TFO Code - Ch. 5 Edition

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PURPOSE

This document describes Fiat specifications to implement diagnostic functions in onboard vehicle electronic systems defining general rules.

Change	Date	Description		
-	Sept. 95	Edition 1 -	New.	(AF)
-	Apr. 97	Edition 2 -	Paragraph 3.3.3, 4.2.1, Annex 1 (par.1.1.2) modified. Par. 4.3 added.	(AF)
-	Sept. 99	Edition 3 -	Fully revised. Annex 1 eliminated from this Standard and added to Standard 07273.	(AF)
-	12.09.99	Edition 4 -	Paragraphs 4.3.4, 4.11.4. sub-paragaphs 7(a), 4.11.5 parameter file table, 11.7.modified, paragraphs 4.5.1. and 4.5.2. added.	(AF)
-	07.21.00	Edition 5 -	New paragraphs added: 4.2.7.1, 4.2.7.2, 4.2.7.3, 4.2.7.4, 4.2.7.5, 4.3.1, 5.4. Paragraphs modified: 1, 4.2.7, 4.3.2, 4.9, 5.9.2, 4.11.5 (new tables added).	

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1 REFERENCE STANDARDS

In diagnostics, the following standards refer to:

/1/ Standard ISO 9141, Specifications for diagnostic information exchanges concerning vehicles.

/2/ Standard FIAT 07223, Communication protocol KW 2000

/3/ Standard FIAT 07273, Standard diagnostic protocol FIAT 9141.

/4/ Standard FIAT 07274, Standard diagnostic protocol FIAT on C.A.N.

/5/ Standard FIAT 7.Z0050, Check of self-diagnostic functions on electronic control units.

/6/ Standard FIAT 7.Z0140, Electronic systems –Low-speed C.A.N. nodes – Check of physical level.

/7/ Procedure FIAT 07224, Procedure to implement diagnosis on Memoria Tecnica electronic systems.

/8/ Standard ISO/CD 15031-6, Road vehicles – Emission related diagnostics – Communication between vehicle and external equipment – Diagnostic Trouble Code Definition.

/9/ European directive 98/69/EC dated October 13, 1998.

2 SCOPE

This document describes general requirements of diagnostic and self-diagnostic strategies of all product control electronic systems for FIAT AUTO.

This general specification must be considered as the initial issue of **SDF** (**S**pecifica di **D**iagnosi **F**inalizzata) for each system, containing definitions of all parameters and functions concerning diagnostic performances previously agreed upon by supplier and FIAT AUTO system manager.
A specific example of **SDF** (**S**pecifica di **D**iagnosi **F**inalizzata) is described in the Annex to this Standard.

3 DEFINITIONS AND ABBREVIATIONS

Some basic technical terms, used in a "Diagnosis" context, are defined below

"CAN" (Controller Area Network) COMMUNICATION BUS – Used to exchange data between electronic systems; it can be used for diagnostic communication as an alternative to K diagnostic line.

ERROR CELL – This cell contains information suitable to describe a single malfunction.

ISO CODE – This code univocally identifies electronic system under DIAGNOSTIC point of view and is assigned by FIAT AUTO DT-SIEE-SSE. It is transmitted by electronic systems when communication is started (see **/2/**) or when requested by diagnostic instrument (see **/3/** and **/4/**).

DIAGNOSIS – ability of electronic system, equipped with microprocessor, to cyclically check internal (microprocessor, memory, …) and external (sensors and actuator) components – the system consists of - properly operate. Any malfunction (permanent or intermittent) is recorded in dedicated error cells of non-volatile memory.

ACTIVE DIAGNOSIS – Functions of electronic system, able to receive commands from diagnostic instrument and activate system actuators following special modes.

DTC (DIAGNOSTIC TROUBLE CODE) – Error code identifying a faulty component/function or a malfunction recorded by the system.

IDENTIFICATION – Series of data used to identify ISO code, drawing numbers, software, hardware and other information concerning electronic system version.

INITIALIZATION – This is used to activate diagnostic communication following the indications specified in standards **/2/**, **/3/** or **/4/**.

“K” DIAGNOSTIC LINE – This line is used for digital serial communication between diagnostic electronic system and diagnostic instrument.

NON-VOLATILE MEMORY – Part of electronic system memory able to preserve its data also when system power is completely cut-off.

ENGINEERING PARAMETERS - These are physical parameters, recorded by the sensors and successively processed by the electronic system, which the diagnosis instrument is able to acquire via the diagnosis line.

COMMUNICATION PROTOCOL - This is the group of rules governing communication between electronic system and diagnostic instrument. All the information used to convert the parameters acquired by the electronic system are contained in this protocol.

RECOVERY - These are strategies inside the electronic system which, in the event of an anomaly, manage system operating decay and allow the system to complete its specific mission. (LIMP-HOME)

SNAPSHOT - A group of engineering parameters, which the diagnosis instrument is able to acquire in block form, is termed snapshot. There may be numerous blocks of snapshots.

DIAGNOSTIC INSTRUMENT – Electronic appliance (Examiner, line-end instrument,....) able to communicate with diagnostic electronic systems.

4 DIAGNOSTIC PERFORMANCES

The electronic systems must be equipped with the following self-diagnosis performance:

- Management of transmission physical means (CAN bus or K serial line dedicated) used to communicate with external diagnostic instrument.
- Recognition of the malfunction on sensors, actuators and on the system and also, if necessary, of faults or malfunctions affecting mechanical parts and electronic system power, with the possibility of distinguishing between **faults** (effective malfunctions) and disturbances which must be filtered;
- Fault management procedure (filtering, memorisation and cancelling of faults) in accordance with the specific methods.
- Actuation of the suitable recovery strategies for each time of malfunction identified;
- Management of the malfunction warning lights in accordance with the specified methods;
- Transmission of the engineering parameters on diagnosis serial line;
- Capacity to pilot the system actuators (active diagnosis) by proper controls;

The following functions are options and can be required by system manager (RSC) to be used during Production and Technical Assistance:

- Storing of statistic parameters defined with FIAT AUTO DT-SIEE-S-SE;
- Possible regulations and calibration by proper controls.
- Electronic system re-programming (upon request of system manager– RSC).

4.1 Management of communication physical level

The electronic system must manage information exchange on diagnostic serial line. Diagnostic communication can take place by using one of the following configurations:

- **"K" serial line**

Information exchange must fully comply with one of the following standards:

- Standard FIAT **07223** (see **/2/**)

- Standard FIAT **07273** (see **/3/**)

- **C.A.N. communication bus**

Information exchange must fully comply with the following standards:

- Standard FIAT **07274** (see **/4/**)

4.2 Troubleshooting

4.2.1 General regulations

Troubleshooting on system components must be performed under all vehicle conditions, as hereinafter described:

- Key on .... KEY ON.................................... **(KO)**
- Thermal engine ignition .... CRANKING .... **(CR)**
- Thermal engine started up .... ENGINE RUN............................ **(ER)**
- Running vehicle .... VEHICLE RUN .... **(VR)**
- Power - latch (or after - run)[1] .... POWER-LATCH .... **(PL or AR)**

If a component is faulty, diagnostic strategies using information from this component must be stopped..

For each system component troubleshooting mode must be described and this description must be added to **SDF** (**S**pecifica di **D**iagnosi **F**inalizzata) (section: Diagnostic Functions Summary) in the following columns:

- Identification conditions
- Possible Causes
- Troubleshooting modes

4.2.2 Faulty sensors/actuators

Electronic control systems must be able to identify both malfunctions on sensors/actuators cable and malfunctions on sensors/actuators themselves.
Particularly, the following must be identified:

- OPEN CIRCUIT (O.C.), GROUND SHORT CIRCUIT (S.C. GND), BATTERY VOLTAGE SHORT CIRCUIT (S.C. VB) on signal lines and possibly on power lines of each sensor/actuator;

- PLAUSIBILITY of signals: software checks allowing to evaluate reliability of a signal, generated by a single sensor or actuator feedback, by comparing it with all the others directly connected to it.

- (to be agreed upon with DT-SIEE-S-SE) SHORT CIRCUIT with signal lines of other sensors/actuators, SHORT CIRCUIT between signal lines and any reference voltages.

These strategies must distinguish the following:

- Malfunctions of single sensors / actuators;

- Malfunctions of system components, or electronic system itself, common to several sensors/actuators (for example: common power of several sensors/actuators).

4.2.3 Faulty electronic system

Electronic control system must be equipped with self-diagnostic strategies, i.e. monitoring of system electronic components involved in its regular operation.
Memory access errors, malfunctions in control electronic devices, etc. must be diagnosed, if necessary.

[1] *The condition where system power (+15) is cut off, but the electronic system is "self-powered" is defined as **Power-Latch** or **After-Run**. This strategy is implemented in some electronic systems to save data in non-volatile memory and perform test which cannot be executed under other conditions.*

4.2.4 Faulty power

If separate electronic and power supplies exist, power supply shortage must be diagnosed by storing the relevant error code in the electronic system and any switching of warning light.
Detection of any battery under-voltages must be provided for (threshold to be agreed upon with DT-SIEE-S-SE), since in this case the system is not able to properly operate; if proper operation is ensured by a certain voltage range, out-of-range powered system does not perform diagnostic which could generate false fault identifications.

4.2.5 Faulty mechanical components

In compliance with hardware / software feasibility, as well as with costs, variations in mechanical parameters must be controlled, measured and checked (for example: pump motor seizure in hydraulic circuit, starter block, compression decrease or misfire in engine control systems), by all system sensors or dedicated monitoring lines.

4.2.6 Faulty lines connecting electronic systems

If electric connections exist between electronic systems, all electronic faults on this signal must be identified (ground short circuit, short circuit in V_{batt}, open circuit) when appearing on this signal. This identification must be implemented in the receiving electronic system, while it is optional for the sending system.

4.2.7 Faulty CAN communication lines and relevant data

Nodes connected to CAN network and equipped with diagnosis, must provide for the following information codified on 2 bits by CAN network:

GenericFailSts – Indicates that one or more cells containing fault information exist on node memory.

CurrentFailSts – Indicates that a present fault exists on node (DTC Fault Status = DTC Present at time of request).

Possible faults linked to CAN communication are described hereinafter with reference to Fig. 1.

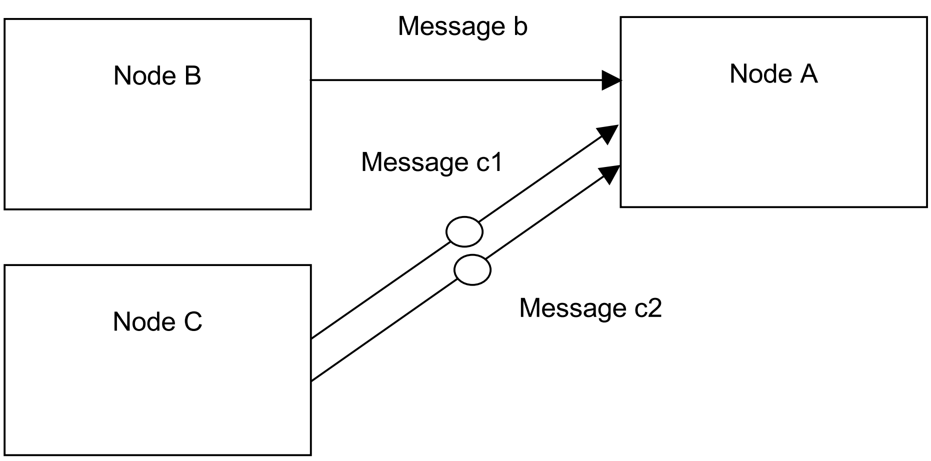


Fig. 1

1. **ABSENT node**: A node recognises C node as being absent from the network. This fault is detected when ALL messages monitored are missing (A node checks reception of both messages transmitted from C node).
2. **FAULTY node**: implementation of this fault is OPTIONAL and CAN only be provided for if more than 1 message is monitored. A node also detects C node improperly operating in the network since A node does not receive any “c1 message”, but continuously receives “c2 messages”.
3. **MUTE node:** A node recognises its disconnection from network. A node can check its CAN Controller error status (passive error, warning), and the type of CAN Controller error (ACK error) combined with the reception of one of the messages provided for by nodes B and C.
4. **BUS-OFF node:** A node detects a bus-off condition. A node checks its CAN Controller error status (bus-off).
5. **FAULT on CAN WIRES:** A node detects a physical error on CAN connections (for example: B node has a CAN cable disconnected or short-circuited on GND, or short-circuited in VBATT, or two CAN cables short-circuited between them).

NOTE: incoming messages with 'DLC' field lower than value specified on message map are to be considered as "not received" by A node. In this way, an ABSENT node or FAULTY node error is detected.
NOTE: Signals considered as “faulty” or “invalid” inside messages received, cannot be considered as CAN error. This error is provoked by information exchanged by CAN network, but it is not due to CAN network itself.

4.2.7.1 General rules

- Detection of faults linked to CAN communication is only enabled during normal operation of each node. Each supplier must state characteristics of normal operation for its node.
  Example:
  (KEY_ON) AND
  (VBATT > 10V) AND
  (STARTUP PHASE FINISHED) AND
  (NO CRANCK)
- Detection time of each DTC must be calibrated on application needs; in general values selected must be as high as possible. If no special application requirements exist, a 2.5-second detection time is to be applied, in compliance with “Network Operational Specifications”.
- In this case, a DTC is to be stored if, due to a fault, a node signals a recovery condition to the user (fault light on).

4.2.7.2 ABSENT node

- A single DTC is to be assigned to each source node (B and C nodes in Fig. 1 are source nodes for A node), independently of the number of messages, waited for by source node, controlled by the node which detects the fault.
- This error detection is to be disabled during silent period following bus-off condition in the node which is detecting the fault.
- A long-term filter is to be adopted and, anyway, detection time must be higher than maximum silent period for the bus-off specified for the source node.
- This error detection is to be disabled as soon as the node has detected a **Mute node error**, and be enabled again when **Mute** node error has become “not present”.

4.2.7.3 FAULTY node

- A single DTC is to be assigned to each source node (B and C nodes in Fig. 1 are source nodes for A node), independently of the number of messages, waited for by source node, controlled by the node which detects the fault.
- This error detection is to be disabled during silent period following bus-off condition in the node which is detecting the fault.
- This error detection is to be disabled as soon as the node has detected a **Mute node error**, and be enabled again when **Mute** node error has become “not present”.

4.2.7.4 MUTE node

- This fault detection must disable detection of **ABSENT** node and **FAULTY** node faults, as well as detection of any other fault depending on reception of messages/signals from the network (for example: immobilizer protocol). As soon as MUTE node error disappears, detection of these faults is to be restored.
- A long-term filter is to be adopted and, anyway, detection time must be higher than maximum silent period for the bus-off specified for the source node.

  Detection time for this fault is to be shorter than times adopted for ABSENT node and FAULTY node faults, as well as for any other fault depending on the reception of messages/signals from the network.

4.2.7.5 BUS-OFF node

- Silence following bus-off detection (as specified in "Network Operational Specifications") all faults linked to CAN communication are to be disabled.
- Detection mechanism is the following: after detecting a BUS-OFF condition, the relevant node performs a shutoff of its CAN Controller, waits for <Tbusoff> and activates a new initialization of CAN Controller. <Tbusoff> time is defined on the basis of application requests, and anyway inside the range defined in the following table, for C-CAN nodes, while it is specified as accounting for 1 second ±200 ms for B-CAN nodes. Whenever a node detects a BUS-OFF condition, it must increase an error counter. This counter must be set to 0 at Key On. It is stored like error after <n> conditions of BUS-OFF (error counter updated) unsuccessfully during Key On / Key Off cycle. <n> counter must be set to 0 to the following Key On.
  For nodes which, in case of BUS-OFF, immediately enter recovery mode and switch fault light on, <n> value is to be set to 1 (immediate detection).

	Typical value	MIN value	MAX value
C-CAN systems <Tbusoff>	500	30	1000
<n>	7	1	10

4.3 Malfunction management procedure

4.3.1 Malfunction filtering

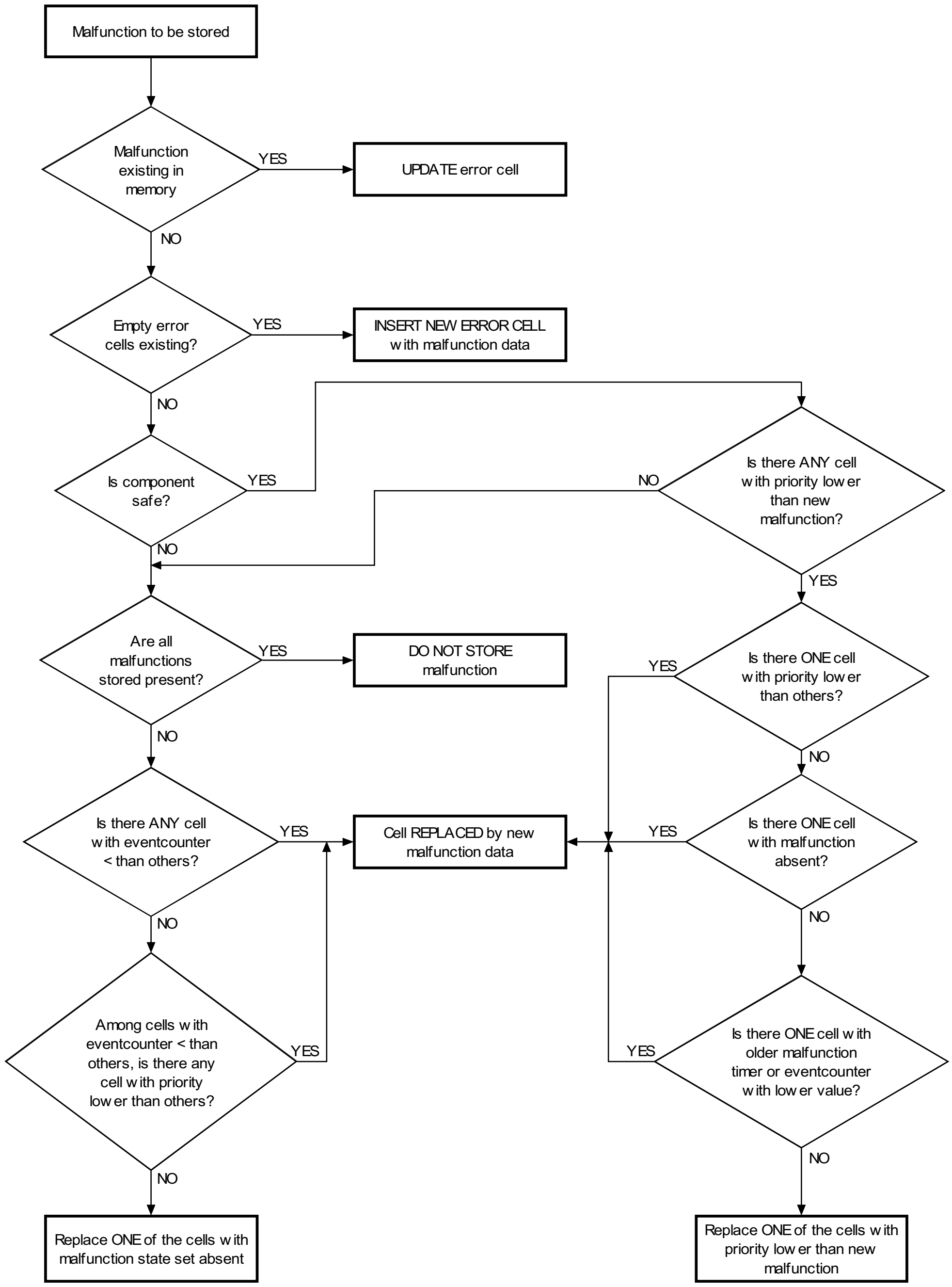
After identifying any malfunction, the electronic system enters fault filtering state; during this phase, fault cannot be considered as present yet.
Filtering time is used to isolate any disturbance due to real malfunctions, then each diagnostic routine must have its typical time setting during system calibration; this time must be added to **SDF** (**S**pecifica di **D**iagnosi **F**inalizzata) (section: Diagnostic Functions Summary) in the "Identification time" column.

4.3.2 Malfunction storing and warning light switching on

When fault filtering phase is completed, the electronic system must:

1. Store all information necessary to describe fault and its present state (present/absent) in non-volatile memory. This information is contained in **ERROR CELLS** described in Fiat Standards 07223, 07273 and 07274 (see **/2/**,**/3/** and **/4/**). The whole data structure described must remain in non-volatile memory of electronic system, with all data recorded, independently on vehicle state, speed, as well as with engine and electronic system off. Data integrity is to be ensured also during power voltage drops (within the limits specified(and during quick Key On – Key Off – Key On operations.
2. Switch on warning light, if required. The system manager (RSC) must define faults provoking switching on of warning light. This information is to be added to **SDF** (**S**pecifica di **D**iagnosi **F**inalizzata) (section: Diagnostic Functions Summary) in the “Warning lights” column.
3. Systems with CAN interface to Body Computer update GenericFailStatus and CurrentFailStatus bit state on message map.

The following diagram shows switching on/updating modes of fault information in non-volatile memory:



In general, error cells consist of the following field:

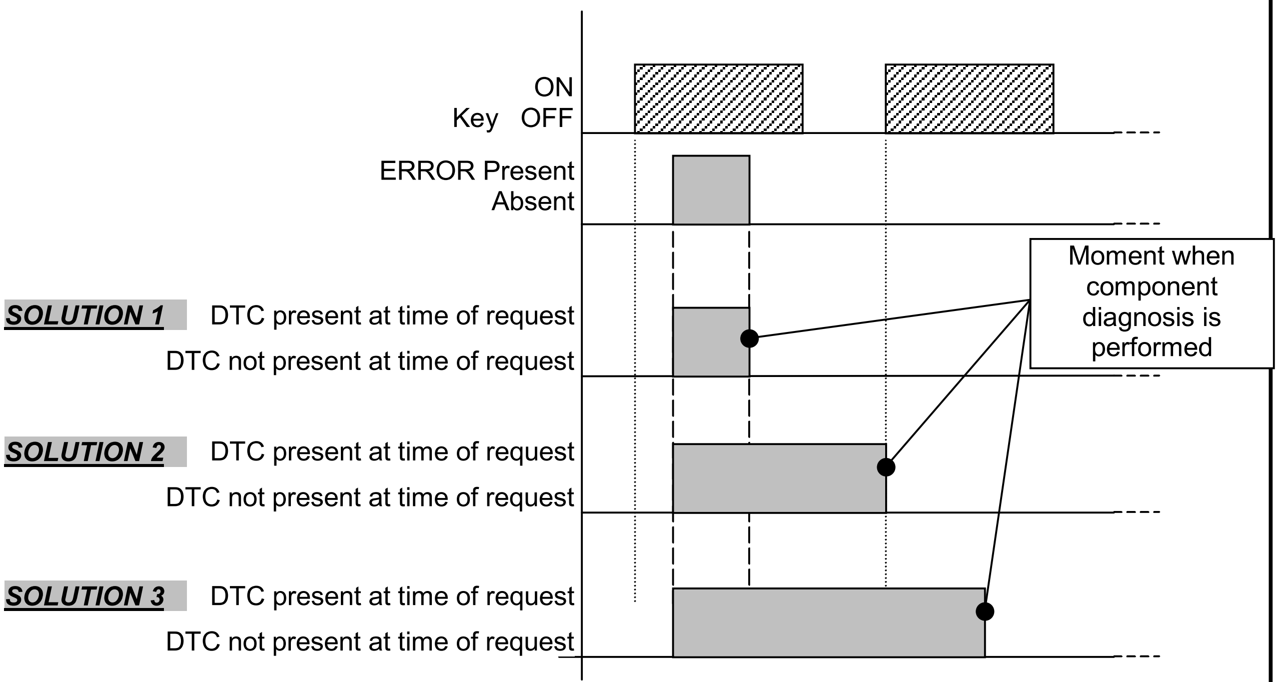
- Error code (DTC)
- Fault state (present/absent, type)
- Environmental parameters
- Error counter (eventCounter)

If error cell is updated, ONLY update fault state (DTCStrageState, bit 6 and 5 in StatusOfDTC) indicating if fault is present or not, as well as complete/uncompleted test datum, if managed (DTCReadiness, bit 4 in StatusOfDTC).
All other data must necessarily remain to the value set before updating, eventCounter data included.

4.3.3 Criteria to modify malfunction state

When fault is no more physically present, the electronic system must ONLY update fault state to "Non present", value, while other fault information from non-volatile memory must not be modified, except for eventCounter described in the following paragraph.

Fault presence/absence updating can be managed as follows:



Solution must be selected in compliance with the following criteria:

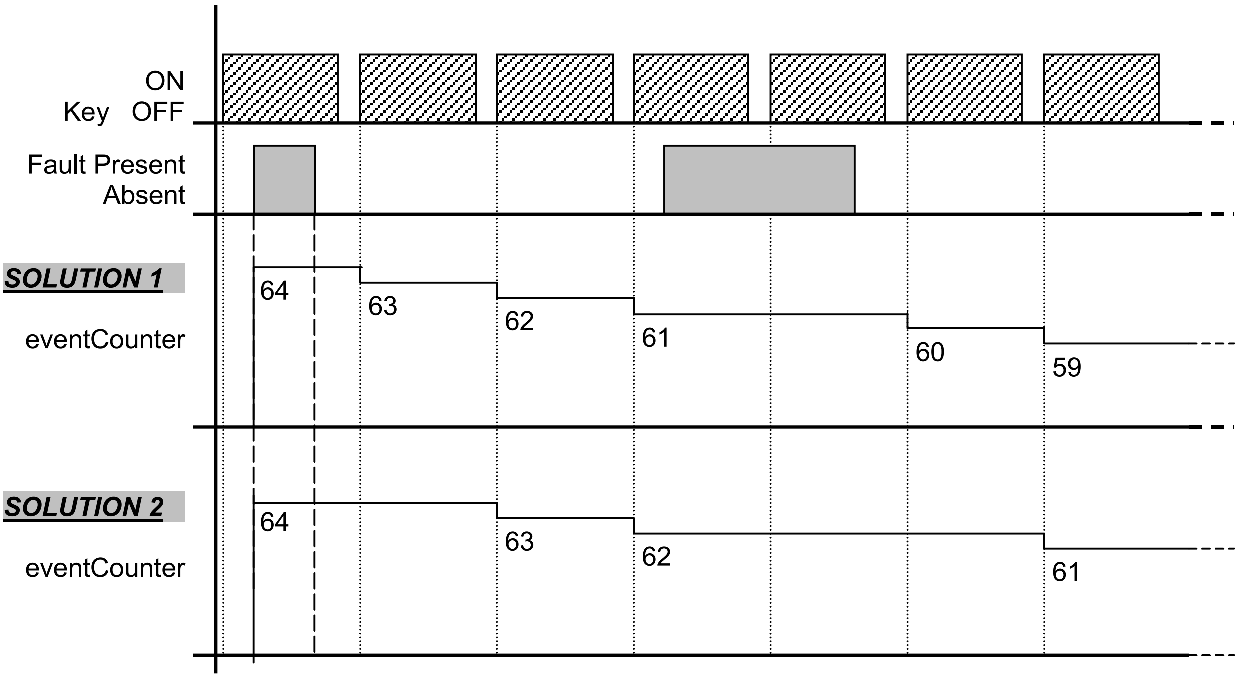
Solution 1 – This solution must be adopted if the electronic system, after checking the relevant fault is absent, can terminate implementation of recovery strategy and immediately return to normal operation; fault presence/absence signal must be immediately updated.

Solution 2 – This solution must be adopted if the electronic system remains in recovery state up to the following key ON, then, after checking the relevant fault is absent, returns to normal operation. Fault presence/absence signal is updated at the following key ON.

Solution 3 – Solution 3 must be adopted if the electronic system remains in recovery state up to the following key ON and absence of relevant fault is checked only under special system conditions. Since, this way, no more Key ON cycles can be performed without complying with fault check conditions, it is better to adopt this solution only for safety components requiring very accurate checks.

4.3.4 EventCounter management

EventCounter parameter must be set at decimal 64 value (except for EOBD systems, see paragraph 4.3.7) when stored for the first time in the error cell. Starting from the following key ON, when absence of the relevant fault is checked, counter is decreased by one unit, until 0 is reached. For this decrease, one of the following solutions can be used:



Data contained in error cell are to be eliminated when eventCounter reaches 0.

4.3.5 Error memory deleting

Deleting the content of the entire error memory must be possible, by a specific control, by diagnosis. Moreover, error cells with eventCouter equal to 0 must be automatically deleted by electronic system.

4.3.6 Error structure transmission to diagnostic instrument

Transmission of error structure by diagnostic instrument (following relevant control) must consider the following regulations:

1. Cells containing data are transmitted only.
2. When fault is identified, the electronic system must be able to transmit error information to diagnostic instrument in real time.
3. The electronic system must sent <u>all</u> error information to diagnostic instrument; this is valid for both information in non-volatile memory and identified in real time.

4.3.7 EventCounter management for EOBD systems

PowerTrain electronic systems having impact on vehicle emissions, must manage "fault state" (present/absent) and "eventCounter" information in compliance with European directive 98/69/EC dated October 13, 1998. In particular, eventCounter must comply with the following rules:

- it must be set at value 40 decimal when error cell is stored for the first time.
- counter is decreased by one unit per warm-up if the corresponding malfunction is repaired. Decrease takes place immediately if the corresponding malfunction has not provoked the switching on of MIL pilot light, otherwise it can only take place after MIL pilot light is switched off (see paragraphs 3.7 standard 98/69/EC).
- if the malfunction appears again, take the counter to 40 decimal again.
- data contained in error cell and the relevant data are eliminated when eventCounter is equal to 0 (see paragraph 3.8 standard 98/69/EC).

4.4 Recovery strategies

When a malfunction appears, the electronic system must be able to activate the recovery strategy required. These strategies have a double purpose: avoiding further damages to the system and allow its operations, even if with lower performances.
If sensors are faulty, the electronic system replaces old values obtained from faulty sensors with recovery values agreed upon with system manager or, if possible, it calculates them again indirectly from reading/processing of other parameters.
In case of malfunctions to actuators, recovery strategies to be adopted depend on the actuator examined.
All recovery strategies, both concerning sensors and actuators, differ in component type, and must be agreed upon singularly with the system manager / RSC.

4.5 Warning light management

4.5.1 Management of fault pilot light of non-EOBD systems

The warning light signals user that a malfunction is affecting a specific electronic control system. This signal is generated by controlling warning light when one or more malfunctions are stored in memory if warning light switching on is activated for them. This switching on must only be activated when malfunction is stored to avoid warning light switching on without any trace of diagnosis set in non-volatile memory.
Warning light switching on agreed, for each component, with RSC and included in system **SDF** (**S**pecifica di **D**iagnosi **F**inalizzata).

Moreover, to check that warning light properly operates, **it must be piloted when switched on for 4 ± 0.05 seconds,** then, procedure described before must be followed. In this period of time, the electronic system must perform tests necessary to check all its components properly operate.

If warning light switching on/off go through dedicated serial lines or CAN line, warning light initial switching on (4 ± 0.05 seconds) is locally managed from the dashboard; moreover, the lack of information on these lines to the dashboard must provoke automatic switching on of the relevant warning light.

The warning light proper operation must be controlled during experimentation by applying Test Standard 7.Z0050 (see **/5/**).

4.5.2 Management of MIL pilot light (EOBD systems)

MIL fault light must remain on by Key ON until engine is started-up and switched off after engine ignition, if no malfunction is identified. MIL pilot light operation is described in European directive 98/69/EC dated October 13, 1998, in paragraph 3.5.

4.6 Engineering parameters transmission

All engineering parameters generated by sensors and processed by electronic system, must be available on diagnostic link, as well as some parameters calculated and used for control and activation.
These parameters are available on diagnostic link upon single request or as a block by a specific control (snapshot); moreover, they must be accessible in key ON state, with engine running and under any vehicle speed.

In case of errors on a component, the relevant parameter transmitted must be the parameter really read by sensor, not the recovery parameter used by electronic system.

4.7 System identification data

Each electronic system must be able to transmit data for its univocal identification to the diagnostic instrument. The structure of these data is described in reference standards **/2/, /3/** and **/4/**. In particular, the ISO code is used to identify univocally the electronic system diagnosis.

FIAT system manager (or the supplier, if delegated by him/her) must required a new ISO CODE to FIAT (DT-SIEE-S-SE) whenever one of the following changes having impact on diagnostic functions is agreed upon:

- New electronic system / hardware change
- New pins of electronic system
- Changes to diagnostic protocol
- New sensor(s) / actuator (s)
- Sensors/actuators added/eliminated
- Changes in conversion formulas
- Information exchanged by diagnostic communication added/modified

4.8 Active diagnosis

Active diagnosis is a function allowing to piloting system actuator by diagnostic control, or anyway changing system output values transmitted by other electronic systems.
During active diagnosis, the electronic system must activate all diagnostic strategies existing during system normal operation.
Active diagnosis <u>must be provided for</u> in the following situations:

- the component must only be diagnosed in special conditions, difficult to be obtained; otherwise, the component can be piloted by active diagnosis to immediately check its operation (by reading error memory).
- visually and audibly inspect component activation.
- it is necessary to calibrate the component itself.

Active diagnosis <u>should be avoided</u> in the following situations:

- the component is continuously diagnosed.
- the component can be activated by external control (for ex.: parking lights, heated rear window). In this case, external control state must be “visible” from diagnostic appliance, to allow distinction between system input and output faults.
- on signals existing on CAN line, used for plausibility checks from other electronic system; really it must avoid the activation of plausibility diagnostic controls when situation around is not correct.

If necessary, active diagnosis on systems connected to CAN networks must be performed as a normal system function. Thus, if a component activation requires component state signal on CAN network or activation of the relevant warning light (for ex. parking lights), the system must act in the same way when receiving a control by diagnosis.

Single activation of components is preferable. If more component must be activated at the same time or in sequence, pre-programmed or Routine dedicated activations must be used.
If active diagnosis consists of default cycle, this cycle duration must be as low as possible, but sufficient to ensure actuator operation, in order to ensure that, even under the worst conditions, actuators are properly controlled and diagnostic routine can identify any malfunction.
It must also be ensured that activation of system components (solenoid valves, motors, etc.) by Diagnostic Instrument can only be performed under safe conditions and without any damage to the system or its components (for ex.: time limits depending on vehicle speed/ engine revolutions).

4.9 Statistic functions

Statistic functions allowing to re-trace vehicle and electronic system history or information describing the use of the system itself can be added to diagnostic functions required by the system. Also the total number of missions, the number of missions affected by malfunctions, the number of activation of a component and whatever is deemed as necessary by FIAT AUTO departments using these functions can be stored.
The following paragraphs describe basic functions of motor control systems.
For the acquisition of relevant control unit parameters, see paragraph 5.4 (Assignment of RLI codes).

4.9.1 "Engine runaway speed rate“ function

General – Runaway speed rate functions aim at evaluating stress engine is subject to during its life, considering both activations of rpm limiting device during propulsion phases and rpm limit exceeding during motoring over phases.
These two types of events are not compromised either while assessing diagnostic index or while defining activation time and revolution thresholds.

Specification – A “rpm limiting device” is a strategy, defined by the supplier, aiming at limiting maximum operation speed when engine generates a positive torque, i.e. propulsive; limitation is performed by acting on injection or throttle (according to engine type, diesel or gasoline, traditional or with motorised throttle engines).
The “runaway speed rate” event is the activation of “rpm limiting device” during propulsion or exceeding time and revolution thresholds calibrated for rpm limiting device, during motoring over phases.

The following indexes must be calculated, stored in EEPROM and made available for diagnostic instruments:

- number of “runaway speed rate” events identified (expressed on 1 byte)
- total time of “runaway speed rate” (±10 % tolerance, expressed on 2 bytes)
- maximum engine speed rate measured

The following indications are also valid:

- Indexes 1 and 2 must be saturated at the end of scale value
- These indexes are not set to zero by diagnostic instrument
- If electronic system is re-programmed, values of these indexes must remain unchanged

4.9.2 "Odometer" function

Description– Odometer function indicates the no. of Km covered by vehicle and can be used for ASSISTANCE operations at the authorised shops:

- It ensures exact number of km covered by vehicle with maximum 3% tolerance;
- Indicates the no. of Km covered by last assistance operation performed:
  - software updating of FLASHEPROM in ECU by Re-programming.

Specification

- Odometer function must reside in ECU as RAM variable (during vehicle operation) and in EEPROM (last value storing) to reduce its access and re-writing (writing in EEPROM is acceptable whenever x Km are covered during vehicle running to reduce any risk of RAM data loss).
- Parameters concerning ODOMETER function must be displayed by diagnostic instrument.
- Value read by diagnostic instrument is the result of algorithm processed by ECU whose initial datum is the number of pulses/revolution from speed sensor and tolerance must not exceed ± 3%.
- The number of pulses/revolution depends on the type of sensor used (for ex. 16 pulses/revolution or 4 pulses/revolution) and must be configured in calibration to detect different types of sensors.
- pulses/revolution must be computed and divided by ECU in “packages containing the same number of pulses” and the number obtained must be available as variable (for ex. the counter must increase every 1024 pulses/revolution if sensor transmit 16 pulses/revolution or 256 in case of 4 pulses/revolution).
- The maximum number of packages stored must be represented by 3 bytes.
- The ECU must ensure reset of all parameters concerning operation in the first installation.
- Reset or regulation of these parameters must not be accessible to any diagnostic instrument.
- Odometer value is to be kept also after complete re-programming of the control unit (FLASH programming).

Application on CAN networks – If engine control ECUs apply to CAN network, an “event” message must be available on network transmitted whenever vehicle covers 10 meters.
Engine control ECU must process this message as specific (see previous paragraph), except for “event” message calibration configuration instead of pulses/revolution and “events” number received instead of “package” number.

4.10 Regulation and writing in memory by diagnosis line

Operation on components or groups to be replaced during repairs, and whose installation implies calibration, settings or customisations, must be performed by diagnostic serial line. Methods to perform these procedures must be agreed upon with DT-SIEE-S-SE and fully described in **SDF** (**S**pecifica di **D**iagnosi **F**inalizzata). The following paragraph described re-programming modes.

4.11 Electronic system programming

Among diagnostic procedures to be performed by diagnostic instrument, re-programming is the operation allowing instrument (belonging to Technical Management, Production Management or Service/Spare Parts departments) to send information to the system, which receives, controls and stores them.
Some systems can “learn” values also during different procedures (for example learning of throttle angle by different engine controls); in these cases, the diagnostic instrument only starts learning control, not values; these procedures are not intended as re-programming phases.

Re-programming must be necessarily performed by system standard protocol and is to be considered a diagnostic function under any point of view.
Like other diagnostic functions, re-programming must be provided for by system manager (RSC) and added to requirements contained in operating specification; RSC must also indicate the type of re-programming to be provided for (see following paragraph), as well as manage departments’ requirements performing it on vehicle; these requirements are expressed both as information and procedures (for example Production Standards).

Anyway, if a certain type of re-programming must be implemented by an electronic system, it must fully comply with Fiat standards mentioned hereinafter: management, operation and protocol (for diagnostic protocol, Fiat 07223 and 07274 standards only are referred to hereinafter).

Like other procedures involving diagnosis, it is necessary that these operation requirements are agreed upon at the beginning of the project, since Fiat Auto standards can involve resources inside electronic system to be provided for by the supplier by properly dimensioning the system, and set instruments to be used to perform procedures on vehicle (in Production and Service).

Programming types

There are three increasingly-complex programming levels:

- Single writing (of a single parameter)
- Extended writing (more parameters in a single operation)
- Real re-programming, both total or partial ("*download*" of system memory, usually in Flash-EPROM technology)

4.11.1 Single writing

Writing of single information (on one or two bytes) to be necessarily defined by name, not physically; with reference to Fiat standard protocols, *LocalIdentifier* are used to designate information and *WriteDataByLocalIdentifier* command to write.

A system can require several information from Diagnostic Instrument and if information is independent or can be written in different moments without compliance problems among data, different single writing operations are activated on that system.
This operation is commonly used to inform the system that a certain value must be selected for one of internal parameter, usually resident in non-volatile memory; if, following information writing, system function is modified, affecting confidential aspects, operation performance can be protected by *Security Access* service provided for by the protocol.

Commonly, an acceptance range exists in specification for information to be received; checking datum received complies with range provided for (*range-check*) must be performed by electronic system.

4.11.2 Extended writing

Writing by a complying series of information (to be identified singularly) by a single operation , writing up to 255 bytes.
Information can represent a value matrix, a table or a series of separate single elements, to be written by a single operation to ensure compliance of data set, not to save protocol time (for example, Body Computer system configuration table, where compliance of information about vehicle characteristics is necessary).

Following information content and specific system to be re-programmed, operation can be protected or available only inside a specific diagnosis; considering information and system characteristics, it is implemented by *WriteDataByLocalIdentifier* service or *InputOutputControlByLocalIdentifier* by *short/long term adjustment* options.

Commonly, an acceptance range exists in specification for information contained in extended writing message; as above, checking datum received complies with range provided for (*range-check*) must be performed by electronic system.

4.11.3 Flash-EPROM re-programming

Re-programming mechanism (“*download*”) is the only performing an adjacent cell writing in memory, which are physically addressed, not logically as before: for these characteristics, electronic system cannot control information received, except for transmission compliance (“*Checksum*”).
What stated above, also implies that a wrong or interrupted re-programming operation leads to a non-operating system, then Flash-EPROM re-programming is always protected by *Security Access*.

For Fiat, the only protocol defining flash-EPROM re-programming is Key-word 2000 described in Standard Fiat 07223, containing services used for transmission; refer to this document for details on diagnostic services involved.

The protocol provides for the possibility to partially re-program memory, named “page” re-programming. This opportunity limits time necessary for operation, but represents a strong bound to develop electronic system development: content to be programmed (for example engine control system calibration) must necessarily have the same address on page beginning and end, the same order and format of all system versions and releases.

To perform this operation, for example in an installation shop where different systems appear to be re-programmed, usually by different suppliers, a very flexible instrument must be set, able to program pages of different dimensions following system appearing at the moment; managing instrument updating to different electronic system software changes will be difficult.

For these reasons, it was agreed upon that this type of re-programming is not to be used in Fiat Service applications, where time factor is not crucial; as for Production applications, it is recommended to develop instruments able to perform high-frequency total re-programming operations (see details on protocol document), rather than nominal-frequency partial operations.

4.11.4 Basic requirements for Flash-EPROM re-programming

Basic requirements to be met by electronic system are described hereinafter. These requirements allow Fiat setting to Flash-EPROM re-programming by its diagnostic instruments:

1. Re-programming must be allowed without acting on vehicle harness; thus, no external activation lines must be set (*write_enable* pin), hardware “keys” to be inserted into Diagnostic Single Outlet or other similar mechanisms

2. Re-programming file to be inserted into diagnostic system must be crypted; the supplier is responsible for crypting and ensuring data non-violation; de-crypting must be fully performed by electronic system, without any operation necessary by diagnostic instrument.

3. Diagnostic instrument must not know file content, but simply send it entirely

4. Selection of values assigned to parameters (memory address, data format [compression/crypting], dimensions of memory portion to be programmed, etc...) necessary to create commands to implement re-programming (see “*Request Down Load*” service), must be contained in the support files. These files allow to organise re-programming (see next paragraph) and are treated in a “transparent” way by diagnostic instrument.

5. The entire information block identifying electronic system (i.e. answer to *Read ECU Identification* service, option 80) must always be available, also in case of interrupted re-programming followed by partial or corrupted Flash content. The same information block must be automatically updated by electronic system when a re-programming is completed successfully.
   Updating performed when a re-programming is completed successfully cannot involve HW fields (see paragraph 7d)

6. Checksum of programmed area must be compared with checksum sent from re-programming instrument; in case of difference, the electronic system must interpret this difference like a data compliance error and send *Negative Response* code as required by protocol

7. Re-programming must only be possible for electronic systems ensuring the following functions concerning operator safety and information:

   (a) If electronic system is active in vehicle protection mechanisms, re-programming must only be enabled when these mechanisms are properly operated; in case of engine checks, the electronic system must enable operation for “virgin” system only or if communication is successful (no error).

   (b) "Seed & Key" procedure is properly completed.

   (c) Before starting downloading, the diagnostic instrument performs a direct writing (*WriteDataByLocalIdentifier)* of its identification code (*Repair Shop Code* or *Tester Serial Number*), as well as the current date (*Programming Date*); system checks this writing is performed.
   If tester code is not written, the electronic system must reject programming and provide for *Negative Response* as specified in the protocol.
   Following this procedure, information is already in Flash-EPROM before download is started; this ensures that, in case of further problems (wrong re-programming, communication interrupted, etc.), operation “tried” by diagnostic instrument is tracked in electronic system memory.
   “Tester code” field can be written by the following modes:
   Supplier:
   “Supplier Name” as suggested by supplier whose unicity is ensured by DT-SIEE-SSE.
   Fiat:
   Following requests by different departments, characterised as follows:
   management 3 bytes (ex.:”DT ”, ”AT ”,.....)
   department 4 bytes (ex.:”SIEE”, ”EXA ”,....)
   progr. no. 3 bytes (ex.:”0001”)
   Programming has been never performed, ECUs encoding can be different from the above-mentioned.

   (d) Information transferred from diagnostic instrument to system, must also contain hardware number and version; the electronic system must compare this information with information existing in its ROM memory, and, in case of differences, the system must reject re-programming and provide for *Negative Response* described in protocol (77h lockTransferDataChecksumError).
   This negative response can be sent back when checksum calculation is required.

8. Reprogramming must be allowed with battery voltage between 10 and 14.5 Volts.

4.11.5 Operations organisation

When deciding to set a service network to re-program flash-EPROM of an electronic system, three files with the following contents are available by DMC-SPV-Assistenza Tecnica department to support operation organisation:

1. data file (binary): containing code and data to be downloaded in electronic system memory, already crypted by supplier; for this reason, no interaction exists with this file, except for reading and sending of its block-to-block content to electronic system following flow described in the paragraph below

2. parameters file (readable): containing all parameters, in order, used by protocol during re-programming (Target Address, Baud Rate, Access Mode, etc.); the contents of these files allow to develop a single application software to manage re-programming.
   Really, application software on diagnostic instrument reads values contained in this file and manages communication with specific electronic system; if the content of these files is not correct, operation cannot be properly performed.

3. index file (readable): containing all operations necessary to match a pair of data+parameters files of an electronic system, which is the operation target; also contents of the third file are fundamental for a proper re-programming of flash-EPROM.
   Really, the electronic system cannot know, before, if a program it is requested to store is executable or not, for other reasons: as already said before, it can only check if program is suitable

to its hardware. Also this check is allowed after program is received, i.e. when previous program has already been deleted.
Thus, diagnostic instrument manages matching between a program and the electronic system it is devoted to.

Remember that each Fiat standard electronic system is identified by an information block structured as follows (for formats, refer to Fiat Standard 07223):

Hex Value	Identification Option	ECU Identification Data Format	# of bytes	Data Format	Owner
80	Identification Code	All data 91..99	61	---	---
91	FIAT drawing number	xxxxxxxxxxx	11	ASCII	**FIAT**
92	ECU hardware number	xxxxxxxxxxx	11	ASCII	**Supplier**
93	HW ECU version number	x	1	UNSGN	**Supplier**
94	ECU software number	xxxxxxxxxxx	11	ASCII	**Supplier**
95	SW ECU version number	xx	2	UNSGN	**Supplier**
96	Homologation code	xxxxxx	6	ASCII	**Homo. Depart.**
97	ISO code	xx xx xx xx xx	5	UNSGN	**FIAT DT**
98	Tester code	xxxxxxxxxx	10	ASCII	**FIAT**
99	Re-programming date	xx xx xx xx [Y-Y-M-D]	4	BCD	---

Structure of index file is shown in the following table:

Identification Option	ECU Identification Data Format	# of bytes	Data Format	Owner
New FIAT drawing number	NEW xxxxxxxxxxx	11	ASCII	FIAT DT
New ECU hardware	OLD xxxxxxxxxxx	11	ASCII	Supplier
New HW ECU version	OLD x	1	UNSGN	Supplier
New ECU software number	NEW xxxxxxxxxxx	11	ASCII	Supplier
New SW ECU version number	NEW xx	2	UNSGN	Supplier
New homologation code	NEW xxxxxx	6	ASCII	Homol. Depart.
New ISO code	NEW xx xx xx xx xx	5	UNSGN	FIAT DT SIEE
Data file name	Nomefile.ext	12	ASCII	FIAT / Supplier
New software authorisation date	xx xx xx xx [Y-Y-M-D]	4	BCD	FIAT / Supplier
ECU software number 1)	OLD xxxxxxxxxxx	11	ASCII	FIAT / Supplier
SW ECU version number (1)	OLD xx	2	UNSGN	FIAT / Supplier
ECU software number (2)	OLD xxxxxxxxxxx	11	ASCII	FIAT / Supplier
SW ECU version number (2)	OLD xx	2	UNSGN	FIAT / Supplier
(…)				
ECU software number (n)	OLD xxxxxxxxxxx	11	ASCII	FIAT / Supplier
SW ECU version number (n)	OLD xx	2	UNSGN	FIAT / Supplier

Identification Option	Num. of bytes into ECU Memory	Data Format into ECU Memory	Value	Num. of bytes into *.idx file		Data Format into *.idx file
New FIAT drawing number	11	ASCII	80808080801	11	+CR+LF	ASCII
New ECU hardware	11	ASCII	ABCDEFGHIK1	11	+CR+LF	ASCII
New HW ECU version	1	UNSGN	A6	2	+CR+LF	ASCII
New ECU software number	11	ASCII	SWNUMB00004	11	+CR+LF	ASCII
New SW ECU version number	2	UNSGN	A6A7	4	+CR+LF	ASCII
New homologation code	6	ASCII	123456	6	+CR+LF	ASCII
New ISO code	5	UNSGN	A8A9AAABAC	10	+CR+LF	ASCII
Data file name	12	ASCII	NOMEFILE.BIN	12	+CR+LF	ASCII
New software authorisation date	4	BCD	19991129	8	+CR+LF	ASCII
ECU software number 1)	11	ASCII	SWNUMB00003	11	+CR+LF	ASCII
SW ECU version number (1)	2	UNSGN	A6A6	4	+CR+LF	ASCII
ECU software number (2)	11	ASCII	SWNUMB00002	11	+CR+LF	ASCII
SW ECU version number (2)	2	UNSGN	A6A5	4	+CR+LF	ASCII

In index file, all UNSGN and BCD values are to be written in ASCII, for example 0xA6 (1byte) **is not** to be imported in the file like binary (character "ª" would be displayed if this binary value is read with a test editor), but be written like ascii "A6" (2 bytes).
Conversion from ASCII to UNSGN and from ASCII to BCD is run by Examiner application program which manages these files.
Each field of index file must end with a line feed and a carriage return (0x0D e 0x0A)

This structure is generated by the following remarks:

- during operation check, the whole identification block of the "new" system must be available, i.e. system programmed with new software, to allow the relevant checks.

- it is necessary to know number and name of "old" versions of programs to be updated by the new program; hardware data of these versions are not necessary, as they must be the same as the new program; drawing number is not necessary as it is not an univocal system identifier and anyway it is covered during operation.

- it is necessary to know the name of data file containing program; on the contrary, all index files are gathered to create the information base of diagnostic instrument, to be examined to determine if the software of an electronic system can be updated or not, then correspondence between an index file and the relevant data file is lost.

- it is necessary to state the new software date, to manage different programmings possibly referring to the same electronic system; we believe the following examples are useful:

    1. after deciding re-programming flash-EPROM of a certain electronic system, the diagnostic instrument defines the information base consisting of all index files belonging to it, searching for data occurrences of the system examined; if more are found, it always uses software with the most recent release date
    2. if a system is equipped with software "A"; then software B is delivered to replace software A; if software C is released, saying it must replace software B, it is necessary to state that it must also replace software A.
       Really, the instrument alone cannot decide to perform an operation, then transitive property is not valid: saying that B→A, then C→ B does NOT mean that instrument can also perform C→A, unless it is expressly instructed to.

It is obvious that maximum care is required when filling in index file data, as well as parameters and software file: operation can be automatically performed only in presence of a compliant and correct series.

Structure of parameters file is shown in the following table:

N	Parameter name	HEX dimension	SID memo	Example
1	Target Address	1 byte	STC	10
2	Max Baud Rate ID	1 byte	STDS	03
3	P2 Min [0.5 ms/bit]	1 byte	ATP	1E
4	P2 Max [25 ms/bit; FFh = ∞]	1 byte	" "	02
5	P3 Min [0.5 ms/bit]	1 byte	" "	01
6	P3 Max [250 ms/bit; FFh = ∞]	1 byte	" "	14
7	P4 Min [0.5 ms/bit]	1 byte	" "	00
8	AccessMode = [requestSeed]	1 byte	SA 1	01
9	AccessParameter **(*)**	1 byte	" "	00
10	Type of Seed&KeyId	1 byte	SA 2 (prog)	04
11	start address (high byte)	1 byte	STRBLI	00
12	start address (middle byte)	1 byte	" "	0F
13	start address (low byte)	1 byte	" "	00
14	stop address (high byte)	1 byte	" "	02
15	stop address (middle byte)	1 byte	" "	FF
16	stop address (low byte)	1 byte	" "	FF
17	MemoryAddress (high byte)	1 byte	RD	00
18	MemoryAddress (middle byte)	1 byte	" "	0F
19	MemoryAddress (low byte)	1 byte	" "	00
20	DataFormatIdentifier	1 byte	" "	04
21	UnComprMemorySize (high byte)	1 byte	" "	02
22	UnComprMemorySize (middle byte)	1 byte	" "	F0
23	UnComprMemorySize (low byte)	1 byte	" "	FF
24	start address (high byte)	1 byte	STRBLI	00
25	start address (middle byte)	1 byte	" "	0F
26	start address (low byte)	1 byte	" "	00
27	stop address (high byte)	1 byte	" "	02
28	stop address (middle byte)	1 byte	" "	FF
29	stop address (low byte)	1 byte	" "	FF
30	Expected checksum (high byte)	1 byte	" "	AB
31	Expected checksum (low byte)	1 byte	" "	CD

(*) Necessary for BOSCH applications only

Values suggested for parameter file:

N	Parameter name	HEX dimension	SID memo	Example
3	P2 Min [0.5 ms/bit]	1 byte	ATP	1E
4	P2 Max [25 ms/bit; FFh = ∞]	1 byte	" "	02
5	P3 Min [0.5 ms/bit]	1 byte	" "	01
6	P3 Max [250 ms/bit; FFh = ∞]	1 byte	" "	14
7	P4 Min [0.5 ms/bit]	1 byte	" "	00

Possible values for "Type of Seed&Key":

Identification (hex)	Type of algorithm
01	BOSCH by sending Access Parameter
02	MARELLI
03	HITACHI
04	LUCAS

4.11.6 File names

File name complies with the following definitions:

Data file: <nome_file>.BIN
Parameters file: <nome_file>.PRM
Index file: <nome_file>.IDX

where <nome_file> is structured as KKXXYYZZ with the following conventions:

KK: 2 alphabetical characters indicating supplier (example BO for Bosch)
XX: 2 numerical characters indicating system type (example 01 for engine control)
YY: 2 numerical characters indicating system (example 01 for M3.1)
ZZ: 2 numerical characters indicating system version

4.11.7 Data Transfer Flow

The following flow diagram (simplified) shows information exchange sequence used to initialise, develop and properly terminate data transfer.

Diagnostic instrument:		***Electronic system:***
Fast Init [or 5-baud initialisation] ↓		
Start Communication Request	→	
	←	Start Communication Positive Response
Start Diagnostic Session (Baud Rate modified)	→	
		Start Diagnostic Session Positive Response
Access Timing Parameter (Limits reading)	→	
	←	Access Timing Parameter Positive Response
Access Timing Parameter (Limits setting)	→	
	←	Access Timing Parameter Positive Response
Access Timing Parameter (Present values reading)	→	
	←	Access Timing Parameter Positive Response
Security Access Request 1 (Request SEED)	→	
	←	Security Access Positive Response (Transfer SEED)
Security Access Request 2 (Transfer KEY)	→	
	←	Security Access Positive Response (KEY OK)
Write Data by Local Id. (Repair Shop Code)	→	
	←	Write Data by Local Id. Positive Response
Write Data by Local Id. (Programming Date)	→	
	←	Write Data by Local Id. Positive Response
Start Routine by Local Id. Request (Erase Flash Memory)	→	
	1. ←	Start Routine by Loca Id. Positive Response (Routine Erase Flash Memory Started)

← **.1.**

Request	Direction	Response
Request Routine Result by Local Id. Request (Erase Flash Memory)	→	
	←	Request Routine Result by Local Id. Positive Response (Routine Erase Flash Memory successfully finished)
Request Download (Memory Address, Data Format Identifier, Memory Size)	→	
	←	Request Download Positive Response
Transfer Data Request (Data from file)	→	
		Transfer Data Positive Response
Request Transfer Exit Request	→	
		Rquest Transfer Exit Positive Response
Start Routine By Local Id. (Routine Calculate CRC-Checksum, Start Address, End Address, expected CRC-Checksum)	→	
	←	Start Routine By Local Id. Positive Response (Routine Calculate CRC-Checksum started)
Request Routine Result by Local Id. Request (Calculate CRC-Checksum)	→	
	←	Request Routine Result by Local Id. Positive Response (Routine Calculate CRC-Checksum successfully finished)
Stop Diagnostic Session Request	→	
	←	Stop Diagnostic Session Positive Response
Stop Communication Request	→	
	←	Stop Communication Positive Response
End of procedure: Key-OFF/Key-ON and defects setting to zero		

The system must update the following data between procedure proper end and following Key ON:

- No. of correct re-programming.
- Value of odometer parameter (if available)

The operations flow described above does not include different negative responses (listed in protocol document) because in case of negative response by the electronic system, it is only possible to stop procedure and try again.

In case of problems neglected during flash-EPROM re-programming, it is recommended to implement a mechanism on service network diagnostic system. Thanks to this mechanism, any new re-programming attempt is performed at communication basic frequency (10.4 kbaud) instead of using maximum frequency tolerated by instrument and electronic system: obviously, when frequency is decreased, operation time is increased, but it limits any risk of interference or disturbance possibly making operation unsuccessfully.
Adoption of these solutions must be decided by DMC-SPV- Assistenza Tecnica.

Note that it is impossible for an electronic system terminating operation in a faulty way (or interrupted) to provide support to identify the problem; typically, memory part devoted to application softwares deleted or corrupted. These softwares also include diagnostic application software, inactive during flash-EPROM re-programming (boot-block operating only). Thus, in case of unsuccessful or interrupted re-programming, system state cannot be checked in any way.

5 REQUIREMENTS AND ACTIONS TO IMPLEMENT DIAGNOSIS

The following paragraphs are reference points to be considered while designing electronic system.

5.1 Diagnostic address assignment

An address is assigned to each type of electronic system equipped with diagnosis; this address is used to start diagnostic communication. This address is to be agreed upon with DT-SIEE-SSE.

5.2 Non-volatile memory dimensioning

Non-volatile memory (EEPROM, Flash EPROM, etc...) must contain information about both present and past faults. Each error must be structured as specified in reference standard **/2/, /3/** or **/4/**.
Minimum number of error cells to be stored is **5**, moreover, memory dimensions are linked to system complexity, as well as to priority/criticality of different DTCs; a general dimensioning can be given by the following ratio:

$$\text{Minimum number of cells to be stored} = \frac{\text{Error codes number}}{3}$$

5.3 DTC codes assignment

A **single** DTC code must be assigned to each component or function of electronic system to prevent error cells filling with different DTC codes linked to a single faulty element.
A DTC code must also identify a system component to be entirely replaced, in case of breaking.

DTC parameter is used by electronic system to point out any system fault by a two-byte BCD number. DTC format is specified in **/8/**. Decoding is shown in the following table:

Bit 15,14: P,C,B,U/A	Bit 13,12: Sub-groups 0-3	DTC numbers (Binary Coded Decimal) field: 001 - 999		
0 0 (**P**)owertrain	0	0	0	1
:	:	:	:	:
0 0 (**P**)owertrain	3	9	9	9
0 1 (**C**)hassis	0	0	0	1
:	:	:	:	:
0 1 (**C**)hassis	3	9	9	9
1 0 (**B**)ody	0	0	0	1
:	:	:	:	:
1 0 (**B**)ody	3	9	9	9
1 1 (**U**)Network/All	0	0	0	1
:	:	:	:	:
1 1 (**U**)Network/All	3	9	9	9

Subgroup 0 must be used for DTCs controlled by ISO/SAE uniform by definition. Otherwise, subgroup 3 is reserved: DTCs in this group must not be used by ECU.

FIAT coding for DTCs follows these regulations:

- DTCs must belong to subgroups 1 or 2 (“manufacturer controlled”), unless differently specified.
- A DTC must identify an ECU subcomponent to be entirely replaced by assistance. Ex.: it is not necessary to distinguish between an electronic system with a memory portion faulty and an electronic system with problem on I/O driver; since the entire electronic system must be replaced in both cases. In this case, use the same DTC with different DTCFaultSymptoms reducing DTC total number.

5.3.1 DTC linked to CAN communication

DTCs to be assigned to faults linked to CAN communication are specified in the following table. Since not all fault detections are to be implemented in each node, node types are also specified in the table.

CAN failure	DTC	DTCFaultSymptom	Node(s)
Node ABSENT	U1 7NN (*)	0100 (no signal)	Mandatory for C-CAN nodes
Node FAULTY	U1 7NN (*)	1000 (invalid signal)	Mandatory for C-CAN nodes
Node MUTE	U1 601	0100 (no signal)	Mandatory for C-CAN nodes
Node BUS-OFF (C-CAN)	U1 601	0000 (no symptom)	C-CAN nodes
Node BUS-OFF (B-CAN)	U1 602	0000 (no symptom)	B-CAN nodes
FAULT on CAN WIRES	U1 602	1000 (invalid signal)	B-CAN master nodes

(*) NN must be the same as the fault node address as specified in 'Message map' for the project

5.4 Assignment of RLI codes

Standard RLI (Local Identifier) codes are shown in the following table for Engine control systems:

RLI (Hex)	Description	Reading	Writing	Byte number	Conversion
01	Immobilizer state	###	NO	1	TBD
03	Odometer	###	NO	3	TBD
08	Number of out-of-revolution events	###	NO	1	TBD
09	Maximum speed exceeding time counter	###	NO	2	TBD
0A	Maximum speed reached	###	NO	1	TBD
0B	Number of FlashRom re-writings (F-ROM)	###	NO	1	TBD
0C	Odometer content to the last F-ROM updating	###	NO	3	TBD

5.5 Buffer dimensioning on diagnostic serial line.

Transmission/reception buffer of diagnostic line must be dimensioned on the basis of the longest message provided for in applied communication general protocol (see **/2/**, **/3/** or **/4/**).

5.6 Variations communicated to assign ISO code

As described in paragraph 4.7, when a change of electronic system affects diagnostic functions the system manager (directly or delegating the supplier) must require the emission of a new ISO code to FIAT. Then, the following data must be communicated to DT-SIEE-S-SE:

Electronic system name	:	
Supplier's name	:	
FIAT drawing number	:	
Supplier spare code	:	
Application vehicle	:	
Vehicle characteristics	:	
Characteristic elements / changes to previous version and notes	:	

6 CONNECTION ELECTRIC CHARACTERISTICS

6.1 Communication lines configuration

Diagnostic communication can use one of the following configurations:

- "K" serial line (ISO 9141)
- C.A.N. communication bus

6.1.1 "K" serial line physical level

Level
Physical level of "K" serial line must fully comply with **Standard ISO 9141** (see **/1/**).

Interface circuit of "K" serial line can be configured in two ways:

- "Open Collector" connection
- pull-up resistance between "K" line and Battery Voltage (V_B)

If pull-up resistance is used, this resistance must not exceed 10 kΩ x *n*, (where *n* is the number of electronic systems connected) and *n* reference value is 10.

Physical level of "K" line must be checked by experimentation standard **7.Z0050** (see **/5/**).

6.1.2 CAN communication bus physical level

Physical level of low-speed CAN communication bus must comply with transceiver Philips TJA 1053, high-speed bus must comply with ISO standard 11898.

Physical level of low-speed CAN communication bus must checked by experimentation standard **7.Z0140** (see **/6/**).

6.2 Electric connection on vehicle (specific diagnostic connector for each electronic system)

6.2.1 Diagnostic connection

This configuration is used on vehicles projected before 1997, and cannot apply on new vehicles. Obviously, diagnostic connection by CAN bus must be performed on unified diagnostic connector (see 6.3).

On all vehicle models produced before 1997, each electronic system with diagnosis must be connected to a connector consisting of a three-way polarised female connector with characteristics specified in unified element FIAT AUTO no. 1/23314/87 Tab. 91332/41 (shown in figure 1).
This joint must be protected with a protection cover.

6.2.2 PIN layout on female connector (vehicle side)

Communication lines layout on three-way polarised female connector must comply with figure 1.

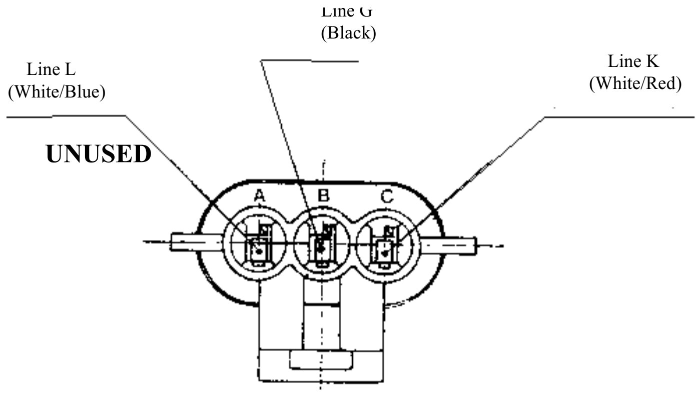


Figure 1 – View of female connector from cable input side

Connection lines must be made with normalised cables ∅ 0.5 + 1 mm to be identified by cable colour as follows:

- line "K" :white/red
- line "L" :white/blue
- line "G" :black

6.2.3 Connector on diagnosis appliance side

Three-way polarised male connector must have the same characteristics as specified unified element FIAT AUTO no. 1/23324/87 Tab. 91332/1.

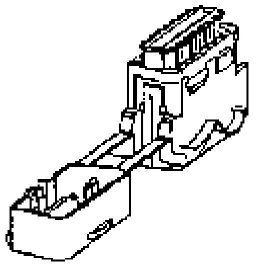
6.3 Electric connection on vehicle (unified diagnostic connector for all electronic systems)

6.3.1 Diagnostic connection

On all vehicle models produced after 1997 a connector must be used complying with Standard SAE J 1962 / ISO 15031-3, as specified by **EOBD directive** (15031), consisting of a three-way polarised female connector with characteristics specified in unified element FIAT AUTO no. 01/01534/87 Tab. 91343/42.

6.3.2 PIN layout on female connector (vehicle side)

Communication lines layout on sixteen-way polarised female connector must comply with figure 4.



1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16

No.	Definition	Notes
1	ABS system	/
2	Bus + Line, SAE J1850	Unused at present
3	AIR BAG system	/
4	Body ground	Shared with other charges
5	Signal ground	To be directly connected to battery negative terminal (if impossible, connect to body ground avoiding share with engine and/or induction charges)
6	C.A.N. HIGH (or B)	Low-speed C.A.N. (High or B) line
7	K Line, ISO 9141 CARB	Engine control systems K line (and systems important for EOBD)
8	IMMOBILIZER	/
9	AGGREGATE 1	Electronic systems K lines connected to dashboard cable
10	Bus + Line, SAE J1850	Unused at present
11	Radiofrequency receiver + Alarm	/
12	AGGREGATE 2	Electronic systems K lines connected to engine compartment cable
13	AGGREGATE 3	Electronic systems K lines connected to rear cable
14	C.A.N. LOW (or A)	Low-speed C.A.N. (High or A) line
15	L Line, ISO 9141 CARB	Control systems L lines (and systems important for EOBD)
16	Battery power (+30)	/

Figure 2 – Female connector on switching on side

6.3.3 Connector on diagnosis appliance side

Sixteen-way polarised male connector consisting of a male connector (ref. CINCH 94200EV.16.M1) with its plug (ref. CINCH 49110EV16M5).

6.4 Access to connection outlet

Diagnostic connection outlets must be located to allow operator to easily connect diagnostic test equipment both during production and service; then, when vehicle is completed, **diagnostic outlet must be accessible without removal**.

As for connection on unified diagnostic outlet, connector is located inside the passengers' compartment, close to the dashboard (as described in the above-mentioned Standard SAE J 1962 ISO / ISO 15031-3).

7 EXAMPLE OF SDF (SPECIFICA DI DIAGNOSI FINALIZZATA)

Each ECU with diagnosis requires drawing of a **SDF** (Specifica di **D**iagnosi **F**inalizzata) consisting of the following sections:

- Physical level section – used for communication.

  Specify configuration to be used for diagnostic connection among those specified in paragraph **6.1**.

- Protocol service – services used and typical parameters.

  On the basis of physical level, the communication protocol to be implemented must be selected (as specified in paragraph **4.1**) using one of the 3 protocols allowed (07223, 07273, 07274).
  Fill in this specification part by using format of the above-mentioned standards specifying paragraphs names by one of the following:

  N.U. UNUSED
  U.C. USED IN COMPLIANCE WITH STANDARD
  U.C.D. USED IN COMPLIANCE WITH STANDARD + DATA
  U.N.C. USED NOT IN COMPLIANCE WITH STANDARD

  If a whole group of sub-paragraph is not used, specify **N.U.** on initial paragraph and omit the other parameters.
  Sections specified as **U.C.** and **U.C.D.** must only show paragraph name, as well as any tables to be filled in with the necessary data.
  Sections specified as **U.N.C.** must only contain the description of changes from standard.

- Procedure section – to be performed on line end or service.

  If special procedures are to be performed during vehicle production (ex.: key programming) or service (ex.: learning to be activated after replacing a component), specify their performance in details.

- Diagnostic Functions Summary section.

  For each error code (**DTC**) provided for by the ECU, specify the following by using the reference table:

  Types of malfunction associated to this symptom
  Vehicle conditions allowing troubleshooting
  Any error causes
  Identification strategy
  Identification time
  Invalidation time
  Action of any warning lights
  Any recovery strategies

Models to fill in **SDF** (**S**pecifica di **D**iagnosi **F**inalizzata) (referred to standards **/2/**, **/3/**, **/4/**) can be directly required to DT-SIEE-SSE.