Twin Tec — TCFI Idle Tuning Tech Note

CAUTION: CAREFULLY READ INSTRUCTIONS BEFORE PROCEEDING. NOT LEGAL FOR SALE OR USE IN CALIFORNIA OR ON ANY POLLUTION CONTROLLED VEHICLES. .

INTRODUCTION

This tech note provides detailed information about the operation of the TCFI Gen 3, Gen 4, and Gen 5 series and specifically addresses common idle tuning issues. **The term TCFI is used throughout this document as a generic term. Unless otherwise noted, values shown in tables and figures are for illustration purposes only and not necessarily representative of any particular application.**

OVERVIEW OF IDLE CONTROL

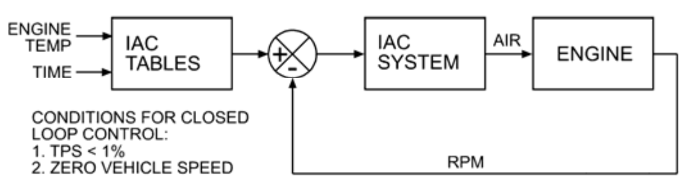
The TCFI controls idle RPM and AFR (air/fuel ratio) using individual control loops. Each control loop can operate open loop (without feedback correction) or closed loop (with feedback correction) depending on conditions. The AFR control loop functions the same at idle as under other engine operating conditions, but some special considerations apply at idle.

If you are not familiar with control systems concepts such as open and closed loop operation, we suggest that you order Understanding Automotive Electronics (Sixth Edition) by William B. Ribbens from www.amazon.com. Chapter 2 includes an excellent introduction to control system theory.

IDLE RPM CONTROL LOOP

The output of the idle RPM control loop is idle air control (IAC) stepper motor position. A higher IAC value allows more air flow and increases engine RPM.

TCFI CLOSED LOOP IDLE SPEED CONTROL



The IAC value is calculated based on the following equation:

IAC = IAC Start Adder + ET Based IAC + Nominal IAC + Closed Loop Correction

Engine RPM is used as feedback during closed loop control. Actual engine RPM is compared to the desired set point value in the Engine Temperature (ET) Based Idle RPM 2D table and the closed loop correction value is adjusted accordingly.

Table 1 – ET Based Idle RPM

ET (deg C)	-16	0	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
Idle RPM	1398	1320	1250	1172	1102	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

The following two conditions are required for closed loop idle RPM control:

Zero vehicle speed. If the vehicle speed sensor (VSS) is not connected or the output is incorrectly scaled (VSS frequency parameter – refer to the TCFI Installation and Tuning Manual for details), the idle control loop will fail. This situation is frequently encountered with custom motorcycles and some aftermarket transmissions.

Throttle position sensor (TPS) < Idle TPS value. If the TPS sensor is not properly adjusted (refer to the TCFI Installation & Tuning Manual for details), the idle control loop will fail. This situation is one of the most common causes of tech support calls.

Unless the motorcycle is at a complete stop with the throttle closed, idle RPM control is open loop. During open loop control, the IAC value is calculated based on:

ET Based IAC Position 2D table. This table consists of an IAC value as a function of engine temperature. This value is continually read and updated as engine temperature changes. The primary purpose is to provide temperature compensation since a cold engine typically requires more air to support the required idle RPM. The table values should always taper off to zero at normal operating temperature (i.e. above 96 deg C).

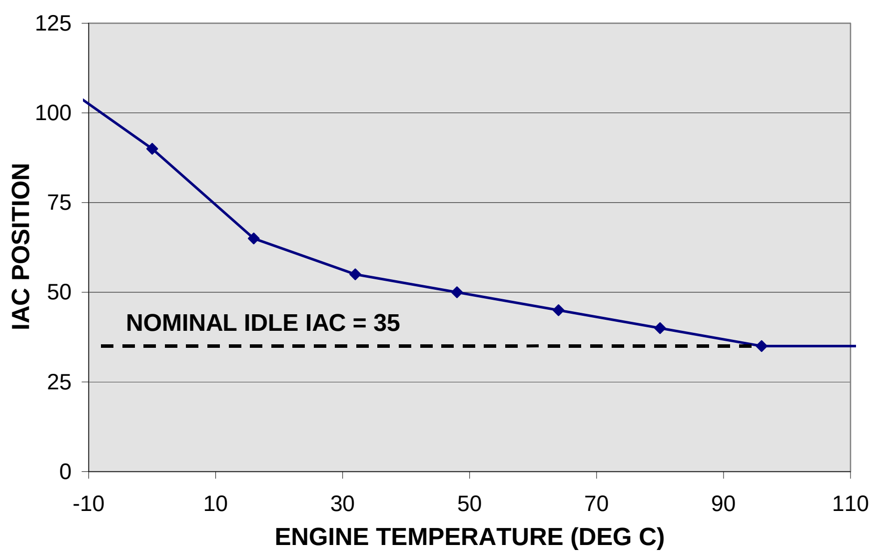
Table 2 – ET Based IAC Position

ET (deg C)	-16	0	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
IAC	75	55	30	20	15	10	5	0	0	0	0	0	0	0	0	0	0

Nominal Idle IAC steps. This parameter (from the basic module parameters screen) determines the nominal IAC position.

The closed loop correction factor is only updated when closed loop conditions are met. Ideally the closed loop correction factor should be close to zero. As the engine reaches normal operating temperature, the IAC position will gradually taper down to the nominal value as shown in Figure 1. Note: for the example shown in Figure 1, the IAC start adder term is assumed to be zero (several minutes elapsed since engine start). The closed loop correction term is also assumed to be zero.

FIGURE 1 - IAC POSITION VERSUS ENGINE TEMPERATURE



During engine start and the first several minutes of operation, two additional tables affect the IAC value:

ET Based IAC Start Adder 2D table. This table also consists of an IAC value as a function of engine temperature. However this value is only read at engine start. The primary purpose is to provide additional idle air during engine start.

Table 3 – ET Based IAC Start Adder

ET (deg C)	-16	0	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
IAC	20	20	20	15	5	0	15	30	30	30	30	30	30	30	30	30	30

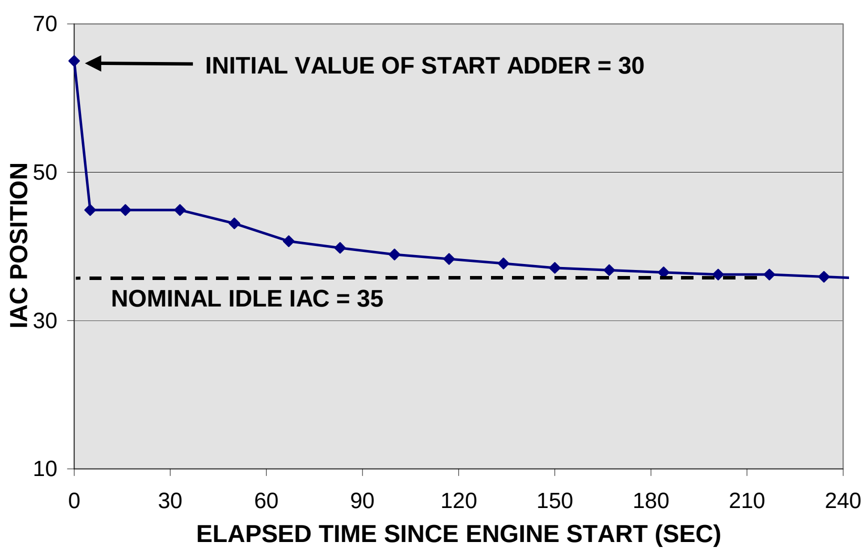
Time Based IAC Start Adder 2D table. This table consists of a multiplier factor (percent units) that is a function of elapsed time since engine start. The multiplier factor is applied to the IAC start adder in order to compensate for time dependent characteristics of the throttle body after engine start, especially after a hot soak. The table values should always taper off from some initial value at zero elapsed time and must reach 0% at the maximum value of elapsed time (268 seconds).

Table 4 – Time Based IAC Start Adder (Multiplier)

Time (sec)	0	16	33	50	67	83	100	117	134	150	167	184	201	217	234	251	268
Mult%	33	33	33	27	19	16	13	11	9	7	6	5	4	4	3	2	0

Figure 2 shows the action of the time based start adder. The example in Figure 2 is for a hot start above 96 deg C (after a hot soak) with the IAC start adder value at 30 and a typical time based multiplier ramping down from 33% to zero. Since the engine is at 96 deg C, the value contributed from Table 2 is zero. When the engine is started, the IAC position is at 65. The value ramps down quickly as the engine RPM stabilizes a few seconds after engine start. After 30 seconds, the IAC position slowly ramps back down to the nominal value as the throttle body and injectors cool down. This will occur even as the motorcycle is being driven. When the engine returns to idle, the IAC value will already be back at the correct nominal value – requiring very little if any closed loop correction.

FIGURE 2 - IAC POSITION VERSUS ELAPSED TIME



Note: for the example shown in Figure 2, the ET based IAC term is assumed to be zero (engine at 96 deg C). The closed loop correction term is also assumed to be zero.

Idle IAC Tables 2-4 allow temperature and time compensation so that under open loop conditions the IAC position will remain close to the required value. The default tables in the PC Link TCFI III sample setup files should be reasonable for most applications. Simple techniques for optimizing this compensation for troublesome applications will be discussed further on.

TCFI units have two additional IAC related features that are selected by means of checkboxes under Module Parameters:

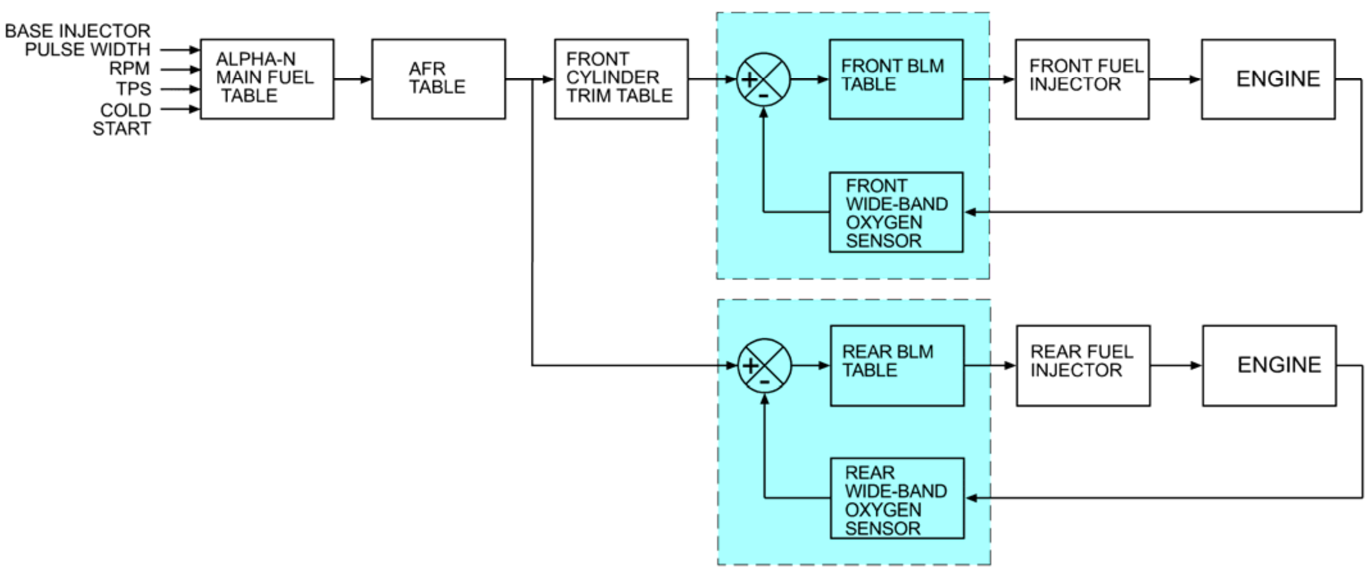
Automatic Nominal Idle IAC Update Mode – recommended for most applications. The nominal idle IAC value (IAC steps once engine is fully warmed up and at stable idle condition) is automatically sampled and updated. This occurs after 8 seconds of stable idle whenever vehicle speed returns to zero while the motorcycle is operated. The updated value is saved after engine shut down. This feature eliminates the requirement to set the nominal idle IAC value as part of the tuning process and allows the system to automatically accommodate different throttle bodies (as long as the actual value stays within a reasonable range of 25-40 as per the guidelines in the TCFI Installation & Tuning Manual). Some problematic throttle bodies may exhibit very erratic behavior with the nominal idle IAC value changing after every engine start. If you observe this type of erratic behavior, you may obtain more consistent results by manually entering a reasonable value and unselecting the checkbox to disable the automatic update.

Anti-Stall IAC Mode – for problem applications where occasional engine stalling occurs when the clutch is pulled in. In anti-stall IAC mode, closed loop idle speed control is always active when engine RPM is below the target idle RPM. This may cause an unexpected increase in idle RPM if the engine is inadvertently “lugged” down below the target idle RPM. Some problematic throttle bodies may exhibit erratic behavior due to mechanical binding, thermal effects, or intermittent vacuum leaks. For example, assume that a small vacuum leak is present. The additional airflow tends to increase idle RPM and causes the idle RPM control loop to compensate by decreasing the IAC value. After the motorcycle is driven some distance, the vacuum leak disappears (perhaps the intake manifold heats up, expands, and makes better contact with the seals). When the throttle is closed and the clutch is pulled in, engine RPM may drop very low. If the motorcycle is still moving, the idle RPM control loop is not active, and the engine may stall. Anti-stall IAC mode reduces the likelihood of the engine stalling. Selecting anti-stall IAC mode should be considered a last resort if the underlying problem cannot be resolved.

AFR CONTROL LOOP

The output of the AFR control loop is injector pulse width. A higher pulse width causes more fuel to be injected and decreases the AFR towards a rich condition.

TCFI CLOSED LOOP FUEL CONTROL



Injector pulse widths are calculated based on the following equations:

Front Injector PW = Base PW x CF x Front CSE x Alpha-N x (14.7/AFR) x Front Cyl Trim x Front BLM

Rear Injector PW = Base PW x CF x Rear CSE x Alpha-N x (14.7/AFR) x Rear BLM

Where:

Front Injector PW **Rear Injector PW**	Injector pulse width (milliseconds)
Base PW	Base injector pulse width (milliseconds)
CF	Correction factor (barometric pressure, air temp, and battery voltage)
Front CSE **Rear CSE**	Cold start fuel enrichment (percent). There are independent front and rear cold start enrichment tables
Alpha-N	Main fuel table (percent)
AFR	Air/fuel ratio (numeric AFR value)
Front BLM **Rear BLM**	Block learn multiplier tables (closed loop correction factor as percent)
Front Cyl Trim	Front cylinder trim table (percent)

The Alpha-N 3D table is the main fuel table (Alpha-N is the technical term for throttle position and RPM). The Alpha-N table values are in percent units. The calculated base injector pulse width (determined by engine horsepower and injector size settings on the basic module parameters screen) is corrected for cold start enrichment, intake air temperature (IAT), and battery voltage. The corrected value is then multiplied by the Alpha-N table value to determine the theoretical injector pulse width for a 14.7 air fuel ratio. This value is then multiplied by the AFR table to arrive at the desired air/fuel ratio. A feedback correction is applied based on the oxygen sensor signal and the stored closed loop correction values in the block learn multiplier (BLM) table.

Sections of typical fuel related tables with idle cells are shown below.

Table 5 – Alpha-N Table

TPS/RPM	500	750	1000	1250	1500	1750	2000	2250	2500
0%	28.5	23.0	22.0	20.0	17.0	16.0	15.0	15.0	15.0
2.5%	35.0	33.5	31.5	27.5	24.5	24.5	25.5	23.0	20.0
5.0%	45.0	45.0	39.5	38.0	32.5	30.5	27.0	24.0	24.0
7.5%	62.5	62.5	54.0	39.5	39.0	35.5	31.0	30.0	25.5
10%	75.5	75.5	75.0	53.0	49.0	47.0	42.0	38.0	35.5
15%	90.0	90.0	90.0	80.5	67.0	62.0	55.5	52.0	46.0
22.5%	91.5	91.5	91.5	91.5	89.0	82.0	73.5	71.0	64.0
35%	93.5	93.5	93.5	93.5	93.0	93.0	90.0	86.0	78.0

Exhaust gas based AFR measurements from the WEGO system are used for feedback during closed loop control. AFR reported by the WEGO is compared to the desired set point value in the AFR 3D table. A section of the AFR table with idle cells is shown below.

Table 6 – AFR Table

TPS/RPM	500	750	1000	1250	1500	1750	2000	2250	2500
0%	12.8	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
2.5%	12.8	13.2	13.2	13.2	13.2	13.5	13.5	13.5	13.5
5.0%	12.5	12.8	12.8	12.8	12.8	13.8	13.8	13.8	13.8
7.5%	12.5	12.5	12.5	12.5	12.5	13.8	13.8	13.8	13.8
10%	12.5	12.5	12.5	12.5	12.5	13.8	13.8	13.8	13.8
15%	12.5	12.5	12.5	12.5	12.5	13.8	13.8	13.8	13.8
22.5%	12.5	12.5	12.5	12.5	12.5	13.8	13.8	13.8	13.8
35%	12.5	12.5	12.5	12.5	12.5	12.8	12.8	12.8	12.8

At any point in time, the system is operating in a given cell based on TPS% and RPM. The closed loop correction is applied to the corresponding BLM (block learn multiplier) 3D table cell as a percentage value. If the system must decrease the amount of fuel to maintain the required AFR value, the BLM value decreases below 100%. If the system must increase the amount of fuel, the BLM value increases above 100%. Updated BLM values are stored in EEPROM memory. Think of the BLM value as a percentage correction factor that the system learns over time. This approach to closed loop AFR control and the terminology are automotive industry standards that have been in widespread use since 1981 when oxygen sensor systems first appeared in production.

From a practical standpoint, the Alpha-N and front cylinder trim tables must be within about ±20% of the required values for the TCFI system to successfully correct the injector pulse width based on closed loop feedback from the WEGO system.

BLM cell values 0 and 1 command special functions and these cells are highlighted in blue. Closed loop feedback is disabled in any BLM cells with value 0. This is useful in operating areas where exhaust reversion effects may cause incorrect sensor readings. The BLM table shown above has the special value 0 in cells corresponding to decel (RPM above idle and closed throttle) where reversion effects are most pronounced.

Table 7 – Typical BLM Table (After Auto-Tuning)

TPS/RPM	500	750	1000	1250	1500	1750	2000	2250	2500
0%	0	100	93	90	91	0	0	0	0
2.5%	100	100	97	98	99	97	93	97	102
5.0%	100	100	96	98	101	97	103	100	98
7.5%	100	100	100	101	95	102	102	103	105
10%	100	100	100	100	97	89	100	98	98
15%	100	100	100	100	95	86	95	98	102
22.5%	100	100	100	100	100	99	98	102	97
35%	100	100	100	100	100	100	101	99	99

BLM update, but not closed loop feedback, is disabled in any BLM cells with value 1. The BLM table shown above has the value 1 in cells corresponding to idle (750-1250 RPM and closed throttle). Air-cooled engines tend to have an unstable idle characteristic with significant changes in fuel requirements, including balance between front and rear cylinders, as the engine reaches operating temperature. The TCFI system with dual WEGO sensors can operate in closed loop within 30 seconds after engine start. Most TCFI applications will not require using the special BLM value 1 in the idle cells.

During auto-tuning, BLM values are only saved if the engine reaches 95° C (200° F) and runs for at least 5 minutes. This is set by warm engine temperature and engine warmup time parameters. In cold climate areas, you may have to use a lower value for warm engine temperature.

Table 8 – Typical Front Cylinder Trim Table

TPS/RPM	500	750	1000	1250	1500	1750	2000	2250	2500
0%	95	95	95	95	95	90	90	90	98
2.5%	110	110	110	112	118	100	105	88	111
5.0%	120	120	120	145	145	145	145	145	140
7.5%	106	106	110	126	133	134	145	140	132
10%	110	110	103	108	107	130	139	139	125
15%	120	120	120	113	120	107	130	110	94
22.5%	104	104	108	116	104	104	108	116	103
35%	110	110	109	114	110	110	109	114	105

Cold Start Enrichment

The TCFI features enhanced cold start enrichment calculations based on five 2D tables. Two of the tables affect the AFR command and the remaining three tables directly affect the injector pulse width.

The AFR value used in the main fuel equations shown on page 5 is calculated from the AFR table value (refer to Table 6) and the two AFR cold start enrichment tables based on the following equation:

> **AFR = AFR Table Value/(1 + (ET Based AFR Cold Start Enrichment x Time Based AFR Cold Start Enrichment))**

The Time Based AFR Cold Start Enrichment table consists of a cold start AFR multiplier (percent units) that is a function of elapsed time since engine start. Time based cold start enrichment should always taper off from 100% at zero elapsed time and must reach 0% at the maximum value of elapsed time.

Table 9 – Time Based AFR Cold Start Enrichment

Time (sec)	0	8	16	33	50	67	83	100	117	134	150	167	184	201	217	234	251
AFR Mult%	100	50	25	15	8	3	0	0	0	0	0	0	0	0	0	0	0

The ET Based AFR Cold Start Enrichment table consists of a cold start AFR multiplier (percent units) that is a function of engine temperature. As with all cold start enrichment tables, this table does double duty for hot soak enrichment. Note that a significant enrichment is required at high temperatures due to thermal effects on the throttle body. Some of the engine temperature cells are highlighted in red. These red cells correspond to invalid sensor readings.

Table 10 – ET Based AFR Cold Start Enrichment

ET (deg C)	-16	0	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
Fuel Add%	17	14	14	12	12	12	12	12	12	12	14	14	14	14	14	14	14

The AFR cold start enrichment provides a richer (lower) AFR value during the initial period after engine start. The table values result in enrichment similar to the original equipment ECM and should be correct for most applications. For example, assume that the time and ET based AFR cold start enrichment values are 50% and 14% respectively and the AFR table value is 13.5. The actual AFR (from the equation above) is 12.6 = 13.5/(1 + (.50 x .14).

To avoid problems with excessive closed loop corrections during the initial period after engine start, the TCFI system must also increase the injector pulse width to match the richer AFR command with additional fuel. The remaining three cold start enrichment tables provide this function (Front and Rear CSE in the main fuel equations on page 5.

The Time Based Fuel Cold Start Enrichment table consists of a cold start fuel multiplier (percent units) that is a function of elapsed time since engine start. Time based cold start enrichment should always taper off from 100% at zero elapsed time and must reach 0% at the maximum value of elapsed time.

Table 11 – Time Based Fuel Cold Start Enrichment

Time (sec)	0	8	16	33	50	67	83	100	117	134	150	167	184	201	217	234	251
Fuel Mult%	100	50	30	20	15	11	9	7	5	3	2	1	1	0	0	0	0

The ET Based Front and Rear Cylinder Cold Start Enrichment tables consist of a cold start multiplier (percent units) that is a function of engine temperature. As with all cold start enrichment tables, this table does double duty for hot soak enrichment. Note that a significant enrichment is required at high temperatures due to effects such as reduced injector flow. Some of the engine temperature cells are highlighted in red. These red cells correspond to invalid sensor readings.

Table 12 – ET Based Front Cylinder Cold Start Enrichment

ET (deg C)	-16	0	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
Fuel Add%	84	82	79	70	50	40	30	25	25	25	25	25	25	25	25	25	25

Table 13 – ET Based Rear Cylinder Cold Start Enrichment

ET (deg C)	-16	0	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
Fuel Add%	35	25	20	15	15	15	20	20	20	20	20	20	20	20	20	20	20

The overall fuel cold start enrichment for each cylinder is determined by the following equation:

CSE = 1 + (ET Based Cold Start Enrichment x Time Based Cold Start Enrichment)

For example, assume that the time and ET based cold start enrichment values are 50% and 30% respectively. The CSE term is then 1.15 = 1 + (.50 x .30) corresponding to 15% overall enrichment.

Individual tables are used for each cylinder because most engines exhibit significant differences in the characteristics of the front and rear cylinders.

Compensation of Throttle Position for IAC

Tables 5-8 are all 3D fuel tables with rows corresponding to TPS%. In an Alpha-N fuel control system, IAC position must be considered. A high IAC position (high idle air flow) is the same as opening the throttle. The IAC Based TPS Adder 2D table is used to compensate for air flow through the IAC system.

Table 14 – IAC Based TPS Adder

IAC	0	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240	256
TPS Add%	0.0	0.9	2.0	3.0	4.1	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0

The TPS% value used for table lookup by the TCFI system is calculated based on the following equation:

Table Lookup TPS% = Measured TPS% + TPS Adder%

The IAC value used for lookup in the IAC Based TPS Adder table is calculated based on the following equation:

Table Lookup IAC = IAC Position – Nominal Idle IAC

If the throttle body is correctly adjusted as per the guidelines in the TCFI Installation & Tuning Manual, the actual IAC position required to maintain idle RPM in a warm engine should be close to the nominal value. In this case the Table Lookup IAC and the TPS Adder% values will both be zero. Under cold start (or hot restart) conditions, the actual IAC value will be higher than the nominal value, and both the Table Lookup IAC and the TPS Adder% values will be greater than zero. The Table Lookup TPS% will be greater than the measured TPS% resulting in higher values being read from the various fuel tables. Fuel delivery will increase to match the additional air flowing through the IAC system.

The IAC Based TPS Adder 2D table and the two equations above link the idle RPM and AFR control loops. The default values for the IAC TPS Adder table given in the PC Link TCFI III sample setup files are reasonable unless the throttle body has been modified. However, you can readily see that serious problems would arise if the Nominal Idle IAC value was incorrect. The injector pulse width calculation would be incorrect with the error tending to be greatest during cold start and hot restart conditions.

The TCFI includes an Automatic Nominal Idle IAC Update Mode setting for basic module parameters. This setting is recommended for most applications. The nominal idle IAC value (IAC steps once engine is fully warmed up and at stable idle condition) is automatically sampled and updated. Enabling this setting allows the system to automatically adjust for long term drift (errors) in the throttle body as long as the IAC values stay within a reasonable range.

IAC START ADDER

The Time Based IAC Start Adder will eliminate problems some customers encountered with high idle RPM several minutes after a hot restart. It provides time based compensation for thermal effects within the throttle body.

If you open a setup file originally created with an earlier version of PC Link TCFI, the values in the Time Based IAC Start Adder table will appear as zero. You can use the values shown in the examples that follow or in the sample setup files supplied with the new PC Link TCFI III software as a starting point for editing your own setup file. You may also want to re-examine and optimize the ET Based IAC Start Adder table values in your setup file.

RECOGNIZING AND CORRECTING AN UNSTABLE IDLE CHARACTERISTIC IN TCFI APPLICATIONS

Typical manifestations of an unstable idle characteristic appear after some auto-tuning and include:

1. One or more BLM cells in the idle range (750-1500 RPM and 0-5% TPS) have abnormally low values.
2. If the BLM tables have been applied, one or more Alpha-N or front cylinder trim cells in the idle range (750-1500 RPM and 0-5% TPS) have noticeable dips or spikes compared to adjacent cells. In general, these tables should be fairly smooth in the idle range, with Alpha-N values decreasing with RPM and increasing with higher TPS.
3. At normal operating temperature the engine runs OK and BLM values appear reasonable, but problems such as extremely high BLM values or very lean AFR are noted during cold start or hot restart. In a worst case scenario, the engine now stalls 10-15 seconds after cold start, even though it did not exhibit such behavior before auto-tuning.

Corrective action is to use the special BLM value 1 in the problematic idle cells. We suggest that you use the special BLM value 1 throughout the idle range as shown in Table. This special value forces the system to always start with the value 100% in these idle BLM cells.

Then go back to the Alpha-N and front cylinder trim tables and manually calibrate the tables for a slightly rich idle as the engine is warming up before closed loop fuel control is enabled. Smooth out any dips or spikes in the affected cells. You can use the following guidelines to smooth the Alpha-N table:

1. At part throttle (low TPS%), Alpha-N values in each row will tend to decrease as RPM increases (because the throttle is choking air flow).
2. At wide open throttle, Alpha-N values in each row will tend to follow the engine torque curve.
3. In any given RPM column, Alpha-N values must always increase with TPS.

Run additional cold start and hot restart tests and examine the data with TCFI III Log to verify that AFR values are reasonable.

The fuel cell display feature implemented in TCFI III Log helps identify problematic BLM cells. You can examine logged data, such as data collected during a cold start, and determine what BLM cell is active at any point in time.

Table 15 – BLM Table Showing Special Value 1 in Idle Cells

TPS/RPM	500	750	1000	1250	1500	1750	2000	2250	2500
0%	0	1	1	1	1	0	0	0	0
2.5%	100	1	1	1	1	97	93	97	102
5.0%	100	1	1	1	1	97	103	100	98
7.5%	100	100	100	101	95	102	102	103	105
10%	100	100	100	100	97	89	100	98	98
15%	100	100	100	100	95	86	95	98	102
22.5%	100	100	100	100	100	99	98	102	97
35%	100	100	100	100	100	100	101	99	99

Table 16 – Alpha-N Table Smoothing Guidelines

TPS/RPM	500	750	1000	1250	1500	1750	2000	2250	2500
0%	28.5	23.0	22.0	20.0	17.0	16.0	15.0	15.0	15.0
2.5%	35.0	33.5	31.5	27.5	24.5	24.5	25.5	23.0	20.0
5.0%	45.0	45.0	39.5	38.0	32.5	30.5	27.0	24.0	24.0
7.5%	62.5	62.5	54.0	39.5	39.0	35.5	31.0	30.0	25.5
10%	75.5	75.5	75.0	53.0	49.0	47.0	42.0	38.0	35.5
15%	90.0	90.0	90.0	80.5	67.0	62.0	55.5	52.0	46.0
22.5%	91.5	91.5	91.5	91.5	89.0	82.0	73.5	71.0	64.0
35%	93.5	93.5	93.5	93.5	93.0	93.0	90.0	86.0	78.0

Decreasing with RPM →

Increasing with TPS ↓

OPTIMIZING ET BASED IAC POSITION TABLE VALUES

Before you attempt to optimize your ET Based IAC Position table, make sure that you have completed the basic idle tuning steps in the TCFI III Installation & Tuning Manual and that when the engine is completely warmed up, the nominal IAC value is within the recommended range of 25-40.

A typical ET Based IAC Position table is shown in Table 2 on page 2. If the ET Based IAC Position values are not correct for your application, you may encounter unexpectedly low or high idle RPM immediately after the clutch is pulled in. The sample setup files supplied with PC Link TCFI III have reasonable values, but if you change the throttle body or have a very large engine displacement, you may need to optimize the table values. To avoid undesired interactions during this test, set the Time Based IAC Start Adder table values to zero. Before you conduct this test, you also need to know the nominal IAC value. Do a cold start. Use a fan to provide some engine cooling. Monitor engine data with TCFI III Log. Let the engine warm up until it reaches about 115 deg C. Then use TCFI III Log software to download and examine the data.

Figure 3 – Cold Start Test Showing ET and IAC Data

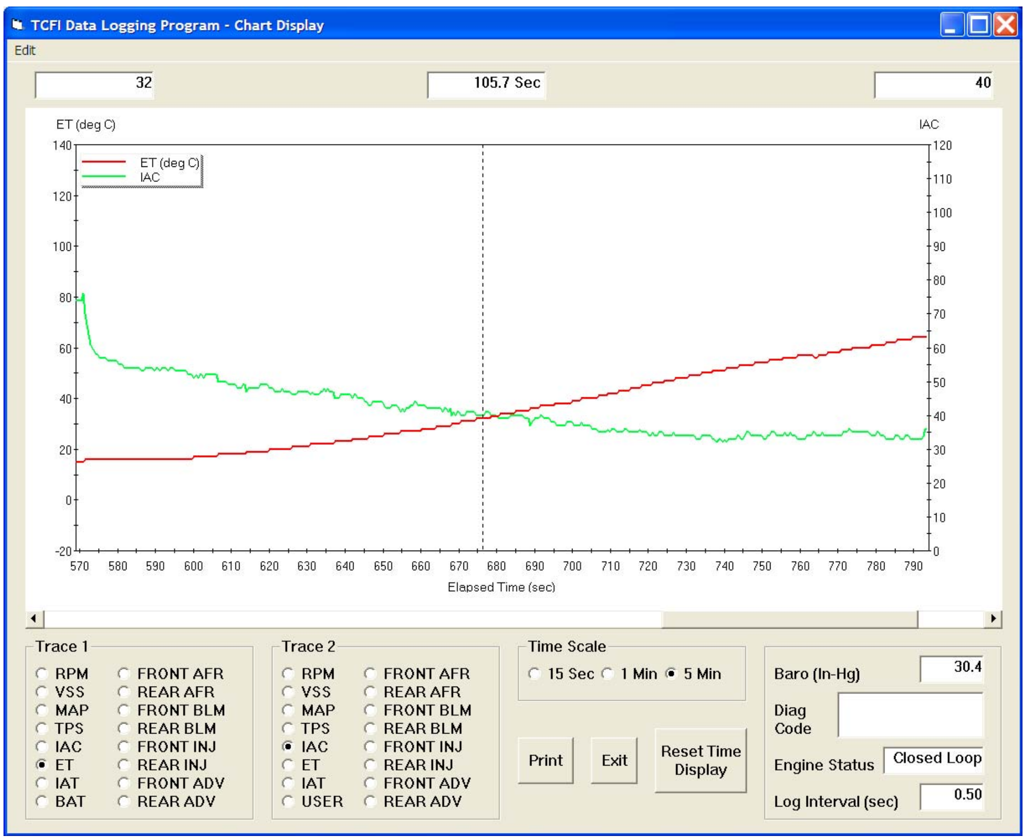


Figure 3 shows data logged from a cold start test. The chart shows engine temperature (ET) and IAC position data. The time display has been reset to zero at engine start at the very left side of the chart. The effect of the IAC start adder is apparent immediately after engine start. Within a few seconds, the IAC value stabilizes and slowly starts to drop with temperature.

Record the IAC values at the various temperature columns in the ET Based IAC Position table, i.e. at 16, 32, 48, 64, 80, 96, and 112 deg C. Depending on the season and your geographical location, you may not be able to obtain data at lower temperatures. You may have to extrapolate the data for the lower temperature columns in the table. You should only use data where the engine is operating in closed loop and you know that the AFR values are correct.

Refer back to the IAC equation on page 1:

IAC = IAC Start Adder + ET Based IAC + Nominal IAC + Closed Loop Correction

You want the values in the ET Based IAC Position table to be very accurate so that no closed loop correction is required. Once a few seconds have elapsed after engine start, the IAC start adder term is also zero. Assuming both these terms are zero and solving the equation for the ET Based IAC value gives:

ET Based IAC = IAC – Nominal IAC

Thus the required table value at any given temperature is the observed value (from the chart data) minus the nominal value. For the example in Figure 3, the observed IAC value at 32 deg C is 40. Let us assume that the nominal IAC value is 25. The ET Based IAC Position table value in the 32 deg C column should be 15.

OPTIMIZING ET BASED IAC START ADDER TABLE VALUES

Before you attempt to optimize your ET Based IAC Start Adder table, make sure that you have completed the basic idle tuning steps in the TCFI III Installation & Tuning Manual.

Use the values given in Table 3 or in one of the new sample setup files supplied with the PC Link TCFI III software as a starting point. You can then run tests to optimize the values. Do a cold start and let the engine idle for about a minute. Then use TCFI III Log software to download and examine the data. Then operate the motorcycle long enough for the engine to fully warm up. After a 10 minute hot soak, restart the engine. Repeat the same test.

Figure 4 – Hot Start Test with Correct IAC Start Adder

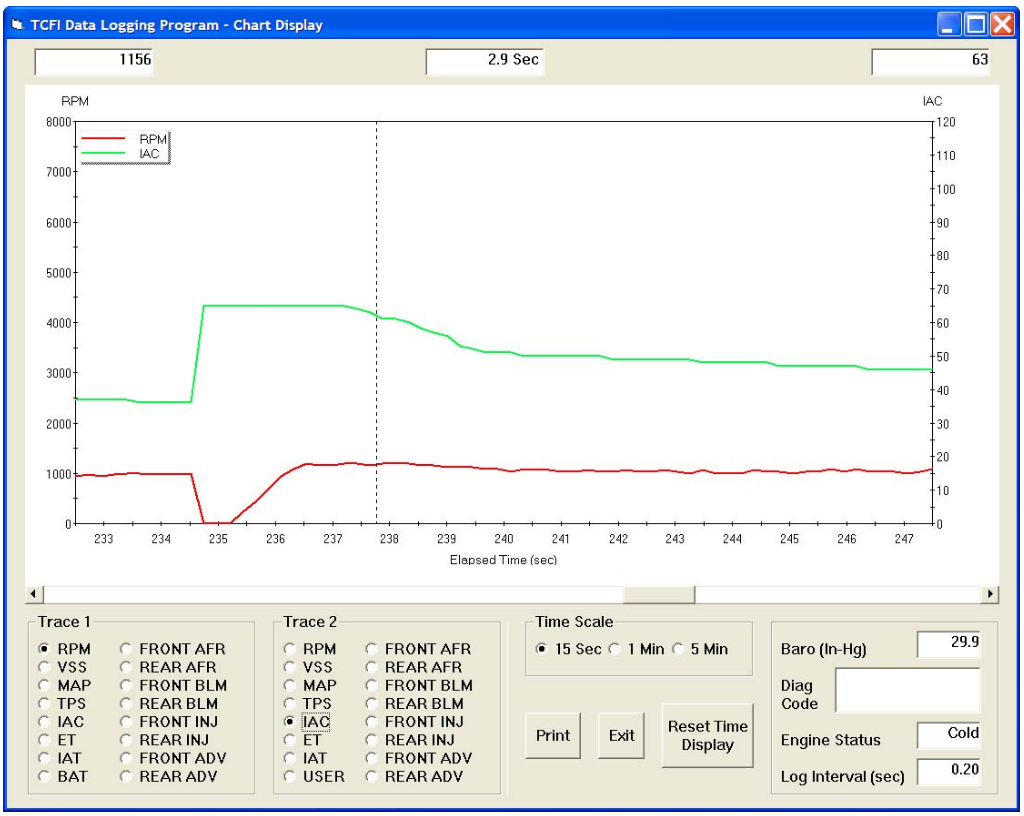


Figure 4 shows data logged from a hot start test using reasonable ET Based IAC Start Adder values (taken from Table 3). Time display has been reset to zero at engine start. RPM and IAC values are displayed. Engine RPM increases smoothly after cranking and then quickly levels off to 1,000 RPM. The correct amount of additional air is being provided during engine start. You can see that the IAC values follow a curve similar to Figure 2.

Figure 5 – Hot Start Test with Low IAC Start Adder

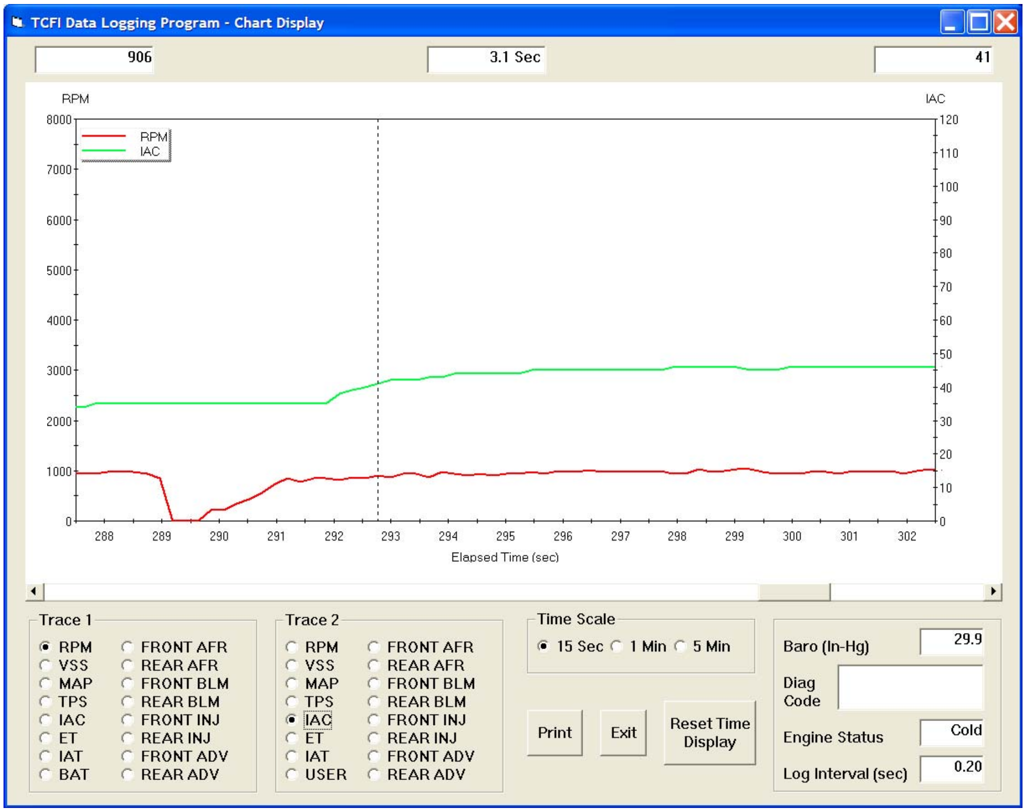


Figure 5 shows data logged from a hot start test with ET Based IAC Start Adder values that are too low. Time display has been reset to zero at engine start. RPM and IAC values are displayed. The engine cranks slowly and several seconds elapse before the engine reaches a stable idle at 1,000 RPM. The problem is insufficient additional air during engine start. You can see the action of the idle RPM control loop as it ramps the IAC value up while the engine is running below the 1,000 RPM idle set point.

If your data looks like Figure 4, you have reasonable ET Based IAC Start Adder values. If your data looks like Figure 5, you need to increase the values in your table. If you have values that are too high, the engine RPM will race up excessively after engine start and then take several seconds to come back down again.

OPTIMIZING TIME BASED IAC START ADDER TABLE VALUES

Before you attempt to optimize your Time Based IAC Start Adder table, make sure that you have completed the basic idle tuning steps in the TCFI Installation & Tuning Manual and that you have reasonable values for your ET Based IAC Start Adder table.

Use the values given in Table 4 as a starting point (Figure 2 shows the resulting IAC action). You can then run tests to optimize the values. Operate the motorcycle long enough for the engine to fully warm up. After a 10 minute hot soak, restart the engine. Let the engine idle for about 15-20 seconds and then operate the motorcycle for about 4-5 minutes without coming to a complete stop. The purpose is to avoid closed loop idle RPM control during this period so that you can determine if the Time Based IAC Start Adder function is properly adjusting the IAC position during open loop conditions. After the 4-5 minute operating period, let the engine idle for about 30 seconds. Then use TCFI III Log software to download and examine the data during this 30 second idle period.

Figure 6 – Return to Idle Test with Incorrect Time Based IAC Start Adder

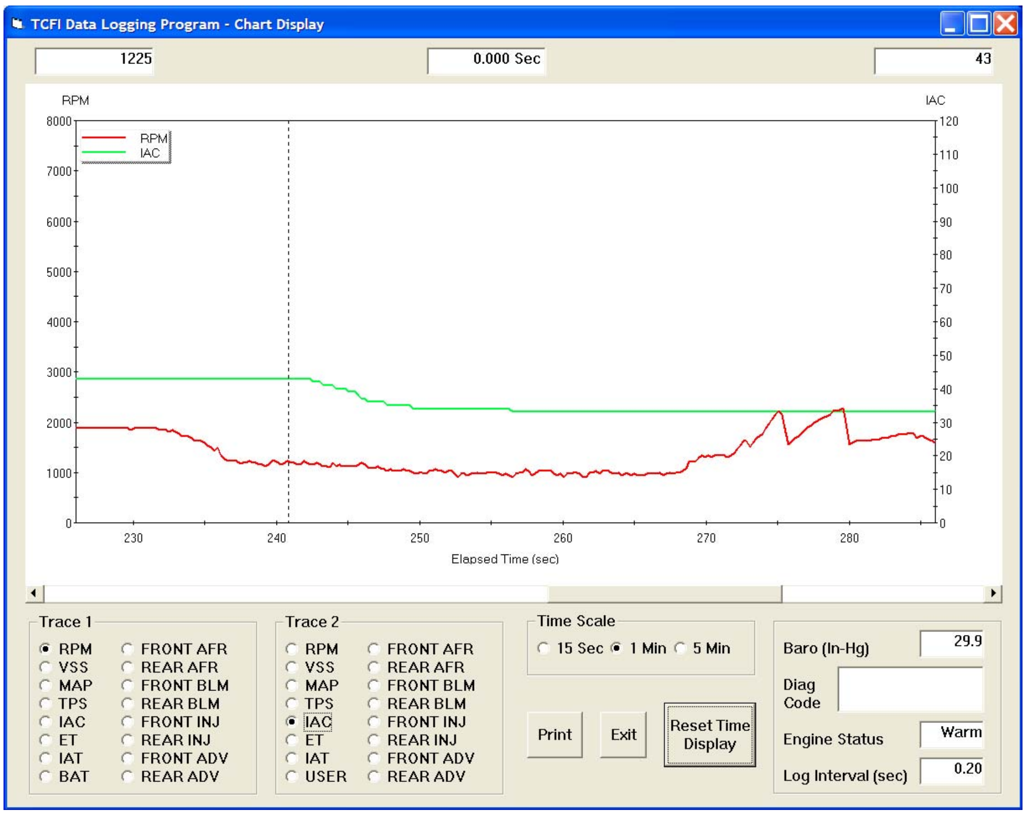


Figure 6 shows data logged from a hot start test with return to idle after several minutes of operation. In this example, the time based IAC start adder values were zero. The cursor line shows the approximate point in time when closed loop idle RPM control occurs (TPS < 1% and VSS = 0). Without time compensation, the IAC position is slightly high (at 43) and the engine initially idles above 1,200 RPM. You can see the action of the idle RPM control loop as it ramps the IAC value down to 33 so that the engine returns to the 1,000 RPM idle set point.

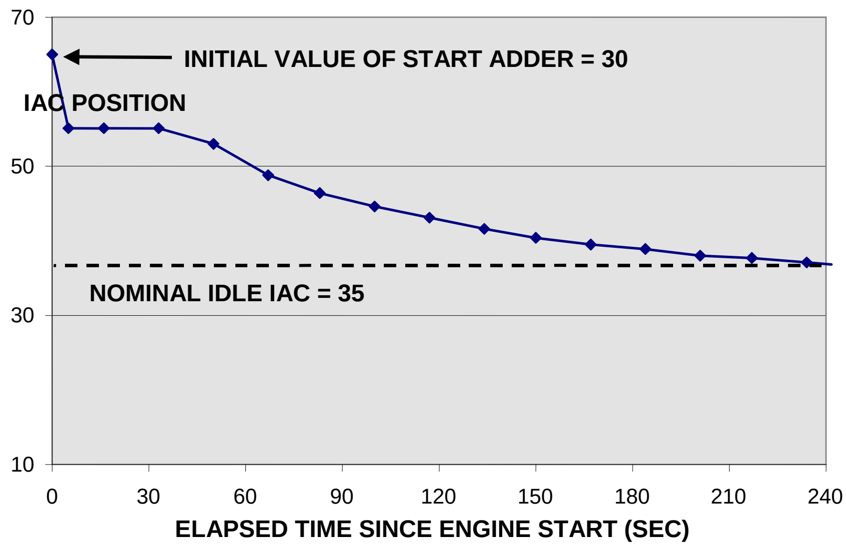
If your data looks like Figure 6, the values in your Time Based IAC Start Adder table are too low. If your table values are correct, the IAC value will be back down to near the nominal idle IAC value several minutes after a hot restart. If your table values are too high, excessive time based compensation may reduce the IAC value below the nominal idle IAC value. In this case, when the engine returns to idle for the first time, RPM will be below the idle RPM set point. The engine may even stall before the idle RPM control loop has a chance to recover.

We suggest that you start with values given in Table 4. If these values do not provide sufficient time based compensation, try the more aggressive values shown in Table 17. Figure 7 shows the resulting IAC action.

Table 17 – Aggressive Time Based IAC Start Adder

Time (sec)	0	16	33	50	67	83	100	117	134	150	167	184	201	217	234	251	268
Mult%	67	67	67	60	46	38	32	27	22	18	15	13	10	9	7	4	0

FIGURE 7 - IAC POSITION VERSUS ELAPSED TIME



OPTIMIZING ET BASED FRONT AND REAR CYLINDER COLD START ENRICHMENT TABLE VALUES

Before you attempt to optimize your ET Based Front and Rear Cylinder Cold Start Enrichment tables, make sure that you have completed the idle tuning and auto-tuning steps in the TCFI Installation & Tuning Manual. Any changes to BLM tables will greatly affect the results, so optimize cold start enrichment tables as the last tuning step.

The table values given in the sample setup files supplied with the PC Link TCFI III software should be reasonable for most applications. However, if time permits, you can do some engine start tests and further optimize the front and rear cylinder tables. We recommend that you leave the remaining cold start enrichment tables (refer to pages 7-8 for details) unchanged.

Do a cold start and let the engine idle for about a minute. Then use TCFI III Log software to download and examine the data (use the 10 samples/sec download option). Then operate the motorcycle long enough for the engine to fully warm up. After a 10 minute hot soak, restart the engine. Repeat the same test. Let the engine cool down until engine temperature is about 60 deg C. Repeat the test again. You now have three sets of data for cold, warm, and hot engine conditions.

Figure 8 – Front and Rear AFR Values After Engine Start

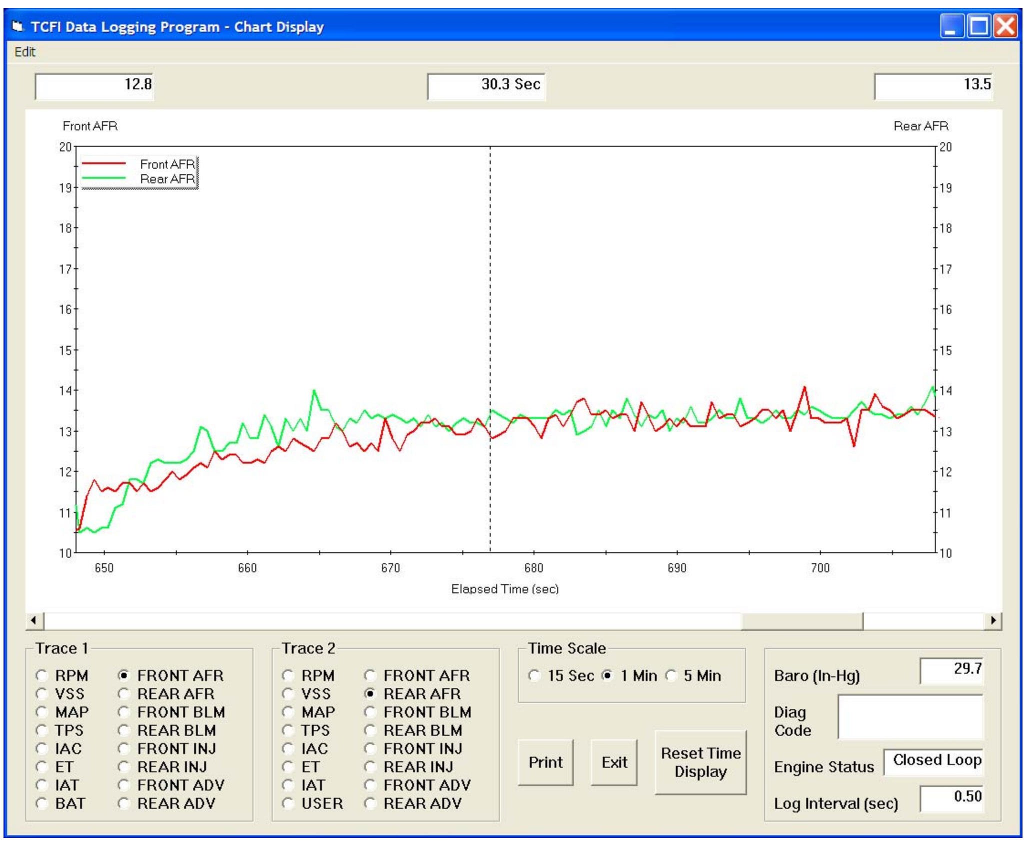


Figure 8 shows data logged from a hot start test. The chart shows front and rear AFR data. The time display has been reset to zero at engine start at the very left side of the chart. 30 seconds after engine start, closed loop operation commences. The front and rear AFR values track each other closely and ramp up smoothly during the first 30 seconds before closed loop operation commences. If your data looks like Figure 8, you do not require any changes to your cold start enrichment tables. If your data shows that one cylinder is significantly leaner or richer than the opposite one, you can edit the values in your ET Based Front and Rear Cylinder Cold Start Enrichment tables at the temperature corresponding to your test conditions. If a given cylinder is too lean, increase the corresponding table value. Smooth out the values at intermediate temperatures.