Technical Bulletin

The Power of WAI

COM Regulators in Intelligent Charging Systems 2020

Today's automotive charging systems demand a more dynamic control over the alternator for efficient battery charging and engine load management. This is achieved with an intelligent charging system. A key component in the system is a voltage regulator that can be dynamically managed and provide status of its current operating conditions.

The COM voltage regulator is next in the evolution of regulators to take its place in the in the intelligent charging system. The regulator can be managed over a single wire local communication network via the vehicle ECU/PCM. Earlier versions of single wire control where for example PCM type regulators (Denso RLO, GM RVC) these technologies were invented in the mid 1990's and used into the 2000's. The early communication was limited since it is one way and simple in comparison to the latest COM regulators which are more advanced allowing for more flexibility in today's intelligent charging system.

The newer local communication networks used in today's charging systems are similar to the networks we have become accustom to in our home and office. The network is bidirectional allowing for passing information to and from the COM regulator in the form of data packets used to setup/control functions in the regulator and provide operating status/identity information back to the ECU/ PCM of the vehicle. There are many communication protocols used in the automotive industry for example TTP/A and CAN. Although in today's charging systems the most common network protocols used are LIN (Local Interconnect Network) and BSS (Bit Synchronous Signal wire) because of their simplicity to implement, low cost and robustness. Both protocols are a hierarchical (master/slave) and perform the similar task of setup/control and status/identity information query. But that's where the similarity stops. They are two very different protocols (languages) with two different electrical signal formats.
Unlike the first unidirectional single wire controlled regulators that could only control the voltage set point for improvement of alternator operating efficiency. The LIN/BSS COM regulators with a true bidirectional local communication network interface have opened up the ability for controlling multiple operating parameters and reading operating conditions via the ECU/PCM of the vehicle.

The ECU/PCM can setup/control the COM regulators VSP (Voltage set point), LRC (Load Control Response), LRC Cutoff frequency, Current, and Duty Cycle. Through the manipulation of these parameters the ECU/PCM can achieve dynamic control over the alternator for load management, efficient battery changing, reducing idle for better fuel economy, operating temperature management, torque and more. Furthermore the ECU/PCM has access to a host of operating status information by querying the regulator. Field excitation duty cycle, Field current, VSP (on some regulators), Temperature, Fault status (mechanical, electrical, temperature, communication and timeout errors), and Setup configuration (on some regulators) can be requested to aid in the management of the charging system. ID information may also be queried from the regulator which will provide MFG ID, Class, Type information, and version depending on the regulator COM protocol type (LIN or BSS).

The LIN/BSS COM interface protocols provide a simplified way of achieving reliable bidirectional communication required for optimum alternator performance in an intelligent charging system. Both protocols provide some form of data integrity check on the data being transferred between the ECU/PCM and the COM regulator.

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1. LIN performs parity checks and check sum calculation which has evolved as LIN has evolved from early LIN 1.3 to LIN 2.2.
2. BSS performs parity checks on the data and acknowledgment of data transfer.

Furthermore with every engine start, the ECU/PCM must initiate communication with a COM regulator. This initial communication synchronizes the com speed and the protocol negotiation hand-shake to establish and maintain two-way communication between the ECU/PCM and COM regulator. The regulator must recognize the handshake and respond to it correctly. The communication speeds for LIN and BSS are as defined below.

1. LIN communication speed is from 2.4 to 19.2 K Baud.
   - **a**. LIN 1.3 communication speed is fixed typically at 9.6 or 19.2 K Baud.
   - **b.** LIN 2.2 communication speed is auto adjusted. The COM regulator auto adjusts to the speed of the

ECU/PCM which can range from 2.4 to 19.2 K Baud. But typically is 9.6 or 19.2 K Baud.
BSS communication speed is fixed at 1.2KBps.

If communication fails to be establish or is lost during operation most COM regulators will operate in a default operating mode. Although the alternator/regulator is changing, if the ECU/PCM senses anything wrong with the communication (even one bit of data), it will very likely turn on the charge warning lamp to inform the vehicle operator.

To summarize, COM regulators make intelligent charging systems in today's vehicles robust and reliable. There operating parameters can be adjusted to accommodate current operating condition which makes them very dynamic. Furthermore, the protocol provides operating status to keep the ECU/PCM aware of operating conditions and potential fault conditions.

WAI Global is on the cutting edge of the LIN/BSS COM regulator aftermarket. Our engineers are experts in the LIN/BSS protocols and OE manufacturer's unique command/data formats. Furthermore, our knowledge base continues to evolve as the protocols and OE manufacturers evolve their COM regulators. WAI Global designs and manufactures Bosch, Denso, Mitsubishi and Valeo aftermarket COM regulators which are used in applications from Ford to BMW. Our current LIN/BSS regulator data base consists of the following regulators listed below in the LIN and BSS COM regulator tables 1 and 2. The tables only show the released COM regulators. There are many more in development and prototype stage.

	LIN COM Regulators
Bosch	IB0839, IB5378, IB5379, IB6020, IB6037, IB6056, IB6067, IB6139, IB6150, IB6165, IB6197, IB818, IB823, IB827, IB828, IB835, IB840, IB855, IB867, IB885
Denso/Hairpin	IN3300, IN3570, IN4400, IN6363, IN6370, IN6373, IN6374, IN6376, IN7521, IN7541, IN7630, IN7740, IN8150
Mitsubishi	IM629, IM624, IM404
Valeo	M183, M233, M234, M236, M300, M339, M565, M568, M573, M573V1, M576, M583, M584, M591, M594, M595, M596, M601, M603, M609, M610, M620, M636, M647,M652

Table 1

COM Regulators 2020

	BSS COM Regulators
Bosch	IB203, IB262, IB293, IB321, IB5289, IB5290, IB5302 IB5881, IB6024, IB6066, IB6088, IB6132, IB6135, IB678, IB6866
Denso/Hairpin	IN6325, IN6367, IN7720
Mitsubishi	IM912
Valeo	M154, M173, M256, M379, M446, M464, M543, M545, M567, M571, M575, M586, M597, M600, M646, M648

Table 2

WAI Global also designs/supports testers for testing voltage regulators (COM and Multifunction) on the bench or in Alternator application. The two testers discussed in this article are the VRC2010 and WAI1000.

The **VRC2010** is primarily designed to test voltage regulator function (COM or Multifunction) on the bench. The tester simulates the alternator interface to the regulator during testing (See test diagrams in the next section).

The VRC2010 test features are:

1. A and B type regulators
2.12 and 24 Volt regulators
3. Voltage set point displayed on Voltmeter display
4. Regulators with Dual stator
5. Choke test
6. Over voltage lamp test
7. LIN/BSS test capability at 13,14 and 15 Volts
8. "C" function test
9. Ford PCM test capability 13, 14, 15 Volts
10. Test PD type regulators

The **WAI1000** is designed to test voltage regulator operation installed in the alternator application (run on alternator test bench or in vehicle). Although, the tester may also be used in conjunction with the VRC2010 (or similar tester) if more function/information other than Voltage set point control is desired. The WAI1000 tester functions as the COM/Multifunction control interface to the regulator.

The WAI1000 test Features are:

1. 12 volt regulators.
2. Generates COM(LIN/BSS), C, RLO, PD, RVC and SIG(PCM) to Regulator
3. Accepts DFM for multifunction regulators for Duty Cycle.
4. Control Knob to select
  a. Function type: COM and Multifunction types.
  b. VSP (Voltage set point) during testing

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5. Graphical Display for:

- **a.** Voltage set point setting/measurement
- **b.** Duty Cycle for COM or Multi function
- **c.** COM regulator ID information
- **d.** COM regulator Mechanical, Electrical and Temperature error information

Shown below in figures 2 and 3 are front panel views of the WAI1000.

Fig 2

Fig 3

Both testers are capable of testing COM and Multifunction regulators. But, since COM regulators are the focus of this article the tester application examples will be focused on COM regulators. Below are three COM regulator test examples using the VRC2010, WAI1000, and VRC2010/WAI1000 combination.

Shown below in **Figure 4** is a COM regulator test example with the VRC2010. The COM connections are shown as dotted lines since the connection will be determined by the COM type (LIN or BSS).

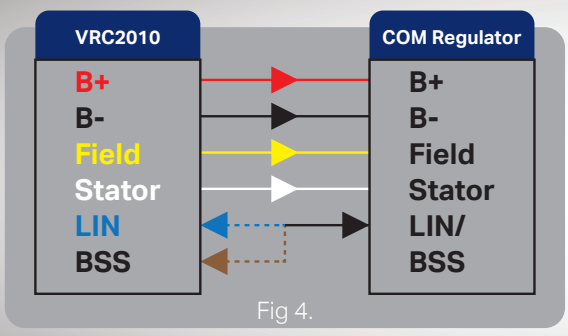

Fig 4.

In this test topology the COM regulator is being bench tested. The VRC2010 is the alternator simulation source and is responsible controlling VSP (Voltage set point) of the COM regulator. In order to test the COM regulator with the VRC2010 the regulator COM connection must be connected to the correct protocol (LIN or BSS). Once the proper protocol connection has been connected the VRC2010 will establish communication with the regulator. If Communication has been properly established the Volt Meter display will display the VSP (Voltage set point) selected on the COM Voltage selector switch. Otherwise the regulator will remain at its default voltage set point. At this point the COM regulator is ready for testing.

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Shown below in **Figure 5** is a COM regulator/Alternator installed in a Vehicle test example with the WAI1000. The COM connection will be determined by the COM type (LIN or BSS).

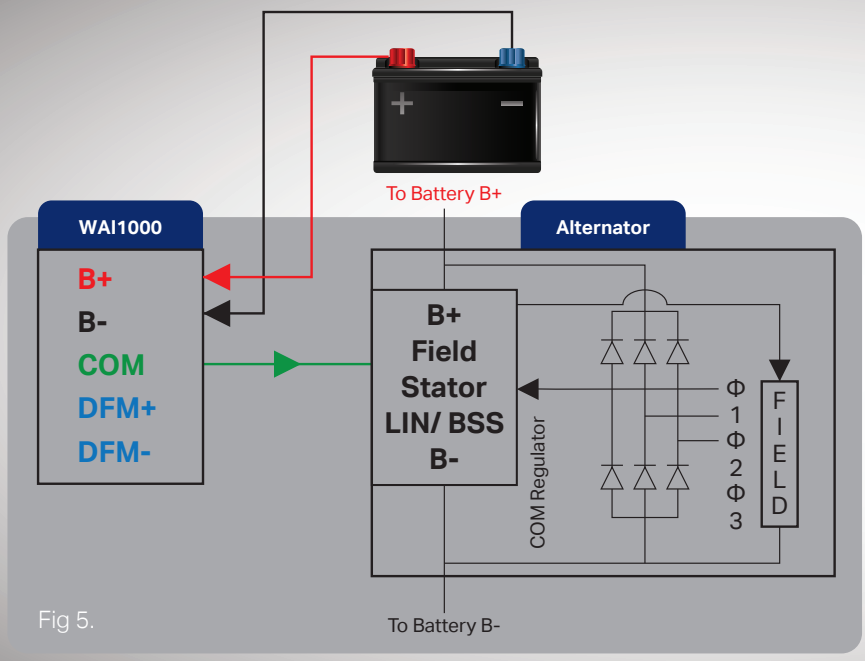

Fig 5.

In this test topology the COM regulator/Alternator is being tested in a Vehicle. In the Vehicle test example the WAI1000 is responsible for controlling and displaying status of the COM regulator. Also it should be noted the ECU/PCM communication is disconnected from the COM regulator since the WAI1000 will be taking the place of the ECU/PCM during testing as shown in figure 5. Most importantly the Vehicle should be switched off while connecting tester. After all connections are established the Vehicle may be started. In order to test the COM regulator with the WAI1000, COM is selected from the top level menu. The WAI1000 will determine the COM type (LIN or BSS) and speed. Once communication is established the display will display Protocol version, ID information, Errors, VSP (Voltage set point) and Duty cycle. At this point the COM regulator is ready for testing.

Shown below in **Figure 6** is a COM regulator test example with a VRC2010/WAI1000 combination. The COM connection will be determined by the COM type (LIN or BSS).

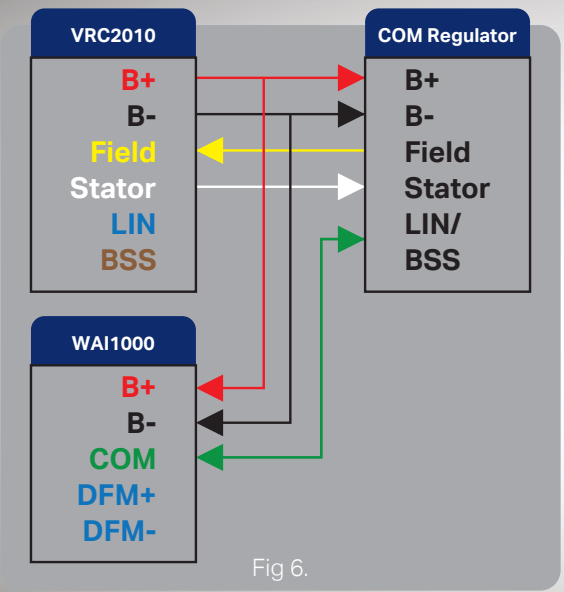

Fig 6.

In the above test topology the COM regulator is being bench tested. The VRC2010 is the alternator simulation source and the WAI1000 is responsible for controlling and displaying status of the COM regulator. In order to test the COM regulator with the WAI1000, COM is selected from the top level menu. The WAI1000 will determine the COM type (LIN or BSS) and speed. Once communication is established the display will display Protocol version, ID information, Errors, VSP (Voltage set point) and Duty cycle. At this point the COM regulator is ready for testing.
The Above three test examples were meant to show the reader how WAI Tester line can be applied to test COM regulators. It is also important to note the VRC2010 and WAI1000 testers are very capable testers. Along with COM regulators they are capable of testing a wide variety of Multi-function regulators. Also with multifunction regulators the VRC2010 and WAI1000 are capable of performing on their own and in combination depending on the test application.

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