ELECTRICAL SYSTEM

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NOTES

This document is applied for Kubota WG3800, WG2503 and WG1605 engines for OEM.

This document is intended to provide installation guide for the engine to the application.

The information in this document subject to change without notice.

The latest document is available on the K-iSS website. Printed copies are for reference only.

1. GENERAL

An electrical system consists of starting device, such as a starter ; charging devices, such as an alternator and battery ; control device, such as an ECU ; sensor devices, such as a water temperature sensor and a TMAP sensor ; actuator devices, such as a throttle body and a fuel pump.

2. STARTING DEVICE

[1] GENERAL

The starting device is composed of the starter, starter switch, fuse, battery etc., and the outline of the basic operation is as the followings ;

1) Voltage from battery is added to the B terminal of starter switch through the fuse.
2) If the starter switch is turned on, B terminal will be connected to AC, and the electrical current will flow to each load.
3) If the starter switch is turned to the starting position, B terminal will be connected to AC, 19, and 50 will be connected to the ST terminal of starter (in case of the type with safety relay, it shall be connected via relay) to start the engine.
4) After the engine is started, if you have let your hand off the starter switch, it automatically returns to ON position.

[2] STARTER

(1) P Type Starters

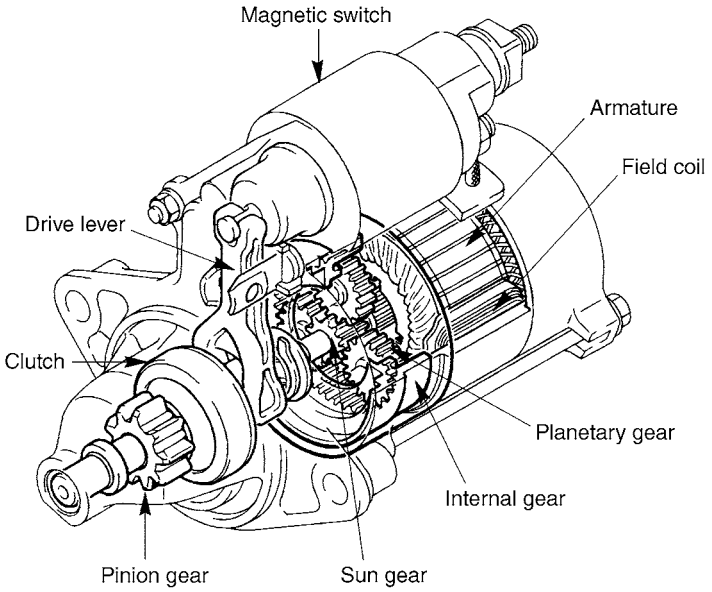


Figure 1

- The P type starters are reduction type starters that uses a planetary gears. The P types use the same type of compact, high-speed motor as the reduction type, and have planetary gears between the clutch and armature. As a result, a more compact and lightweight starter design has been achieved.
- To engage with the engine, the magnetic switch moves the clutch forward via the drive lever. The clutch slides along a shaft (planetary carrier shaft) connected to the planetary gears.
- The P type starters are equipped with shock absorbers that reduce the shock generated during starter actuation.

Starter switch on

When the starter switch turns on, current flows to both the pull-in coil PC and holding coil HC, and the plunger is pulled in by the electromagnetic force generated in both coils.

The pinion gear is thus pushed out to the left, and engages with the ring gear.

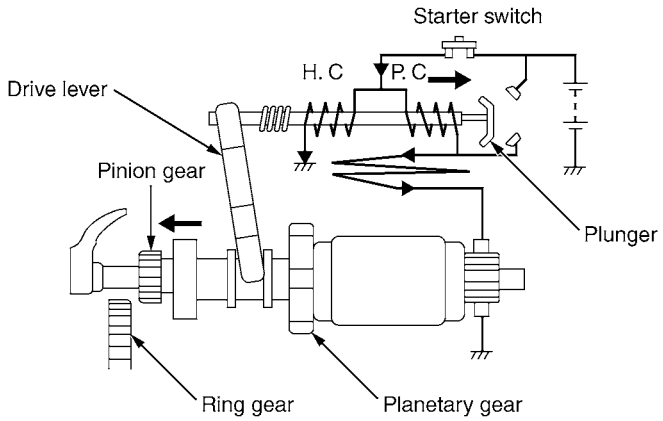


Figure 2

When the pinion gear engages with the ring gear without collision

When the pinion gear engages with the ring gear at a certain position, the magnetic switch main contact closes, and a large current flows through the main contact to the armature.

The force of the armature spiral spline pushes the pinion gear forward, engaging the pinion gear with the ring gear to start the engine.

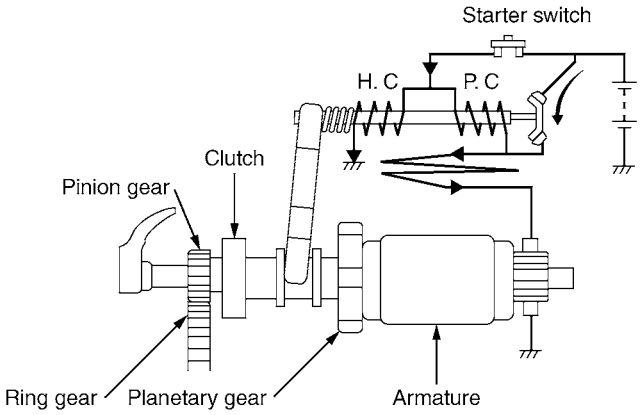


Figure 3

When the pinion gear and ring gear collide

If the pinion gear and ring gear teeth contact, the pinion gear cannot move any further. If this happens, the magnetic switch drive spring compresses, and the magnetic switch contact closes. As a result, the armature rotates at high torque, and the teeth alignment position slides. The compression force of the drive spring and the force of the armature spiral spline move the pinion gear forward, engaging the pinion gear with the ring gear to start the engine.

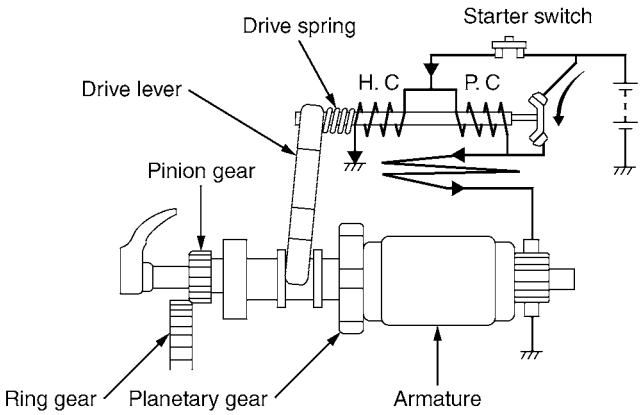


Figure 4

When the engine is started

When the engine starts, the clutch idles to prevent the ring gear from driving the armature in reverse.

Starter switch OFF

When the starter switch is turned OFF, the magnetic switch attraction is cancelled and the pinion gear is returned by the magnetic switch return spring.

The main contact then opens, interrupting the flow of current to the armature.

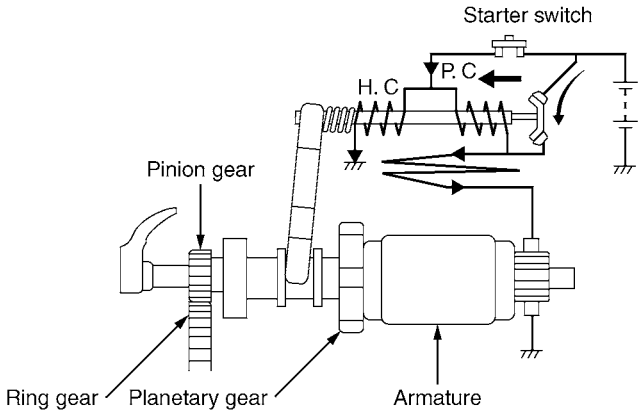


Figure 5

(2) Gear Reduction Type Starter

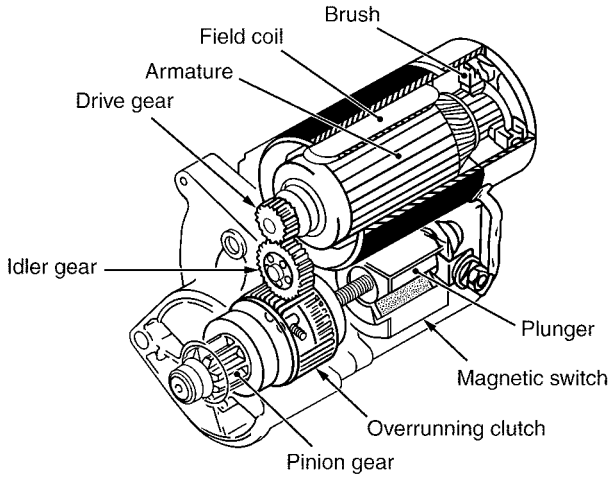


Figure 6

- This type drives the pinion reducing the speed of the small-sized high-speed large-output motor by 1/3 to 1/5, so that the motor can be made smaller and lighter.
- The starter is made lighter by using aluminum die cast metal, and in addition, there is no exposure of the pinion sliding surface and waterproofing is improved.

Starter switch on

When the starter switch is turned to start position

a) If the starter switch is turned to start position, electrical current will flow to holding coil (H.C) and pulling coil (P.C), and it will excite the 3 coils, and suck the plunger.
Consequently, the pinion gear will move out to the fly wheel side, and the ring gear and pinion gear will be intermeshed.

b) Electrical current will also flow to the armature from P.C, and it will remove the load in the initial stage of armature rotation.

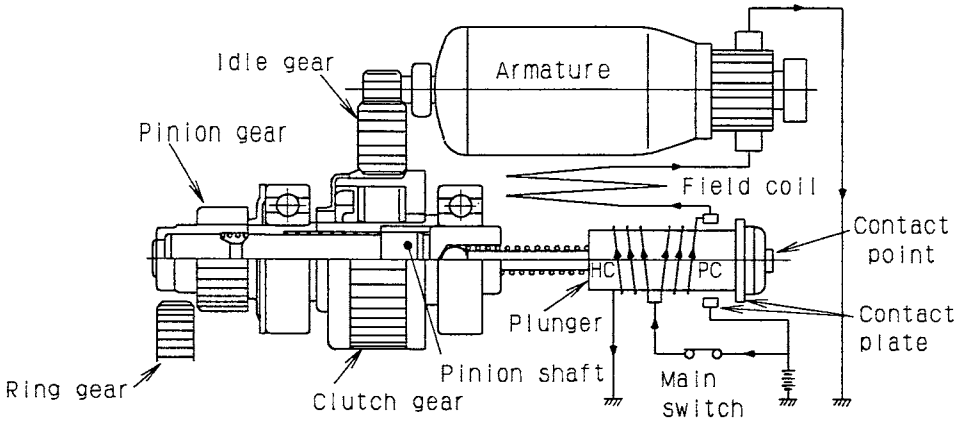


Figure 7

During cranking of the engine

a) If the pinion gear and ring gear are fully intermeshed, the main contact point will be closed, and the field coil and armature coil will be directly connected from the battery so that a large amount of electrical current flows and the pinion gear rotates.
b) Potential difference of P.C will become zero by the voltage from the main switch and the voltage from the main contact point, making the magnetic force nonexistent.
c) Therefore, the plunger is supported by H.C alone while the pinion is intermeshed with the ring gear.

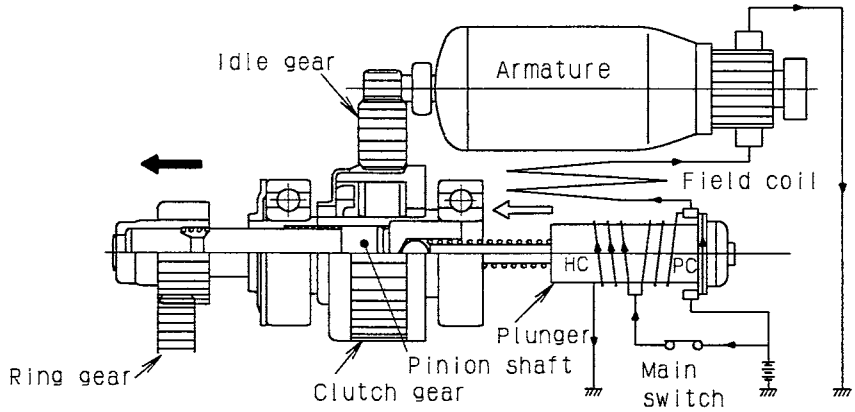


Figure 8

When the engine is started

a) When the engine is started, rotation of the gear will become faster than rotation of the pinion gear. (If such a state is left as it is, rotation of the engine will be driven directly into the armature, and may damage it.)
b) In case that rotation faster than that of the armature is transmitted to the pinion gear, the overrunning clutch will begin to race, and will protect the armature from abnormal rotation.

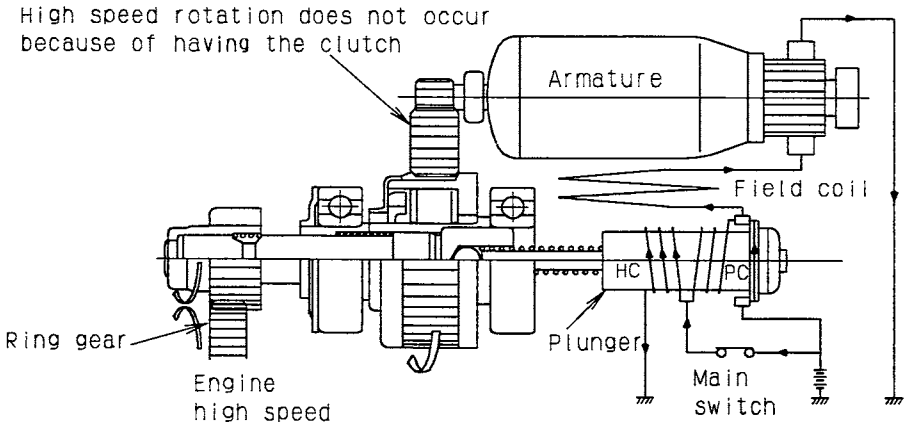


Figure 9

Starter switch off

a) If the starter switch off, energizing to H.C will be shut off.

b) The force on the plunger will cease and the pinion gear will be returned by the return spring. At the same time, the main contact point will be opened as well, and rotation of the armature will be stopped. Braking of the armature is performed by abrasion force of the brush and commutator.
For an instance, potential difference of the C terminal becomes higher than that of the S terminal, and electrical current flows from the main contact point to the direction of P.C and H.C so that engaging force of the plunger will be offset each other, and the plunger will be returned quickly.

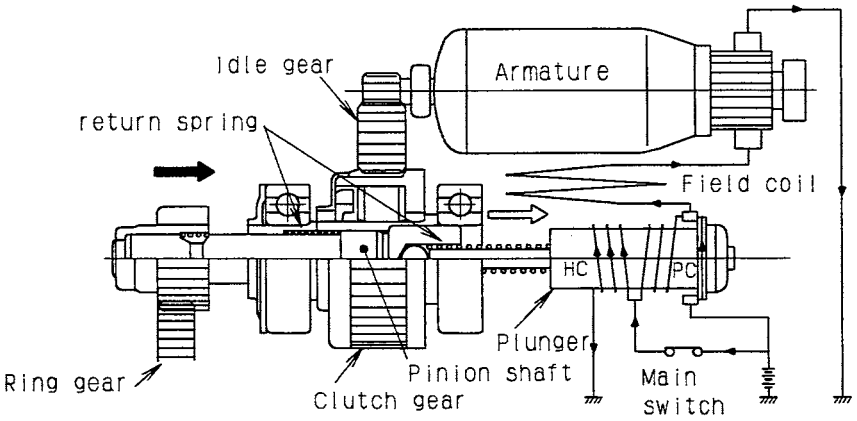


Figure 10

(3) Overrunning Clutch

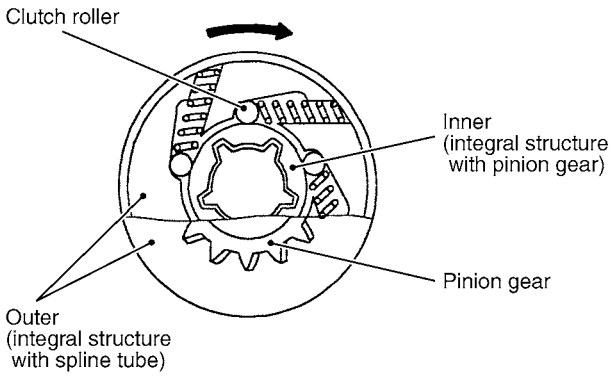
Function

In case that the pinion gear and ring gear are still intermeshed even when the engine is started, the motor will be forced to run in abnormal rotation, and the armature, brush, etc. will be damaged.

In order to prevent such an error, the overrunning clutch will function as the device to let the pinion race against the armature shaft when the engine is started, and to shut off transmission of rotation of the engine to the motor.

Action

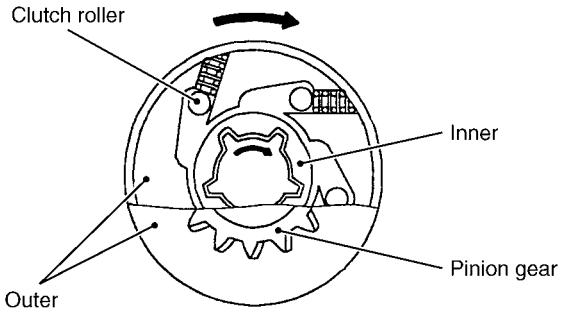
1) When starting:
   If the outer is rotated in the arrow mark direction receiving rotation of the armature, the clutch roller will be pushed toward the narrower side of clearance between the outer concave side and the inner so that the outer and inner will be engaged. The roller will function as a wedge between the inner and outer, and will transmit the rotation of the outer to the inner, and both will rotate in the same speed.
2) After the engine is started:
   When the pinion is forced to rotate by the ring gear, rotation of the inner (rotation of engine x gear ratio) will become faster than that of the outer (rotation of armature), and the clutch roller will move toward the direction that compresses the spring.
   Consequently, clearance between the outer concave side and the inner becomes wide to prevent overrunning of the armature.
   (It is required to decrease the contact pressure of the pinion gear and ring gear to make smooth separation of the pinion gear, and for the purpose of this, the pinion gear must be idle running during engine running.)



State that the outer and inner are engaged.

WG1605_089A

Figure 11



State that the outer and inner are free.

WG1605_090A

Figure 12

[3] STARTER SWITCH

Starter switch is an important part comprising of the starting device of engine. Particularly, as seizing of the starter may be incurred due to failure of the starter switch, careful consideration is required for the installation position, place, and direction, so that rain or cleaning water should not directly splash on the starter switch.

Shown in the Figure 9-13 is an example of a starter switch.

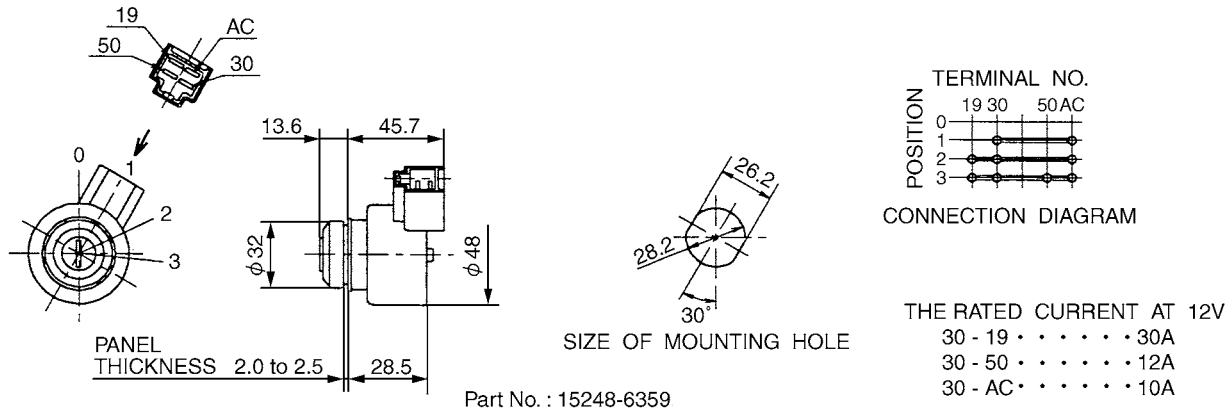


Figure 13

[4] STARTER SAFETY SYSTEM

The ECU can be configured for either auto cranking (crank until starting) or crank limiting (maximum crank time and disabling of starter if frequency and number of attempts is too high).

3. CHARGING DEVICE

[1] GENERAL

The function of the charging device is to charge batteries.

[2] IC REGULATOR BUILT-IN TYPE ALTERNATOR

The alternator is the incorporated with an IC regulator, this has been made small size and light weight by the semiconductor technique of the IC regulator.

The cooling property and safety is improved by incorporating the cooling fan and roller that is an integral structure.

Further, the serviceability is also improved by facilitating mounting and removal of the rectifier and IC regulator.

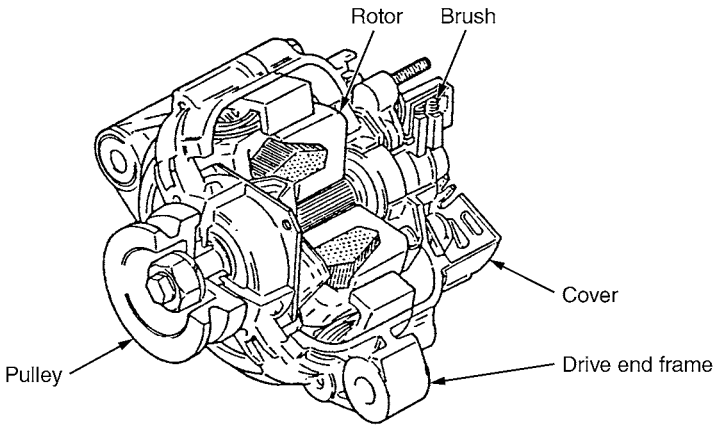


Figure 14

D2 Type Regulator

IC regulator has a special feature that makes it possible to interrupt field current by using the transistor or IC instead of the contact-point-type regulator.

IC regulator has the special features as follows :

1) Readjustment for this regulator is unnecessary because the control voltage does not change over time.
   Further, IC regulator has excellent vibration-proof property and durability due to no moving parts exsisting.
2) Since IC regulator has over-temperature compensation property, which makes the control voltage low if the temperature is increased, it makes it possible to properly charge the batteries.
   The circuit inside IC regulator is as shown in the following figure.
   It is composed of the monolithic IC-incorporated hybrid IC. (Since the inside circuit of the monolithic IC is extremely complex, it is described as M.IC circuit.)
   Tr1 has the function as the contact point to control field electrical current, and as the charging lamp relay to light the charging lamp.
   M.IC controls Tr 1 and Tr 2 by detecting decrease of the output voltage of alternator, decrease of the L-terminal voltage, disconnection of the rotor coil, etc.

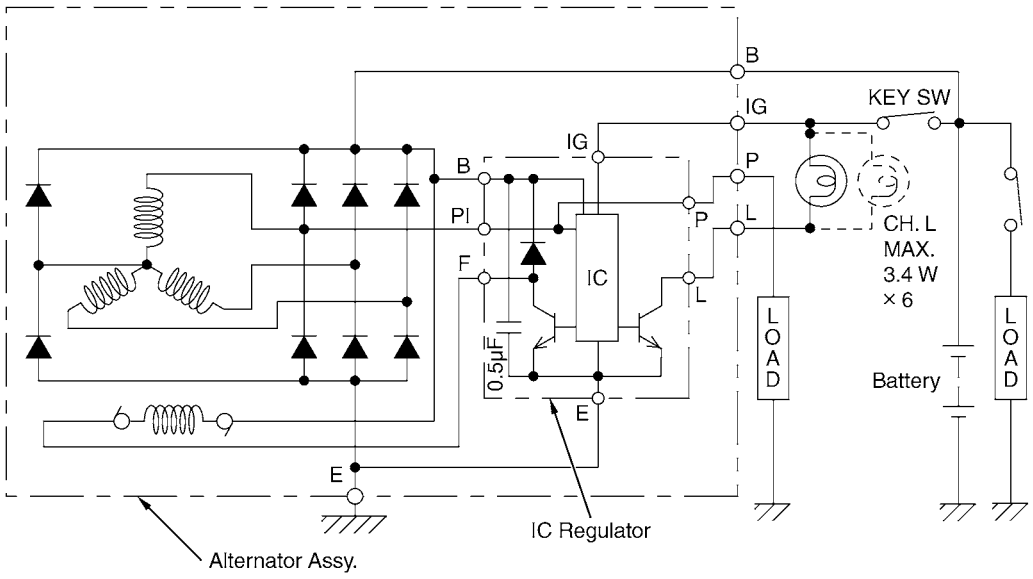


Figure 9-15

Charge Light Control

Turns the charge light ON and OFF in accordance with alternator power generation.

Standard pulley dimensions

	Fan drive pulley mm (in)	**Alternator pulley mm (in)**
WG1605	105 (4.13)	58.5 (2.30)
WG2503	125 (4.92)	65.0 (2.56)
WG3800	143 (5.63)	70.0 (2.76)

Specification of alternator with IC (incorporated with) regulator

Nominal voltage	12 V
Maximum output	40 A (WG1605), 60 A (WG1605, WG2503), 100 A (WG3800)
Rotational direction	Right as seen from pulley side
Armature wiring	3 phase, Y wiring
Rectifying system	Total wave rectification★
min^{-1} (rpm) with no load (cold condition)	14 V at 0 A 1050 to 1350 min-1 (rpm)
min^{-1} (rpm) at max. output (cold condition)	14 V at maximum output below 4000 min-1 (rpm)

Generating capacity will be determined by rpm of engine and pulley ratio.

★ Total wave rectification

In case of the generator for mobile equipment of which purpose is to charge the batteries, alternating current cannot be used as it is. Because of this, it is required to conduct the action called rectification so that the alternating current can be changed to direct current. Alternator conducts rectification by means of diode.

If the voltage is applied to diode in the normal direction, enough electrical current can flow even by small voltage, however if applied in the reverse direction, it inhibits the reserve flow of electrical current.

Using this property, alternate current generated in the stator coil is changed to the direct current.

As for the rectification using diode, there are two methods, i.e., 'half-wave rectification' that takes out only positive portion of alternate current, and 'total-wave rectification' that rectifies both positive and negative current and change to the direct current.

Half-wave Rectification

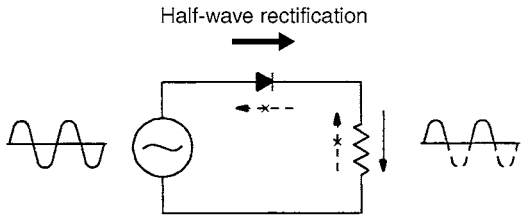


Figure 16

Total-wave Rectification

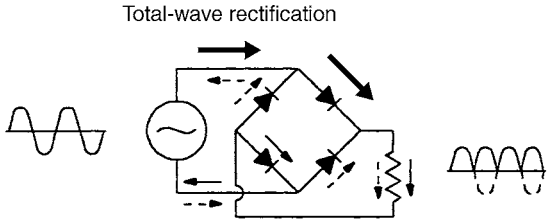
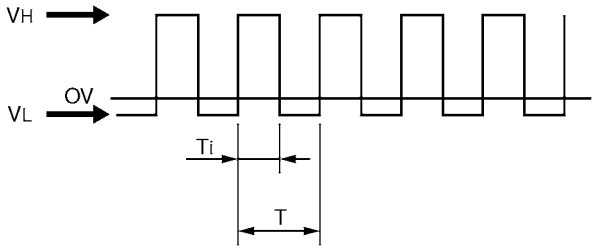


Figure 17

Alternator P Terminal

(1) P terminal waveform: The alternator P terminal outputs rotation signals required by a tachometer, etc.
The P terminal corresponds with one phase of the alternator stator and the output waveform during power generation is a waveform equivalent to the rectangular wave with a frequency in proportion to the number of revolutions of the alternator.



Reference waveform (outline)

Figure 18

Frequency (1/T) : Number of revolutions of alternator [rpm] / 10 [Hz]
Duty (Ti/T) : approx. 50 %
VH (average) : about +0 to 2 V with reference to the alternator B terminal voltage (average)
VL : about −2 to 0 V

■ **NOTE**

- **As with the B terminal waveform, the P terminal waveform includes noise, which varies depending on the number of revolutions, output and wiring (see the waveform in a separate material).**
- **Surge voltage may be generated by any charging cable disconnection (especially with high number of revolutions/high output), etc.**

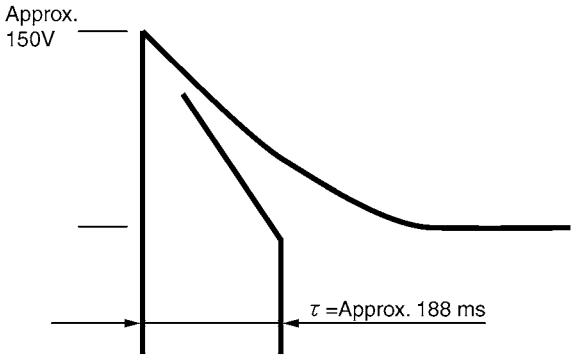


Figure 19

Surge voltage waveform with any charging cable disconnection. (Alternator : F3A - H, 40 A 15000 rpm, max output)

- **May be VHmin = 6.5 V in high electric load shedding or unloaded condition with the battery fully charged.**

P terminal voltage with reference to the GND (E)

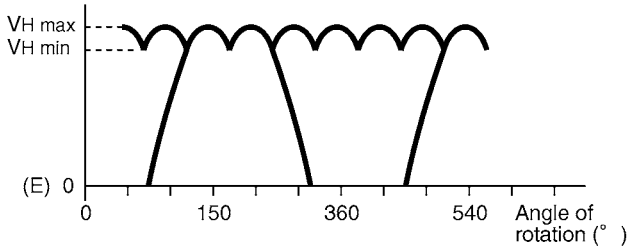


Figure 20

(2) Load connected to the P terminal
P terminal output current: 0.5 A max (average current)

■ **NOTE**

- **Ensure that there is no load short circuit or wrong wiring.**
- **Do not connect inductive or capacitive load (connection of such load subject to discussion of the specification).**
- **When detecting a waveform, take the noise and VHmin into consideration.**
- **Take the surge voltage into consideration for the input of the load.**
- **Use the actual equipment for sufficient check of the operation of the load.**

4. CONTROLLING DEVICE

[1] ECU

The ECU will utilize signal inputs from the engine sensors, to control the fuel metering and speed control, while the engine is running. As well, the ECU will provide diagnostic control, over the fuel system.

Normal operating temperature range : –40 to 105 °C (–40 to 221 °F)
Maximum allowable vibration : 5 G

Current consumption of WG1605 and WG2503.

Gasoline

Engine Speed (rpm)	Current Consumption (A)	
	Average	Max. (Ignition Coil ON)
800	4.2	11.0
2700	5.6	12.4
3600	5.7	12.4

LPG / NG

Engine Speed (rpm)	Current Consumption (A)	
	Average	Max. (Ignition Coil ON)
800	2.0	8.6
2700	3.0	10.0
3600	4.1	10.8

Current consumption of WG3800.

Gasoline

Engine Speed (rpm)	Current Consumption (A)	
	Average	Max. (Ignition Coil ON)
700	4.4	13.3
2600	6.1	13.6

LPG / NG

Engine Speed (rpm)	Current Consumption (A)	
	Average	Max. (Ignition Coil ON)
700	2.7	11.2
2600	3.1	11.1

5. SENSOR DEVICE

[1] WATER TEMPERATURE SENSOR

Ignition timing, fuel rate, and boost levels can be configured to vary with engine coolant temperature. This is typically done at very cold or very hot conditions. Coolant temperature is also used in the airflow models in the ECU.

Operating temperature range : –30 to 120 °C (–22 to 248 °F)
Storage temperature range : –40 to 120 °C (–40 to 248 °F)

Resistance characteristics

Temperature	Resistance
°C	**kΩ**
–20	13.84 to 16.33
0	5.74
20	2.32 to 2.59
40	1.15
60	0.584
80	0.310 to 0.326
100	0.1836
110	0.1399 to 0.1435

[2] TEMPERATURE AND MANIFOLD ABSOLUTE PRESSURE SENSOR (TMAP SENSOR)

TMAP sensor is mounted in the intake manifold and measures the absolute pressure as well as the temperature of the air/fuel stream. MAP data is used by the ECU for calculating airflow pressure. The temperature information from the TMAP is used for a density correction in the mass air flow calculation.

Operating temperature range : –30 to 120 °C
Storage temperature range : –40 to 120 °C
Performance characteristics

Pressure Sensor

Pressure	Voltage
kPa	**V**
20	0.729 to 0.849
46.66	1.782 to 1.902
101.32	3.94 to 4.06

at -30 to 120 °C
(-22 to 248 °F)

Temperature Sensor

Temperature	Resistance
°C	**kΩ**
0	5.4 to 6.6
80	0.282 to 0.388

[3] CRANKSHAFT POSITION SENSOR

The Crankshaft Position Sensor provides engine speed information.

WG1605, WG2503

Operating temperature range : –30 to 120 °C (–22 to 248 °F)
Storage temperature range : –40 to 120 °C (–40 to 248 °F)
Resistance between the terminals : 1850 to 2450 Ω at 20 °C

WG3800

Operating temperature range : –30 to 135 °C (–22 to 275 °F)
Storage temperature range : –30 to 140 °C (–22 to 284 °F)
Resistance between the terminals : 950 to 1250 Ω at 20 °C

[4] CAMSHAFT POSITION SENSOR

The Camshaft Position sensor informs the ECU which cylinders are in compression to signal spark timing.

WG1605

Operating temperature range : –20 to 200 °C (–4 to 392 °F)
Storage temperature range : –30 to 60 °C (–22 to 140 °F)
Resistance between the terminals : 470 to 530 Ω

WG2503, WG3800

Operating temperature range : –30 to 135 °C (–22 to 275 °F)
Storage temperature range : –40 to 140 °C (–40 to 284 °F)
Resistance between the terminals : 950 to 1250 Ω

[5] KNOCK SENSOR

The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity.

In most applications the knock sensor is used to protect the engine from damage that can be caused from detonation or knock based on fixed spark advance.

Operating temperature range : –40 to 130 °C (–40 to 266 °F)
Sensitivity at 5kHz (with new sensor) : 18 to 34 mV/g
Change of sensitivity over lifetime : max. –17% at room temp. 18 to 28 °C, humidity of 45 to 75% RH

Figure 21

[6] FUEL PRESSURE MANIFOLD (FPM)

The ECU is equipped to provide Pulse Width Modulation control of the fuel pump. This control feature and fuel pressure manifold combination prevent the build-up of excess heat in the gasoline tank which in turn reduces the evaporative emissions.

Operating temperature range : –40 to 125 °C (–40 to 257 °F)

Pressure Sensor

Pressure	Median Voltage
kPa	**V**
50	0.50
1000	4.50

Temperature Sensor

Rated resistance : 2.35 to 2.65 kΩ at 20 °C (68 °F)

6. ACTUATOR DEVICE

[1] THROTTLE BODY

The ETB (Electronic Throttle Body) is connected to the intake manifold of the engine.

The ETB utilizes an electric motor connected to the throttle shaft. In addition, an accelerator position sensor (a foot pedal position sensor) is located in the operator's compartment.

When the engine is running, electrical signals are sent from the accelerator position sensor (the foot pedal position sensor) to the Engine Control Unit (ECU) when the operator depresses or releases the foot pedal.

The ECU then sends an electrical signal to the motor on the ETB to increase or decrease the angle of the throttle blade, thus increasing or decreasing the air flow to the engine.

Environmental temperature range : –40 to 140 °C (–40 to 284 °F)
Storage temperature range : –10 to 50 °C (14 to 122 °F)

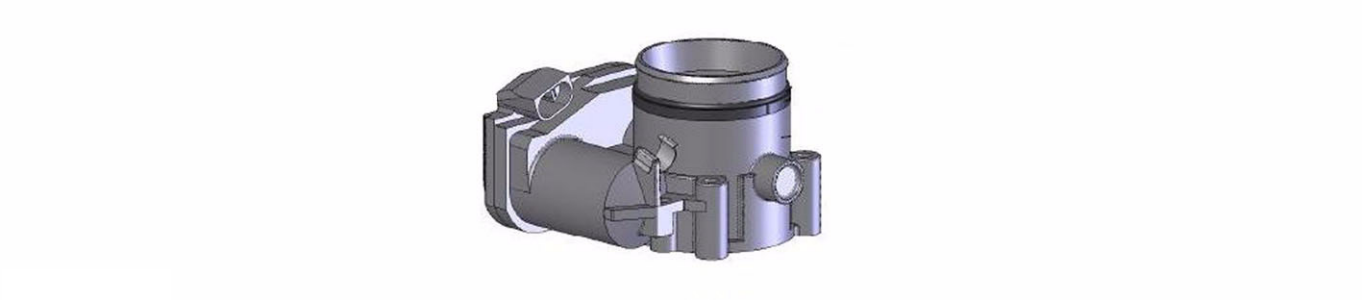


Figure 22

[2] FUEL PUMP

The fuel pump has a roller vane type pumping element driven by an electric motor with permanent magnets. The motor is flown through with fuel without forming an explosive composition. Nominal fuel pressure is 300 kPa.

Storage temperature range :–30 to 60 °C (–22 to 140 °F)
The atmospheric humidity must not exceed 60 % during storage.
Ambient temperature range : –40 to 80 °C (–40 to 176 °F)

Permissible vibrational acceleration : 3 G
Maximum allowable suction pressure : ≤10 kPa (below ambient pressure)

[3] DIRECT ELECTRONIC PRESSURE REGULATOR (D-EPR)

The D-EPR controls the gaseous fuel rate to the engine by regulating the pressure supplied to the air/fuel mixer.

Maximum vibration operating : <15 G
Nominal operating temperature range : –40 to 105 °C (–40 to 221 °F)
Storage temperature range : –40 to 135 °C (–40 to 275 °F)

[4] LOCK-OFF VALVE

Fuel Lock-off Valve is used to isolate the D-EPR and all downstream components from upstream fuel pressure when the engine is shut-off.

Operating temperature range : –20 to 120 °C (–4 to 248 °F)
Coil resistance : 12.15 to 13.15 Ω at 20 °C (68 °F)
Burst pressure : >6.75 MPa

[5] IGNITION COIL

Ignition coil is a transformer to generate high electric voltage necessary for the ignition. Around the iron core of multi-layer thin crude steel plates, secondary coil is wound, on whose outside, in the same direction, primary coil is wound. The empty space in the case is filled with resin for electric insulation and good heat radiation.

The ignition timing is controlled by ECU and the high voltage is applied to the spark plugs by the ECU signals.

Operating ambient temperature : –30 to 120 °C (–22 to 248 °F)
Storage ambient temperature : –40 to 130 °C (–40 to 266 °F)
Primary resistance : 0.63 to 0.77 Ω at 25 °C (77 °F)
Secondary resistance : 7.29 to 8.91 kΩ at 25 °C (77 °F)

7. WIRING

[1] CAUTIONARY ITEMS FOR WIRING

(1) Equipment should be grounded securely. When the grounding is not properly done, necessary amount of electrical current will not flow, and function of electrical equipment will not be exhibited fully. For example, it is possible that insufficient grounding of the starter will cause failure to start, and in addition, after repeating the starting many times, the starter will seize. Therefore, select a clean metal surface for the grounding wire attachment (on the main machine side as well as engine side), and completely remove the paint to make the contact resistance as low as possible.

(2) The wire diameter of wiring and the electrical current capacity of each fuse are shown in the wiring diagram. However, these are only recommended values, and therefore when applying to the actual case, be careful to use the correct sites taking into consideration the length of wiring and the connection form.

(3) Wiring should be routed and secured, be careful so that the insulation will not be worn off due to contact with other parts during operation, and short circuiting will not occur.
Further, it recommended to protect wiring with corrugated protective covers.

(4) In case that wiring is made mistaking the polarity, wiring materials may be burned and damaged, or it may result in personal injury.
It is important that any mistaken wiring never be made, and in addition, attention and care (by changing the colors and length of wire) should be taken not to let workers perform incorrect wiring.

(5) Use low-voltage wires for automobile (AV SS wire, etc.) for wiring. However, in case that the ambient temperature is more than 75 °C (167 °F), use heatresistant wires (AVX wire, etc.).

(6) To protect wiring, use a fuse or slow-blow fuse.

(7) As for the load that may incur when unexpected current comes into the circuit, such as the case of motors, be careful not to directly connect to AC and any wires connected directly to battery '+'.

(8) Attach covers for covering the battery positive ('+') terminal for preventing from sparks due to accidental contact.

[2] SIZE OF WIRING

(1) General

1) The size of wiring shall be determined taking into consideration the various factors such as the length of cable, electrical current value, allowable voltage drop, etc.

2) When electrical current 'A' (Amperes) flows in the circuit, the resistance 'ohms' always exists as the result of electrical power loss in the cable, and the voltage will be decreased.
The difference between the voltage of electrical power source and the voltage at the connection end of the cable of each equipment is the voltage drop leading to poor performance.

3) Excessive electrical power loss in the cable will cause overheating of the cable and drastic voltage drop.
To resolve such a problem, it is important to take into consideration that the cable resistance is the accumulated value of complete circuit and to correctly use the specified cables.

4) The rated value of the cable shall be determined according to the allowable electrical current value. Electrical resistance depends on the total sectional area of the conductive material (wire).
It is possible to minimize the electrical power loss and voltage drop by using correct cables.
It is important to restrain the temperature increase of the cable for the cables that are used together in a harness.

5) All of the voltage drop in the circuit should not exceed 10% of the regular voltage. (For example, 1.2 V in case of 12 V circuit.)
The voltage drop expected to occur in the circuit can be measured by using the simple formula as shown in below :
Voltage drop = Current value Total cable resistance

6) For the cables in which electrical current will flow continuously for a long period of time, attention and care must be taken for both the temperature increase and voltage drop, and on the other hand, as for the circuit to be used for a short time, care must be taken for the voltage drop.

(2) Battery cable

The battery cable is the first 'connection' in the electric system of engine. Attention and care should be taken so that this cable should be of the sufficient size matching the electrical current required, and the length should be as short as possible.

Take care to securely install the battery terminals, and tightly clamp the cables.

Voltage drop against each battery cable should not exceed 0.6 V DC − 0.8 V DC.

Recommended battery cable :

Cable size 20 mm^2 (AWG size 4) or more.

Cable length 2 m or less.

8. BATTERY

The battery makes it possible to store electric energy as chemical energy, and to take it out as electric energy as needed.

Further, a battery is the device that can repeatedly charge and discharge.

[1] FORMULA OF DISCHARGING AMOUNT

Discharging amount (Ah) = Rated capacity (Ah) × (S.G. when fully charged - S.G. when measuring) / (S.G. when fully charged - S.G. when fully discharged)

In general case :
S.G. when fully charged : 1.28 {20 °C (68 °F)}
S.G. when fully discharged : 1.12 {20 °C (68 °F)}

S.G. : Specific Gravity

Battery capacity is indicated by the electricity amount that can be taken out before the voltage reaches the discharging end voltage, after the fully charged battery is continuously discharged with a electrical current.

Capacity (Ah) = Discharging currenct (A) × Time until discharging end voltage (Hr)

[Meaning of 45 Ah / 20 Hr]
45 Ah / 20 Hr = 2.25 A … 20 hour rate current

Capacity is determined when the battery voltage becomes the discharging end voltage, when the battery is discharged for 20 hours at 2.25 A.

[2] TEMPERATURE RECTIFICATION

Temperature compensation should be made for the specific gravity measured by a gravimeter.

This specific gravity value will indicate that “it is low when the temperature is high”, and “it becomes high when the temperature becomes low”.

Generally, the specific gravity of the electrolyte of battery shall be taken using the temperature of 20 °C (68 °F) as the standard, and as for the rate of the change, the specific gravity decreases by 0.0007 against a temperature increase of 1 °C (34 °F), and the specific gravity increases by 0.0007 against the temperature of 1 °C (34 °F).

It is convenient to use the following formula to convert the specific gravity measured at a certain temperature into the standard temperature of 20 °C (68 °F).

S20 = St + 0.0007 (t - 20)
S20 : S.G. at the temperature of 20 °C (68 °F)
St : S.G. at the temperature of t °C

[Example : In case of electrolyte temperature of 40 °C (104 °F)
Reading of gravimeter : 1.240
S20 = 1.240 + 0.0007 (40 - 20) = 1.254

Consequently, the S.G. converted into 20 °C (68 °F) is 1.254. If looked at on the gravimeter, it appears that it is discharged by about 10%, however, if converted into the standard temperature, it is practically near to the state of full charge.

The charged or discharged state of battery can be known by measuring the S.G. of the electrolyte.

When measuring S.G., it can easily be performed comparatively by using a suction gravimeter.

[3] RELATION BETWEEN SPECIFIC GRAVITY OF ELECTROLYTE AND DISCHARGING AMOUNT

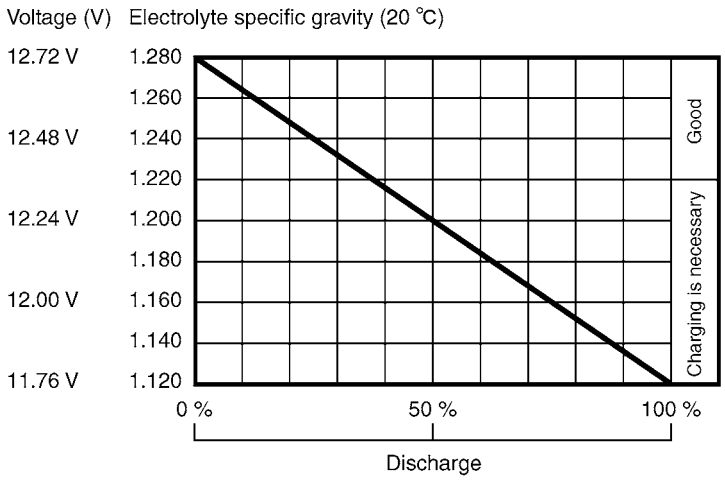


Figure 23

Gravity of electrolyte 20 °C (68 °F)	State of discharging
1.280	100
1.240	75
1.200	50
1.170	25
1.120	Totally discharged

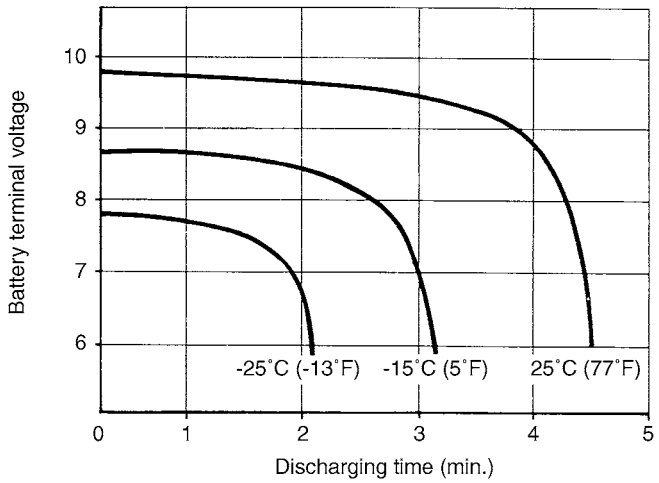
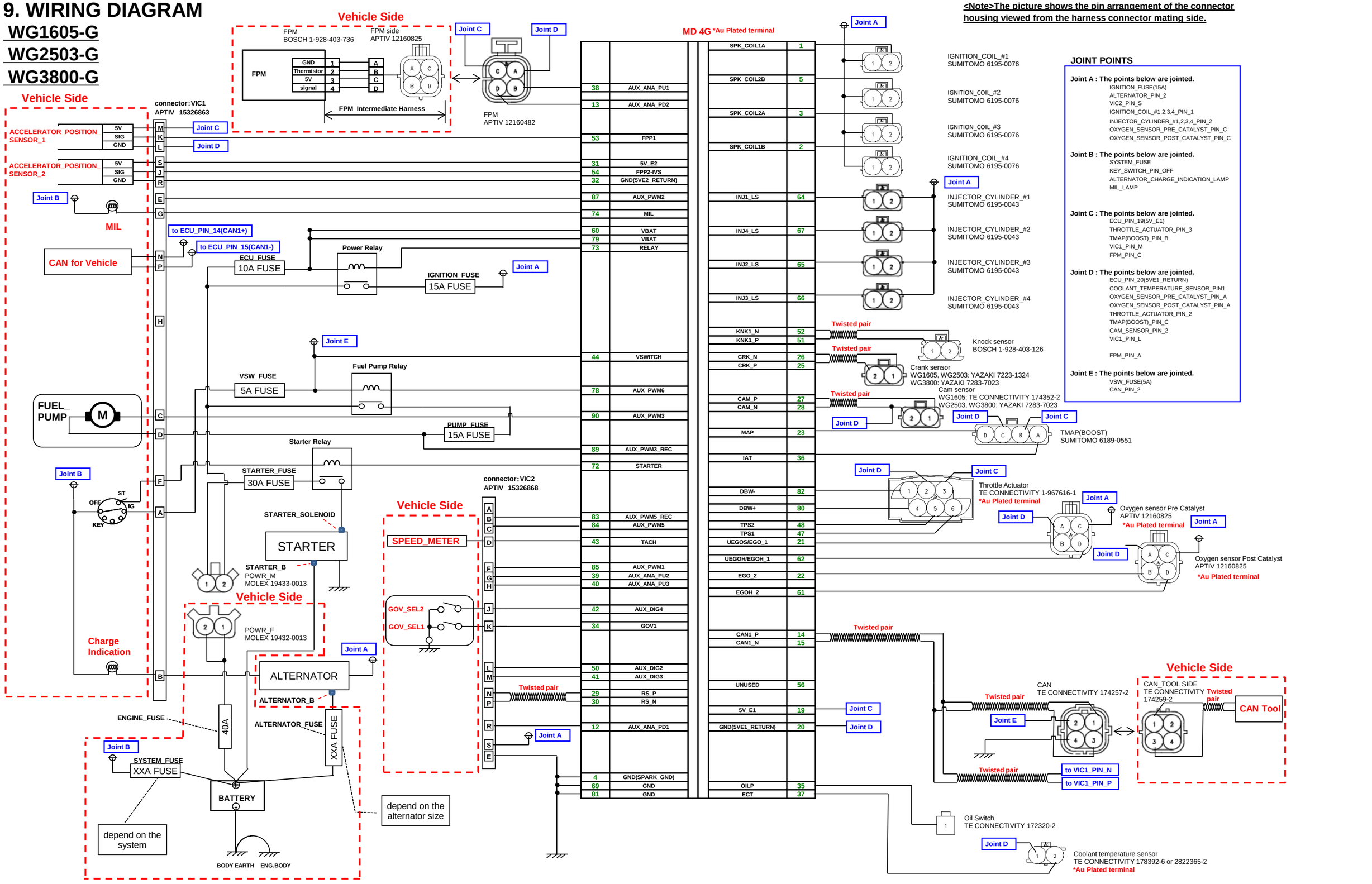


Figure 24

9. WIRING DIAGRAM

WG1605-G
WG2503-G
WG3800-G



<Note>The picture shows the pin arrangement of the connector housing viewed from the harness connector mating side.

JOINT POINTS

Joint A : The points below are jointed.
- IGNITION_FUSE(15A)
- ALTERNATOR_PIN_2
- VIC2_PIN_S
- IGNITION_COIL_#1,2,3,4_PIN_1
- INJECTOR_CYLINDER_#1,2,3,4_PIN_2
- OXYGEN_SENSOR_PRE_CATALYST_PIN_C
- OXYGEN_SENSOR_POST_CATALYST_PIN_C

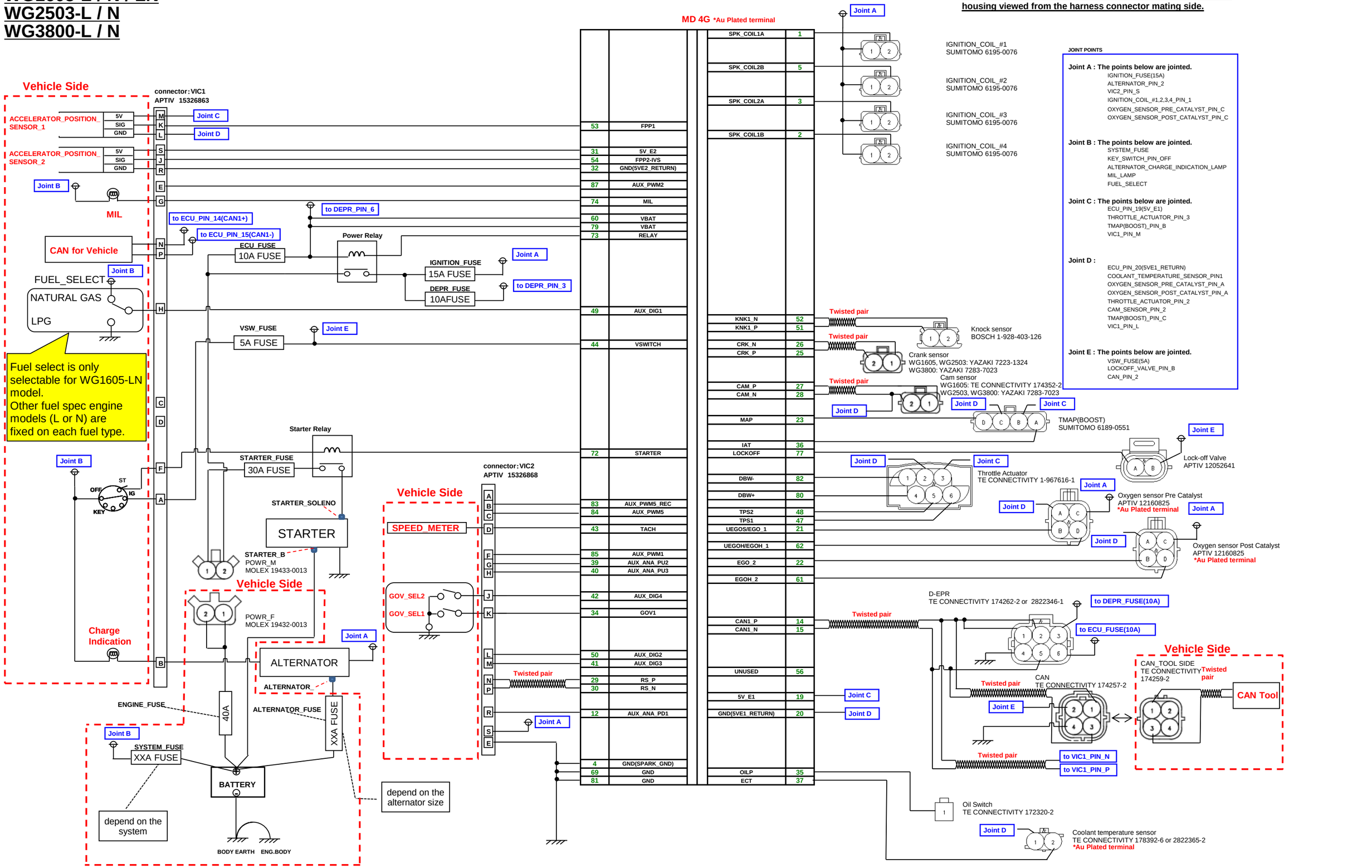
Joint B : The points below are jointed.
- SYSTEM_FUSE
- KEY_SWITCH_PIN_OFF
- ALTERNATOR_CHARGE_INDICATION_LAMP
- MIL_LAMP

Joint C : The points below are jointed.
- ECU_PIN_19(5V_E1)
- THROTTLE_ACTUATOR_PIN_3
- TMAP(BOOST)_PIN_B
- VIC1_PIN_M
- FPM_PIN_C

Joint D : The points below are jointed.
- ECU_PIN_20(5VE1_RETURN)
- COOLANT_TEMPERATURE_SENSOR_PIN1
- OXYGEN_SENSOR_PRE_CATALYST_PIN_A
- OXYGEN_SENSOR_POST_CATALYST_PIN_A
- THROTTLE_ACTUATOR_PIN_2
- TMAP(BOOST)_PIN_C
- CAM_SENSOR_PIN_2
- VIC1_PIN_L
- FPM_PIN_A

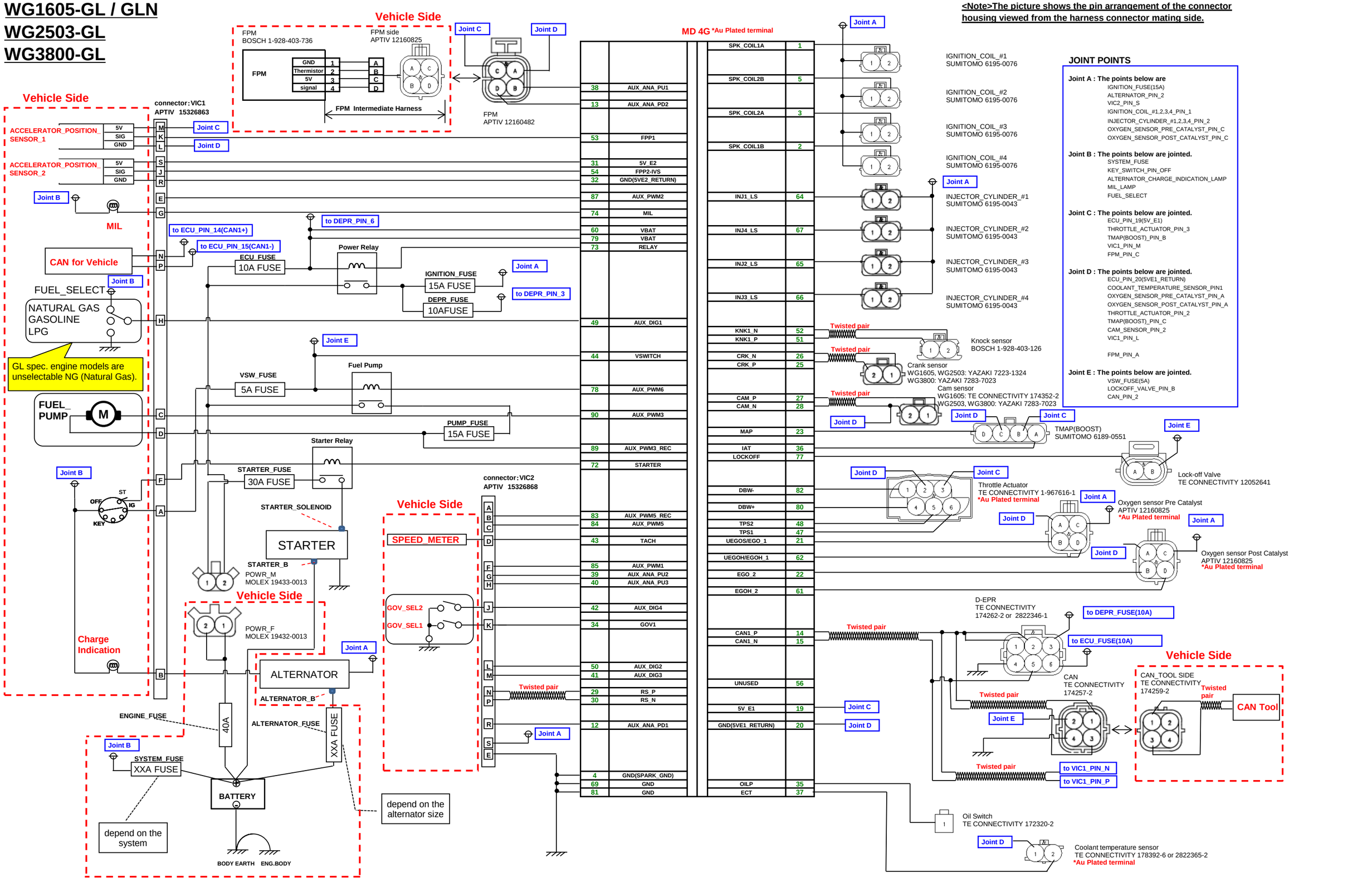
Joint E : The points below are jointed.
- VSW_FUSE(5A)
- CAN_PIN_2

WG1605-L / N / LN
WG2503-L / N
WG3800-L / N



<Note>The picture shows the pin arrangement of the connector housing viewed from the harness connector mating side.

WG1605-GL / GLN
WG2503-GL
WG3800-GL



<Note>The picture shows the pin arrangement of the connector housing viewed from the harness connector mating side.

JOINT POINTS

Joint A : The points below are
- IGNITION_FUSE(15A)
- ALTERNATOR_PIN_2
- VIC2_PIN_S
- IGNITION_COIL_#1,2,3,4_PIN_1
- INJECTOR_CYLINDER_#1,2,3,4_PIN_2
- OXYGEN_SENSOR_PRE_CATALYST_PIN_C
- OXYGEN_SENSOR_POST_CATALYST_PIN_C

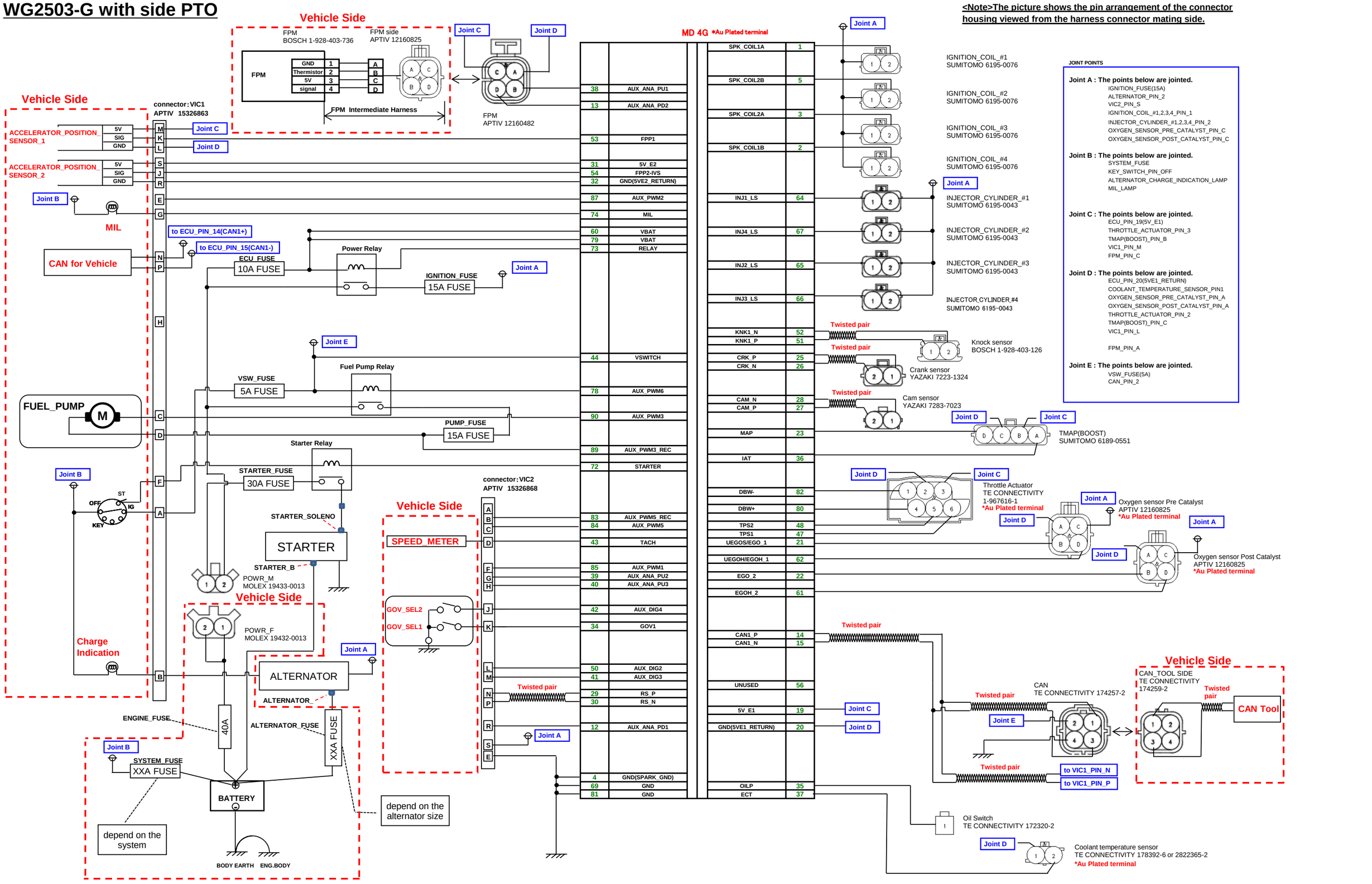
Joint B : The points below are jointed.
- SYSTEM_FUSE
- KEY_SWITCH_PIN_OFF
- ALTERNATOR_CHARGE_INDICATION_LAMP
- MIL_LAMP
- FUEL_SELECT

Joint C : The points below are jointed.
- ECU_PIN_19(5V_E1)
- THROTTLE_ACTUATOR_PIN_3
- TMAP(BOOST)_PIN_B
- VIC1_PIN_M
- FPM_PIN_C

Joint D : The points below are jointed.
- ECU_PIN_20(5VE1_RETURN)
- COOLANT_TEMPERATURE_SENSOR_PIN1
- OXYGEN_SENSOR_PRE_CATALYST_PIN_A
- OXYGEN_SENSOR_POST_CATALYST_PIN_A
- THROTTLE_ACTUATOR_PIN_2
- TMAP(BOOST)_PIN_C
- CAM_SENSOR_PIN_2
- VIC1_PIN_L
- FPM_PIN_A

Joint E : The points below are jointed.
- VSW_FUSE(5A)
- LOCKOFF_VALVE_PIN_B
- CAN_PIN_2

WG2503-G with side PTO



<Note>The picture shows the pin arrangement of the connector housing viewed from the harness connector mating side.

JOINT POINTS

Joint A : The points below are jointed.
- IGNITION_FUSE(15A)
- ALTERNATOR_PIN_2
- VIC2_PIN_S
- IGNITION_COIL_#1,2,3,4_PIN_1
- INJECTOR_CYLINDER_#1,2,3,4_PIN_2
- OXYGEN_SENSOR_PRE_CATALYST_PIN_C
- OXYGEN_SENSOR_POST_CATALYST_PIN_C

Joint B : The points below are jointed.
- SYSTEM_FUSE
- KEY_SWITCH_PIN_OFF
- ALTERNATOR_CHARGE_INDICATION_LAMP
- MIL_LAMP

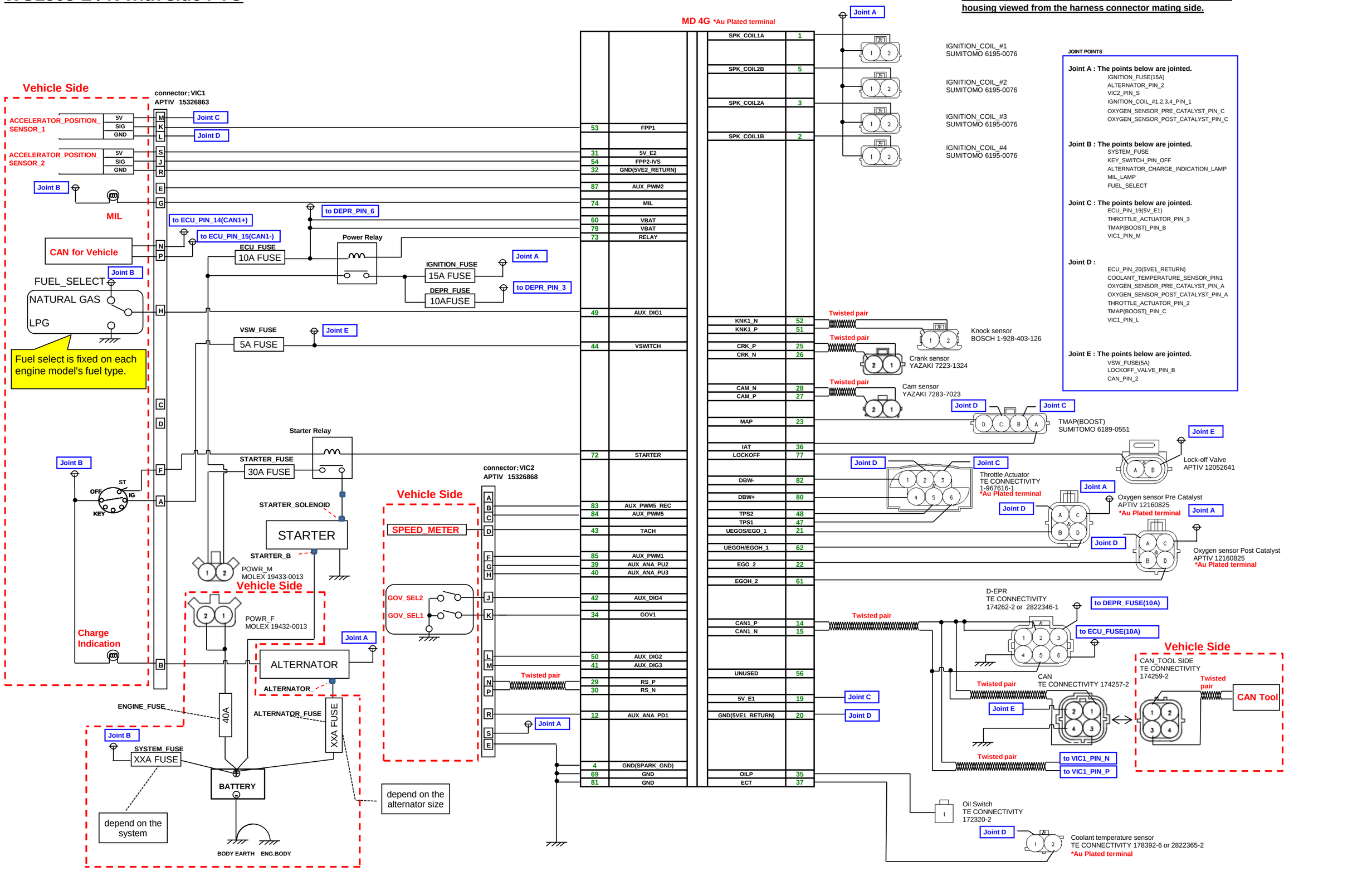
Joint C : The points below are jointed.
- ECU_PIN_19(5V_E1)
- THROTTLE_ACTUATOR_PIN_3
- TMAP(BOOST)_PIN_B
- VIC1_PIN_M
- FPM_PIN_C

Joint D : The points below are jointed.
- ECU_PIN_20(5VE1_RETURN)
- COOLANT_TEMPERATURE_SENSOR_PIN1
- OXYGEN_SENSOR_PRE_CATALYST_PIN_A
- OXYGEN_SENSOR_POST_CATALYST_PIN_A
- THROTTLE_ACTUATOR_PIN_2
- TMAP(BOOST)_PIN_C
- VIC1_PIN_L

FPM_PIN_A

Joint E : The points below are jointed.
- VSW_FUSE(5A)
- CAN_PIN_2

WG2503-L / N with side PTO



REVISION HISTORY

File Name	Remarks	Date
KORD3_19-233_ELECTRICAL_SYSTEM_for_LSI.pdf	Revise diagrams of "9. WIRING DIAGRAM".	Jun. 5, 2019