 4-speed for performance work plus a tall fifth for highway cruising - a 4+1 if you will.

In my driving experience with SP218, the Tremec 3550 transmission and 3.73 rear end were well suited to its 357 cubic inch Windsor engine. First gear at a little over 9000 rev/mile launched the car comfortably with minimum clutch slippage and worked well in slow traffic. Although it would fry the tires in first if provoked, giving the car a fraction of a second to settle back on its haunches before applying maximum power allowed the tires to really hook up and produce all the acceleration the tires could handle. Just about a perfect match.

Gear	1st	2nd	3rd	4th	5th
Trans Ratio	3.27	1.98	1.34	1.00	0.68
Overall Ratio	12.2	7.39	5.00	3.73	2.54
Split		1.65	1.48	1.34	1.47
Rev/Mile	9,127	5,526	3,740	2,791	1,898
1500	10	16	24	32	47
2000	13	22	32	43	63
2500	16	27	40	54	79
3000	20	33	48	64	95
3500	23	38	56	75	111
4000	26	43	64	86	126
4500	30	49	72	97	142
5000	33	54	80	107	158
5500	36	60	88	118	174
6000	39	65	96	129	190
6500	43	71	104	140	205

Second, third, and fourth provided all the gears needed for track work. Fourth at 129 mph at 6000 rpm was just a bit short for the longer straightaways. I did overspeed to 140 at 6500, but that was not a good idea as it turned out. The overdrive fifth provided comfortable cruising at about 1900 rpm at 60 mph. It would be a useful interstate highway gear for speeds over 65 mph even for raucous engines that don't run well below 2000 rpm.

Tremec T-56 6-Speed and 3.73

The Borg-Warner (now Tremec) T-56 has been used in a number of high performance cars including the Corvette, Camero, Firebird, Viper, and the SVT Mustangs. There are many ratios available for this transmission. The ratios shown are for the SVT Mustang.

The SVT Mustang splits show evenly spaced gears (constant split) up through fourth gear. Fifth and sixth are somewhat more closely spaced. Fifth is a performance gear – 161 mph at 6000 rpm is well within the performance envelope of larger engines. Sixth is a cruising overdrive.

At a bit over 8000 rev/mile in first, the car will work well in traffic. At just over 1700 at 60 mph in sixth, it will cruise comfortably on the highway.

This is a good combination with a gear for every purpose. There are a few things to consider if you are thinking about a T-56.

- At 129 pounds, theT-56 is 29 pounds heavier that the 3550.
- It is a good bit more expensive than the 3550.
- The T-56 requires cutting and welding modifications to the transmission cross member to install.
- I have driven a number of cars with the T-56 6-speed. It seems to me to have one more gear than a small car with a big engine needs. This is subjective of course.

Gear	1st	2nd	3rd	4th	5th	6th
Trans Ratio	2.97	2.07	1.43	1.00	0.80	0.62
Overall Ratio	11.08	7.72	5.33	3.73	2.98	2.31
Split		1.43	1.45	1.43	1.25	1.29
Rev/Mile	8,289	5,777	3,991	2,791	2,233	1,730
1500	11	16	23	32	40	52
2000	14	21	30	43	54	69
2500	18	26	38	54	67	87
3000	22	31	45	64	81	104
3500	25	36	53	75	94	121
4000	29	42	60	86	107	139
4500	33	47	68	97	121	156
5000	36	52	75	107	134	173
5500	40	57	83	118	148	191
6000	43	62	90	129	161	208
6500	47	68	98	140	175	225

Tremec 3550 TKO II and 3.08

I did a good bit of engineering and seat of the pants work in selecting the drive train to backup the RDI 427 prototype. These are my opinions, of course. Others will reach other conclusions, and that is as it should be.

Starting with the tires, I decided long ago to stick with the standard 60 series 15 inch tires. I like the original looks. And I don't want more traction. More traction subjects everything to higher loads, which in turn accelerates wear and breakage on the car and on the aging driver. So I will just slide around the corners with a big grin and you are welcome catch me if you can.

For the transmission, I selected the recently introduced Tremec 3550 TKO II. The TKO has a higher torque capacity, needed for the higher torque 427. The II has a 0.82 close ratio fifth gear that makes it a true 5-speed instead of a 4+1. I selected it over the T-56 for a number of reasons. Since this exercise is as much for "us" as it is for me, I wanted to make a choice that was representative of what other owners were doing. Cost, weight, and ease of installation were all factors. And I felt that 5 gears was the right number. Time spent shifting gears is time not accelerating. A light car with a big engine and a broad power band just doesn't need a lot of gears, in my opinion.

In selecting the rear end ratio, I had two objectives. First, I wanted to avoid overpowering the tires in second gear. (Overpowering in first is unavoidable.) Second, I wanted an overall fifth gear that would cruise comfortably on the highway.

As a passenger in a 514 with a 3.73 rear end, I was really impressed with its ability to light up the tires in second at will by simply rolling on the throttle. If fact, I shredded my shorts. Awesome indeed. But from a practical standpoint, it is a sure sign of too much gear in second.

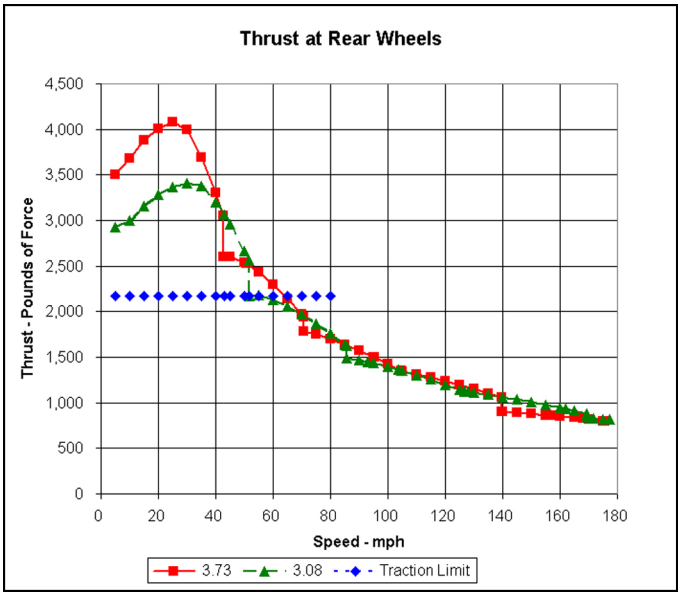
Looking at rear end ratios, all of the available rear-end ratios were evaluated in the performance simulator and produced about the same acceleration.

Ratio	Quarter Mile
3.73	11.76 at 128.81
3.55	11.72 at 128.30
3.27	11.65 at 127.40
3.08	11.60 at 126.85

A 20% change in gearing produced a 1% change in elapsed time and a 2% change in terminal speed. Essentially no difference. The reason is simple. **If a car has enough power to overpower the tires in first gear, then the rear end ratio has little effect on acceleration performance.**

Before you scratch your head, an explanation is in order. Looking at the physics, thrust accelerates the car. Thrust is equal to power divided by speed. For powerful cars, low

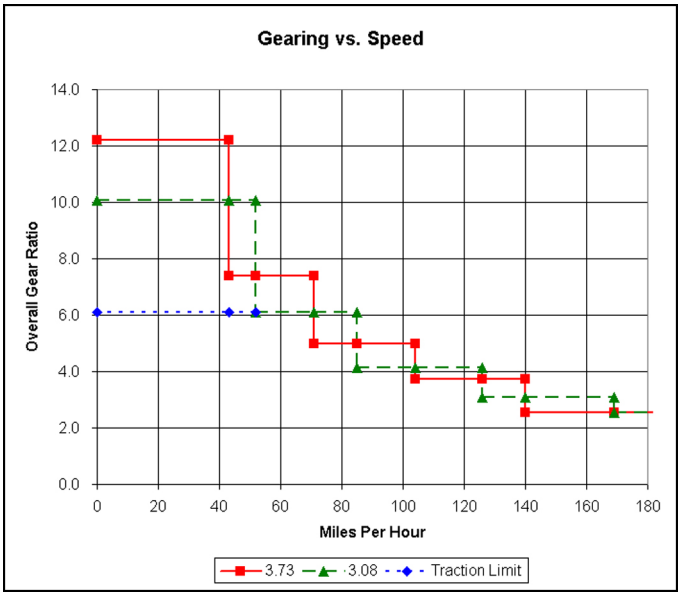
speed thrust is limited by available traction. So the initial acceleration is determined by available traction and after that acceleration is determined by horsepower. As long as the engine is in the power band, the car is accelerating as quickly as it can, regardless of gearing.



The "3.73" and 3.08" thrust curves show the available thrust for those rear end ratios. The "Traction Limit" curve shows the traction limited thrust. Tires, weight, weight distribution, and dynamic weight transfer determine the traction limit. Any thrust above the traction limit is lost to wheel spin. So while the 3.73 rear end does generate more thrust in first, it is over (way over) the traction limit, so it cannot be used. The 3.08 rear end also exceeds the traction limit, so in reality they provide the same traction limited thrust up to about 65 mph.

Above that, both ratios are fully hooked up and both engines are operating in the maximum power band, so the thrust is again equal. Since both rear ends have the same thrust curve from 0 to 180 mph, they have the same acceleration.

The overall gearing chart following gives another perspective. The traction limit is an overall ratio of just above 6.0. Any torque multiplication (overall gear ratio) above that is lost in wheel spin. The 3.73 rear end exceeds this limit in both first and second gear, meaning that the lower gearing of the 3.73 cannot be used fully until third gear. The 3.08 rear end also exceeds the traction limit by quite a bit in first, but is right on the money in second. So up until about 70 mph, both ratios are above or at the traction limit, and therefore equal. Above 70 mph, the 3.08 has lower torque multiplication in every gear, but can stay in a lower gear at higher speeds. At 80 mph for example, the 3.08 is still in second and has a higher overall gearing than the 3.73, which is in third at that speed. The advantage changes with each shift, but on average it equals out.



A few notes…

- There is no point in taking the excessive thrust out of first gear with further reductions in the rear end ratio. It will make the first and fifth gearing too tall for dual-purpose use.
- For lesser cars without the ability to overpower the tires, gearing does matter. A higher numerical ratio will produce better acceleration. But not with our cars.
- Yes, in a third gear roll-on, the car with the higher numerical rear end ratio will win. But in a "you pick the gear that works for you" roll-on, it is a dead heat every time.
- Transmission and rear end gearing are not a significant factor in overall acceleration performance of this car with this engine. Gearing selection is more a matter of personal preference and comfort for the intended use.

Here are the numbers for the TKO II and 3.08.

Gear	1st	2nd	3rd	4th	5th
Trans Ratio	3.27	1.98	1.34	1	0.82
Overall Ratio	10.07	6.1	4.13	3.08	2.53
Split		1.65	1.48	1.34	1.22
Rev/Mile	7,536	4,563	3,088	2,305	1,890
1500	12	20	29	39	48
2000	16	26	39	52	63
2500	20	33	49	65	79
3000	24	39	58	78	95
3500	28	46	68	91	111
4000	32	53	78	104	127
4500	36	59	87	117	143
5000	40	66	97	130	159
5500	44	72	107	143	175
6000	48	79	117	156	190
6500	52	85	126	169	206
7000	56	92	136	182	222

The 7,536 rev/mile in first is about as low as I would want to go. It takes some clutch slip to get started and is a bit high in traffic with a radical cam. Bob Olthoff felt that a 3.27 rear end would have been a better match with the prototype engine and I am inclined to agree. Hopefully with the planned cam change, the 3.08 will work as expected.

The rev/mile in fifth is 1,890, the same as the standard 3550 with 0.68 fifth and 3.73 rear end. This is a good target for highway cruising.

Observe that unlike the standard 3550, the fifth gear split is in a nice progression with the rest of the gears. It feels like a true 5-speed when driven.

The change in rear end ratio brought the speed in fourth up from 129 to 156 at 6000 rpm. Even with the increase in displacement and horsepower, it is unlikely that I will personally ever see fifth on a track.

Updates

Since this article was originally published in 2002, much has changed.

- The Superformance Coupe has been announced
- The Superformance GT has been announced.
- Tremec announced the new TKO-500 and TKO-600 5-speeds and dropped the familiar 3550 and TKO.
- From car 2068 on the Mk III began using the same basic rear end as the Coupe with the same 3.46 ratio.

The Gearing Calculator has been updated to incorporate all these changes.

Suggestions

Mk III with Ford 3.73 Rear End

With the Ford IRS (independent rear suspension) 8.8 rear end used prior to chassis 2068, you have a large choice of off-the-shelf ratios from Ford Racing to consider.

The original gearing article stimulated a lot of owners to re-evaluate their gearing. The then standard 3.73 rear end ratio was OK for a standard displacement 351, but was too short for the growing number of 351 strokers and the 427 and 460 big blocks, rendering first gear all but useless.

Based on these changes and quite a few conversations with owners re-evaluating their gearing, these suggestions are offered as a starting point.

T-56 6-speed Transmission

The T-56 works fine with the 3.73 rear end and the standard 275/60-15 rear tires. First gear is low enough, but not too low. 6th gear is fine for highway cruising. It works with the shorter section 295/50-15 and 335/35-17 tires as well.

Tremec 5-speed Transmissions

The Tremec 5-speed transmissions come with a close ratio 5th gear (0.82) and a wide ratio 5th gear (0.68).

Typically, with a 3.73 rear end, 4th gear is too short for back road cruising. 4000 rpm is only 86 mph. The engine feels strained. Shifting into a wide ratio 5th creates a bog. Fourth and fifth are just too far apart.

Some folks want to change the rear end and change to a close ratio 5th transmission. A better approach might be to change the rear end first and see how you like it with the existing transmission. Changing to a 3.27 rear end with 275/60-15 tires give 98 mph in 4th, much better for back road cruising. It also gives 147 mph at 6000 rpm in 4th. Since you should never go any faster than that even on a track due to the blunt object aerodynamics, you will never need 5th gear as a performance gear. So 5th gear will only be used for interstate cruising and the 4th to 5th bog no longer matters. The 3.27 also solves make 1st gear much more useful.

A number of owners have changed the rear end only and been very happy with the results.

If you are running low profile tires, such as 295/50-15 or 17 inch rims, consider a 3.08 rear end.

Mk III with BTR/Dana 3.46 Rear End

From chassis 2068 on, the Mk III use the same differential as the Coupe. The Coupe use a Hydratrack limited slip while the Mk III uses a standard limited slip.

As far as has been determined at this point, the BTR/Dana IRS rear end only offers 3.46 and 3.91 ratios. For most general purpose uses, the standard 3.46 is the better choice.

Coupe

The Coupe is fitted with a BTR Hydratrack IRS rear end with 3.46 gears. The only known optional ratio at this point is 3.91.

The 3.46 rear end with the 285/50-18 tires is a bit tall with a raucous engine. One owner with a pretty wild engine switched to the 3.91 and was pleased with the change.

GT

The new GT uses a RBT 5-speed transaxle with a standard 3.77 rear end ratio. RBT offers a great variety of transmission and rear end ratios. The standard gears selected for the GT give good 1st gear drivability, 200+ top speed potential in 5th and well placed splits in between.

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