Electronic control system

Date 28 March 2013

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YANMAR

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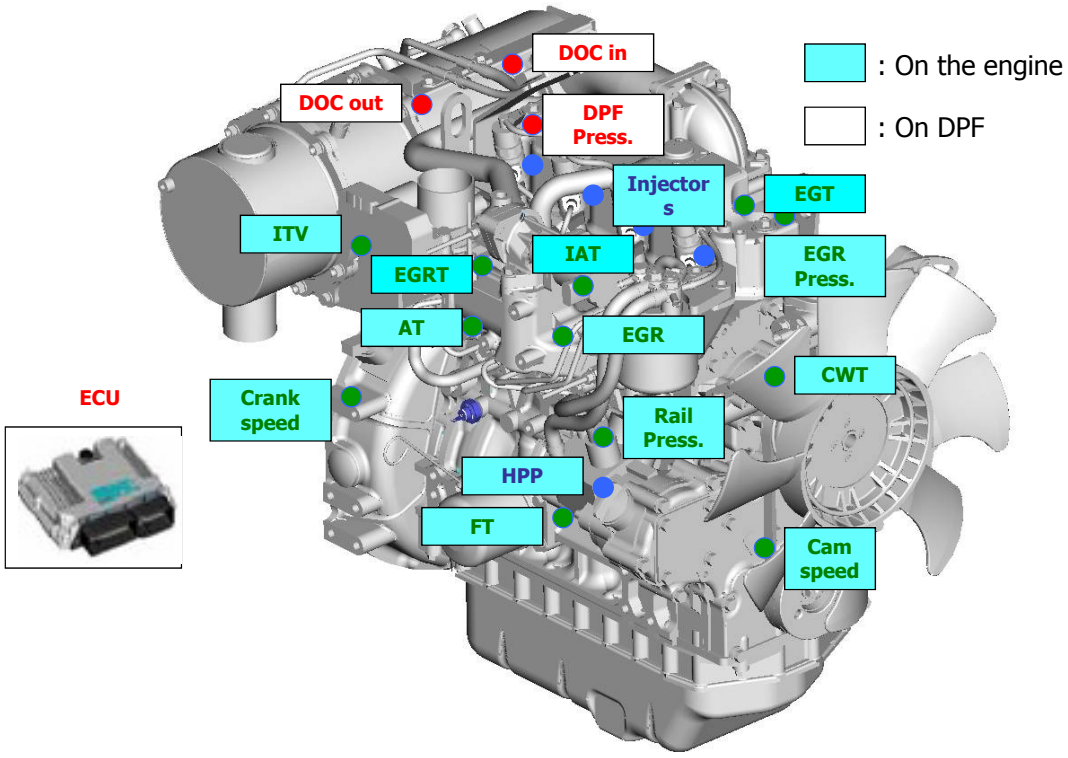
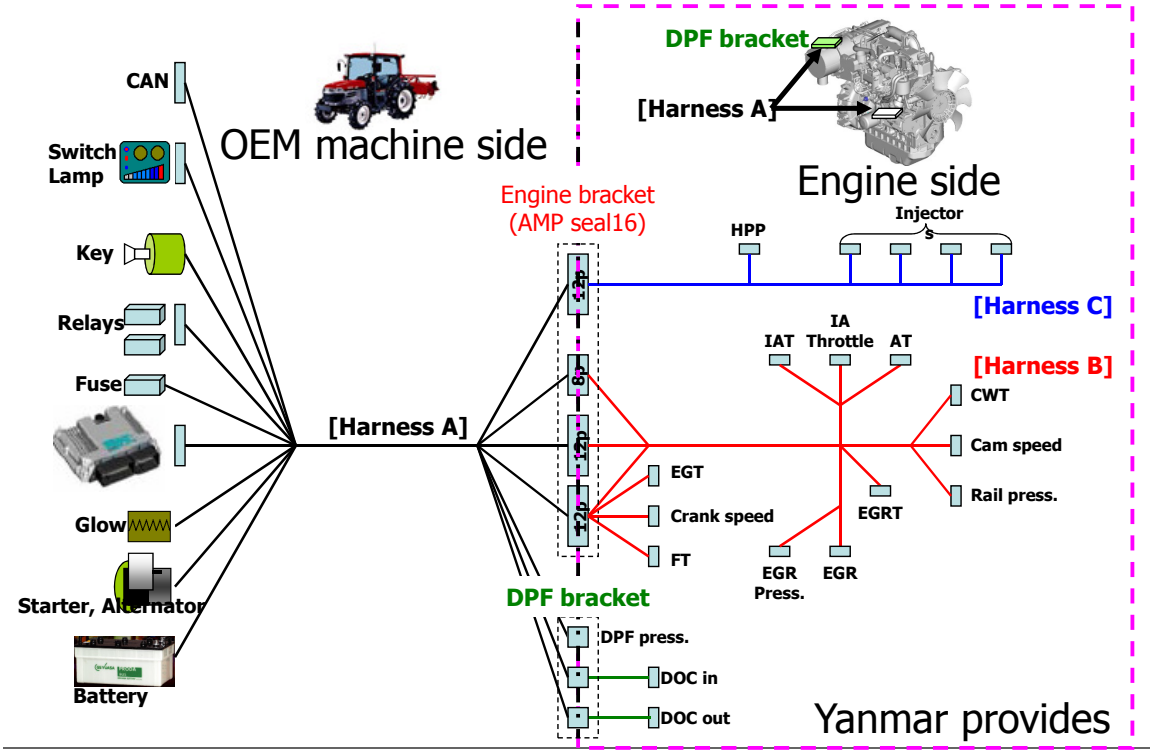
Overview

Engine sensors and actuators



Tier 4 harness concept



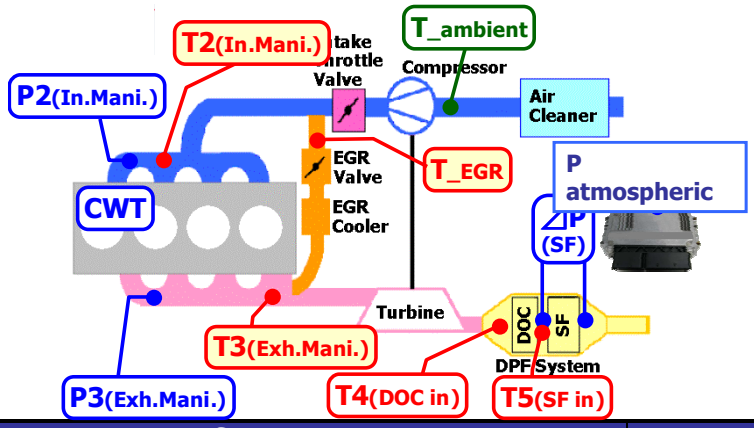
Supply policy of harness

Harness	Monitor Engine	Sample Engine	Mass-Production
Harness A	Supply	Supply (Only the first engine)	Not-Supply
Harness B	**Supply**	**Supply**	**Supply**
Harness C	**Supply**	**Supply**	**Supply**

【Harness A】
- Harness A is prepared by the customer because it is affected by machine layout.
- Harness A will be supplied with the first sample engine for troubleshooting of the harness the customer prepared.

【Harness B,C】
- Harness B and C is supplied by Yanmar in order to guarantee quality of engine performance and electronic devices.

Sensor concept for Tier 4 engines



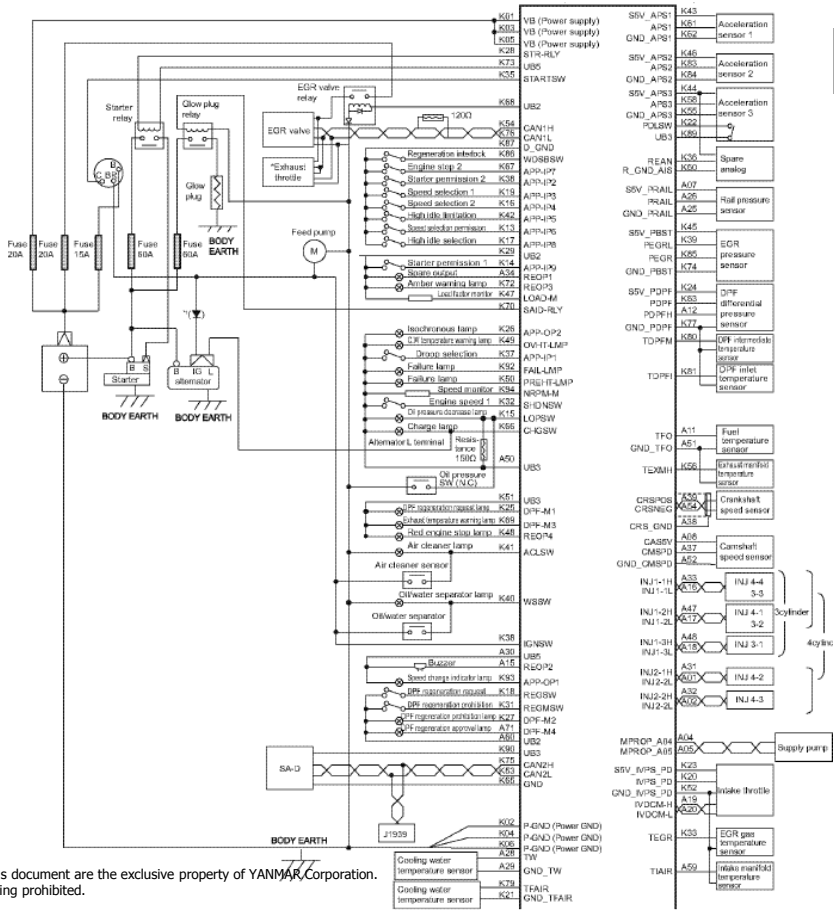
Sensors for Tier4 engine
- 4 press. sensors
- 7 temp. sensors
- 4 CR sensors

15 sensors in total

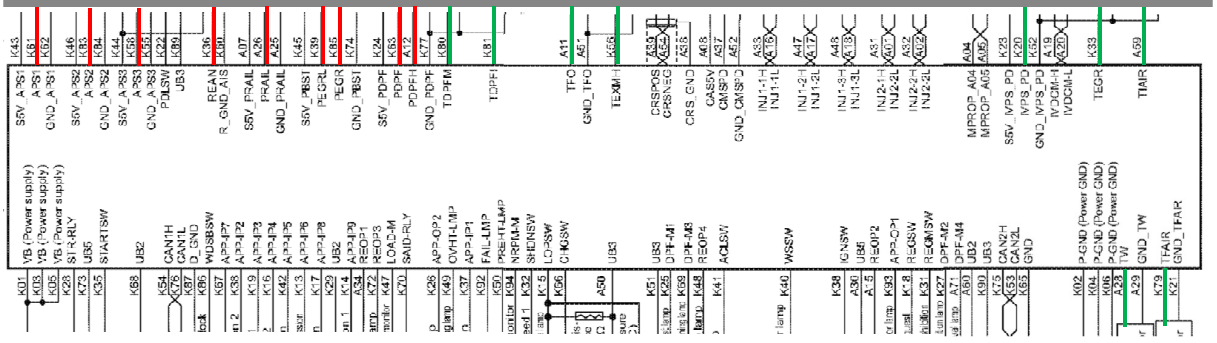
Sensor name		Usage
P atmospheric	Atmospheric press sensor	Atmospheric press correction (injection, etc.)
P2 (Intake mani.)	EGR high press sensor	EGR correction, intake pressure governor
P3 (Exhaust mani.)	EGR low press sensor	EGR correction
⊿P (SF)	DPF differential press sensor	P-method
T_ambient	Ambient temp sensor	Intake temp. correction (injection, etc.)
CWT	CW water temp sensor	Coolant temp. correction (injection)
T2 (Intake mani.)	Intake manifold temp sensor	Air mass calculation, EGR correction
T3 (Exhaust mani.)	Exhaust gas temp sensor	Air mass calculation, EGR correction, temp. governor
T_EGR	EGR temperature sensor	Air mass calculation, EGR correction
T4 (Before DOC)	DPF inlet temp sensor	C-method, temp. governor
T5 (Before SF)	DPF inside temp sensor	C-method, temp. governor

ECU connections

Diagram overview



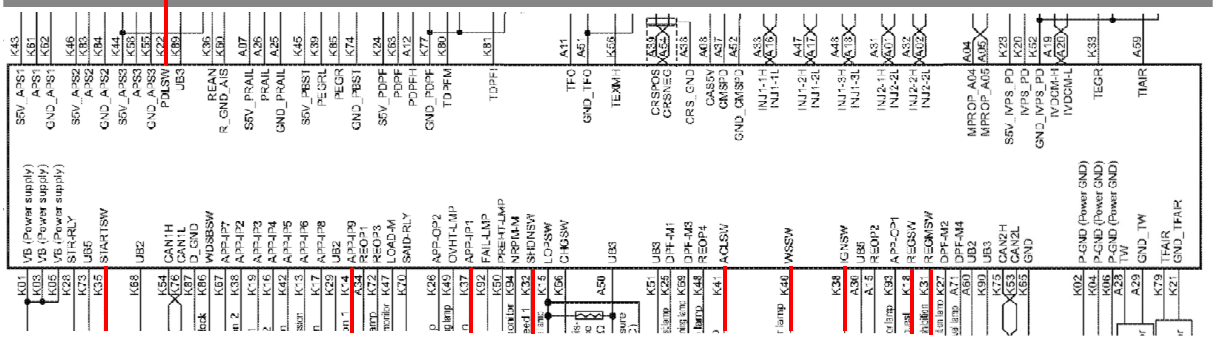
Analog input



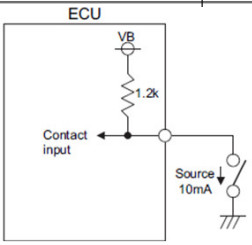
Analog input			
	Rail pressure	PRAIL	A26
	Accel. Sensor 1	APS1	K61
	Accel. Sensor 2	APS2	K83
	Accel. Sensor 3	APS3	K58
	Reserve analog	REAN	K36
	Intake valve sensor	IVPS	K20
	DPF differential pressure sensor	PDPF	K63
	DPF Hi-side pressure sensor	PDPFH	A12
	EGR Hi-side pressure sensor	PEGR	K85
	EGR Low-side pressure sensor	PEGRL	K39

Thermistor			
	CW temperature sensor	TW	A28
	FO temperature sensor	TFO	A11
	Fresh air temperature sensor	TFAIR	K79
	Intake air temperature sensor	TIAIR	A59
	EGR gas temperature sensor	TEGR	K33
	Exhaust gas temperature sensor	TEXMN	K56
	DPF inside temperature sensor	TDPFM	K80
	DPF inlet temperature sensor	TDPFI	K81

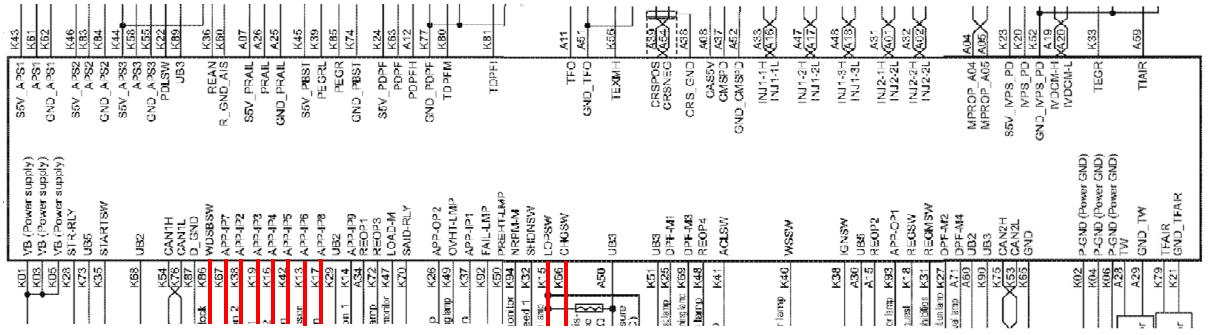
Low side digital input



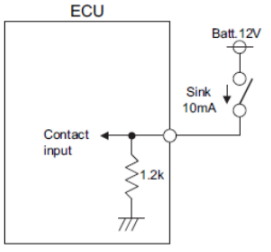
Low-side output				Low-side output			
	Key switch on	IGNSW	K88		Starter permission 1	APP-IP9	K14
	Key switch start	STARTSW	K35		Accel. Pedal	PDLSW	K22
	Engine stop 1	SHUDNSW	K32		Air cleaner sensor	ACLSW	K41
	DPF regeneration request	REGSW	K18		Water separator sensor	WSSW	K40
	DPF regeneration inhibit	REGMSW	K31				
	Droop	APP-IP1	K37				



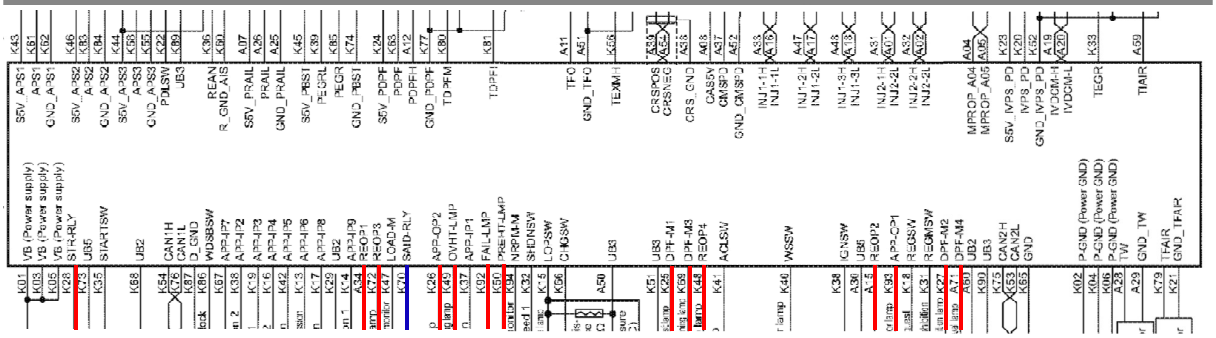
High side digital input



HI-side output				HI-side output			
	Regeneration interlock	WDSBSW	K86		Engine stop 2	APP-IP7	K67
	Starter permission 2	APP-IP2	K38		Hi-idle speed select	APP-IP8	K17
	Speed 1	APP-IP3	K19		Alternator L terminal	CHGSW	K66
	Speed 2	APP-IP4	K16		LO pressure switch	LOPSW	K15
	Hi-idle limit enable	APP-IP5	K42				
	Speed selection enable	APP-IP6	K13				

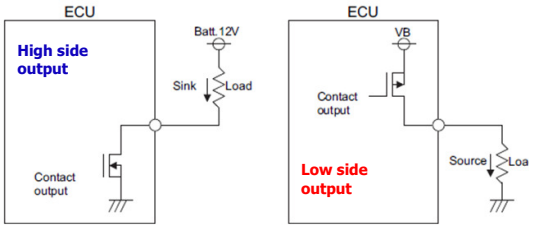


Digital output

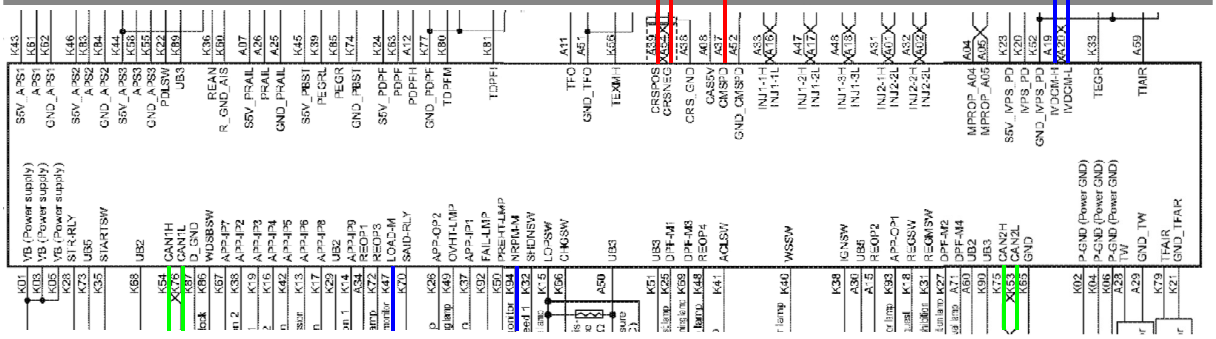


Relay	Starter relay	STR-RLY	K28
	Starting aid relay	SAID-RLY	K70
Lamp	Failure lamp	FAIL-LMP	K92
	Pre-heat lamp	PREHT-LMP	K50
	CWT warning lamp	OVHT-LMP	K49
	Speed selection lamp	APP-OP1	K93
	Iso-chronous lamp	APP-OP2	K26
	DPF regeneration request	DPF-M1	K25

Lamp	DPF regeneration inhibit lamp	DPF-M2	K27
	EGT lamp	DPF-M3	K69
	DPF regeneration acknowledge lamp	DPF-M4	K71
	Reserve	REOP1	A34
	Buzzer	REOP2	A15
	Amber warning lamp	REOP3	K72



Pulse I/O & CAN communication

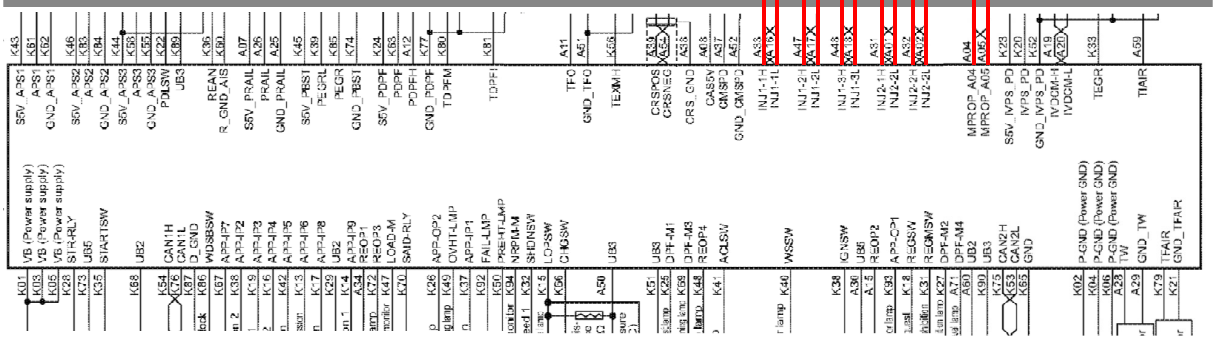


Pulse input	Crank speed	CKSPD	A39, A54
	Cam speed	CMSPD	A37
	Vehicle speed	VS	K34

Communication	CAN-H1	CAN1H	K54
	CAN-L1	CAN1L	K76
	CAN-H2	CAN2H	K75
	CAN-L2	CAN2L	K53

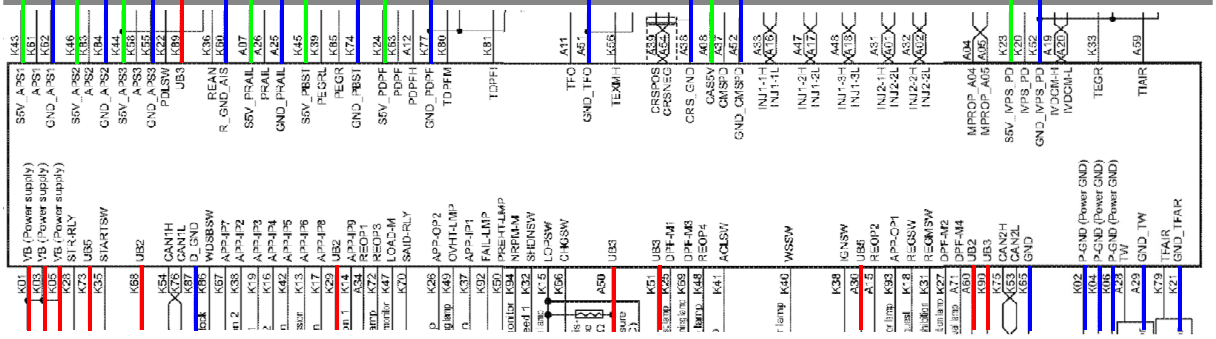
Plus output	Speed monitor	NRPM-M	K94
	Load ratio monitor	LOAD-M	K47
DC motor	Intake valve motor	IVDCM-H, L	A19, A20

Common rail system digital output



Solenoid	Injector H	INJH1 - 4	A33, A47, A31, A32, A48
	Injector L	INJL1 - 4	A16, A17, A01, A02, A18
	SCV H	MPROP-H	A04
	SCV L	HPPSOL	A05

Power supply & grounding



Input	VB	VB	K01, K03, K05
Output	External 12 V	UB2	K68 K29 A60
		UB3	K89 K90 A50 K51
		UB5	K73 A30
Output	Sensor 5 V	5VS	K43 K44
			K23 K45 K46 A08
			K24 A07

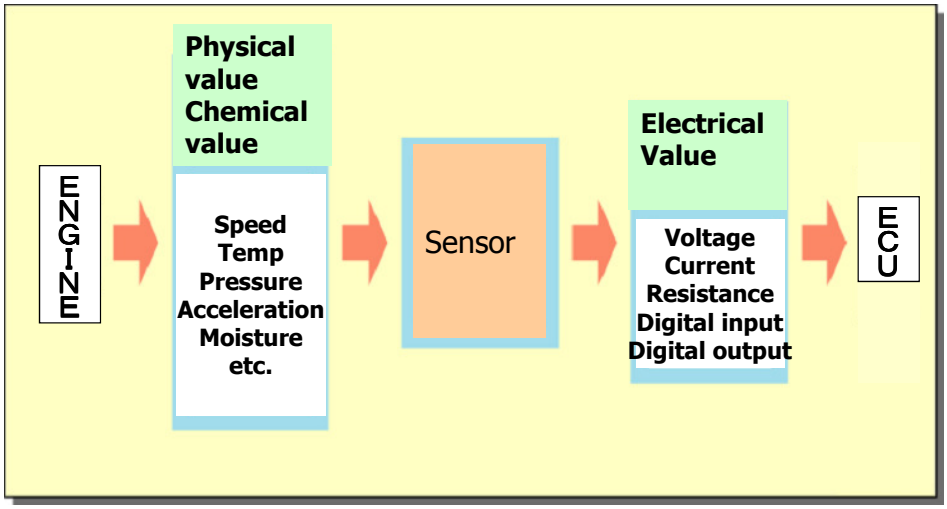
GND	ECU GND	GND	K02, K04, K06
GND-A	Analog GND	A-GND	K21 K77 K74 K52 K62 K84 K55 K60 A29 A51 A25 A52 A38
		D-GND	K65 K87

Sensors

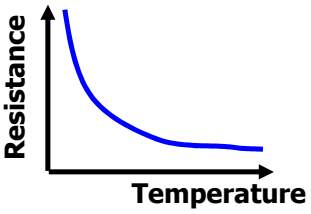
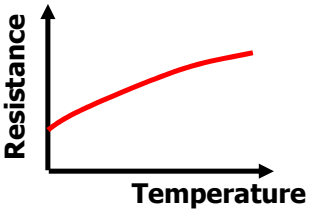
Sensor types and measure principles

(1) Temperature
(2) Pressure
(3) Speed
(4) Position (angle)

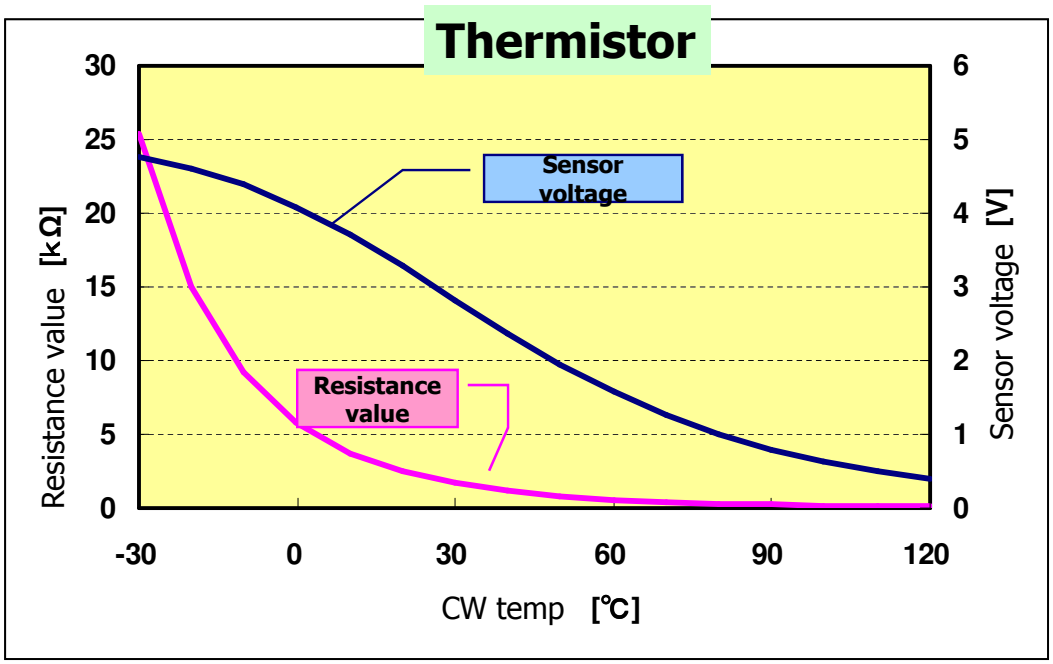
Sensor outline figure



Temperature sensor types and sensing principles

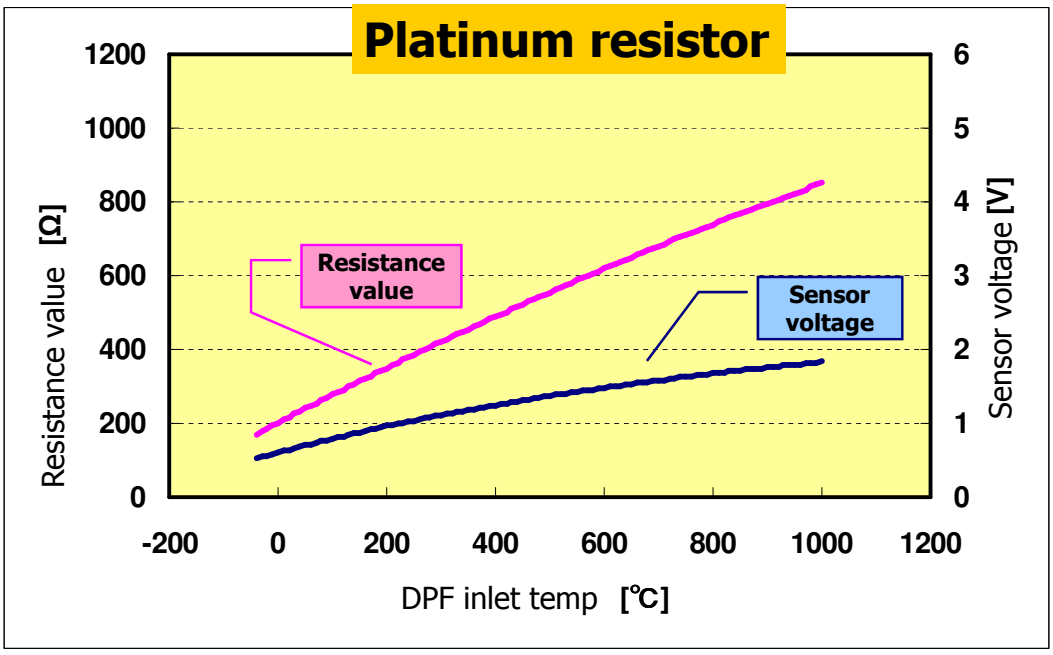
Sensor name	Usable temp. range [°C]	Sensing principle
Fuel temp. sensor	-40 to 150	Thermistor  Temp.: High → Resistance value: Small
CW temp. sensor	-30 to 120	
Ambient temp. sensor	-40 to 150	
Intake mani. temp. sensor	-40 to 200	
EGR gas temp. sensor	-40 to 325	
DPF inlet temp. sensor	-40 to 1000 (diag≧700)	Platinum resistor  Temp.: High → Resistance value: High
DPF inside temp. sensor	-40 to 1000 (diag≧700)	
Ex. gas temp. sensor	-40 to 1000	

Example of characteristic curve for temperature sensor (1)



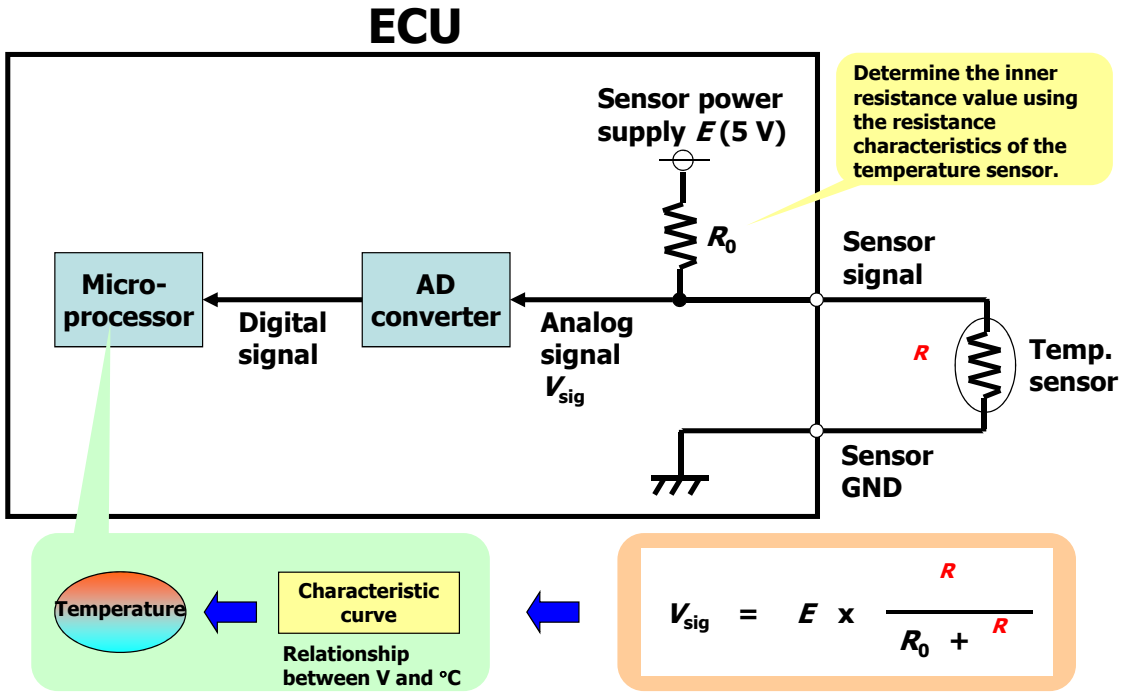
Characteristic curve for CW temperature sensor

Example of characteristic curve for temperature sensor (2)



Characteristic curve for DPF inlet temperature sensor

ECU interface circuit of temperature sensor

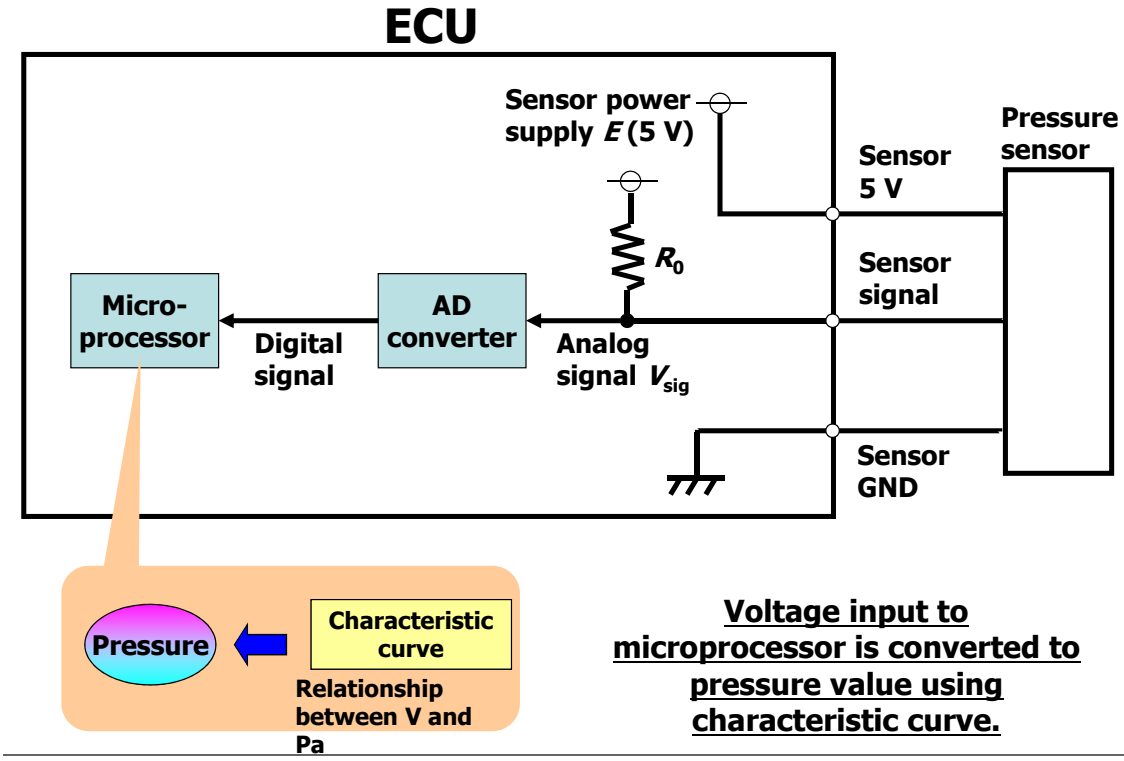


Voltage input to microprocessor is converted to temperature value using characteristic curve.

Pressure sensor types and sensing principles

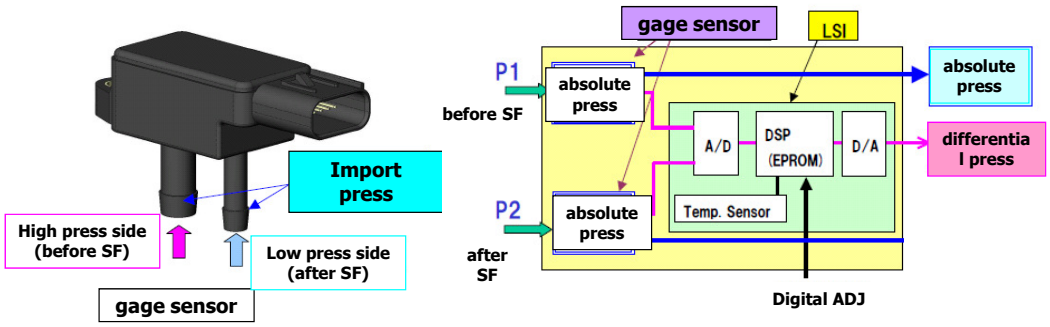
Sensor name		Detected pressure range	Sensing principle
Rail pressure sensor		0 to 1,800,000 hPa	**Strain gage** → Change in electrical resistance value caused when the resistor is deformed by external force (pressure)
DPF differential pressure sensor		0 to 50 kPa	
EGR pressure sensor	EGR high-press. side (ex. mani. pressure)	40 to 300 kPa abs	
	EGR low-press. side (in. mani. pressure)	40 to 300 kPa abs	
Ambient pressure sensor		40 to 110 kPa abs	

ECU interface circuit of pressure sensors



Voltage input to microprocessor is converted to pressure value using characteristic curve.

DPF differential pressure sensor structure

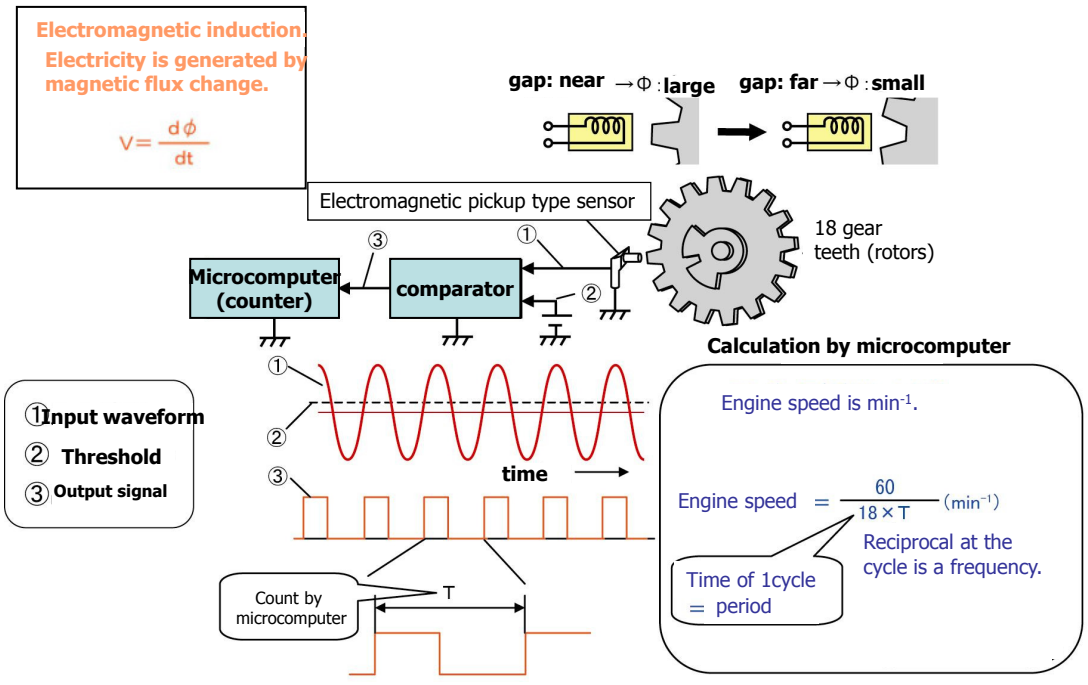


Two gage sensors are adopted, and difference of absolute pressure values is calculated in the sensor to output DPF differential pressure.

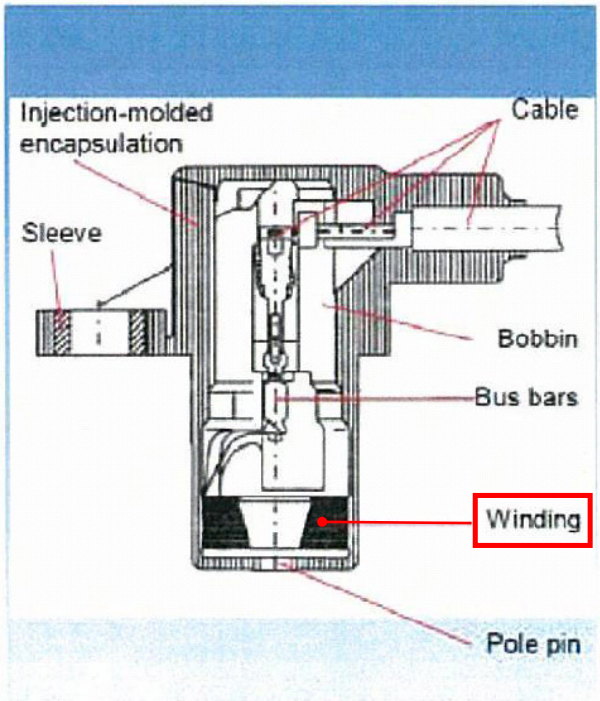
Speed sensor types and their sensing principle

Sensor name	Sensing principle
Crank speed sensor	Electromagnetic pickup
Cam speed sensor	Magnetic resistance element (Hall element)

Principles of speed measurement with electromagnetic pickup



Principle of speed measurement with electromagnetic pickup



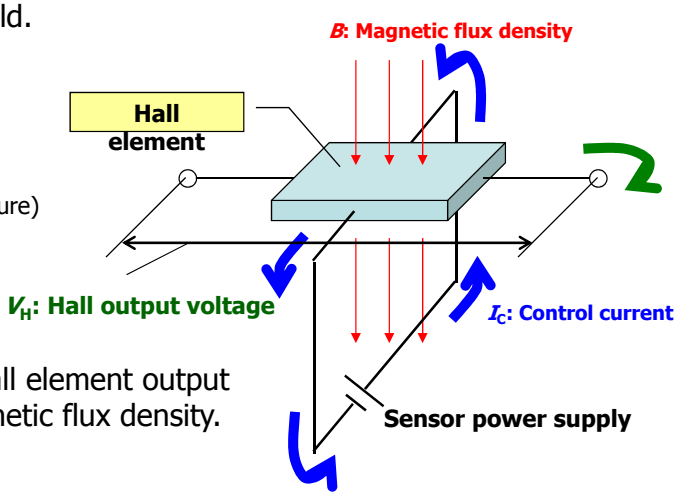
Internal structure of crank speed sensor (Bosch)

Operating principle of Hall element

Magnetic resistance element (Hall element) is an element which detects a magnetic field using the Hall effect. It converts a magnetic field generated by a magnet or that generated by a current into an electric signal, and output it. The Hall effect is a phenomenon that when a magnetic field is applied to an object through which a current is flowing in a direction perpendicular to the electric current, an electromotive force appears in a direction orthogonal to both the current and magnetic field.

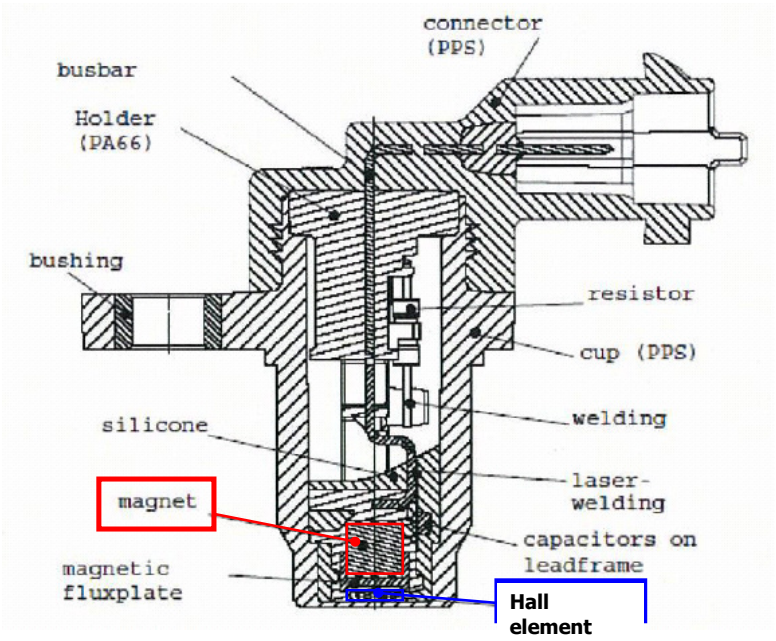
$$V_H = R_H \times I_C \times B$$

V_H: Hall output voltage
R_H: Hall coefficient
(depends on material or temperature)
I_C: Control current
B: Magnetic flux density



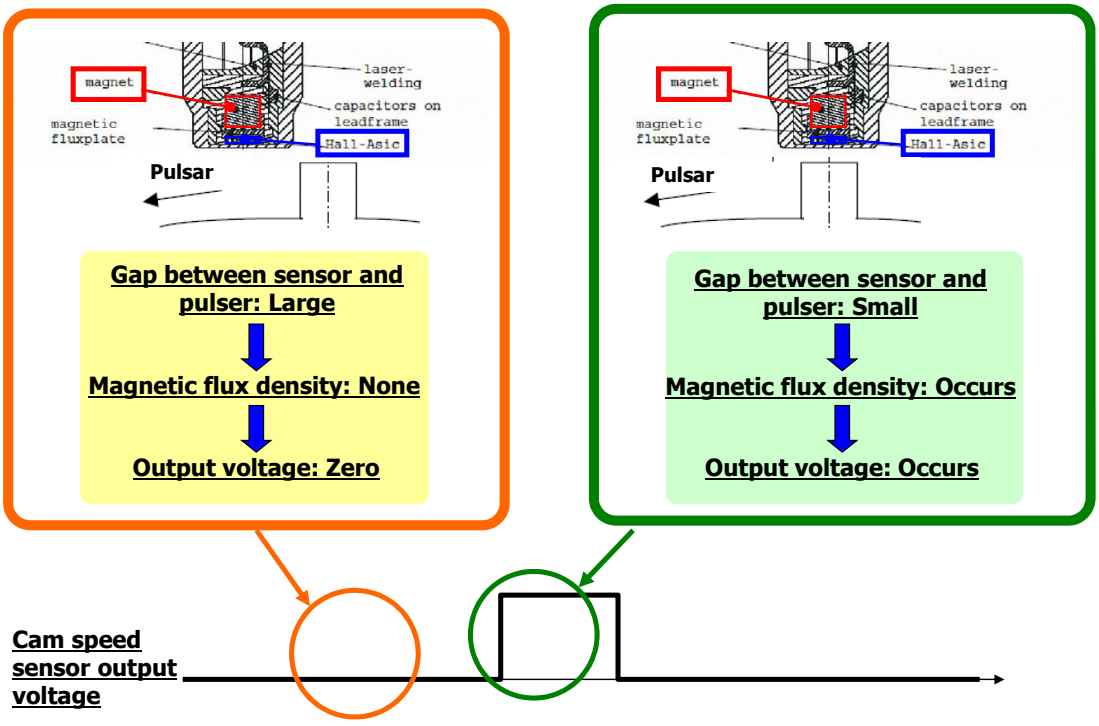
From the above principles, the Hall element output power is proportional to the magnetic flux density.

Principle of speed measurement with Hall element

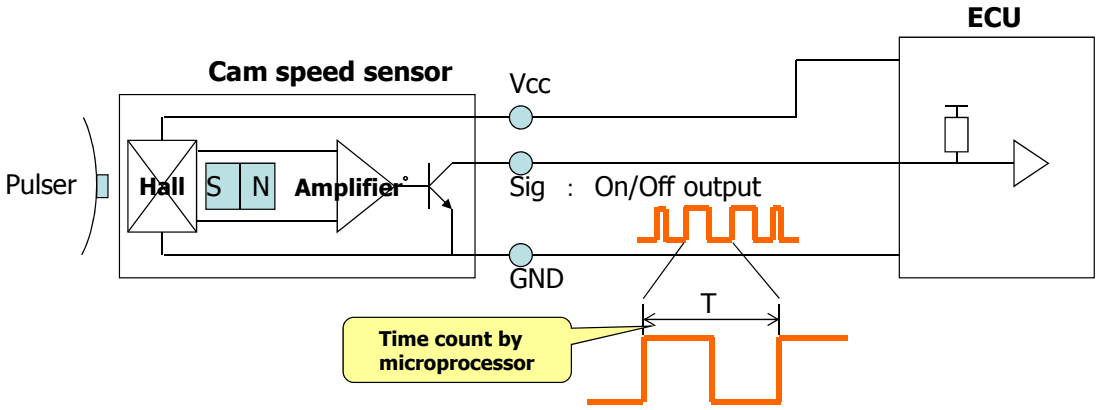


Internal structure of cam speed sensor (Bosch)

Principle of speed measurement with Hall element

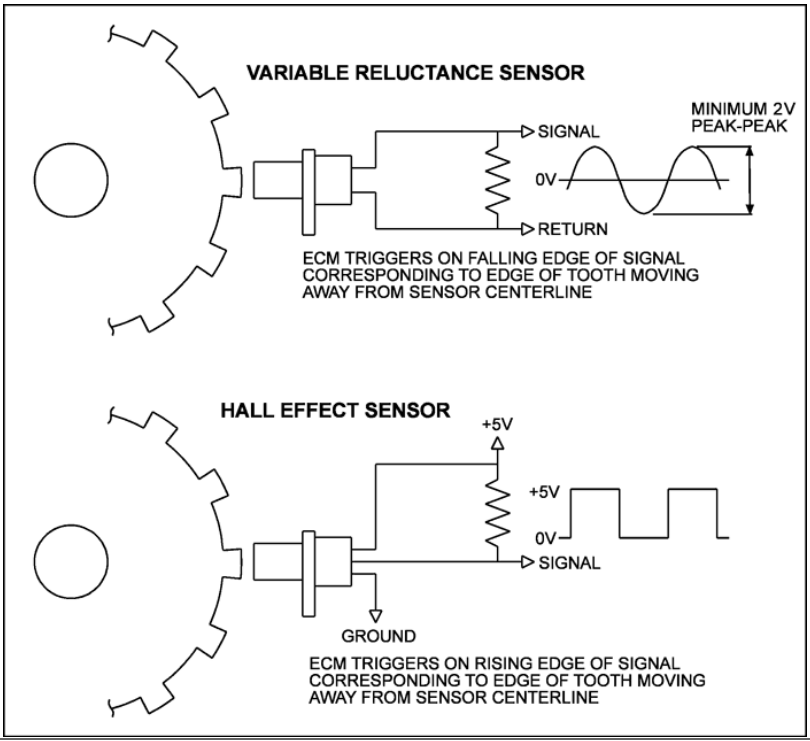


Principle of speed measurement with Hall element

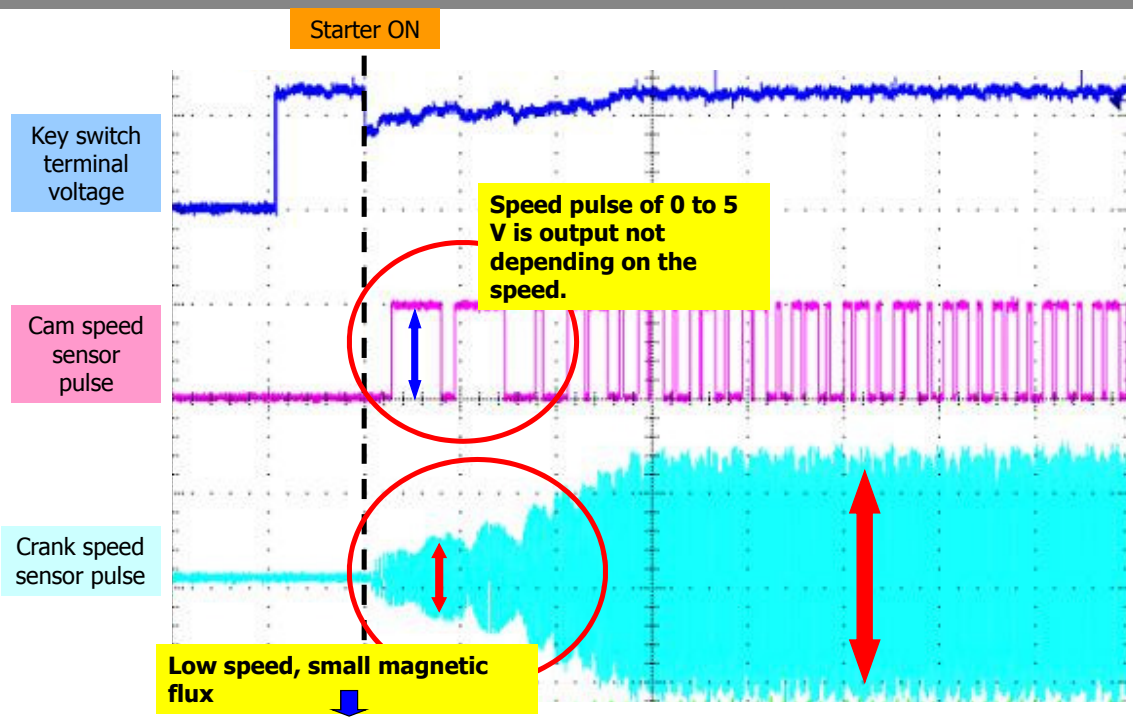


Based on the sensor voltage input from the cam speed sensor to ECU, the microprocessor counts the time from the sensor voltage leading edge up to the next leading edge.

Difference between electromagnetic & Hall sensor



Minimum measurement speed



Voltage necessary for speed pulse detection is not generated. → **ECU cannot detect the speed.**

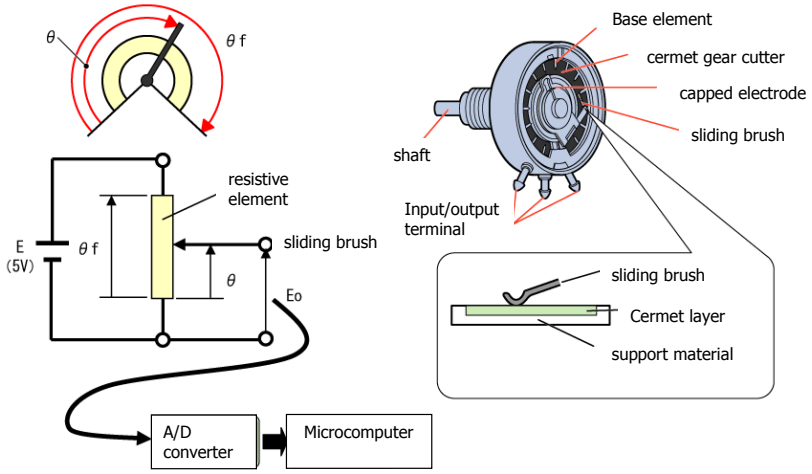
Position sensor types and their sensing principle

Sensor name	Sensing principle
Accelerator sensor	- Potentiometer (sliding resistance) - Contact type
Intake throttle position sensor	- Magnetic resistance element (Hall element) - Non-contact type
Exhaust throttle position sensor	

Principle of position measurement with potentiometer

A sliding brush moves on a resistor, and rotation amount is considered as a change in the resistance value.
Assuming that the total angle of the resistor is θf, the output voltage Eo when the rotational axis turns by θ is

$$E_o = E \times \frac{\theta}{\theta f}$$



Operating principle of Hall element

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$$V_H = R_H \times I_C \times B$$

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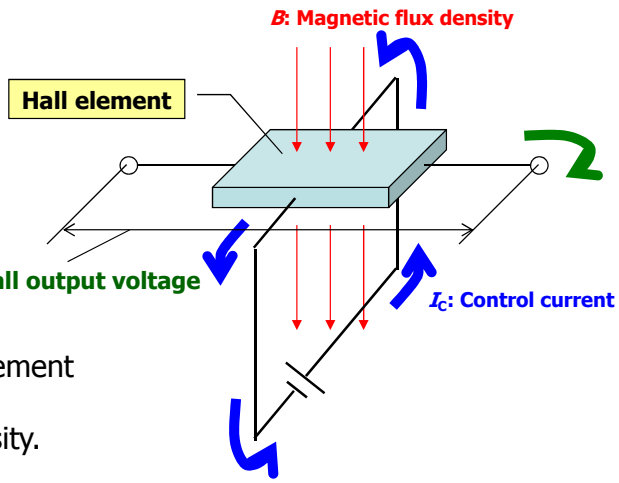
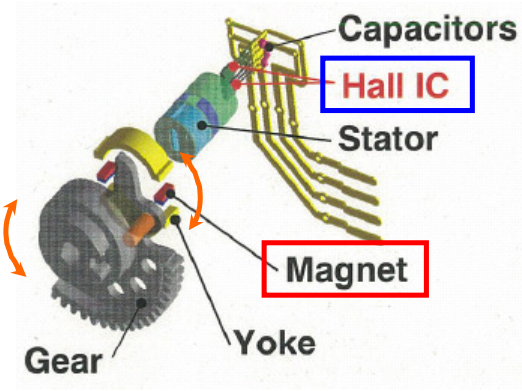
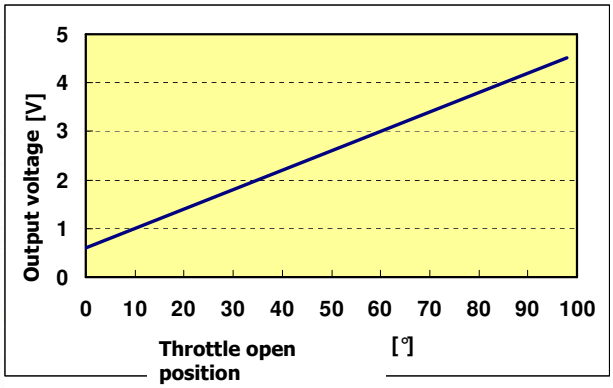


From the above principles, the Hall element can obtain an output power supply proportional to the magnetic flux density.

Operating principle of Hall element



Internal structure of intake throttle position sensor



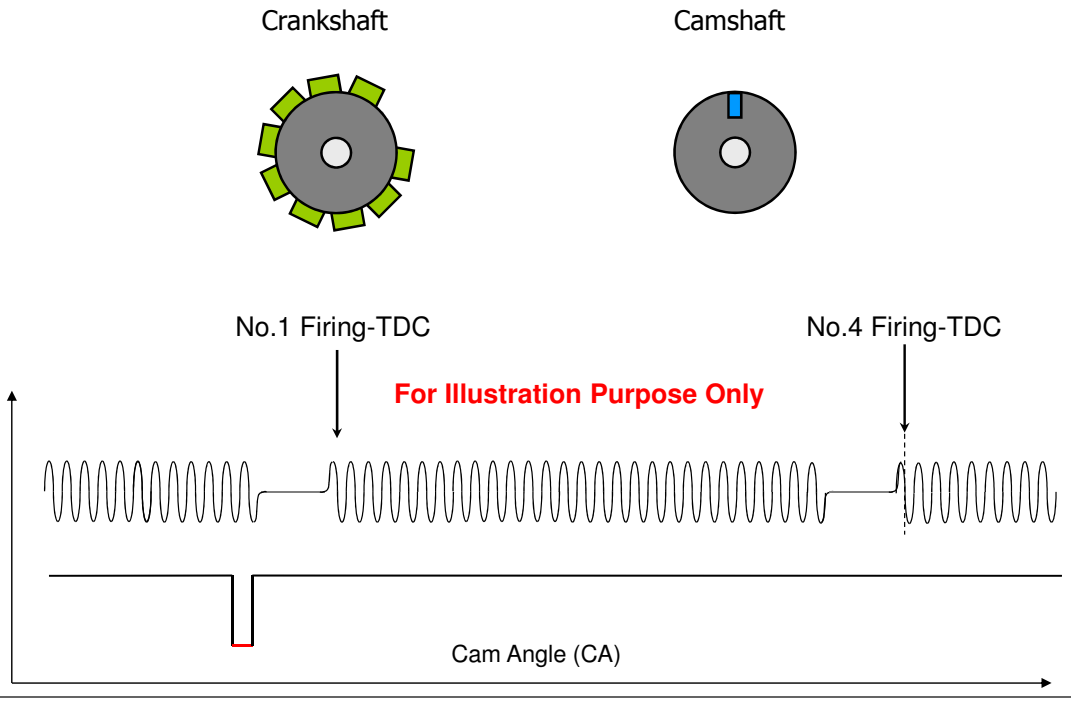
Sensor characteristics

Place a magnet so that the magnet flux density proportional to the travel of an object to be measured (throttle) is applied to the Hall element.

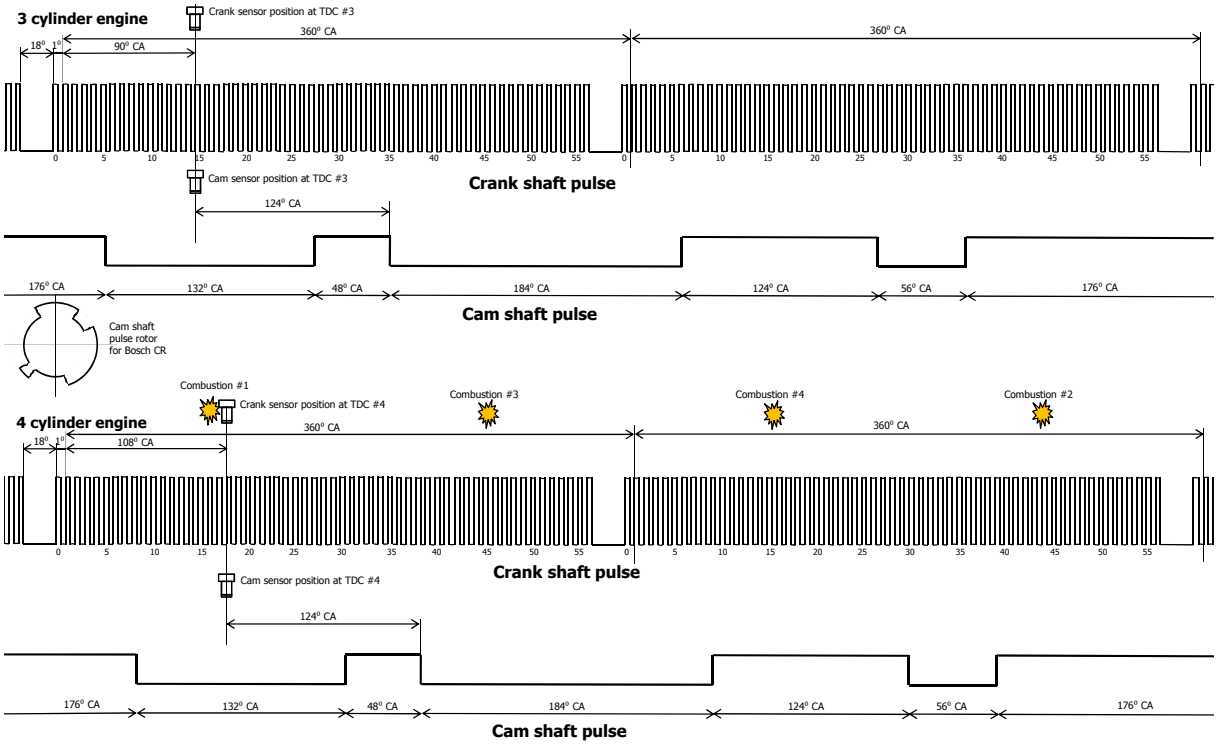
⬇

Obtain the Hall output voltage proportional to the travel.

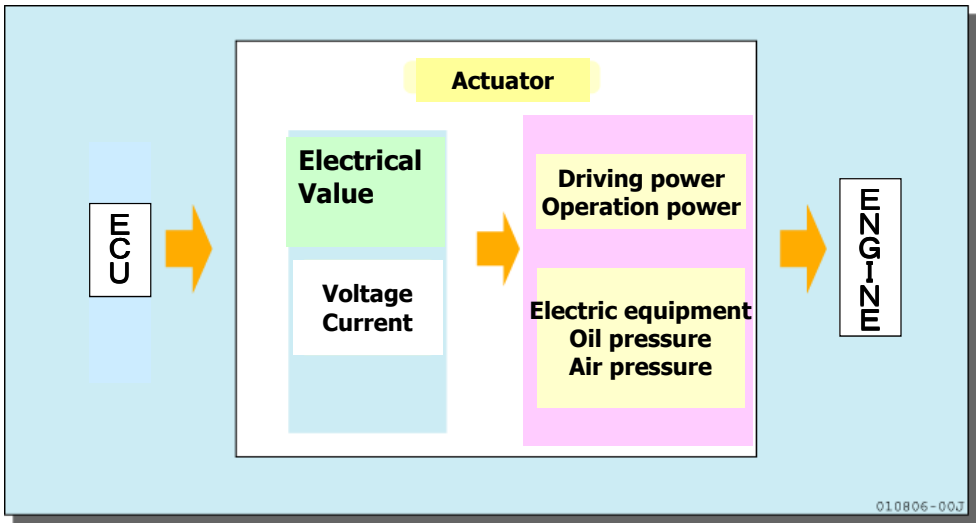
Crankshaft speed/Camshaft position sensor



Crankshaft speed/Camshaft position sensor



Concept diagram of actuators

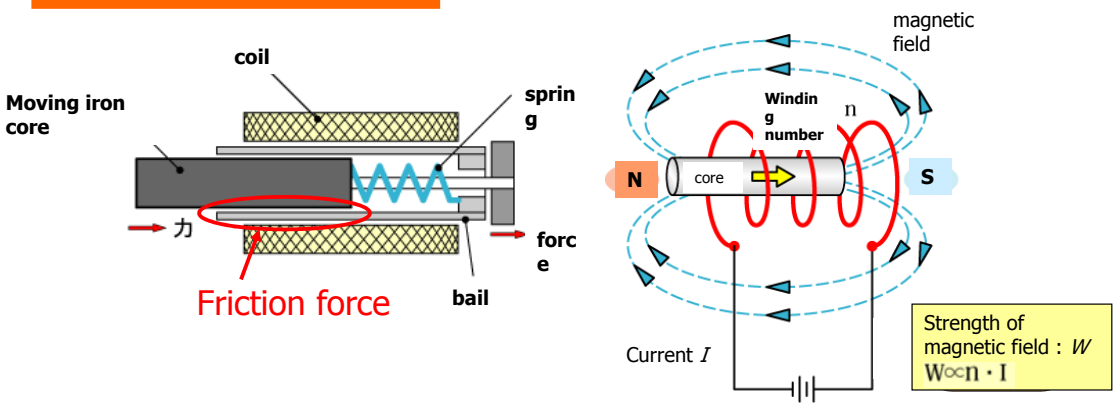


Actuator types and operating principles

Sensor name	Operating principle
Injector	Solenoid control (Pull, Hold)
Supply pump	PWM control (Duty ratio)
Intake throttle	DC motor (with brush) control
Exhaust throttle (optional part)	
EGR valve	DC brushless motor control

Solenoid injector operation principle

Principles of solenoid

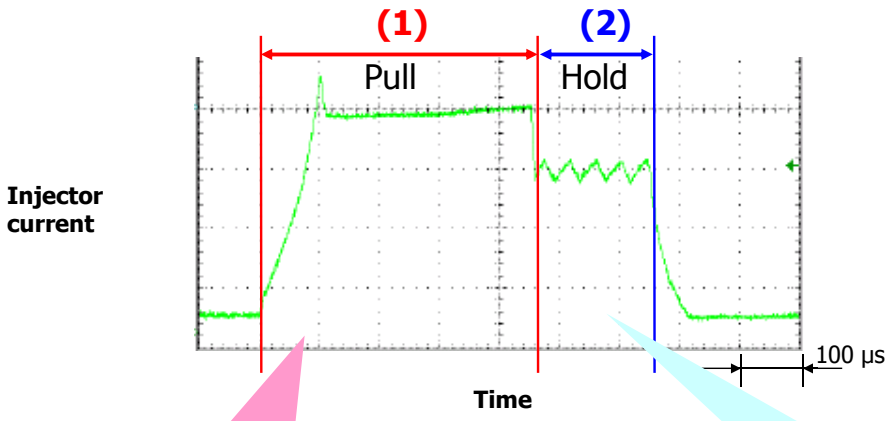


The iron core is moved by a magnetic field generated when the coil is energized.

⬇

Because there is a friction force, it is necessary to apply a larger current through the coil to make the magnetic field stronger in order to move the iron core quickly.

Injector current



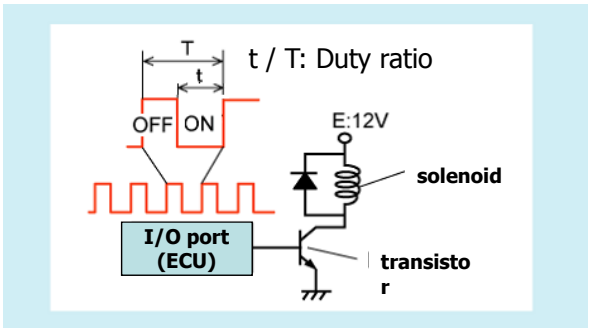
(1) To pull quickly, apply a large current.

Because of heat generation, the same current cannot be applied continuously.

(2) To hold the lifting position, apply the minimum required current.

Apply the injector current in 2 stages.

Supply pump operating principle



PWM control
= Pulse Width Modulation

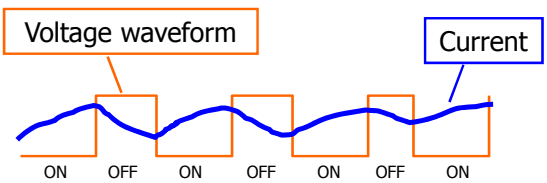
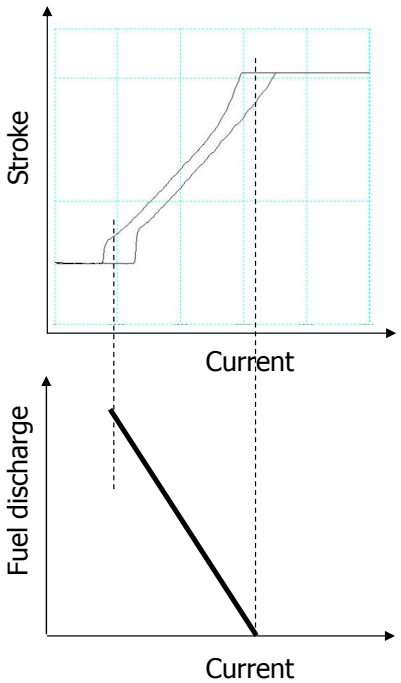


Image figure of voltage waveform and current



Outline figure of pump characteristics

Intake Throttle

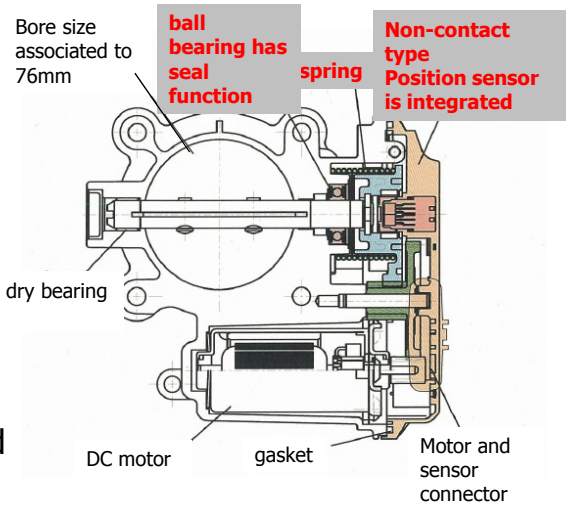
Special features

- Non-contact type position sensor is integrated.
→ Durability is ensured.

-The valve is fully opened by the integrated spring when non-energized.
→ Failsafe is considered

-The energizing time etc. are calculated and controlled from the present valve position and the target valve position to the motor.

→ ECU controls intake throttle.



Internal structure of intake throttle

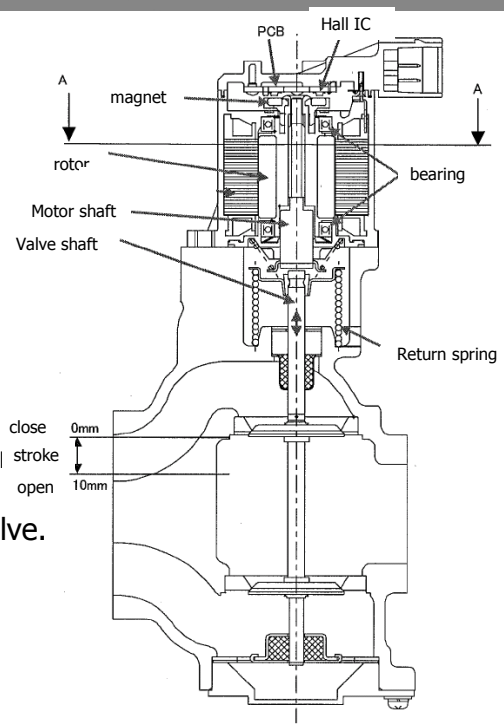
EGR valve

Special features

- The motor has no brushes.
→ No risk of sticking of brush contact point

- Valve position is fed back by non-contact sensor.
→ No loss of synchronization. Quicker response speed

-EGR valve is controlled by the ECU based o a target position as instructed by the ECU.
→ ECU send target valve position to EGR valve. ECU controls EGR valve only by CAN communication.



Internal structure of EGR valve

THANK YOU FOR YOUR ATTENTION.

YANMAR